Voyantic

Tagformance Pro Measurement System

Manual

Tagformance 14.10

Tagformance HF 3.7

Jun-2026

1 Important Information

READ THE COMPLETE USER GUIDE CAREFULLY BEFORE USING THE TAGFORMANCE™ SYSTEM.

Voyantic Ltd. operates an ongoing development policy. Voyantic Ltd. reserves the right to make changes and improvements to any of the products described in this user guide without prior notice.

THE CONTENTS OF THIS USER GUIDE ARE PROVIDED "AS IS". EXCEPT AS REQUIRED BY APPLICABLE LAW, NO WARRANTIES OF ANY KIND, EITHER EXPRESS OR IMPLIED, ARE MADE IN RELATION TO THE ACCURACY, RELIABILITY OR CONTENTS OF THIS USER GUIDE. VOYANTIC LTD. RESERVES THE RIGHT TO REVISE THIS USER GUIDE OR WITHDRAW IT AT ANY TIME WITHOUT PRIOR NOTICE.

General Terms and Conditions of Voyantic Ltd. shall apply.
http://www.voyantic.com/termsandconditions.pdf

THE MEASUREMENT UNIT COVER BOX SHALL NOT BE OPENED. Voyantic Ltd. will inspect the seals of the equipment in case of warranty or maintenance procedures. If the seals are broken, the warranty will be void, and Voyantic Ltd. can be entitled to invoice a contractual sanction if this has been defined in the commercial agreement or in the order acknowledgment document.

The Tagformance Pro can use radio frequencies, use of which may require local or otherwise applicable governmental or official approvals or permissions. VOYANTIC LTD. DOES NOT WARRANT ANY TYPE OF APPROVAL FOR TAGFORMANCE PRO. VOYANTIC LTD. SHALL UNDER NO CIRCUMSTANCES BE LIABLE FOR ANY USE OF TAGFORMANCE PRO.

Use of any additional software requires a valid license. Any copyrights, patents, and other intellectual property rights (including the right to change and further develop) in and to the Tagformance Pro (including any related documentation and other materials delivered by Voyantic Ltd.) shall belong to Voyantic Ltd.

2 Privacy and Data Collection Policy

Service data

We automatically process the data to provide you with the services that you have requested.

- Service automatically collects license information, and this data is used to authorize access to services.

Analytics data

We collect anonymous or pseudonymous data to learn when and how our services are used.

- Upon user consent, the Tagformance test system sends data, such as error logs and usage analytics, for product development purposes.

For up-to-date information about Tagformance privacy and data collection policy, please refer to: *https://voyantic.com/lab/tagformance/privacy.*

3 Table of Contents

About Tagformance

Tagformance Pro is a highly sophisticated measurement system for evaluating the functionality and performance of UHF RFID, HF RFID, and NFC transponders. The Measurement Unit is effectively a network analyzer optimized for RFID measurements. In a typical passive RFID system, the reader generates a carrier that the transponder uses to power up. The reader can modulate the carrier in order to send a command to the transponder, and the transponder, in turn, can modulate the signal reflecting from it. The properties of the transponder are measured while it is active. Tagformance Pro can generate an RF carrier wave and modulate it with an arbitrary waveform. After a command is sent, the Measurement Unit functions as a time-domain network analyzer, providing the carrier for the transponder and recording the response waveform acquired by a quadrature detector.

A transponder's two most important performance parameters are its sensitivity and the strength of the backscatter (UHF) / Load modulation (HF) signal it produces. The sensitivity of a transponder is measured by challenging its power source, i.e. determining the required power level for the transponder to be able to respond to a command. The backscatter/load modulation signal, i.e. the modulated carrier returning from the transponder, is measured by recording the transponder’s response after a command is sent. These parameters are typically measured as a function of an additional parameter, such as frequency, distance, or orientation angle.

The Tagformance measurement system also includes Measurement Software running on a PC or a laptop. The Measurement Unit interfaces with the computer via Ethernet. The Measurement Software takes care of the waveform generation and the actual measurements. The Measurement Unit uses an external power source to power up.

The Tagformance measurement system is intended for use in the laboratory. It should be noted that if antennas or other radiating coupling elements are used with the Measurement Unit, local regulations may limit the frequency range and transmit power that can be used. A typical application environment is inside the Voyantic RFID Measurement Cabinet or other shielded and anechoic chamber.

Tagformance Pro is a CFR 47, PART 15.103(c) exempt device in the United States. However, the Device would violate Part 15 rules if a radiating element were connected to the output port unless the radiating elements were placed in a shielded chamber.

4 Tagformance SW Installation

4.1 System Requirements

Supported operating systems for Tagformance Pro:

- Windows 10
- Windows 11

Minimum system requirements for Tagformance Pro:

- Intel Core i3-7020U or better in CPU benchmark
- One Ethernet port for Tagformance Pro
- USB ports are required for Tag Rotating System and Multiplexer
- 8 GB RAM
- 5 GB free hard disk space
- Minimum screen resolution 1024 x 768
- Mouse, keyboard

The Tagformance Measurement Software installer contains the required LabVIEW drivers. Tagformance Measurement Software is built as a 64 bit application, which requires 64 bit dependencies, among them Microsoft Office. Internet connection is not required, but it enables Voyantic's backend services to obtain up-to-date information for various purposes (requires active maintenance contract) and the option to have the software send application logs, such as error logs, for customer support and software development purposes.

4.2 Installing Software

1. Turn on your computer and wait for Windows to start up. Login to the computer with Administrator permissions.
2. Insert the Tagformance Measurement Software installation media. Do not plug in the Tagformance Pro Measurement Unit yet.
3. If AutoPlay is enabled, the installation program will start automatically. If not, navigate to the installation media and double-click setup.exe.
4. Follow the on-screen instructions. Voyantic recommends that you install the software is in the default folder suggested by the installation program.
5. Reboot your computer when the installation program prompts you to do so.
6. Login as a normal user.
7. Place the license file in the C:\ Tagformance\Data folder.

The default folder for the software is C:\Tagformance\.

Shortcuts to the software and manual are installed on the start-up menu.

4.3 Uninstalling Software

1. If any measurement results, setup files, etc., are stored under C:\Tagformance, please make backups before continuing.
2. Login to the computer with Administrator permissions.
3. Go to Control Panel → Add/Remove Programs.
4. Find National Instruments Software from the list, click the right mouse button on the row and select uninstall/change.
5. Select both NI-PXI Platform Services x.x.x and NI-DAQmx x.x.x and click remove.
6. The uninstaller will inform you that Tagformance depends on these components and needs to be uninstalled as well. Please click “Remove All”.
7. Allow the uninstaller to finish and reboot when prompted to do so.
8. Login to the computer with Administrator permissions.
9. Delete the C:\Tagformance folder.

5 Hardware Installation

It is important to install the software before plugging it into the Tagformance Pro Measurement Unit and turning it on so that the operating system can properly identify the device.

5.1 Overview

Tagformance Pro can be used in UHF RFID (600MHz-1300 MHz) and in HF RFID / NFC (10 MHz – 30 MHz) testing.

Tests can be made in monostatic and bi-static modes.

For UHF RFID, Voyantic offers a standard range antenna (800 MHz—1000 MHz), a wideband antenna (600 MHz—1300 MHz), and a Snoop Pro nearfield coupling element (800 MHz—1000 MHz). Other 50-ohm antennas can also be used.

For HF RFID / NFC, 145 mm and 60 mm diameter loop antennas are available from Voyantic.

The system can be completed with several accessory packages.

This chapter describes some typical ways to connect the system.

5.2 General

Power (18 VDC) and Ethernet are required for system use. The connectors are on the device's back panel.

Figure 1.Tagformance Pro back panel

5.3 Powering Up the Device

When the device is connected to power and network, switch it on with the front panel power button. The green LED surrounding the button turns on. The device starts in about 30 seconds, after which all indicator LEDs blink once, and the power button LED brightness increases. Then, the device is ready for use. When the software is launched, the device is found in the network.

5.4 Network Connection

By default, the device is configured for the DHCP server and expects the network DHCP server to assign an IP address automatically. Alternatively, the device can be configured to use a fixed IP address. Adjustment of Tagformance Pro network settings is done by using the Tagformance Pro Update tool, as described later in Chapter 5.4.2.

Furthermore, if the device is connected directly to the PC, the PC's network adapter must also be configured to match the device settings. The settings can be adjusted through Windows control panels as described later in Chapter 5.4.2, but before applying the changes, it's recommended to consult the IT administration to avoid possible conflicts with Company IT policies.

5.4.1 Checking the IP Address

The IP address can be seen from the Update Tool (in the Tagformance folder). The IP address is in parenthesis after the device serial number when the Update Tool is launched.

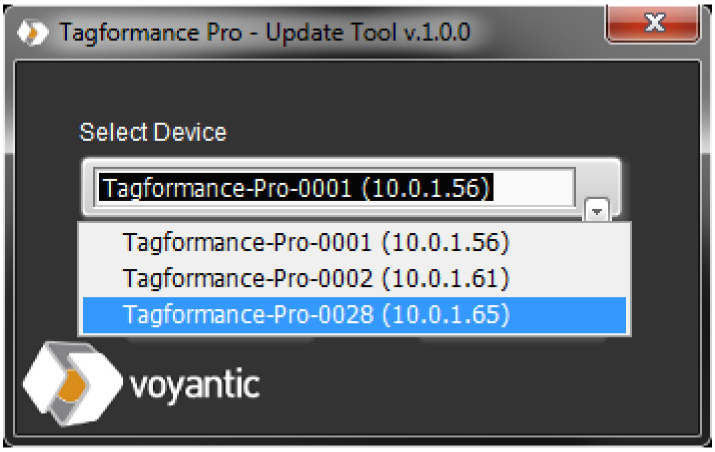
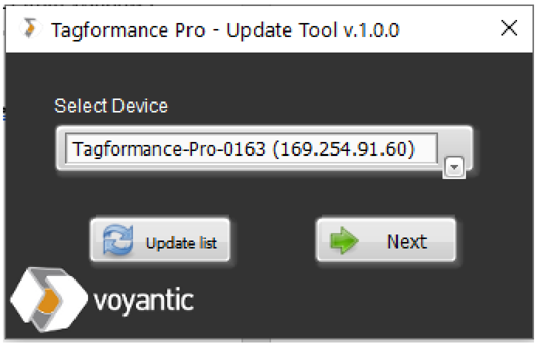


Figure 2. List of devices in the Update Tool

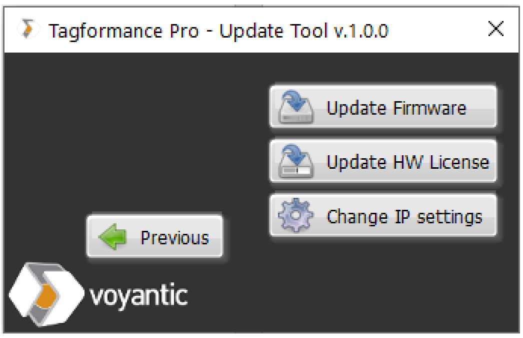
5.4.2 Setting Up a Fixed IP Address or DHCP Connection

To set up new connection settings, configurations must be changed for the device using the Tagformance Pro Update Tool and the network adapter from Windows settings. Before adjusting the settings, it's recommended to consult the Company's IT administrator to avoid any conflicts with Company policies.

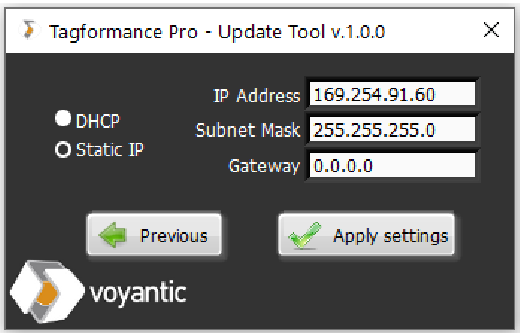
1. Run the Tagformance Update Tool, select the device, and choose the next

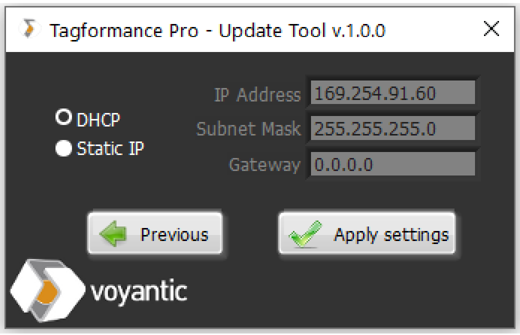


2. Select: "Change IP settings"



3. **For a fixed IP connection**, choose Static IP and set the IP address, mask, and gateway. **For DHCP connection**, select DHCP.





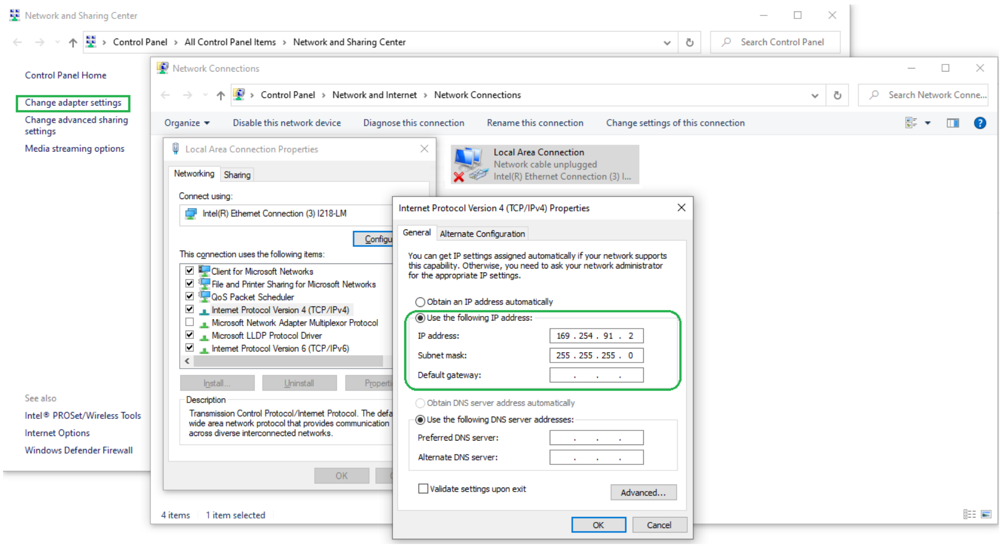
4. Apply settings and wait until the setup is finished

5. Close Tagformance Update Tool.

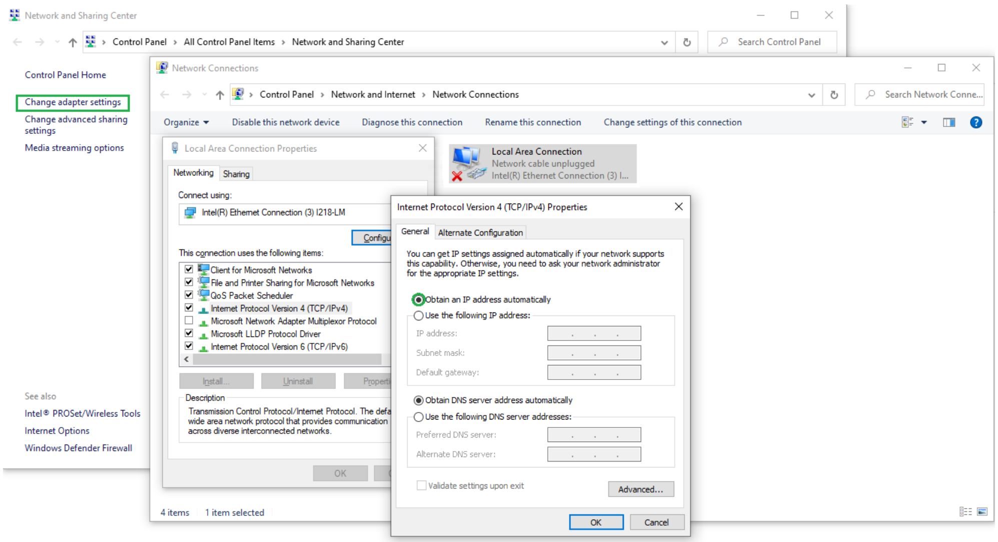
6. Adjust the PC's network adapter settings according to Tagformance Pro if the device is connected directly to the PC

   To configure network adapter settings on a Windows computer, navigate to Network and Sharing Center> Change adapter settings, choose properties of the local area connection, and then edit Internet protocol version 4 properties.

   For a fixed IP connection, choose "Use the following IP address" and define the IP address to match the device IP and Subnet mask. For example, if the device IP is 169.254.91.60, the subnet mask is 255.255.255.0, and the gateway is 0.0.0.0, the Network card should be configured with an IP address that is not reserved in the subnet in question, e.g. 169.254.91.2, the subnet mask is 255.255.255.0, and the gateway can be left empty (by default).



   For DHCP connection, choose "Obtain and I address automatically.



5.5 Hand Carry Kit UHF (HCK UHF) with Standard Antenna

The hand-carry kit is used for desktop measurements. Place the antenna on the table with the tag stand on top, as presented in the picture below. When possible, it is better to have more distance between the Tagformance and other objects to the antenna than in the example pictures.

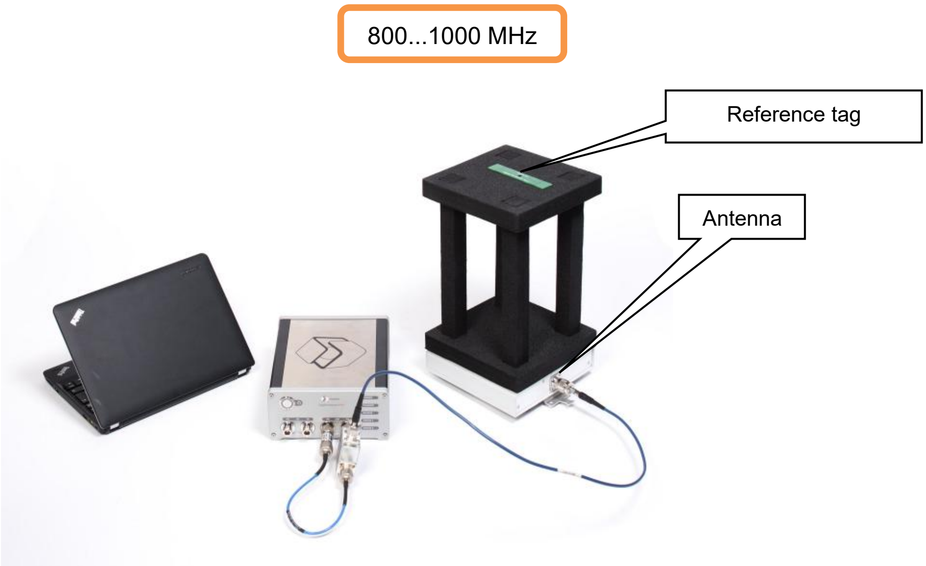


Figure 3.HCK UHF with standard (linearly polarized) patch antenna.

Please note:

- Avoid any metal objects nearby in the radiating direction of the antenna
- Try to have as much free space over the tag as possible, preferably more than two meters
- Typically, 30…50 cm is a good measuring distance when measuring with one antenna
- Greater distance will typically lower the s/n ratio and increase the effect of radio reflections
- Less distance is rarely needed, and the distance below 20 cm is not usable because the tag would be in the antenna's near-field
- The standard patch antenna is linearly polarized

Typical setup

Connect the Circulator (800 MHz - 1000 MHz) as shown below:

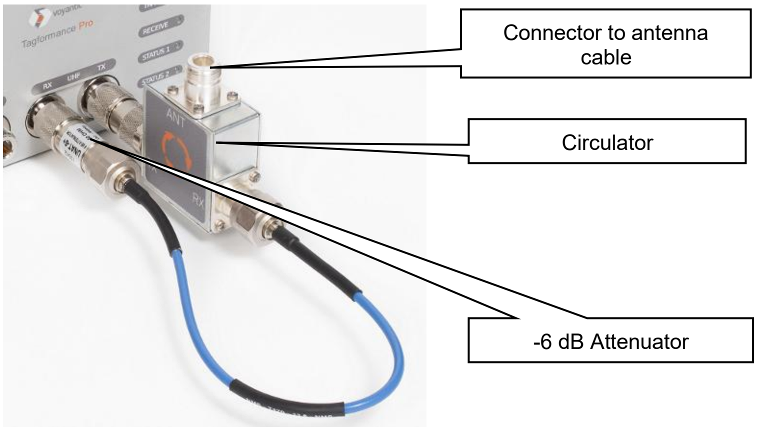


Figure 4.Typical Circulator setup

Setup for Shifted TX Dynamic Range (e.g., for measuring battery-assisted tags)

Tagformance Pro's input power level is limited to 18dBm. If higher backscatter levels are measured, attenuation can be added to the RX port.

If transmit powers smaller than -15dBm are needed, attenuation can be added to the Tagformance Pro's TX port.

The 6 dB attenuator connects the circulator and the RX and/or TX port.

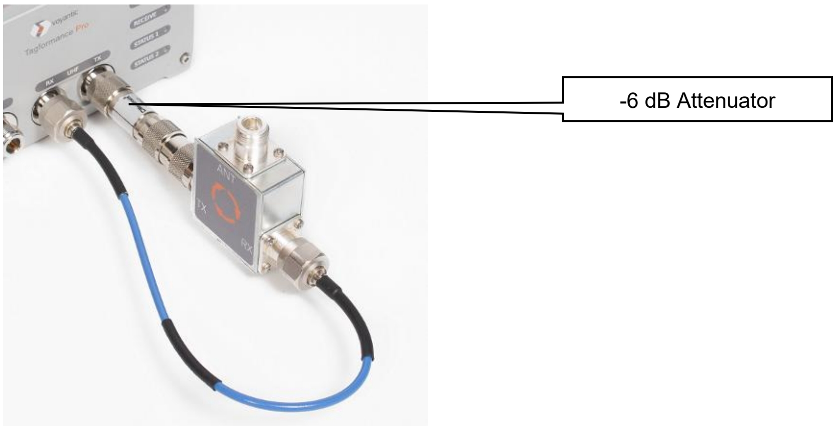


Figure 5.Circular setup for shifted TX dynamic range, decreasing TX power

5.6 Hand Carry Kit UHF (HCK UHF) with Wideband Antenna

Hand Carry Kit is intended for desktop measurements. Place the antenna on the table with the tag stand on top, as presented in the picture below. When possible, it is better to have more distance between the Tagformance and other objects to the antenna than in the example pictures.

Note that the antenna is linearly polarized.

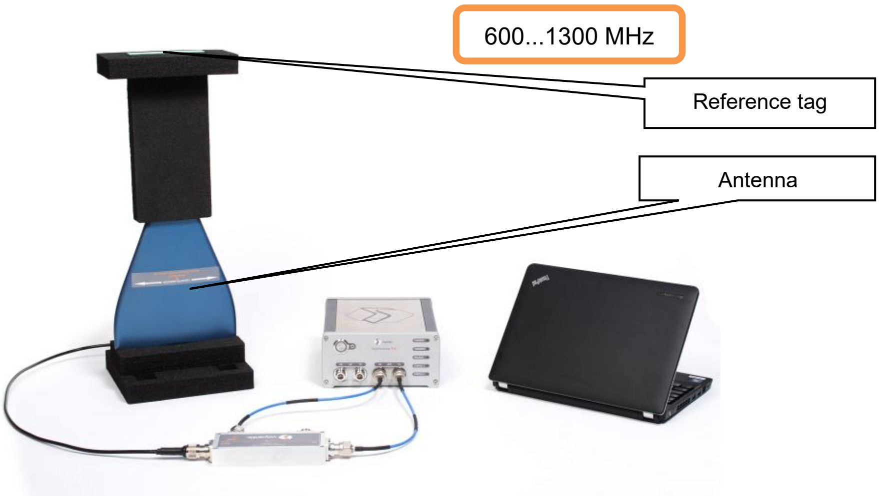


Figure 6.HCK UHF with wideband antenna

Please note:

- Avoid any metal objects nearby in the radiating direction of the antenna
- Try to have as much free space over the tag as possible, preferably more than two meters
- Typically, 30…50 cm is a good measuring distance when measuring with one antenna. Greater distance will typically lower the s/n ratio and increase the effect of radio reflections. Less distance is rarely needed, and the distance below 20 cm is not usable because the tag would be in the antenna's near-field.

Connect the Directional Coupler (600…1300 MHz) as shown below:

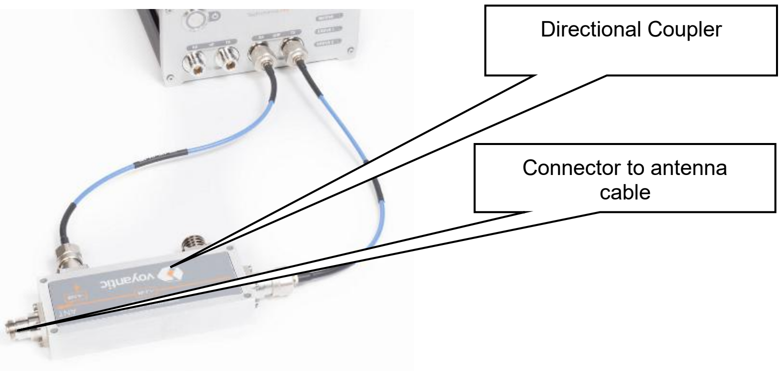


Figure 7.Connected UHF Directional Coupler

5.7 Field Engineer Kit (FEK)

Place the stands so that the distance between the antenna and the tag is min. 30 cm. Carefully align the antenna and the Voyantic reference tag (Wideband UHF Reference Tag v1) in a way that they face each other as shown in the picture below (please note that the antenna is linearly polarized). Please keep the alignment error at less than 10 degrees at all times, as the antenna has quite high directivity.

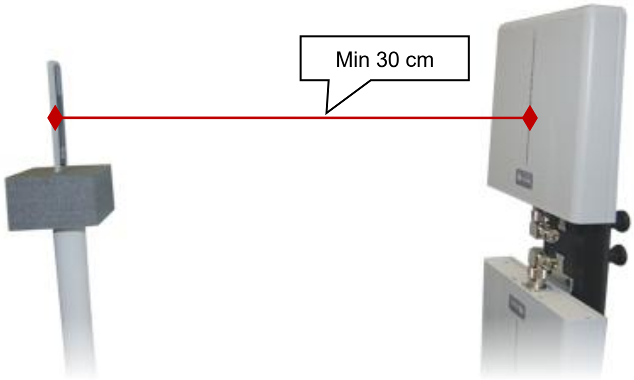


Figure 8.FEK measurement distance

Please note:

- Avoid any metal objects nearby in the radiating direction of the antenna
- Try to have as much free space behind the tag as possible, preferably more than two meters
- Typically, 30…50 cm is a good measuring distance when measuring with one antenna
- Greater distance will typically lower the s/n ratio and increase the effect of radio reflections
- Less distance is rarely needed, and the distance below 20 cm is not usable because the tag would be in the antenna's near-field
- For optimal measurement geometry measuring with one antenna and a circulator is recommended

Monostatic Setup

Connect the circulator as shown below; then connect the 1.8 m (6 ft) antenna cable between the circulator ANT port and the upper antenna.

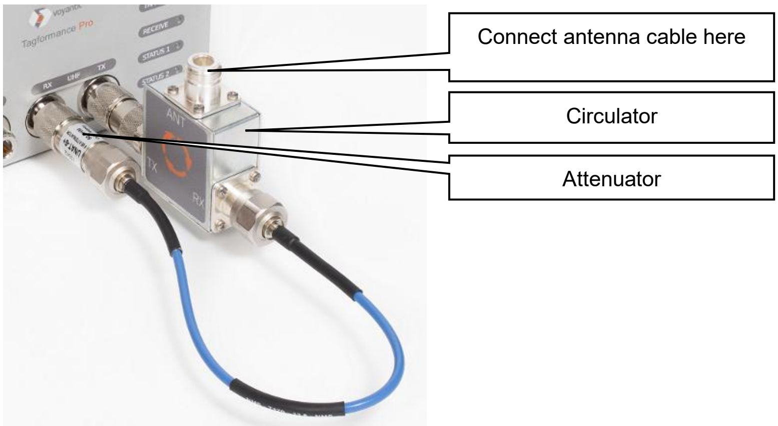


Figure 9.Connected UHF Circulator

Bi-static Setup (Two Antennas)

Connect antennas directly to the TX and RX ports (No circulator/coupler or attenuator).

Using two antennas will give you better isolation and, therefore, higher sensitivity on full power than one antenna with a circulator. To minimize errors from misalignment between TX and RX antennas, the measurement distance should be about 1 meter (3.3 ft) or more.

The wide frequency range of Tagformance Pro requires antennas with equally wide bandwidth.

Direct coupling from the TX antenna to the RX antenna should be avoided. The manufacturer, therefore, recommends that the antennas be situated at least 20 centimeters (8 inches) from each other. The antenna stands and supports should be made of non-conductive material like wood or plastic. Large metallic objects and planes should be kept at least 1.0 meters (3.3 ft) from the antennas. The recommended height for the antennas and the tag is at least 1.0 meters (3.3 ft)
above the floor level.

5.8 Wideband Kit (WBK)

Place the stands so that the distance between the antenna and the tag is 35 cm. Carefully align the antenna and the tag to face each other, as shown in the picture below (please note that the antenna is linearly polarized). Please keep the alignment error to less than 10 degrees at all times.

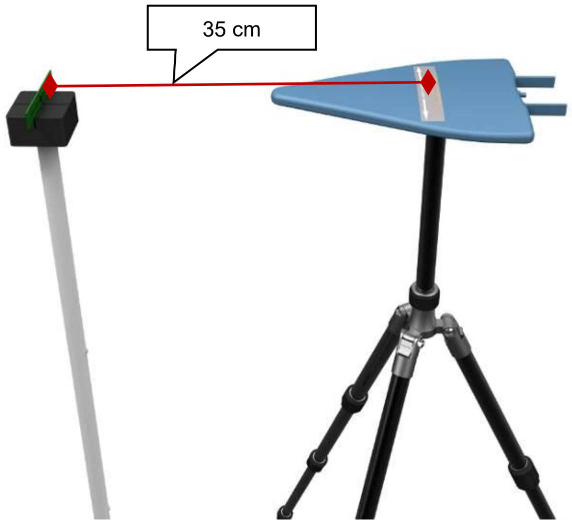


Figure 10.WBK measurement distance

Please note:

- Avoid any metal objects nearby in the radiating direction of the antenna
- Try to have as much free space behind the tag as possible, preferably more than two meters
- Typically, 30…50 cm is a good measuring distance. Greater distance will typically lower the s/n ratio and increase the effect of radio reflections. Less distance is rarely needed, and the distance below 20 cm is not usable because the tag would be in the antenna's near-field.

Connect the Directional Coupler as shown below; then connect the 1.8 m (6 ft) antenna cable between the Directional Coupler ANT port and the Wideband Antenna.

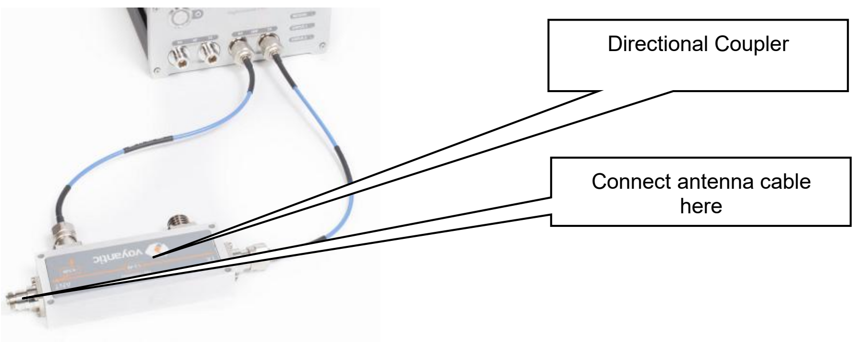


Figure 11.Connected UHF Directional Coupler

5.9 RFID Measurement Cabinet / Chamber

Depending on the setup in use, connect the 1.8 m (6 ft) RF cable between the Cabinet and the Antenna.

5.9.1 Standard Antenna Monostatic Setup (One Antenna)

Typical Setup

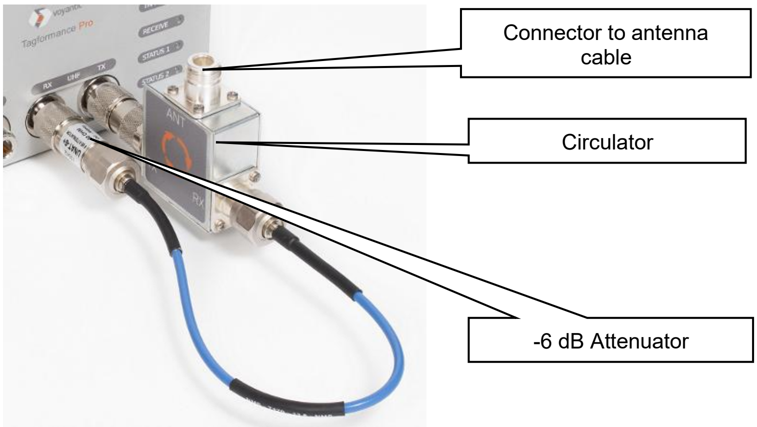


Figure 12.Connected UHF Circulator

Setup for Shifted TX Dynamic Range (e.g., for Measuring Battery Assisted Tags)

Tagformance Pro's input power level is limited to 18dBm. If higher backscatter levels are measured, attenuation can be added to the RX port.

If transmit powers smaller than -15dBm are needed, attenuation can be added to the Tagformance Pro's TX port.

The 6 dB attenuator connects the circulator and the RX and/or TX port.

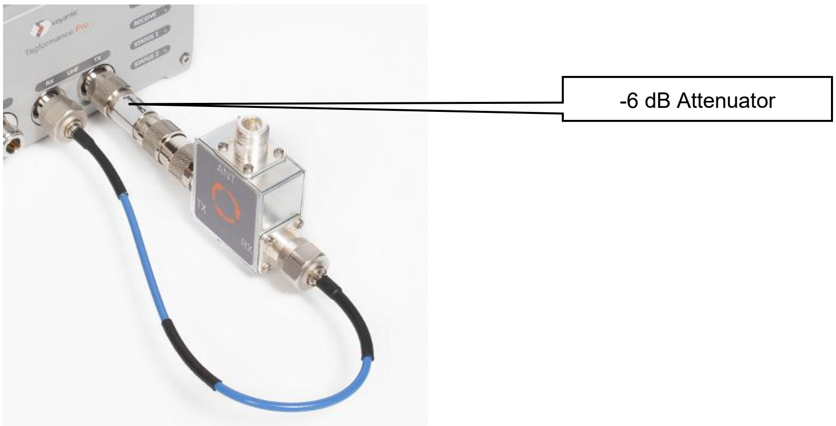


Figure 13.Setup for shifted TX dynamic range, decreasing TX power

5.9.2 Standard Antenna with Bi-static Setup (Two Antennas)

Connect antennas directly to the TX and RX ports (no circulator/coupler or attenuator).

Using two antennas will give you better isolation and, therefore, higher sensitivity on full power than one antenna with a circulator. To minimize errors from misalignment between TX and RX antennas, a measurement distance of about 1 meter (3.3 ft) or more should be used with two antennas.

Direct coupling from the TX antenna to the RX antenna should be avoided. The manufacturer recommends that the antennas be situated at least 20 centimeters (8 inches) from each other. The antenna stands and supports should be made of non-conductive materials like wood or plastic. Large metallic objects and planes should be kept at least 1.0 meters (3.3 feet) from the antennas. The recommended height for the antennas and the tag is at least 1.0 meters (3.3 feet) above the floor level.

5.9.3 Wideband Antenna Monostatic Setup (One Antenna)

Connect the Directional Coupler (600…1300 MHz) as shown in Figure 14.

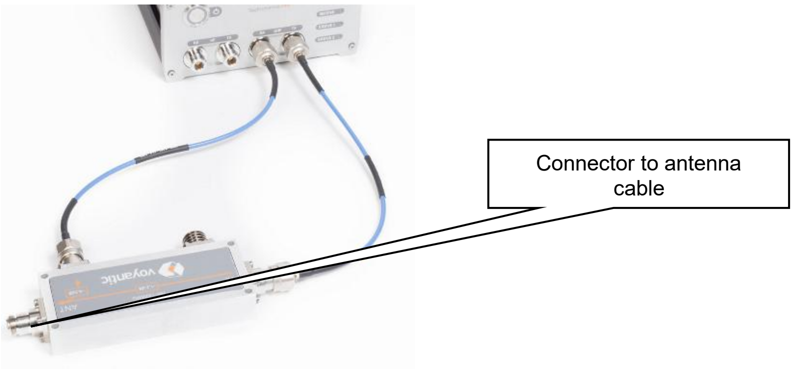


Figure 14.Connected UHF Directional Coupler

5.9.4 Wideband Antenna Bi-static Setup (Two Antennas)

Connect antennas directly to the TX and RX ports (no circulator/coupler or attenuator).

Using two antennas will give you better isolation and, therefore, higher sensitivity on full power than one antenna with a circulator. With two antennas, a measurement distance of about 1 meter (3.3 ft) or more should be used to minimize errors from misalignment between TX and RX antennas.

Direct coupling from the TX antenna to the RX antenna should be avoided. The manufacturer, therefore, recommends that the antennas be situated at least 20 centimeters (8 inches) from each other. The antenna stands and supports should be made of non-conductive materials like wood or plastic. Large metallic objects and planes should be kept at least 1.0 meters (3.3 feet) from the antennas. The recommended height for the antennas and the tag is at least 1.0 meters (3.3 feet) above the floor level.

5.9.5 The 4 Antenna Setup

In the 4-antenna setup, connect the multiplexer center port to the circulator and ports 1-4 to the antennas. Connect the circulator and attenuator as shown in Figure 15.

Figure 15.Connected UHF circulator

The measurement antenna has the polarization marked on it.

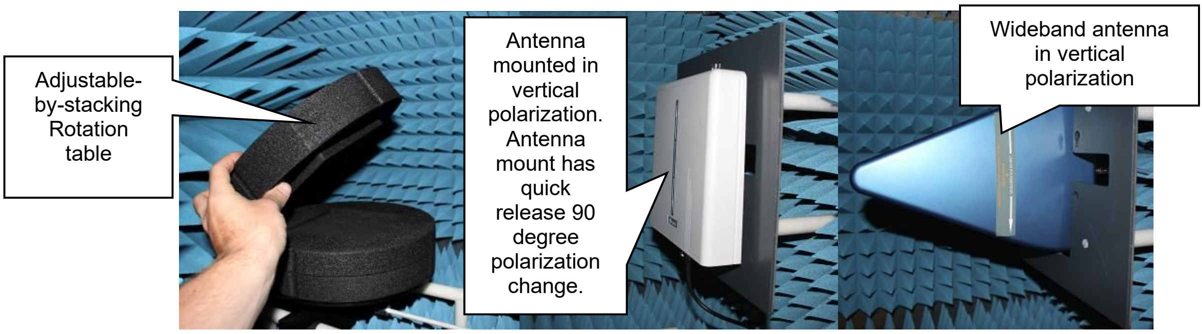


Figure 16.The cabinet rotation table and the antenna polarization

To get good and repeatable measurement results, please perform the measurements with the cabinet door closed.

The measurement distances between the antenna phase center point and rotation table center point are as follows:

	RFID Measurement Cabinet	Large RFID Measurement Cabinet	C50 RFID Measurement Cabinet	C100 RFID Measurement Chamber	C150 RFID Measurement Chamber
Standard Patch Antenna 800…1000 MHz	45 cm	70 cm	50 cm	100 cm	150 cm
Wideband Antenna 600…1300 MHz	40 cm	55 cm	45 cm	95 cm	145 cm
4 antenna setup	NA	NA	50 cm	100 cm	150 cm

5.10 Hand Carry Kit HF (HCK HF)

The basic measurement setup is shown in the picture below. It includes the optional Distance Control Kit; if you do not have a DCK, you can connect one of the two loop antennas, or one of your own antennas directly to the Measurement Unit.

Figure 17.The basic Tagformance Pro and HCK HF measurement setup with the DCK

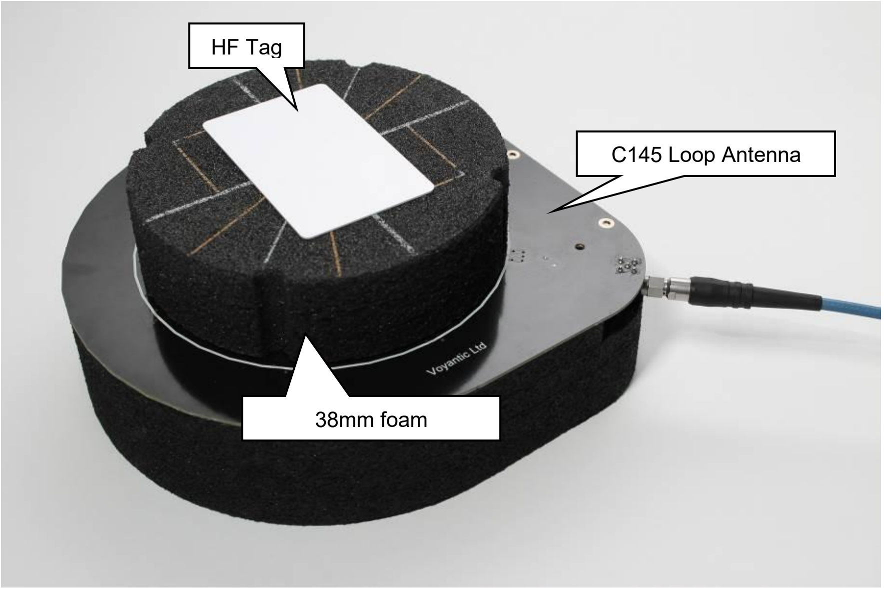


Figure 18.HF antenna setup without the DCK

Connect the HF coupler to TX and RX port; and the loop antenna to the HF coupler.

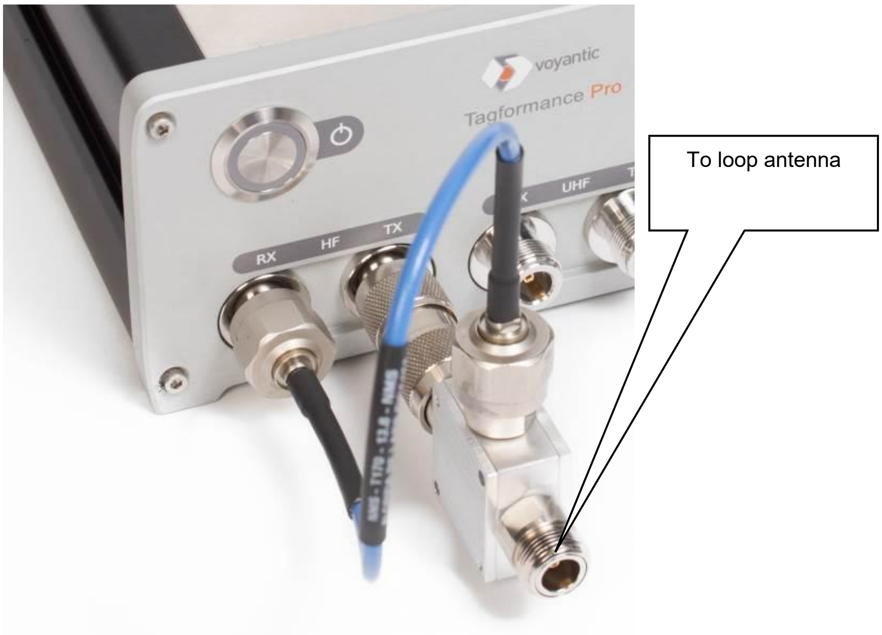


Figure 19.Connected HF coupler

5.10.1 HF RFID / NFC Measurement Antennas

The loop antenna choices offered by Voyantic are the C145 and C60 models. For optimal measurement results, the C145 antenna is always preferred where it can produce a result. However, in some cases, small tags of under 30mm in size may require a stronger test field which the C60 antenna can provide.

NOTE! During transportation, the C60 antenna is stored inside the C145 antenna together with a 38 mm high foam, which must be removed before either of the antennas is used.

Figure 20.The C60 antenna is stored inside the C145 antenna

5.10.2 Selecting the Antenna Size

There are no exact rules for selecting the correct antenna size for a certain tag. The antenna selection and measurement distance should always be verified for each tag.

As a rule of thumb, the best antenna sizes for tags of different sizes (referring to size classes in ISO/IEC14443-1:2008/Amd. 1:2012) are:

- C145 is better for Class 1-3 tags
- Class 1 is a typical smart card size, antenna dimensions between 64 mm x 34 mm and 81 mm x 49 mm
    - Circle Class 2 and 3 tags have antenna diameters of 32 mm – 50 mm
    - Square Class 3 tags have antenna dimensions bigger than 35 mm x 24 mm, but smaller than 50 mm x 40 mm
    - Square Class 2 tags have antenna dimensions between 51 mm x 13 mm and 81 mm x 27 mm
- Class 4 is at the borderline, circle antenna dimensions between 24 mm and 41 mm, square antenna dimensions between 35 mm x 13 mm and 50 mm x 27 mm

- C60 is better for Class 5 and smaller tags. Antenna dimensions smaller than 35 mm diameter in circle tags and smaller than 40.5 mm x 24.5 mm with square tags.

The above list may not apply to every tag. It does not remove the need to verify the correct antenna and distance for each tag to be tested.

5.10.3 Optimal Measurement Distance for Tagformance Pro HF Antennas

From the Tagformance Pro HF antenna's point of view, the magnetic field distribution is even across the antenna area at the optimal measurement distance.

For the C60 antenna, the optimal distance is 16 mm.
For the C145 antenna, the optimal distance is 38 mm.

At optimal distances, the error in the field strength measurement is 14% maximum. The maximum error increases when the measurement distance is further from the optimal. When the tag is positioned exactly at the center point of the antenna, the error is minimized.

The optimal measurement distance from the Tagformance Pro HF antenna point of view is not always the best distance for each tag. The measurement distance must be verified.

5.10.4 Verifying the Antenna and Defining the Measurement Distance

The antenna and measurement distance can be verified with the threshold measurement and magnetic field strength. The measurement should be repeated at least at three points: at the intended measurement distance, at a 10 mm closer distance, and at a 10 mm longer distance.

Figure 21 shows example results when a wrong antenna size is used. When the distance between the tag and the antenna is increased, the magnetic field strength curve shifts. This indicates that at the smaller distance, the tag was loading the antenna. In the example, the tag is moved outside of the read range before the loading effect is minimized.

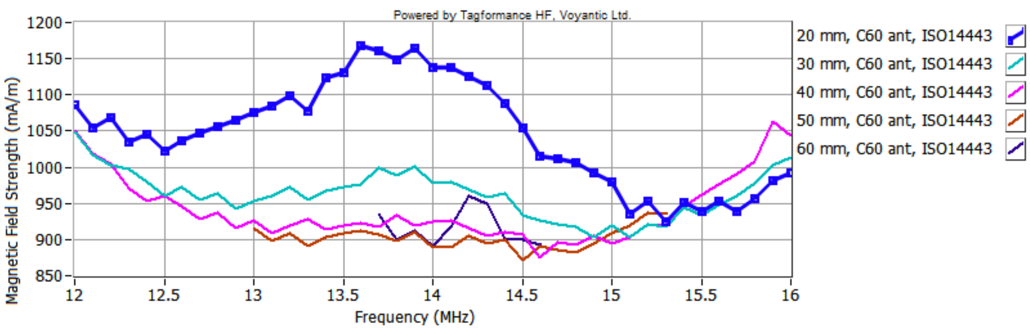


Figure 21.Too small a test antenna for a Class 1 tag

With a correctly sized antenna, the magnetic field strength curves overlap almost completely when a good measurement distance is reached, as in Figure 22. The same ISO14443A Class 1 tag was used in both tests.

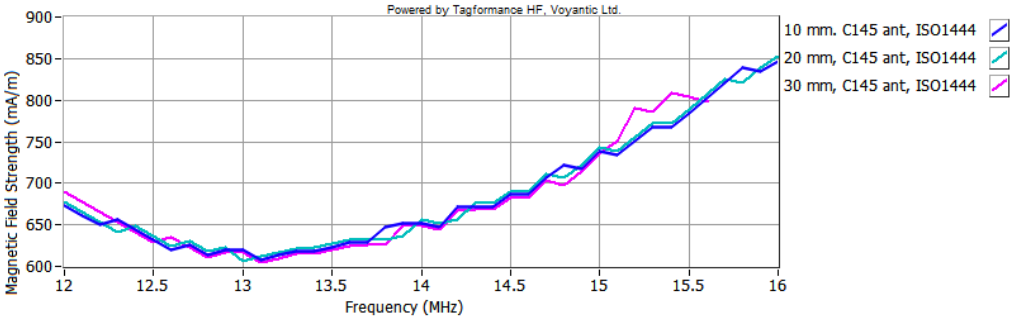


Figure 22. Correct test antenna size for a Class 1 tag

5.10.5 Summary of Antenna and Distance Selection Process

1. Choose the antenna based on the size of the tag
2. Measure the magnetic field strength 10 mm below the optimal distance, at the optimal distance, and 10 mm above the optimal distance.
   b. If the magnetic field strength does not indicate loading at the optimal distance, use the optimal distance in measurements.
   c. If loading is indicated, increase the measurement distance until the loading effect is removed, and test also with the other antenna.
   d. If the tag cannot be tested (too long range), move it closer until a result can be reached, and test also with the other antenna.
   e. If neither antenna can be used with the optimal distance, use the antenna and the distance without loading effect, closer to the optimal measurement distance to that antenna.

5.10.6 Antennas for Passive Measurements

The Voyantic C60 and C145 antennas are designed for active tests (threshold test, load modulation test, and so on). They are tuned and not ideal for passive measurements.

The C145 antenna is less tuned than the C60 and, thus, a better choice for passive tests. To eliminate the antenna tuning from test results, a reference measurement should be made, and normalized result values should be used only.

An untuned antenna, such as a standard single antenna coil, is the best alternative for passive tests (not part of the Voyantic Kit). With an untuned antenna, the S11 and other values from passive tests are also valid.

5.11 Distance Control Kit (DCK)

The Distance Control Kit (DCK) is an optional kit that integrates seamlessly with the Tagformance Pro HF software. It can be used to perform automated read range measurements and to adjust the measurement distance easily.

When you start the Tagformance Pro HF software and have the DCK powered up and connected to your computer, the tag lifter should automatically return to the default position at 12 or 38mm for the C60 and C145 antennas, respectively.

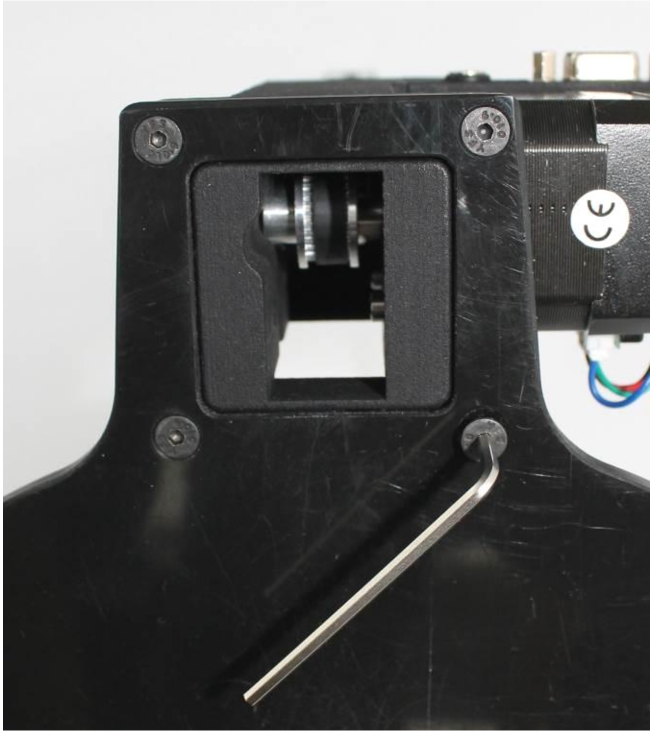
There are two supported lifter models; please examine Figure 23 to determine which model is in use. Please refer to Appendix G: Distance Control Kit Assembly Instructions for more detailed assembly and troubleshooting instructions.

Figure 23.Tag lifter models v2 (left) and v1 (right)

5.11.1 Assembling the Distance Control Kit v2

Place the base plate on a flat surface and mount the actuator on the base plate.

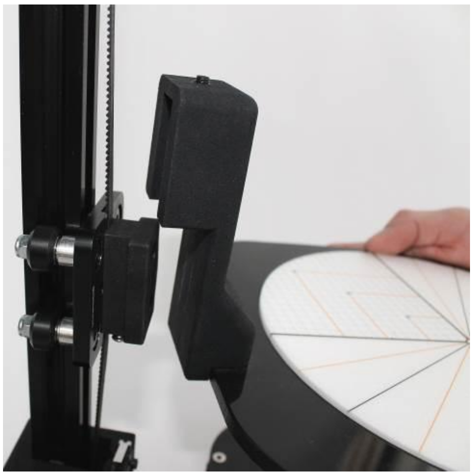
Attach the actuator to the base plate by tightening the 4 screws on the base plate using a 2.5mm hex key.



Choose either the C145 or the C60 loop antenna and place it as shown in the images below.

Connect the RF cable to the antenna.

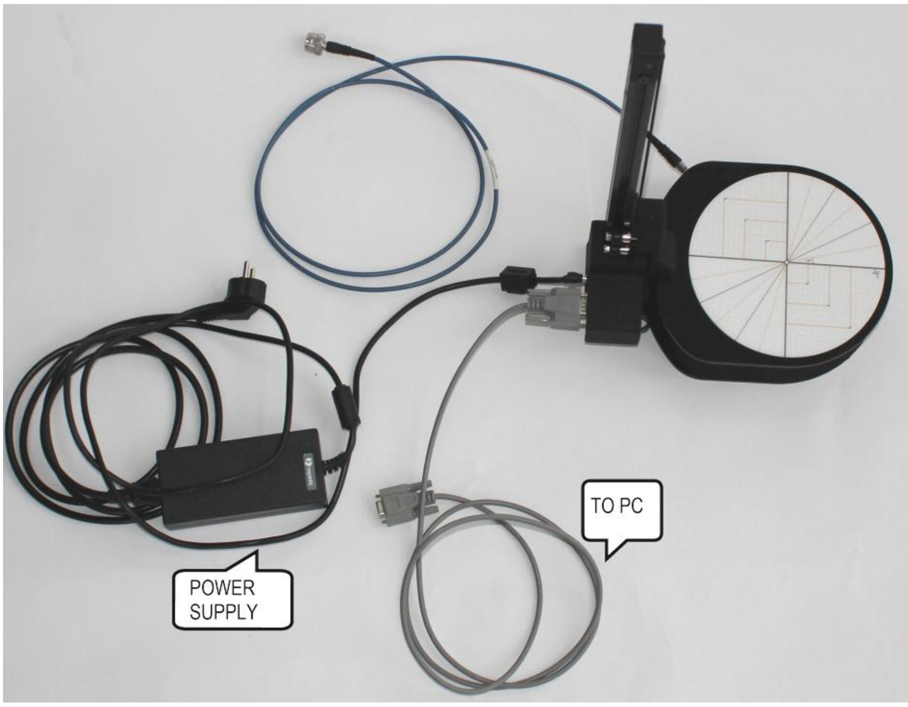
Attach the tag holder to the actuator.



The tag holder vertical offset can be set by adjusting the small set screw shown in the image below.

Please note that the screw has been properly set prior to shipping and should not require re-adjustment.

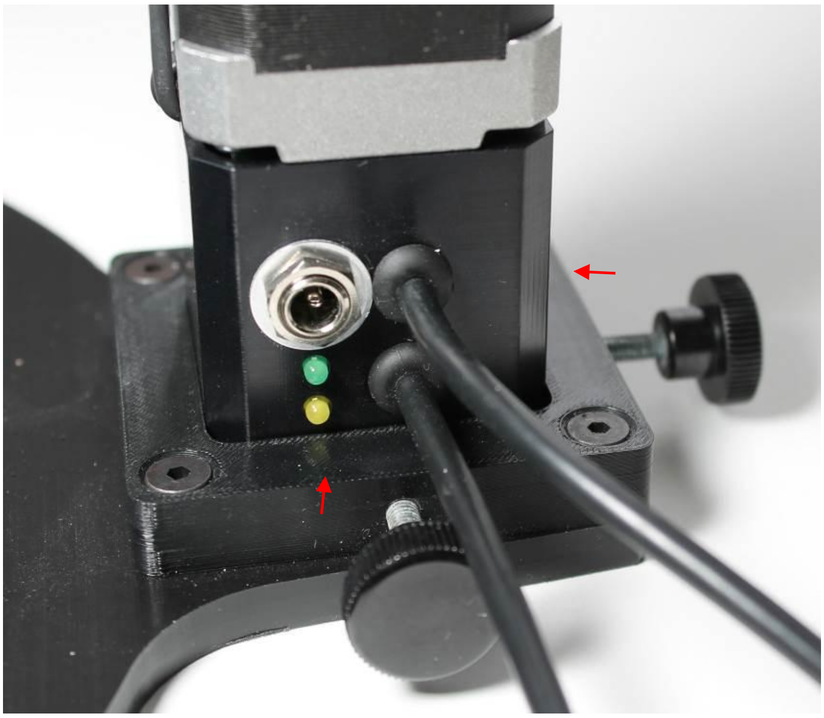
Connect the serial cable to the lifter and plug the other end into your PC. Connect the power supply to the actuator. The motor will emit a faint hum when the power cable is connected.



5.11.2 Assembling the Distance Control Kit v1

Attach the two finger screws to the base plate.

Place the base plate on a flat surface and mount the actuator to the base plate and tighten the finger screws.

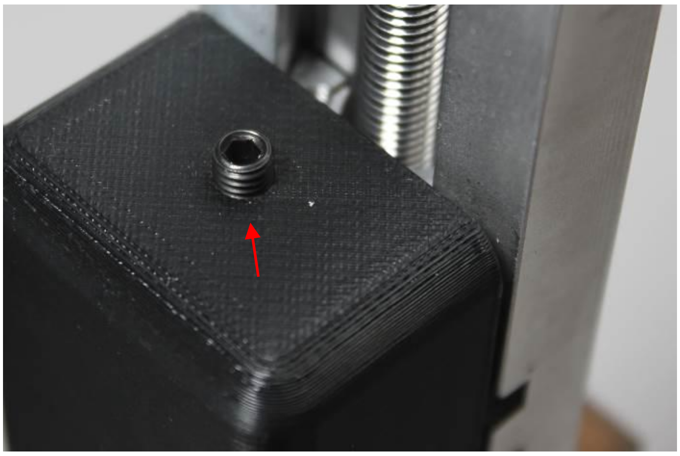


Choose the C145 or the C60 loop antenna and place it as shown in the images below.

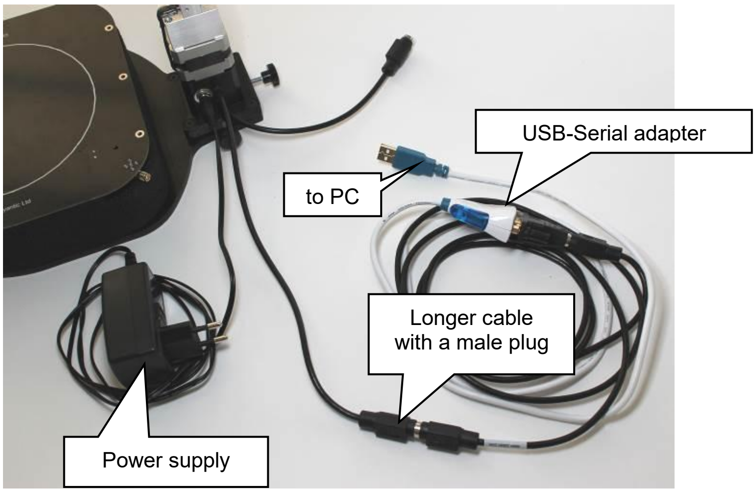
Connect the RF cable to the antenna.

Attach the tag holder to the actuator.

The tag holder vertical offset can be set by adjusting the small set screw shown in the image below.

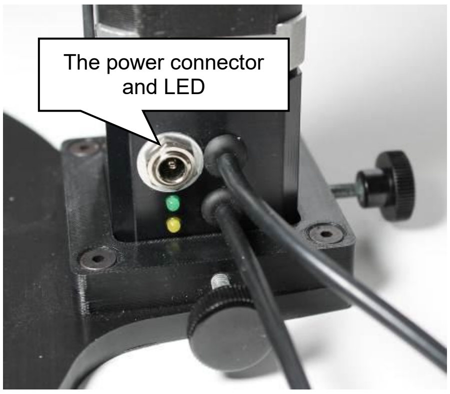


Connect the serial cable (the longer cable with a male plug) to the USB-Serial adapter and connect the adapter to your PC.



Please note that the USB-Serial adapter drivers should be installed before connecting the adapter to your PC. The drivers (FTDI) can be found on the USB memory stick.

Connect the power supply to the actuator. The green LED should light up.



5.12 ETSI RED Kit (ERK)

The contents of the delivery kit are shown below. Different test setup configurations are presented in the following chapters; emission measurement is presented in chapter 13: Tag Emission Test. A use case example showing the measurement flow is described in chapter 17.10..

Important note: The maximum input power for the spectrum analyzer is +20dBm. Applying excessive power causes malfunction and may damage the device. This is especially important to consider when performing measurements with a power amplifier or when introducing a high-gain antenna to the setup.

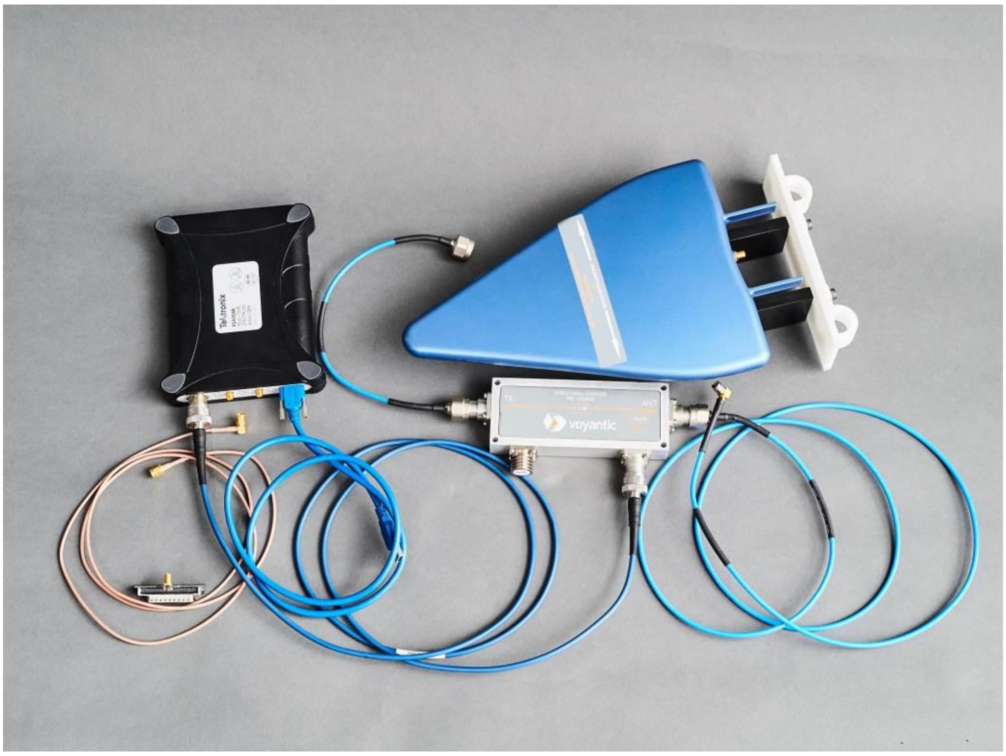


Figure 24.ETSI RED Kit (ERK) is a hardware option for Tagformance to perform ETSI emission test measurements with the Tagformance test system.

5.12.1 Monostatic RED test setup configurations

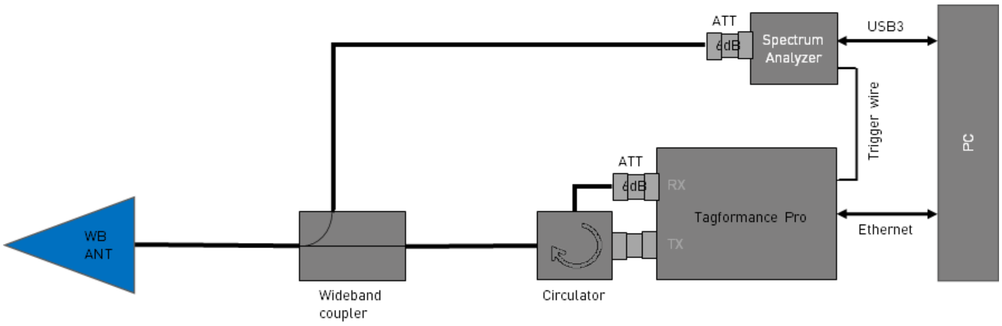


Figure 25.Monostatic RED test setup with circulator

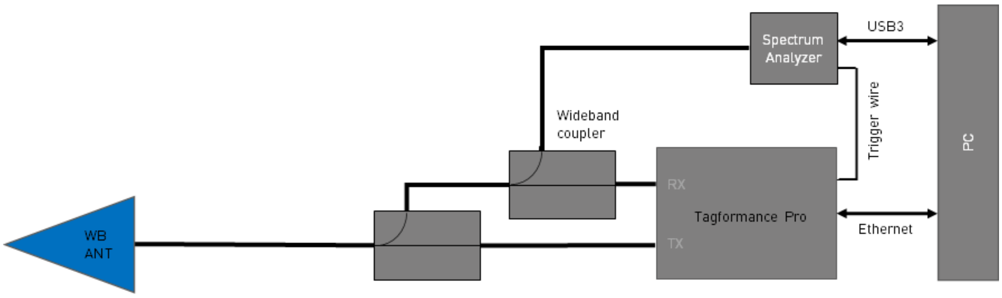


Figure 26.Monostatic RED test setup with a directional coupler

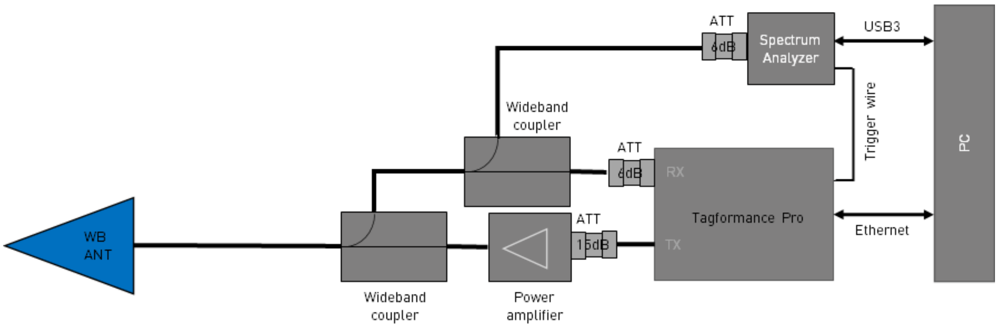


Figure 27.Monostatic RED test setup with high-power kit

5.12.2 Bistatic RED test setup configurations

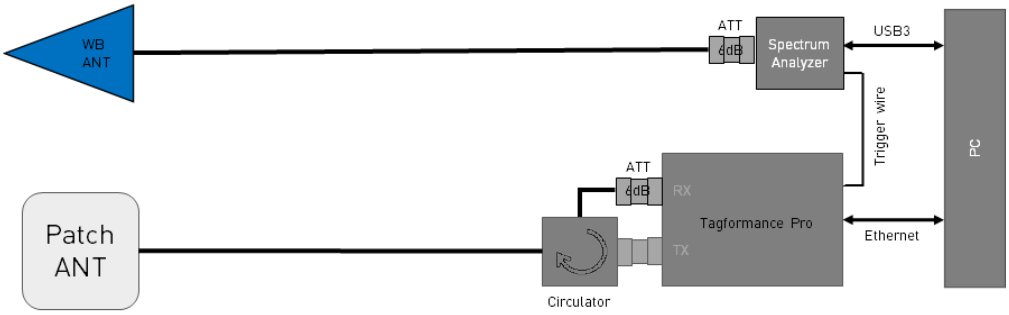


Figure 28.Bistatic RED test setup with standard patch antenna

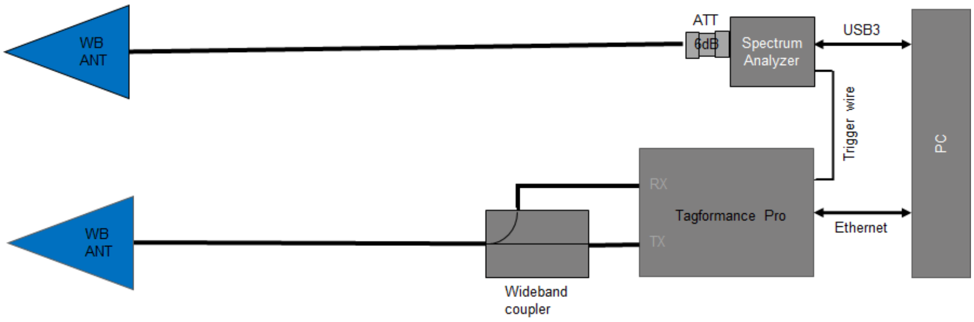


Figure 29.Bistatic RED test setup with wideband antenna

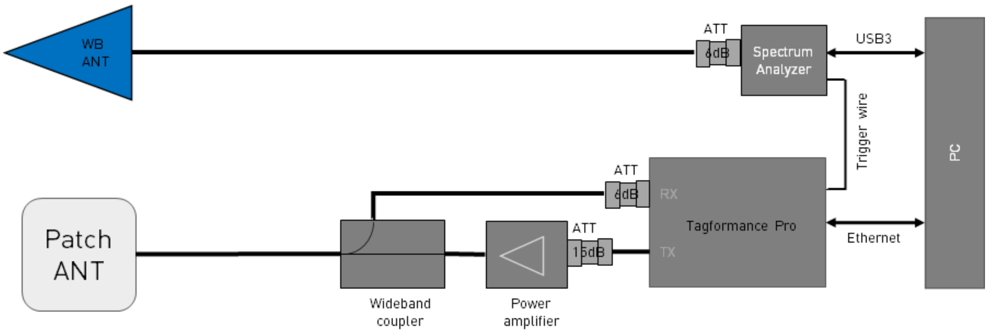


Figure 30.Bistatic RED test setup with standard patch antenna and high-power kit

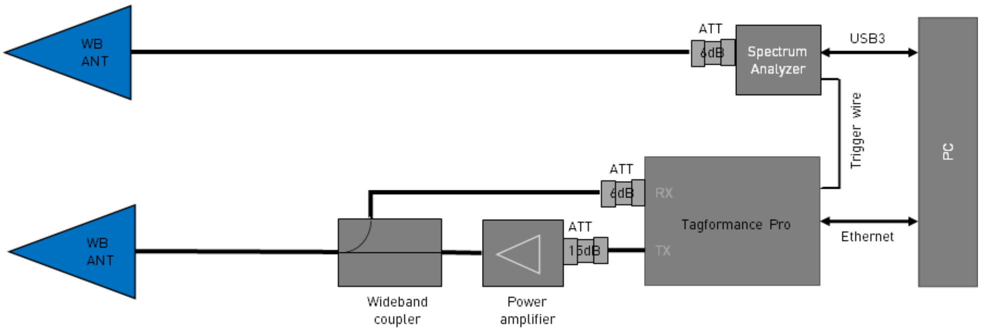


Figure 31.Bistatic RED test setup with wideband antenna and high-power kit

5.12.3 Considerations for setup selection

When selecting a setup, consider the following factors:

- Frequency band
  - Standard patch antenna - 800 – 1000 MHz
  - Wideband antenna - 700 MHz – 2.5 GHz
- Power budget
  - Antenna selection
    - The patch antenna has a higher gain than the wideband antenna, enabling longer standard-compliant measurement distances
  - Coupling elements
    - The circulator has less loss than the directional coupler for the TX – ANT path
  - High power kit
    - Enables longer measurement distances but worsens the signal-to-noise ratio.
  - Take care not to exceed recommended power limits (For details, see A.5 UHF RF Receiver, H.4 Maximum signal levels)
  - Reflections
    - S11 can be as low as -10dB at the edges of the frequency range. For power budget calculations, it is safe to assume a maximum of 10dB is reflected.
    - If no antenna is connected at the antenna port, all the power is reflected back to the system from the unconnected port. Thus, if the carrier is on, the reflected power may introduce high signal levels exceeding the recommended maximum levels at the receiver.
    - Remove unconnected antennas from the cabinet or end the RF port(s) properly to avoid reflections from the floating terminals.
- Antenna setup
  - Single – fits any measurement setup configuration
  - Dual – better signal-to-noise ratio, flexibility for antenna selection (patch for the transmitter to optimize gain, wideband for the receiver to measure a wider frequency band), might not be achievable in all measurement environments

6 Tagformance Pro Hardware

6.1 Introduction to Tagformance Hardware

The RFID Measurement Unit includes all the instrumentation needed for measuring the performance of UHF and HF RFID tags. No external signal generators or amplifiers are needed.

6.1.1 Tagformance Pro version 2.x

Figure 32.Tagformance Pro version 2.0 front panel view

The front panel has a round power switch with a green indicator LED for ‘power on’. Ready and Activity LEDs indicate the device status. The Ready LED indicates when the device is initialized and ready to operate, and the Activity LED indicates the ongoing measurement. Two N-type connectors labeled UHF TX and RX are for 50-ohm antennas for UHF RFID measurements, and two N-type connectors labeled HF TX and RX are for HF RFID / NFC measurements.

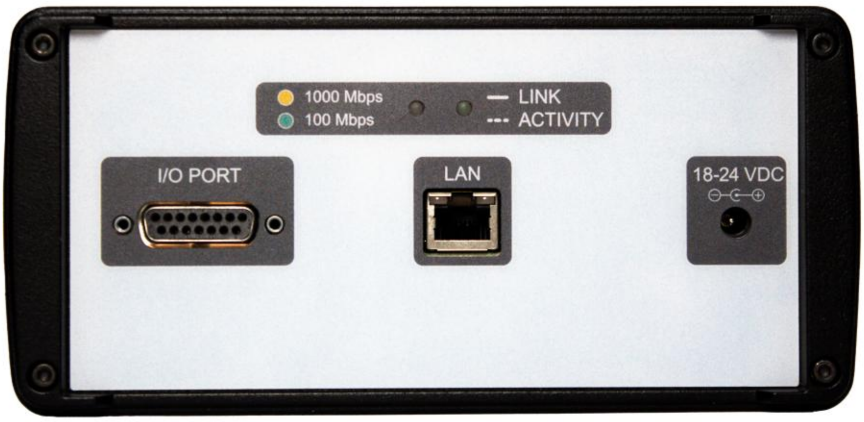


Figure 33.Tagformance Pro version 2.0 back panel view

The back panel has three connectors: 18–24 VDC IN, Ethernet, and IO-connector.

6.1.2 Tagformance Pro version 1.x

Figure 34.Tagformance Pro version 1.x front panel view

The front panel has a round power switch with a green indicator LED for 'power on'. Carrier, Transmit, and receive LEDs indicate how the measurement function proceeds. The STATUS 1 LED is on when the device is connected to UHF RFID software, and the STATUS 2 LED is on when the device is connected to HF RFID software. Two N-type connectors labeled UHF TX and RX are for 50-ohm antennas for UHF RFID measurements, and two N-type connectors labeled HF TX and RX are for HF RFID / NFC measurements.

Figure 35.Tagformance Pro version 1.x back panel view

The back panel has four connectors: 18 VDC IN, Ethernet, RS-232 and IO-connector.

6.2 Technical Data

Technical data of the Tagformance Pro is described in Appendix A: Technical Specifications, and in Appendix I: I/O Port

6.3 Reference Tag

The system is delivered with a reference tag that can be used to verify the measurement setup:

- Is the measurement setup correctly defined in the Software, cable loss, antenna gain, distance from the antenna to the tag, etc.
- How much the reflections or interference affect the measurement result by measuring the reference tag and comparing the result to the reference tag reference result (see the following subchapters).

6.3.1 Wideband UHF Reference Tag v1

Wideband UHF RFID reference tag is a standard Class1 Gen2 UHF tag that can be used from 600 MHz to 1300 MHz.

The reference measurement result for the Wideband UHF Reference Tag v1 can be found after Software installation from C:\Tagformance\Data\Wideband UHF Reference Tag v1.tff.

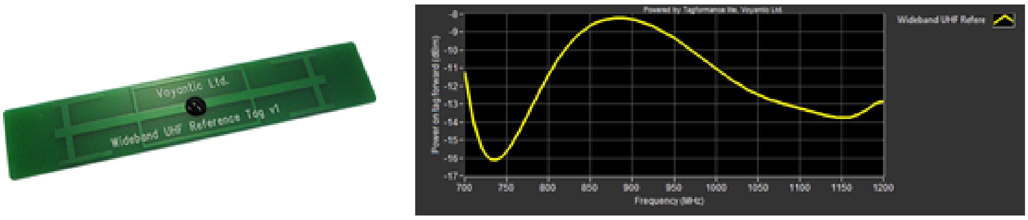


Figure 36.Wideband Reference Tag v1 for 600 to 1300 MHz band

6.3.2 HF Reference Tag v1

HF RFID reference tag is an ISO15693 tag.

Figure 37.HF reference Tag v1

7 Tagformance Software

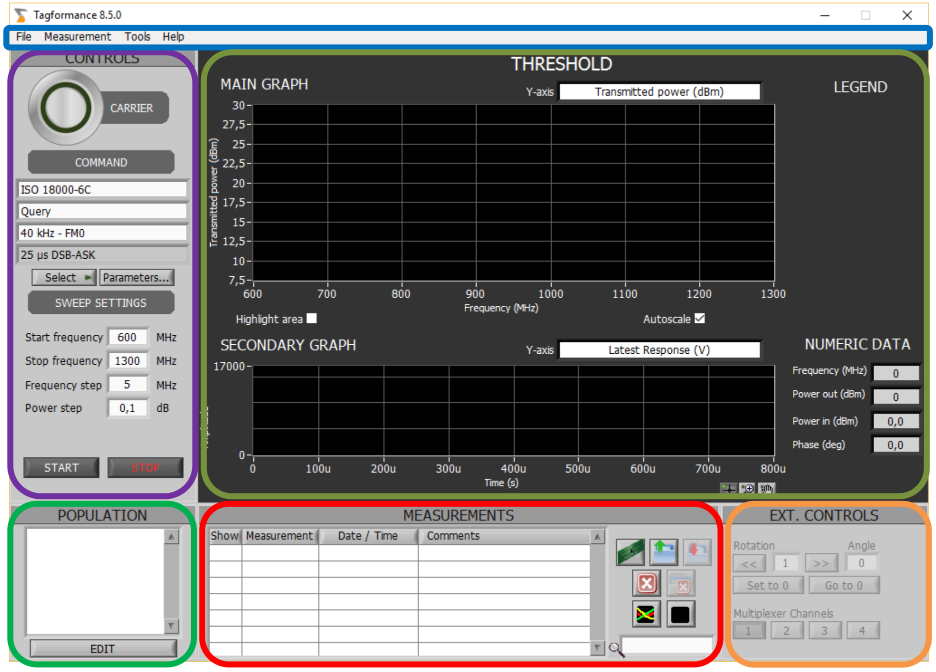


Figure 38. Tagformance Software interface

The interface is divided into the following parts:

- Menu bar
- Measurement window
- Controls
- Population
- Measurements
- Extended Controls (Rotation / Multiplexer / Distance Control Kit)

The menu bar, the population, and the measurement windows are common to all measurement programs.

7.1 Measurement Panel

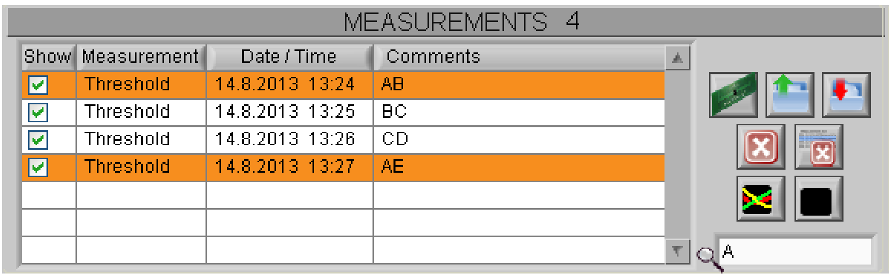


Figure 39.Measurement panel

The measurement panel contains a list of measurements and the controls for editing the measurement data. Next to the measurement list are buttons for list management.

- **Measurement list**—The measurement list is the main element of the measurement panel. Measurements are added to the list when a new measurement is completed or when a measurement file is opened.

  The UHF RFID measurement list shows information about each measurement:
  - Checkbox as a control and indicator of whether the measurement is shown
  - Type of the measurement, which is either:
    - Threshold
    - Backscatter
    - Orientation
    - Read Range
    - Population
    - Interference
    - Grading
    - ARC Test
    - Tag Emission
  - Timestamp
  - Comment attached to the measurement.

  The HF RFID measurement list shows information about each measurement:
  - Checkbox as a control and indicator of whether the measurement is shown
  - Type of the measurement, which is either:
    - Threshold
    - Passive
    - Load Modulation
    - Working Range
  - Timestamp
  - Comment attached to the measurement.

  The selected measurement, or the first measurement in case more than one is selected, is shown with a thicker plot line than the others in the Waveform graph.

- **Load reference tag data** – Loads the wideband reference tag data
- **Open measurement list**—This function loads measurements from a Tagformance measurement file (JSON or TFF) and appends them to the measurement list. Measurements already in the list will not be removed. Multiple files may be selected at once. A progress bar indicates the current file being loaded and overall progress.
- **Save measurement list** – Saves measurements to a Tagformance measurement file (JSON or TFF).
- **Delete** – Removes selected (highlighted) measurements from the measurement list.
- **Clear measurement list** – Removes all measurements from the measurement list.
- **Show all graphs** – Shows all of the measurement graphs.
- **Hide all graphs** – Hides all of the measurement graphs.

- **Search** – Searches the given keyword from the measurement comments. Write a keyword into the search field and accept it with 'Enter'. The search hit measurements will be selected.

7.1.1 Measurement List

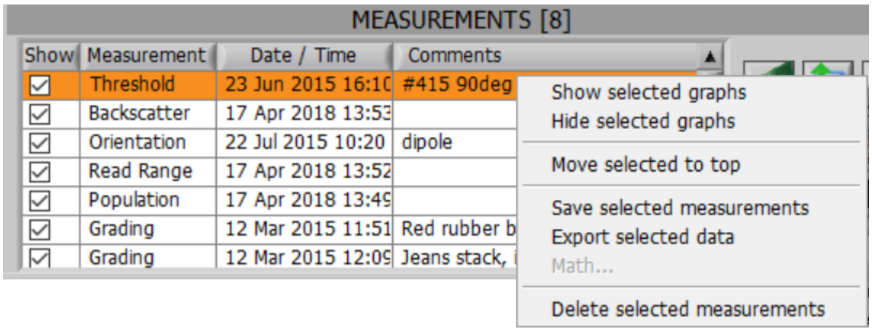


Figure 40.Measurement list, right-click menu

- **Selection** - Selected rows in the measurement list are highlighted with orange color. Common list selection ways are listed below:
    - Ctrl+A
    - Ctrl+[left-click]
    - Shift+[left-click]
    - Arrow up/down
    - Shift+Arrow up/down

- **Arrange** - The measurement list can be arranged in order of each list header **by clicking the list column header**.

- **Drag & Drop** - The measurement order can be changed by dragging and dropping with the mouse.

- **Drag & Drop Tagformance measurement file (JSON or TFF) –** Tagformance measurement files can be dragged from outside the program and dropped into any part of the program window. The measurements in the file will be loaded into the measurement list. Drag and drop works with a single file at a time.

- **Right-click menu** – The right-click menu consists of functions for selected measurements. Functions are listed in Figure 40.

- **Expanded measurement list** – Open the expanded measurement list with the three-dots button at the right end of the measurements section header. Select the visible columns from the menu opening from the three-dots button next to the column headers**.**

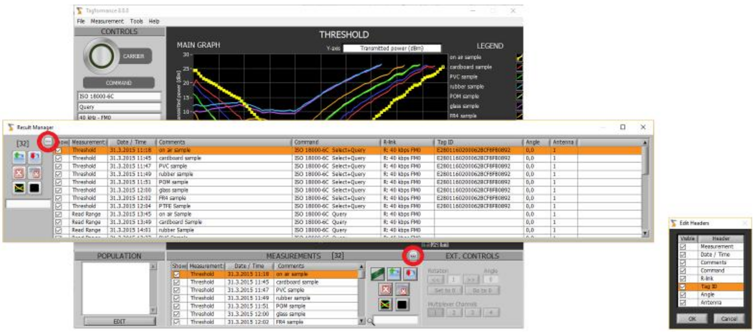


Figure 41.Result Manager – the expanded measurement list

7.2 UHF Math Operations

Math functions are enabled when multiple UHF Threshold measurements are selected in the Measurement list. To open Math functions, right-click on the measurement list with the mouse.

The selected operation will be performed for the selected measurements, or all of the operations will be performed if the “All ops” option is selected. Operations are performed only for the active unit on the Main Graph, and the result will be displayed on the Main Graph. The set of math functions are:

- Difference
- Average
- Median
- Std deviation
- Find the median sample
- Find min and max
- Min
- Max

7.3 UHF Population List

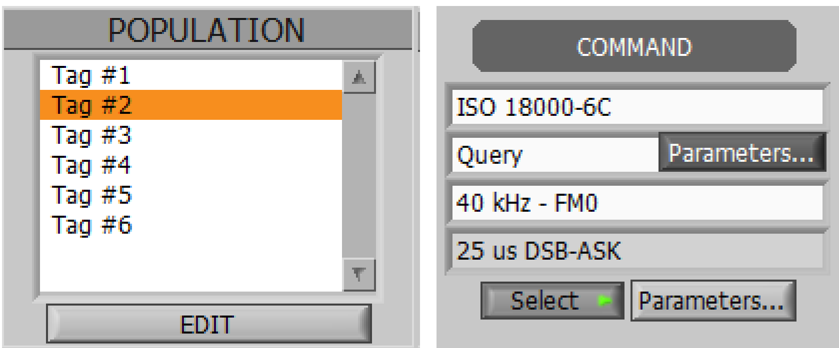


Figure 42.Tag population list and ‘Select’ activation switch in the command menu

The population management panel is activated only if the population management option is activated.

- **Population**—This contains a list of the tags in the population. When the Select command is active with the test command, it addresses the tag chosen in this list. A mouse click selects a tag.
  Ctrl + mouse click will unselect a tag.
- **Edit –** Opens the population list editor; see the description below.

7.4 UHF Population Editor

The population editor is a tool for managing tag populations. It can be used to edit the population list, identify the EPCs, analyze the TIDs of unknown tag populations, and write tag EPCs. When creating the population, the automatic naming can be defined as per the EPC, TID, or Order found.

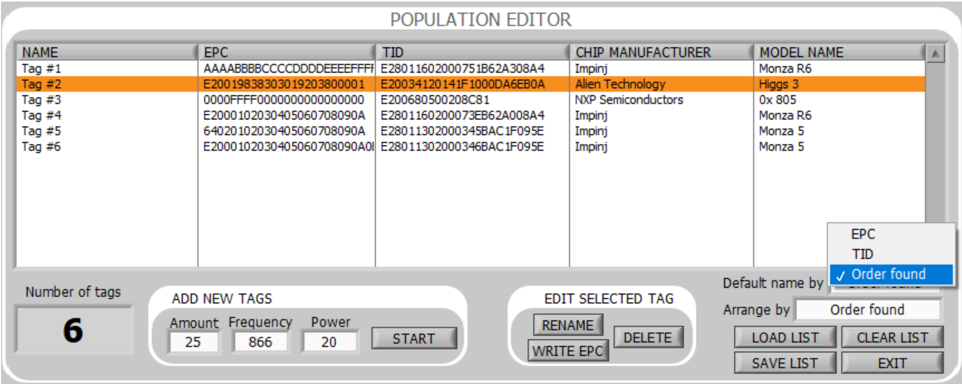


Figure 43.Population Editor

7.4.1 Inventory the Tags

To inventory the tags in the antenna's proximity, please define the estimated amount of tags, frequency, and **power**. When ‘**START**’ is pressed, the system starts doing the inventory. The system will continue looking for new tags until the ‘**STOP**’ button is pressed. Please note that the amount is not an exact number of tags but tells the system roughly how many tags are to be expected. Value ‘1’ is useful if tags are brought to the read field separately or in very small amounts, with only a couple of tags being powered simultaneously.

Load / Save population functions can be found in the Population Editors file menu, as shown in Figure 45.

7.4.2 Write EPC

The EPC of a tag can be changed by selecting the desired tag from the tag list and pressing ‘**WRITE EPC**’.

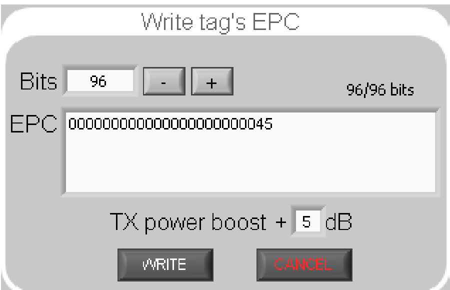


Figure 44.Write the tag’s EPC dialog

- **Bits –** Defines the length of the EPC code
- **- / + –** Decreases/Increases *Bits*-value by 16-bits
- **EPC –** Desired new EPC code
- **Write –** Write the EPC code to tag memory
- **TX power boost –** power boost compared to TX power set in population editor; e.g., if 15 dBm was used to add the tags to the list and +5 dB is used as TX power boost, the resulting power is 20 dBm; tags typically require some 3-5 dB higher power for writing to memory than to respond to the Query command.

Please note that if the same EPC codes need to be written to multiple tags, each tag must have a unique TID. The population editor cannot accept more than one instance of each EPC+TID combination.

7.4.3 Load and Save the Population List

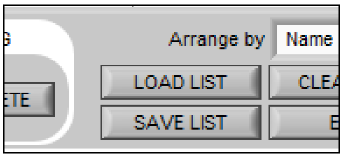


Figure 45.Load / Save population in Population Editor

7.4.4 Editing the Population File Manually

The population files can also be edited with a text editor (an example population file can be found in the *Data\Populations* folder). The population file includes tab-delimited data for one tag per row: the name of the tag, zero (‘0’)*, EPC in hexadecimal, and TID in hexadecimal. For example:

NameOfTag1 0 AAAA3382000906C000000003 E2001093

The above example describes a tag named NameOfTag1, ‘0’, 96-bit mask valued AAAA3382000906C000000003 and TID E2001093.

*) this value is currently not used but has to be zero in order for the file to be read correctly

7.4.5 Editing the TID Analysis File Manually

The TID of a tag is analyzed based on the information defined in the file *TID_manufacturer_list.txt*. The file is located in the *Data* folder. The file contains manufacturer numbers (hexadecimal) and corresponding manufacturer names. Elements following the manufacturer name relate to chip model numbers (hexadecimal) and descriptions. New rows can be inserted, and the existing elements can be edited in the file. The elements in the file are to be tabulated separately, manufacturer and model numbers should be three numbers long, and each model number should have a corresponding description.

7.5 HF Population List

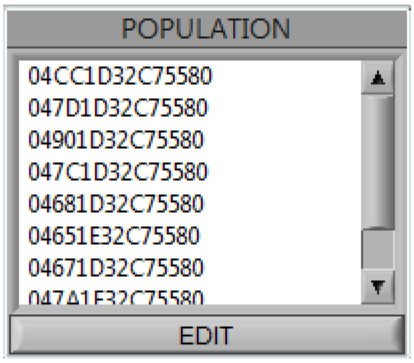


Figure 46.HF Tag population list

- **Population** A list of all the tags in the current population list. Clicking a tag in the list makes it the selected one, meaning that supported protocols and commands will be addressed to that specific tag.

- **Edit** Opens the HF Population Editor

7.5.1 Selecting and de-selecting a tag

Selecting and de-selecting a tag from the list is done by left-clicking the tag in the population list. The currently selected tag is highlighted in the list.

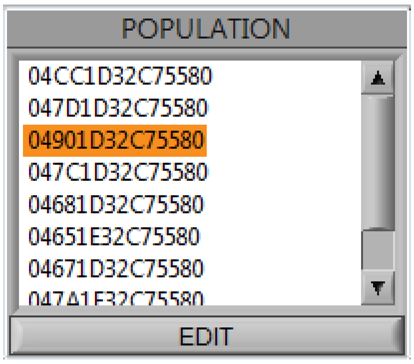


Figure 47.Currently selected tag is highlighted in the list

7.5.2 Supported Protocols and Commands for population selection

Tags in the list that are not compatible with the presently selected Protocol and Command combination will be greyed out

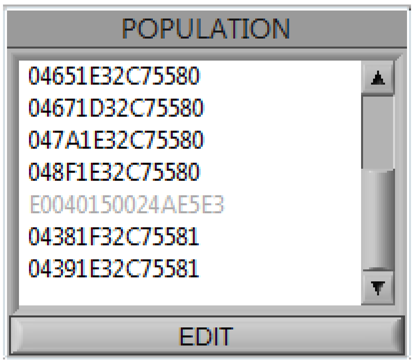


Figure 48.Unsupported tag(s) in the list will be greyed out

Currently, supported Protocols and commands are

- ISO15693
  - Inventory
  - Write Single Block
  - Read Single Block
- ISO14443A
  - Type 2 Read
  - Type 2 Write

7.6 HF Population Editor

The HF Population editor can be used to add/remove tags from the population list

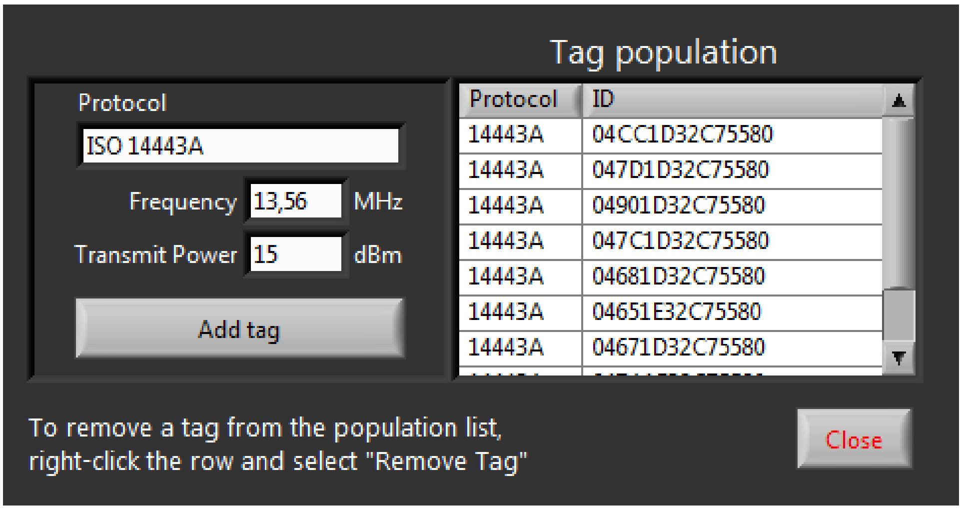


Figure 49.HF Tag population editor

7.6.1 Adding a tag to the population

Place a single tag in the antenna's field of view.
Note: Multiple tags on the antenna simultaneously are not supported when adding tags to the population.

Note: The same link parameters that are used for measurements are in effect. If needed, exit the window, select the appropriate protocol and modify the parameters.

Ensure the protocol is correct and adjust the frequency and transmit power if necessary.

Click the “Add tag” button to add the tag to the population.

The new tag will be added to the population list. If not, either the tag already exists in the list or Tagformance HF could not communicate with the tag.

7.6.2 Removing a tag from the population

Right-click the tag in the list and select “Remove Tag” to remove it from the population.

7.7 Graph Window Controls

Figure 50.Graph window controls

Below each graph window is a **toolbar** for various graph controls. The **crosshair** button moves cursors (cursors will be available in future versions). The **magnifying glass** can zoom in and out on the graph—clicking the icon opens a popup dialog with various zooming options. The **hand** can be used to move the graph.

The axis values can be directly edited by clicking on them when the autoscale is off.

7.8 Screenshots

You can choose which screenshot you want to save by clicking any graph with your right mouse button. You can select which screenshot you want to save by clicking any graph with your right mouse button. The *visual graph* retains the original color scheme used in the Tagformance measurement program. The *simplified graph* option adopts a negative color scheme derived from the visual graph, resulting in a white background.

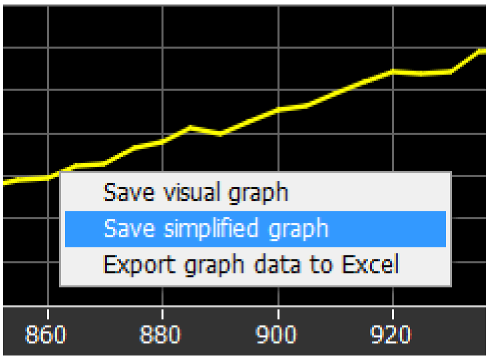
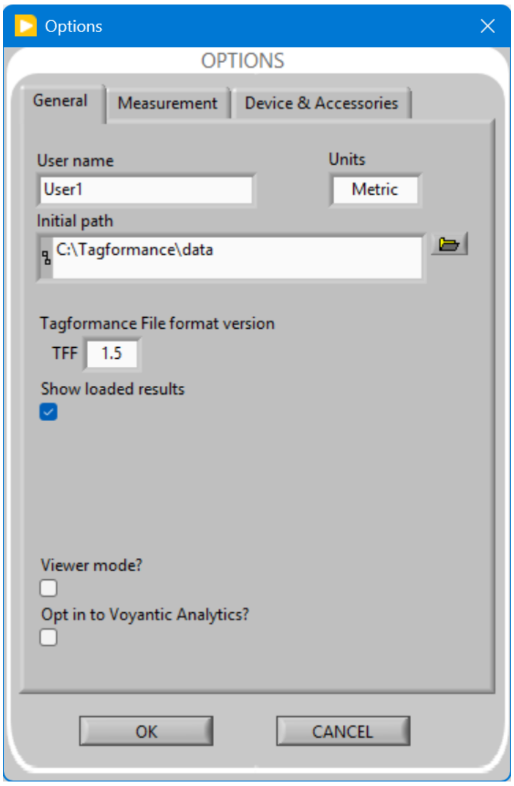


Figure 51.Screenshot menu

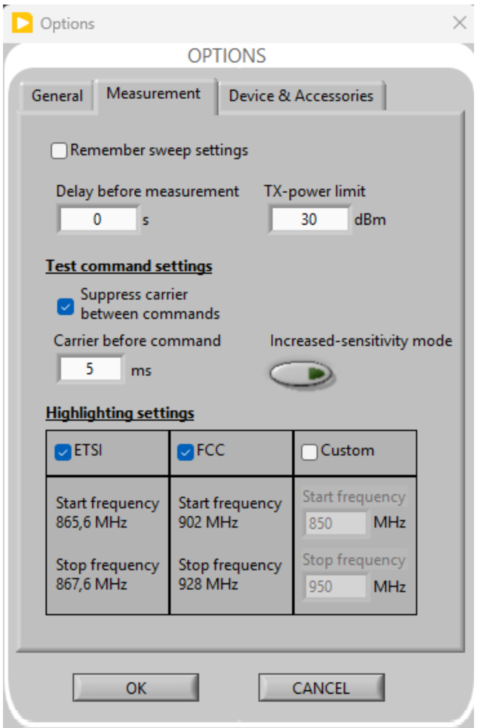
7.9 UHF Options

7.10 UHF Options dialogue

The options dialog contains fields that affect the Tagformance Measurement Software:

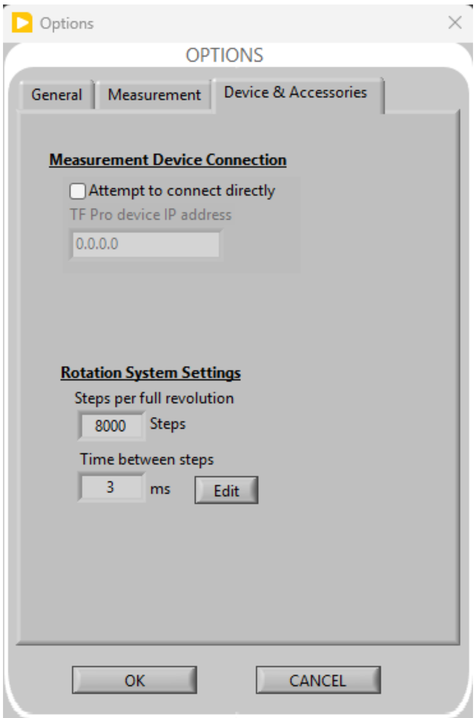


- **User name** – The name of the person or party operating the measurement system. The user name is stored as a parameter in the Tagformance Measurement File.
- **Units** – Distance units used in the geometry settings. The choices are Metric and Feet.
- **Initial path** – Used as the starting point when software opens. Any consecutive file operations use the latest file path set by the user. Closing the options dialog reasserts this value as the latest path.
- **Tagformance File Format version** –This option **only takes effect** if the legacy file format is enabled in the Tagformance runtime options (see Chapter 7.11.2). The default file version when saving measurements to a file.
  There are four versions available:
  - **1.6** supports all measurement types except the Tag Emission Test.
  - **1.5** supports all measurement types except Tag Emission Test and saving ARC Test. This format is supported in Tagformance software versions 10.1 and later.
  - **1.4** supports all measurement types but Memory Management, Tagged Item Grading, Tag Emission Test and saving ARC Test measurements. This format is supported in Tagformance software versions 6 and later.
  - **1.3** does not support Read Range, Memory Management, Tagged Item Grading, ARC Test, and Tag Emission Test measurements. This version is compatible with all previous Tagformance software versions (Tagformance 5 or older).
- **Show loaded results**—When checked, new results are shown on graph when loading a result file. Unchecking this option can make loading large result files faster.
- **Viewer Mode**—Enabling viewer mode disables the Tagformance device search during software startup. It allows users to use the software only as a viewer and not for measurements.
  Note: *When viewer mode is active, "(Viewer Mode)" will be appended to the Tagformance title bar in the software*
- **Opt in, opt out to Voyantic Analytics** – See Chapter 2



- **Remember sweep settings** – Save control values at program closure and load them at the next program start-up.
- **Delay before measurement**—The delay before a backscatter or threshold measurement starts after pressing the Start to sweep. The minimum value is 0 s, and the highest is 60 s. It is adjustable with 1 s intervals.
- **TX-power limit** – Limits the TX-power in Threshold, Orientation, Response Test (Follow Threshold only), Tagged Item Grading and ARC Test measurement programs. Max value 30 dBm, 36 dBm with high-power kit.
- **Suppress carrier between commands** – When checked, the Measurement Unit suppresses the carrier for 10 ms between each measurement point. This setting is overridden to suppress the carrier for:
  - Tag-talks-only protocol
  - Population Editor
  - Measurement programs
    - Protocol Testing
    - Memory Management

- **Carrier before command** – The amount of carrier before the actual command being sent to the tag (default 5 ms).
- **Increased sensitivity mode—**This feature increases the number of sensitivity iterations Tagformance performs before determining a point is non-responding. Enabling this feature will increase the measurement time but can provide increased sensitivity.
- **Highlighting settings –** The predefined settings affect the ighlighting in Threshold and Read Range measurements. The user may select either the predefined frequency ranges of ETSI (European Telecommunications Standards Institute) and FCC (Federal Communications Commission) or create a custom frequency range.



- **Measurement Device Connection –** When fixed IP is set, the connection is established automatically to defined fixed address
- **Rotation system settings**
  - **Steps per full revolution** – This rotation system setting defines how many steps your stepper motor has to do for a complete 360 º circle. This setting affects the orientation measurement.
  - **Time between steps** – The time between steps in the stepper motor control signal.
  - **Select proper values for your rotation system** – In the Stepper Motor Settings (Edit…), you can set the

recommended settings by choosing from the list the rotation system you have in use. There is also a possibility to set custom values.

The chosen options are saved when the Tagformance measurement program is closed and appear as default settings when it is reopened.

7.11 Sofware runtime options

7.11.1 UHF launch arguments

In addition to the configurations available via the dialogue, the Tagformance software may be started with certain options. To see the currently active launch options, go to [Help]->[About] and press “I” to switch the view from license options to launch options.

Launch option	Option Description
license	• Selects the license to be used • To be used when there are multiple licenses for the selected device in the Data folder • Takes priority over other license selections • format: license=<name of the license file in the Data folder> • example: license=license_V13_PRO_UHF-0001.dat
BS_limit	• Sets the minimum backscatter strength of a reply that will be considered a valid response • Format=bs_limit=-<backscatter in dBm> • Example:bs_limit=-60

Example.

Command line call for launching Tagformance using a specific license

C:\Tagformance\Tagformance.exe -- license=license_V13_PRO_UHF-0001.dat

7.11.2 Configuration.cfg

Tagformance\Data\configuration.cfg stores values for certain runtime options. Please, take care to only apply changes to user-definable configuration parameters and values.

User-definable configurations

[Primary Device Connection]	
Enabled	**True**, device search only if the primary cannot be connected **False**, search devices at init
IP	**“xxx.xxx.xx.xxx”**, Tagformance Pro unit IP address

[SW-API]	
Port	**xxxx**, Defines the port used for the service
Remote Connections	**True**, to enable connecting to API from the network **False**, only allow connection from localhost (recommended)

[Tagged Item Grading]	
Fail-Fast	**True**, skip the rest of the test in the cell when detecting failure **False**, follow through with all tests

[ARC Test]	
Fail-Fast	**True**, skip the rest of the test in the cell when detecting failure **False**, follow through with all tests

[Result file]	
Legacy Result Format	**True**, the result file is saved in .tff format **False**, result file saved in JSON format (recommended)

Other configurations – generated by software, do not edit

[Result Manager Window config]	
Window Position	Autoset by software, *do not edit*
List Header Settings	Autoset by software, *do not edit*
[Spectrum Analyzer Configuration]	
RSA API file path	"/C/Tektronix/RSA_API/lib/x64/RSA_API.dll", *do not edit*
[Notifications]	
IDs	Autoset by software, *do not edit*

7.12 HF Options

The options menu for Tagformance HF can be accessed through the top menu bar, by selecting Tools → Options

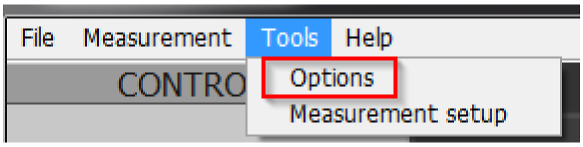


Figure 52.Menu bar for selecting the Options dialog

The options allow for general customization of the Tagformance HF software.

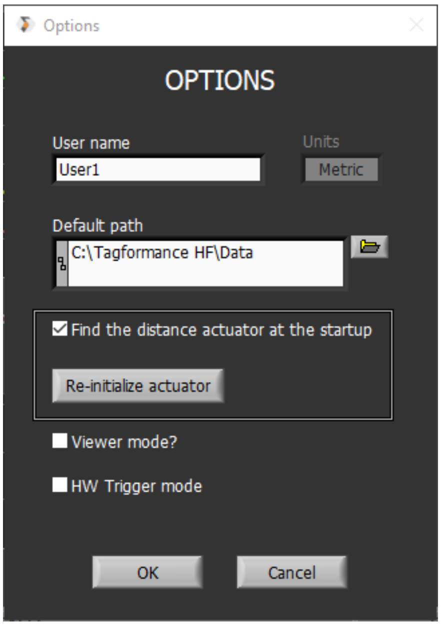
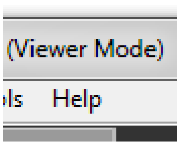


Figure 53.Tagformance HF Options dialog

- **User name**: The user name is stored together with all measurements performed for reference only
- **Default path**: Set a custom default path for operations, such as saving a measurement from the measurement list or saving a graph as a picture.
- **Find the distance actuator at the startup**: Option to enable/disable the automatic search for a connected distance control kit during startup.
- **Viewer mode:** Enabling viewer mode will disable the Tagformance device search during software startup. It can be used when software is only used as a viewer and not measurements.
  It will apply first to the next program startup.
  Note: When viewer mode is active, "(Viewer Mode)" will be appended to the Tagformance HF title bar in the software.



- **HW Trigger mode**: Enables hardware triggered (through the Tagformance Pro I/O port) measurements for Threshold and Load Modulation measurements.

7.13 UHF RFID Measurement Setup

The measurement setup dialog allows the user to select a saved setup file containing path loss information that is used to convert measured values, such as Transmit power (dBm), Backscattered power (dBm), and Backscattered signal phase (deg), to calculated additional units such as Electric field strength (V/m), Theoretical read range (m/ft) and DeltaRCS (dBsqm). Existing setup files can be easily edited to change, e.g., distance or cable loss values.

Path loss correction is used for Threshold, Backscatter, Orientation, Read Range, Tagged Item Grading, and ARC measurements.

The actual measurement setup window has two tabs. The first tab allows the user to select, edit, and create a single measurement setup. The second tab contains five preset setups, in which the user may define and edit setups with a short description.

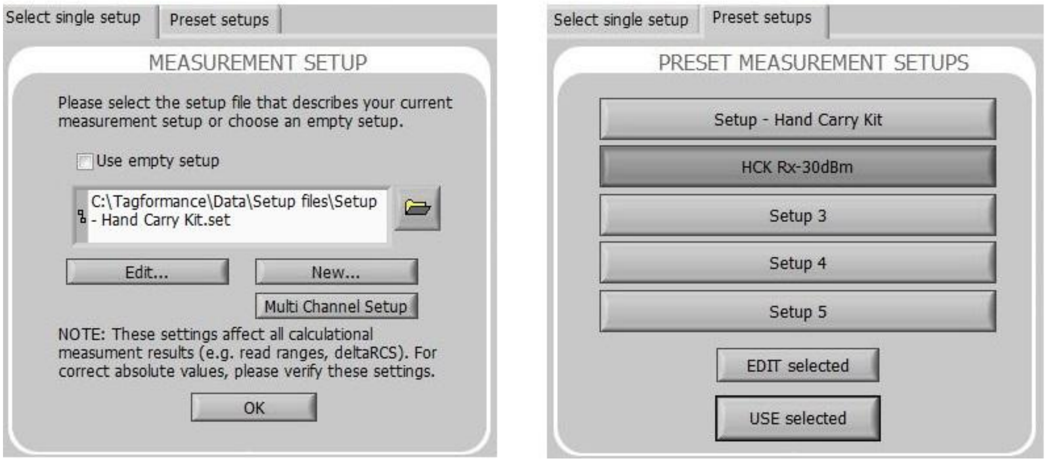


Figure 54.The two tabs of the measurement setup dialog

The user can create a setup file based on **either** calculated path loss values **or** measured path loss values. In some cases, e.g., when evaluating other system components than tags, it may be interesting to try out both and compare the differences. An empty setup can also be chosen, for example, when initiating near-field measurements with coupling elements.

If the Voyantic Multiplexer Unit is connected, the four-channel setup window automatically shows. The Multi-Channel Setup can also be set up manually.

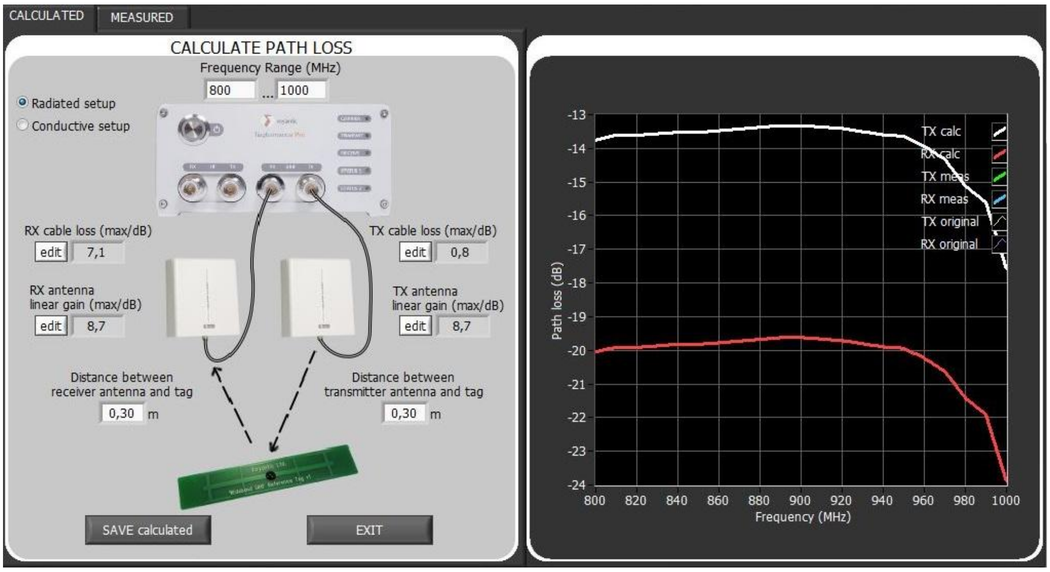


Figure 55.Measurement setup configuration tool, the tab of calculated path loss

The calculated path loss values are computed and plotted based on user-provided values for cable loss, antenna gain, and distance. The resulting path loss curve is thus theoretical in nature and is true in an anechoic environment where no multi-path propagation occurs. The cable loss and antenna gain values can be entered as a single value or as a table to consider the components' frequency dependency. The table can also be loaded from a .txt file where frequency and gain/loss values are in two tab-separated columns. An example file, antenna.txt, is provided with the Software. Finally, the path loss values should be saved as a setup file.

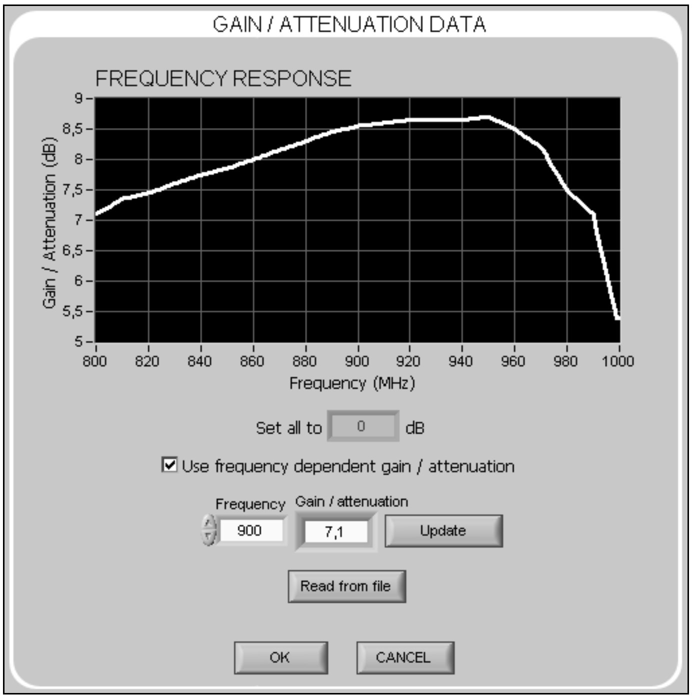


Figure 56.Gain / Attenuation data

Figure 57.Measurement setup configuration tool, the tab of measured path loss

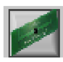
The measured path loss values are a powerful tool to counter uncharacterized components in the measurement system, such as high-power amplifiers, circulators, filters, antennae, or even the environment with multi-path propagation. To use the measured path loss values, the user should place the known reference (e.g., the provided *Wideband UHF Reference Tag*) at the exact measurements location and click on the corresponding reference button on the measurement setup configuration tool. Subsequently, Tagformance Pro will measure the path loss across the entire measurement frequency range in 1 MHz increments. Finally, the path loss values should be saved as a setup file.

With the Measurement setup configuration tool, it is easy to verify the setup by comparing the currently measured path loss with the previously selected one in the Measurement Setup Dialog window shown in Figure 54.

The correct and protected measurement file is loaded automatically in the path loss measurement with the Voyantic Wideband UHF Reference Tag. When asked to select the measurement file for the reference tag, the user can also use other references.

The frequency range for the measurement setup, shown in Figure 55 and Figure 57, can be defined with a resolution of 10 MHz. The user must ensure that the cable loss, the antenna gain (in case of calculated path loss), and the reference tag measurement file (in case of measured path loss) are defined over the whole measurement setup frequency range.

7.14 Verifying UHF RFID Measurement Setup

UHF RFID measurement setup can be verified by comparing test results to reference tag results. After preparing the setup, perform a threshold test for the Wideband reference tag. Bring the test results of the UHF RFID Wideband Reference tag from system memory to the display with the quick button . The measured result and the result from memory should be within +/- 1dBm when Power on Tag Forward is viewed. Note that Transmit power and Backscatter power results can be significant because path loss in the setups can vary significantly.

7.15 HF RFID Measurement Setup

The measurement setup dialog allows the user to select the C145 or C60 antenna. If you wish to use your own antenna, you can load a custom measurement setup file by clicking the *From file* button.

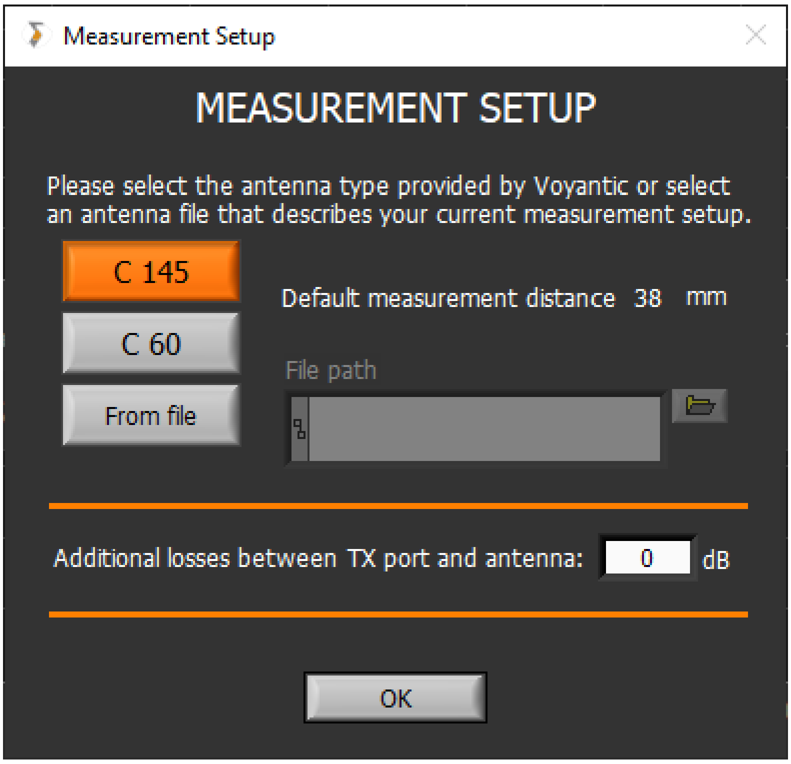


Figure 58.Measurement setup

Fill in the loss (dB) between the TX port and the antenna. The value is **0.8dB** for Tagformance Pro with Hand Carry Kit HF.

If you want to use your own custom antenna, you must create a measurement setup file containing the antenna-specific information. The file consists of a lookup table where the Frequencies (MHz) are on the X-axis, and the Distances (cm) are on the Y-axis. In the upper left corner is the TX Power (dBm) used. The cells marked in red contain the resulting Magnetic Field Strength (A/m) values for each frequency-distance combination.

The antenna file extension is *.txt,* and it is TAB delimited.

	A	B	C	D	E	F	G	H	I
1		10 dBm	Frequency	MHz					
2			10	11	12	13	14	15	16
3	Distance	0	0.065134158	0.069476	0.071648	0.082986	0.088775	0.09746	0.103973
4	cm	1	0.061384901	0.065477	0.067523	0.078209	0.083665	0.09185	0.097988
5		2	0.054474505	0.058106	0.059922	0.069405	0.074247	0.08151	0.086957
6		3	0.046240842	0.049324	0.050865	0.058914	0.063025	0.06919	0.073814
7		4	0.038889356	0.041482	0.042778	0.049548	0.053005	0.05819	0.062079
8		5	0.031537871	0.03364	0.034692	0.040182	0.042985	0.04719	0.050344
9		6	0.026538861	0.028308	0.029193	0.033812	0.036171	0.03971	0.042364
10		7	0.022054455	0.023525	0.02426	0.028099	0.030059	0.033	0.035205
11		8	0.018672772	0.019918	0.02054	0.02379	0.02545	0.02794	0.029807
12		9	0.015879208	0.016938	0.017467	0.020231	0.021643	0.02376	0.025348
13		10	0.013453218	0.01435	0.014799	0.01714	0.018336	0.02013	0.021475
14		11	0.010880198	0.011606	0.011968	0.013862	0.014829	0.01628	0.017368
15		12	0.008380693	0.008939	0.009219	0.010678	0.011423	0.01254	0.013378
16		13	0.007057426	0.007528	0.007763	0.008992	0.009619	0.01056	0.011266
17		14	0.005734158	0.006116	0.006308	0.007306	0.007815	0.00858	0.009153
18		15	0.00514604	0.005489	0.005661	0.006556	0.007014	0.0077	0.008215
19		16	0.004778465	0.005097	0.005256	0.006088	0.006513	0.00715	0.007628
20		17	0.003969802	0.004234	0.004367	0.005058	0.005411	0.00594	0.006337
21		18	0.003675743	0.003921	0.004043	0.004683	0.00501	0.0055	0.005868
22		19	0.003308168	0.003529	0.003639	0.004215	0.004509	0.00495	0.005281
23		20	0.002646535	0.002823	0.002911	0.003372	0.003607	0.00396	0.004225

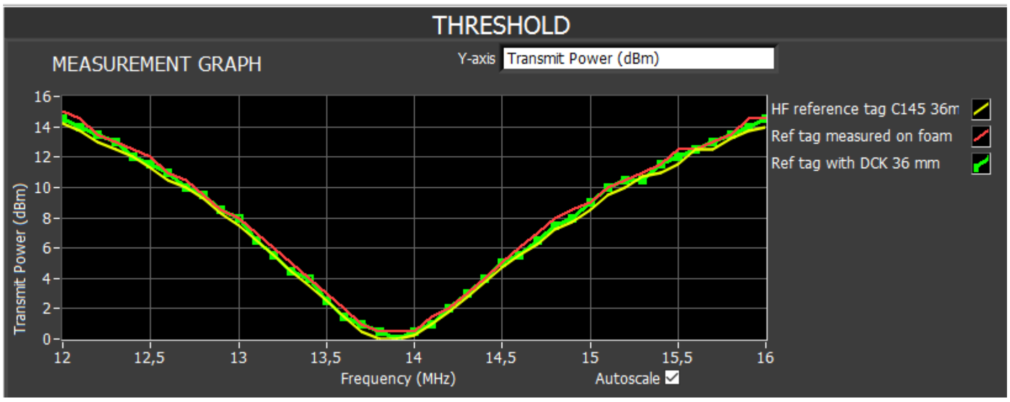
Figure 59.Example of the custom HF antenna setup file

7.16 Verifying HF RFID Measurement Setup

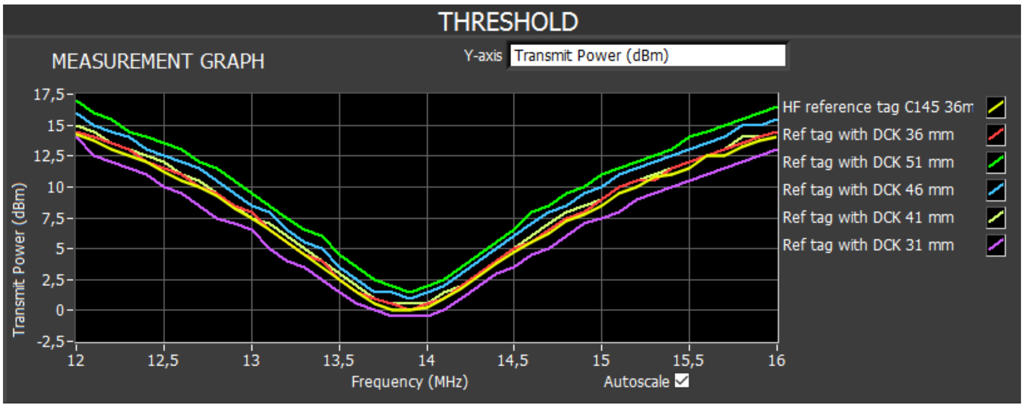
HF RFID measurement setup can be verified by comparing test results to reference tag results.

The test is made with the C145 antenna at a 38 mm distance. For example, use the space foams as in the adjacent picture or set the Distance Control Kit to 38 mm. Remember to adjust the 0-point correctly with the Distance Control Kit by setting the distance and measuring with a ruler or such.

After preparing the setup, perform a threshold test for the HF reference tag and load in the test result. The Measured Transmit Power and result from memory should be within +/-1 dBm. Note that the difference changes if a different antenna or cable is used.



The result is more sensitive to too short a measurement distance than too long a distance.



7.17 Scripter

The scripter allows users to automate measurements with the Tagformance UHF Measurement Software. The scripter is activated only if the scripter option is enabled in the license file.

- **RUN** – Starts running the script from the beginning
- **STOP** – Stops running the script
- **STEP** – Runs the selected line of the script and jumps to the next line
- **EDIT** – Opens the script in edit mode
- **OPEN** – Loads a previously saved script file
- **SAVE** – Saves a script file

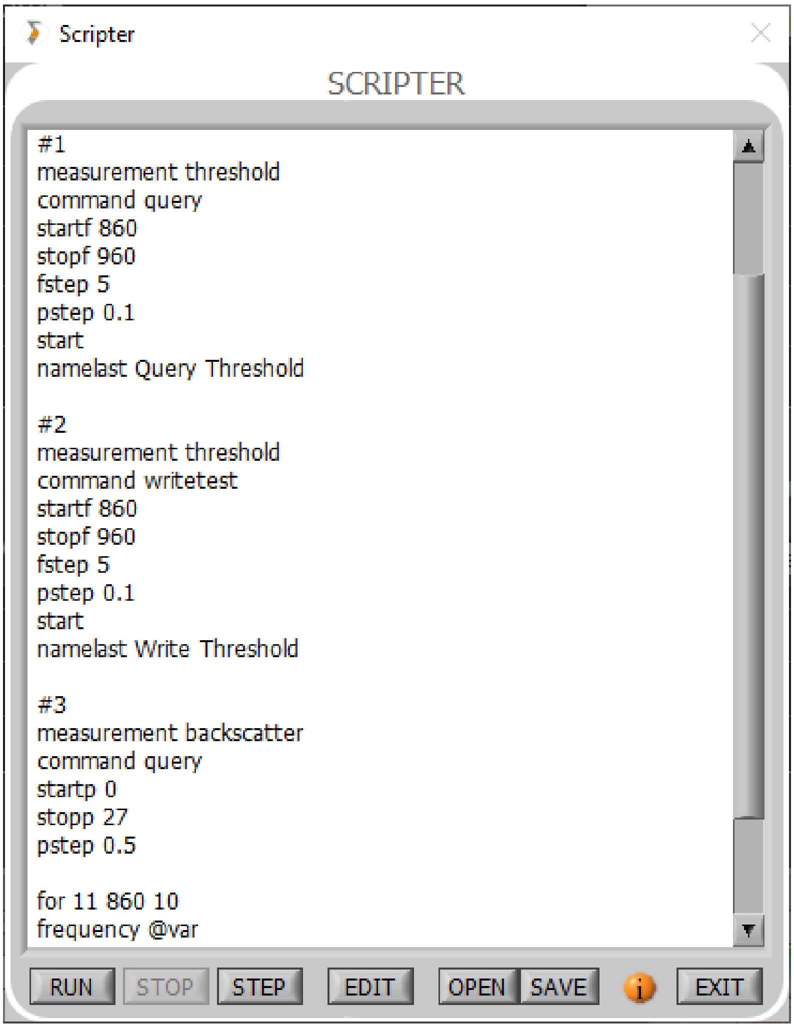


Figure 60.Scripter GUI

For a full list of scripter commands, please see Appendix C: Scripter Commands. Example script can be found from C:\Tagformance\Data\Scripts.

7.18 Graph Legend

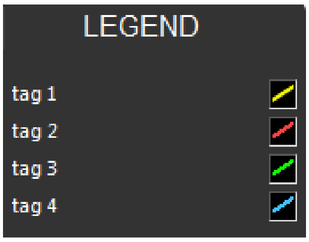


Figure 61.Measurement graph plot legend

The *Threshold*, *Backscatter*, *Orientation Sensitivity,* and *Read Range* have a graph legend on their right. It shows the first ten measurements with the comment field, plot line style, and color sample. The color can be changed from a popup menu that can be accessed by left-clicking the plot name or icon. The line style cannot be changed.

7.19 UHF RFID Protocol and Command Control

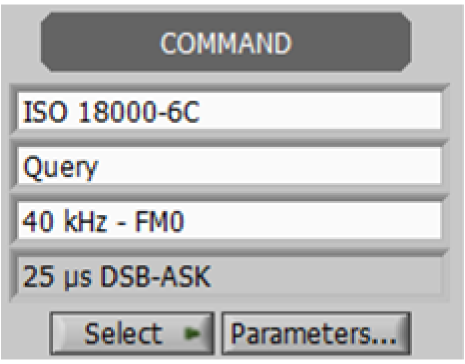


Figure 62.UHF command control and protocol info

Measurement programs have command controls showing which protocol, command, and data rate are used. The parameters can be changed from the drop-down menus. When any of the settings are changed, the other menus are updated.

Available protocols and commands are:

- ISO 18000-6C
  - Query, Read, Write, custom commands (EPC)
  - All with 40 kHz Fm0, 320 kHz FM0, 640kHZ FM0 and 320 kHz Miller 4 (Query, Read, Write), Query+ACK for 320 kHz Miller 4
- ISO 18000-6B
  - Group select, 40 kbps FM0
- GB / T29768
  - Query, Read, Write
  - All with 64 kbps FM0, pilot tone
- SINIAV
  - Query, 320 kHz FM0
- Tag-talks-only
- Custom command (non-EPC)

7.19.1 ISO18000-6C Read and Write Command Parameters

If the optional population management feature is available, the ISO 18000-6C commands can be used with **Select** to address the tag selected in the Tag list of the Population management panel. The selection is parametric. Tags can be selected by TID, EPC, or TID+EPC.

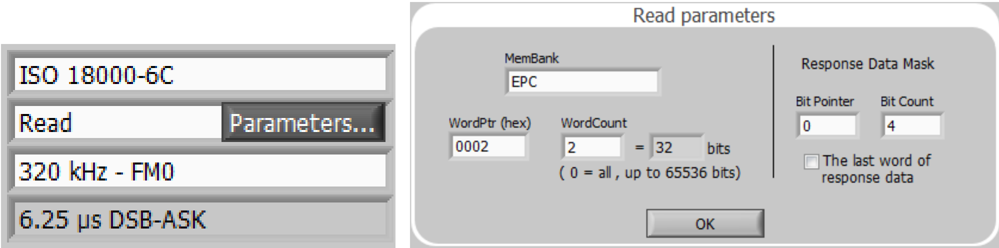


Figure 63.ISO 18000-6C Read parameters

ISO 18000-6C Read and Write commands are parametric. When each command is selected, the respective parameters can be changed through the parameters menu.

With the ISO 18000-6C Read command, it is possible to mark off a data subset from the tag response by the data mask. The masked data will be converted to a number and plotted to the graph. The response data to be masked is the data without Preamble, "Header", RN16, and CRC-16.

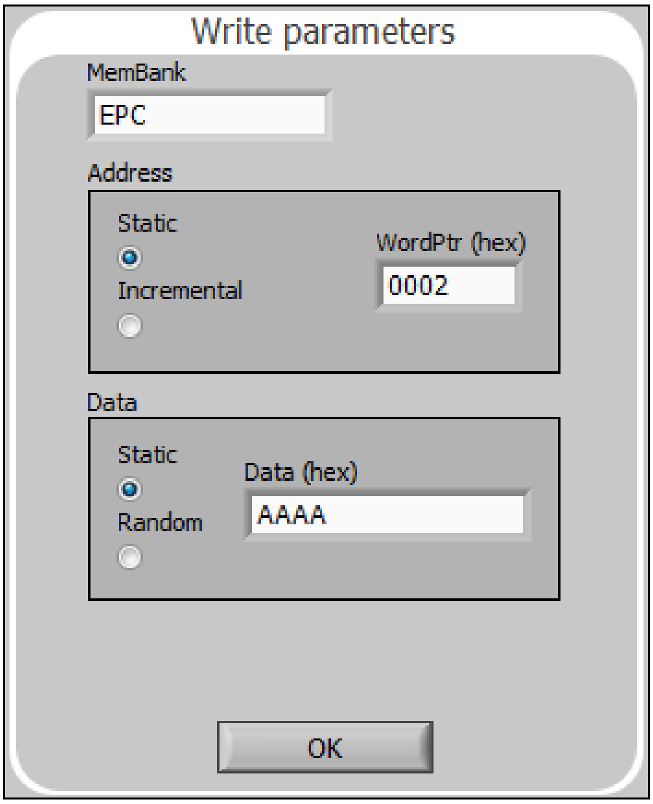


Figure 64.ISO 18000-6C Write parameters

7.19.2 ISO 18000-6C link parameters

The default timings of ISO 18000-6C test commands may be adjusted by modifying the "Tagformance\Data*18000-6C_timing_parameters.ini*" file.

Changes in this file are carried over to the software when:

- Entering a measurement program
- Changing COMMAND (protocol, command, BLF)
- Starting a measurement

The parameters set in this file are applied to all 18000-6C commands, except:

- Miller 4 Query+ACK command, to comply with TIPP standard command)

The parameters set in this file are applied for all test programs and functions, except:

- Population editor
- Protocol Testing
- Memory management
- Tag emission Test – Query Spectrum

When non-default values are used, the *Forward link* field in the Tagformance software will be highlighted. The set values can be seen by hovering over that field. For more information about the feature, please refer to the file.

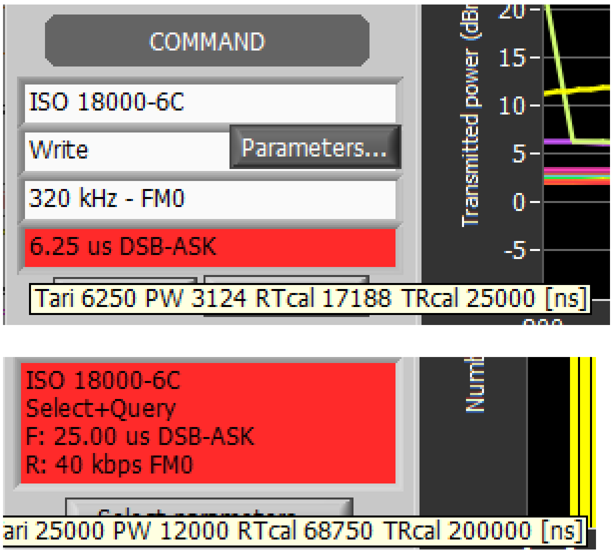


Figure 65.Custom values in use

7.19.3 ISO 18000-6C Query parameters

The ISO 18000-6C Query parameters menu allows for setting up signal averaging to improve the signal-to-noise ratio through different averaging modes.

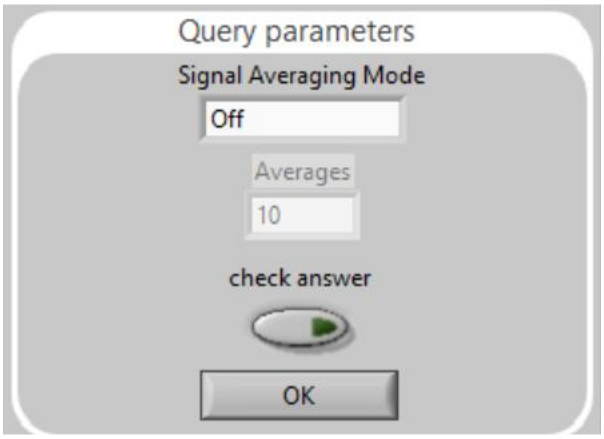


Figure 66.ISO 18000-6C Query parameters

The averaging works by sending and receiving the command several times at the same frequency and power level, and then creating one single waveform out of the average of the waveforms received. This average waveform is then analyzed and checked for tag responses. Since the Query command response contains a random number, the averaged tag response may look distorted towards the end.

The supported modes for averaging are:

Off – Normal operation; no signal averaging will be performed.

Fixed – The number of averages performed is fixed to the number in the Averages field.

Adaptive – The Tagformance Pro software will automatically iterate starting from a low number of averages until it either finds a response or reaches the number of Averages in the field + 1. The software will not attempt to do unnecessary averages if the signal can be clearly found without averaging, thus significantly speeding up the measurement process when there are clear responses.

Check answer is another check on top of query interpretation and signal averaging. Enabling the condition rejects any responses that do not contain the correct number of bits. This feature should only be used with averaging off as it cannot verify averaged results.

Considerations for enabling “check answer”:

Time – measurement duration is increased

Sensitivity – very weak responses may incorrectly be treated as invalid as the decode is less sensitive than the query interpretation algorithm

Glitches – if the measurement contains glitches that are not replicable with another command, e.g. read, the feature should be enabled

7.19.4 Tag-talks-only parameters

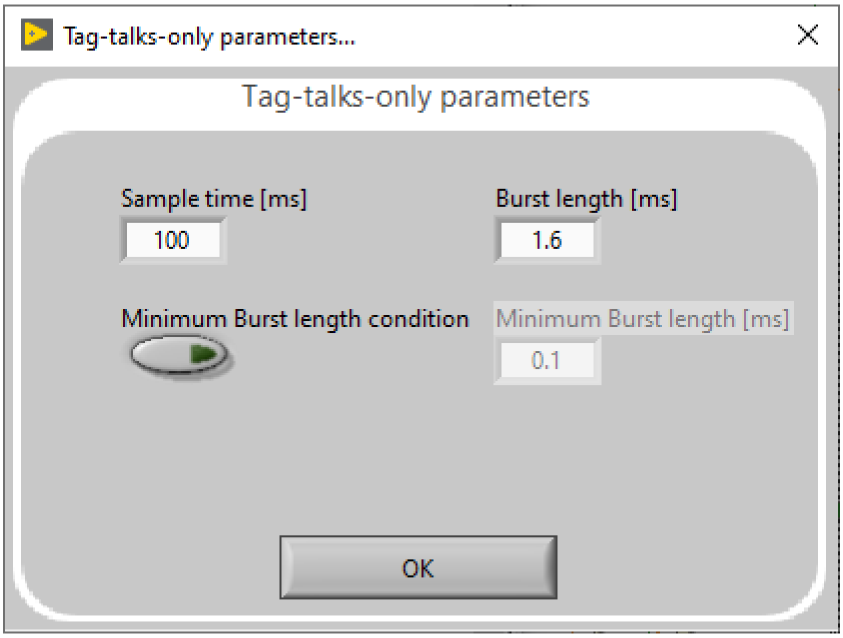


Figure 67.Tag-talks-only parameters

To use Tag-talks-only, the user needs to input the reply length. To determine this, look at the latest response window in Threshold measurement. To improve interpretation robustness, make certain that at least one, preferably multiple replies, is present in the waveform set by sample time [ms].

The measurement sensitivity for this protocol is -65 dBm.

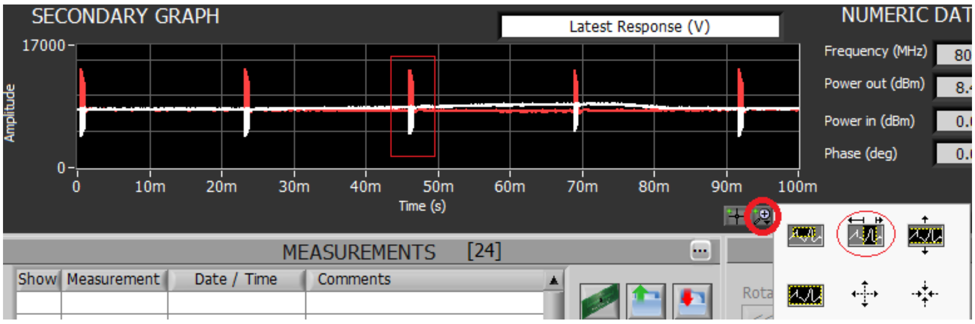


Figure 68.Sample reply from the tag. Zoom in on the response waveform to measure the burst length in ms.

For certain chip types, the “minimum length” condition may be necessary. To determine the requirement, note the length of the response at a transmit power greater than the threshold power. Then, lower the power to a level where the tag does not respond and increase gradually. When the first responses become visible in the latest response window, check their length. The minimum burst length condition is necessary if the length is less than the previously noted length.

Conditions for a valid minimum burst length:

Invalid burst length < minimum burst length

AND

1,5 x minimum burst length < correct burst length

7.20 HF RFID Protocol and Command Control

The Threshold, Load Modulation, and Working Range measurement programs have the protocol and command control where the current command can be selected.

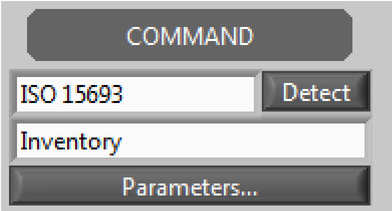


Figure 69.Protocol and Command Selection

Available protocol and commands are:

- ISO 15693
  - Inventory
  - Write Single Block
  - Read Single Block
- ISO 14443A
  - REQA
  - Type 2 Read
  - Type2 Write
- ISO 14443B
  - REQB
  - ST25TB Read_Block
- FeliCa
  - Polling
- ISO 18000-3M3
  - Begin Round
- Tag-Talks-Only
  - PR1101 (Additional license option)
  - PR1102 (Additional license option)
  - NFC barcode (Additional license option)

7.20.1 Detect

Activates Tagformance automatic detection of tag protocol. The current tag in the antenna field of view is tested using several power and frequency combinations to determine the tag's protocol support.

The detected protocol will automatically be selected if it can be found.

Note: The frequency and power combinations have been selected to cover the basic tag designs and might not detect a tag protocol outside those combinations.

7.20.2 Command Parameters

The parameters of HF RFID protocols and commands can be seen in a separate window (see Figure 70 below), which will open after pressing the *Parameters* button. The parameters are editable for some protocols and commands.

As an example, the following parameters are available for some protocol and command combinations:

- **Forward link Speed**
- **Reverse link Speed**
- **Modulation index**
- **Check answer:** When selected, the tag answer is checked to be correct. This can be used for separating correct tag replies from error code replies
- **Block number**: For read and write commands
- **Data (hex):** for Write commands

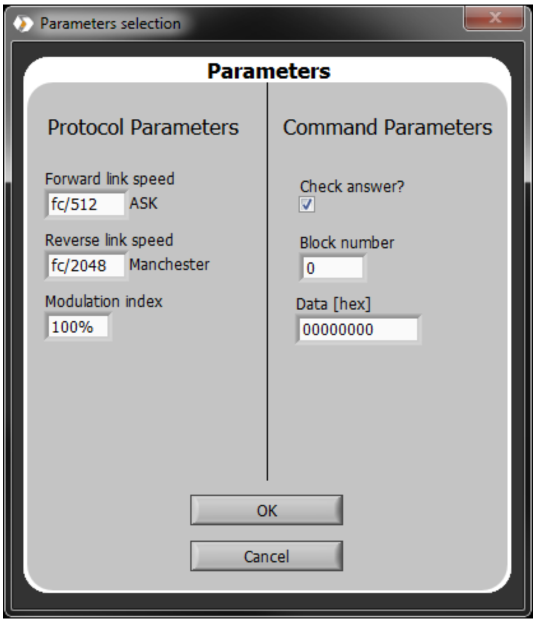


Figure 70.ISO 15693 Write Single Block parameters

7.21 Carrier Indicator

Each measurement function has the carrier indicator, which indicates whether the carrier signal is on or off.

Figure 71.Carrier indicator

7.22 Window Size

Tagformance measurement program has two window sizes: standard and full screen. The size can be changed by selecting **Tools → Window size**. Resizing is disabled if the resolution of the computer's primary display is not wide enough for standard size.

7.23 Storing EPC/TID to Measurement Result File

The EPC / TID data is saved to the measurement file when the ISO 18000-6C command with select is being used.

1. Add the tag to the tag list (please see chapters 7.3 and 7.4)
2. Activate Select and run a measurement with any 6C command
3. After saving the measurements list EPC / TID data appears for
    a. TFF: the *Protocol description* –field
    b. JSON: in the "tags" object

8 Tag Designer Suite

8.1 UHF RFID Threshold

The Threshold measurement function is designed for tag characterization as a function of carrier frequency. This function will analyze the tag's sensitivity, tuning and detuning with material presence.

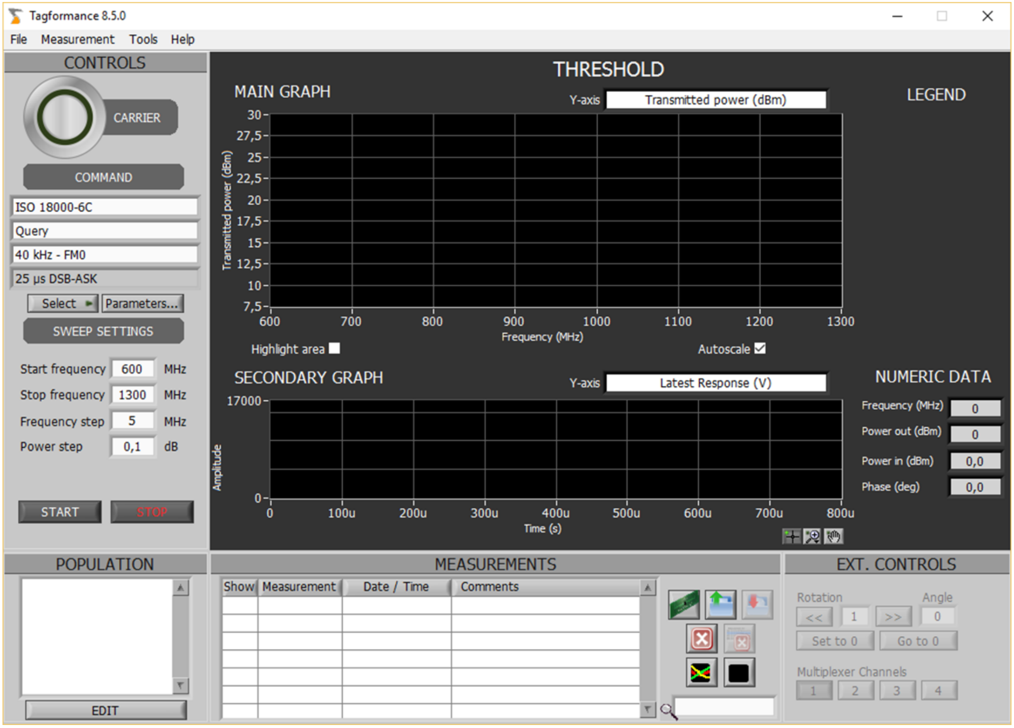


Figure 72.Threshold Measurement Software

The **control panel** contains the following controls.

- **Command** – The protocol and command that is used in the measurement. See chapter 7.19 for detailed information.
- **Sweep settings**
    - **Start frequency** – Sweep start frequency (MHz).
    - **Stop frequency** – Sweep stop frequency (MHz).
    - **Frequency step** – Indicates how much the frequency increases with each measurement point. Possible values are from 0.1 MHz to 100 MHz.
    - **Power step** – Power resolution. The power step can be changed from the drop-down menu. Possible values are 0.1 dB, 0.5 dB, and 1.0 dB.
- **Start sweep** – Starts the sweep.
- **Stop sweep** – Stops the sweep.

In the default view, there is one graph for measurement results and one for the latest detected tag response signal. The secondary graph can be changed to show measurement results through the Y-axis drop-down menu.

The Measurement Unit can be changed from the drop-down menu above the upper graph. The possible values are:

- Transmitted power (dBm)
- Backscattered power (dBm)
- Backscattered signal phase (deg)
- Electric field strength (V/m)
- DeltaRCS (dBsqm)
- Power on tag forward (dBm)
- Power on tag reverse (dBm)
- Theoretical read range forward (m/ft)
- Theoretical read range reverse (m/ft)
- Response Data (data as integer)
- Latest Response (V) (Secondary Graph only)
- Response Data (data as integer)

The **Autoscale** adjusts axes according to data in the frequency range defined in sweep settings and the **Highlight area** activates or disables the highlighting of the graph.

8.2 Backscatter

8.2.1 TX/RX View

The Backscatter TX/RX view tests the tag's backscatter signal strength as a function of the carrier level.

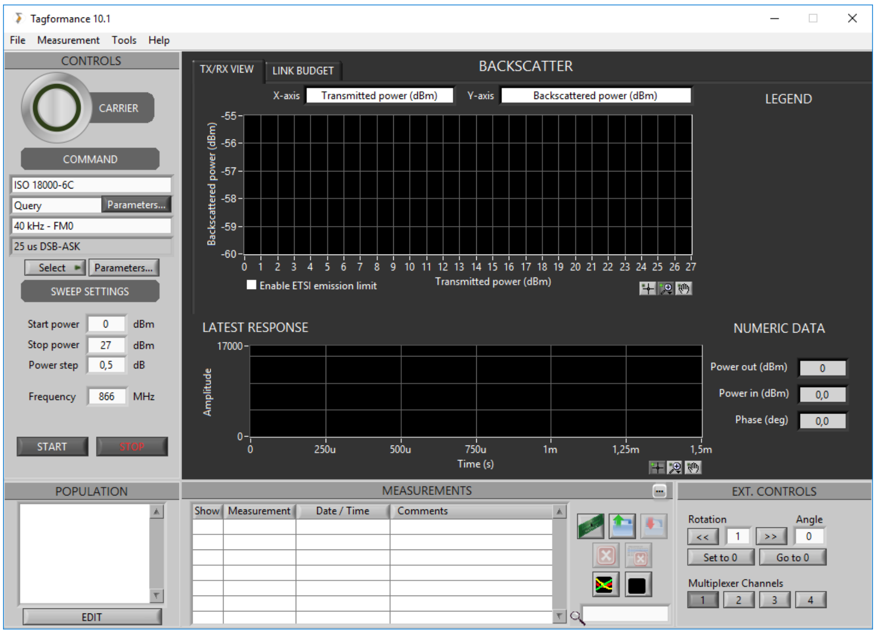


Figure 73.Backscatter measurement – TX/RX view

The elements of **Backscatter Analyzer**'s control panel are:

- **Command –** The protocol and command that is used in the measurement. See chapter 7.19 for detailed information.
- **Select** – The control for setting the select command feature on/off.
- **Selection Parameters** – Change the selection parameters.
- **Sweep settings**
  - **Start power** – Sweep start power in dBm. The minimum value is -20 dBm, and the maximum is +30 dBm (or maximum attainable power).
  - **Stop power** – Sweep stop power in dBm. The minimum value is -20 dBm, and the maximum is +30 dBm (or maximum attainable power).
  - **Power step** – Indicates how much the power increases with each measurement point. The power step can be changed from the drop-down menu. Possible values are 0.1 dB, 0.5 dB, and 1.0 dB.
  - **Frequency** – A control for the frequency used in the measurement
- **Start sweep** – Starts the sweep.
- **Stop sweep** – Stops the sweep.
- **Enable ETSI emission limit** – A control for showing ETSI radiated power limit.

The Measurement Unit can be changed from the drop-down menus above the upper graph.

For the X-axis, the possible values are:

- Transmitted power (dBm)
- Electric field strength (V/m)
- Power on tag forward (dBm)

And for the Y-axis:

- Backscattered power (dBm)
- Backscattered signal phase (deg)
- DeltaRCS (dBsqm)
- Power on tag reverse (dBm)
- Theoretical read range reverse (m/ft)
- Response Data (data as integer)

Enabling ‘Enable ETSI emission limit’ creates a line in the graph. This line indicates the maximum allowed backscatter strength for a tag on ETSI bands according to EN 302 208. The standard defines two frequency bands with individual limit values:

- Lower band 865-868 MHz; tag shall not exceed -20dBm ERP
- Upper band 915-921 MHz; tag shall not exceed -10dBm ERP

To make the limits comparable, they must be offset to match the Voyantic backscatter definition. The corresponding values according to this definition are:

- Lower band 865-868 MHz; tag shall not exceed -10.85 dBm EIRP
- Upper band 915-921 MHz; tag shall not exceed -0.85 dBm EIRP

For more information, please refer to *Appendix B*: Tagformance Measurement Units.

The limit will be shown only if the selected measurement is within either frequency band. If the X-axis is 'Power on tag forward (dBm)' and the Y-axis is 'Power on tag reverse', these values are unaffected by changes in the measurement setup. The interrogator signal strength specified in the standard is highlighted in red on the limit graph.

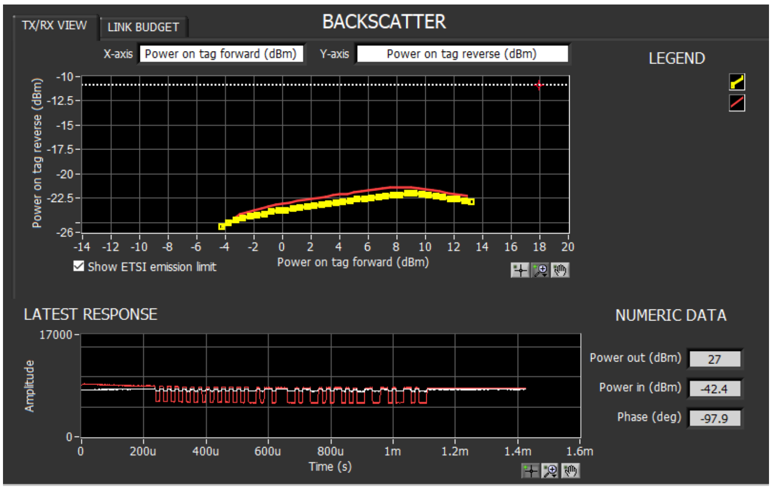


Figure 74.Backscatter measurement with ETSI emission limit indicator enabled (manual scaling)

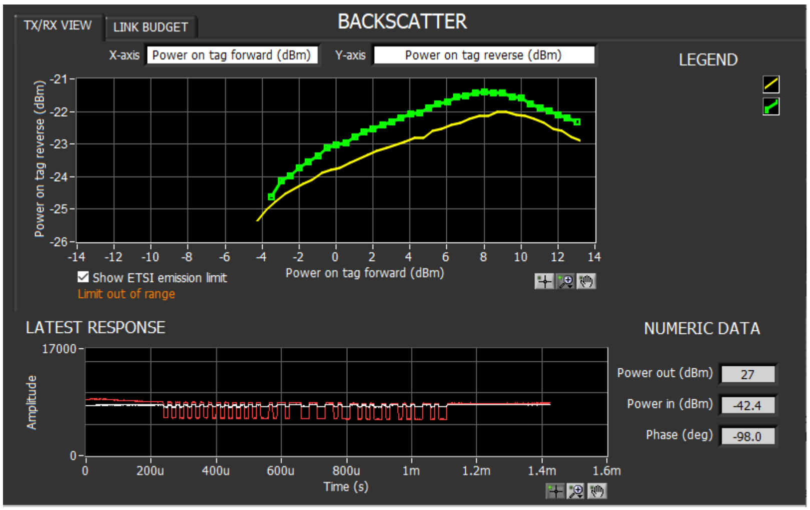


Figure 75.Backscatter measurement with ETSI emission limit indicator enabled (autoscaling). A message is shown to indicate that the measurement is within the upper or lower frequency band, but the limit is outside of the graph's scale.

8.2.2 Link Budget View

Based on the given reader parameters, the Backscatter Link Budget view is another way to evaluate and visualize the tag's available operating range for both the forward and reverse links. These results are based on the same measurements as the *TX/RX VIEW* side results.

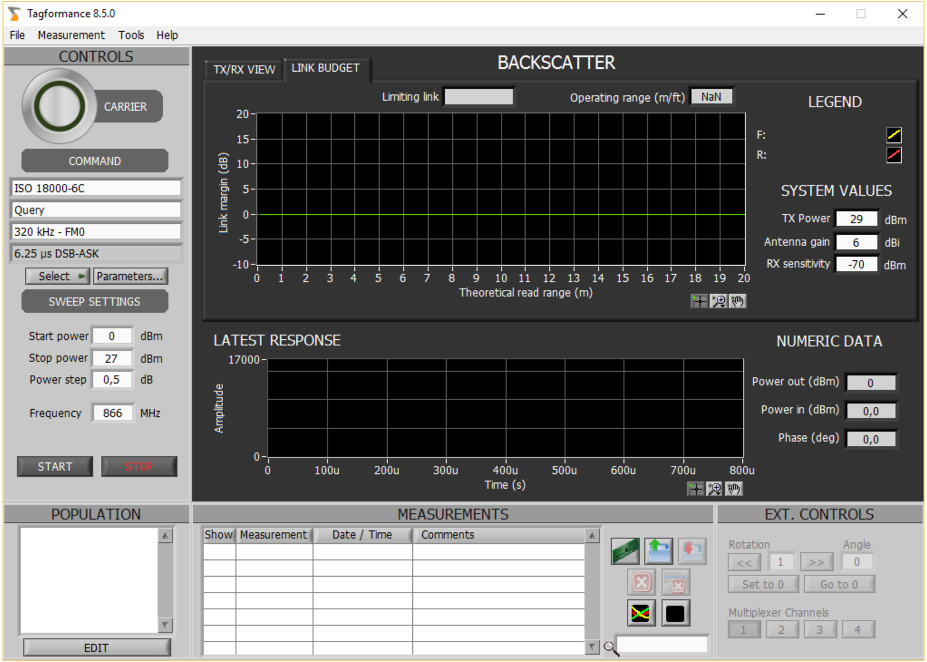


Figure 76.Backscatter measurement - Link Budget view.

Please note that the *start power* must be set below the tag's threshold power level. The best practice is to start from -5 dBm or at least a few times the power step below the threshold power level.

The limiting link is the link that first reaches the 0 dBm margin.

Graph Plot	**Color**	**Explanation**
Forward link	Yellow	The Forward link graph is calculated based on the Power on Tag Forward threshold ($P_{TF,TH}$) value which is the first point of the backscatter plot on the *TX/RX view*.
Reverse link	Red	The Reverse link is calculated based on the Power on Tag Reverse values. The Power on Tag Reverse (P_{TR}) value changes at each point according to the distance (d).

Please see *Appendix B: Tagformance Measurement Units* for more detailed information.

System Value	**Unit**	**Explanation**
TX Power	dBm	The assumed reader TX port transmit power.
Antenna gain	dBi	The assumed reader antenna gain for both transmit and receive.
RX Sensitivity	dBm	The assumed reader receiver sensitivity.

The default values assume a maximum of 2 W ERP transmit power, a reasonably good receiver sensitivity of -70 dBm, and a 6 dBi antenna gain.

8.3 Orientation Sensitivity

Orientation Sensitivity is a measurement program designed to characterize the radiation pattern of tags or tagged objects. The *Orientation Sensitivity* measurement function fully integrates with both the Voyantic *RFID Measurement Cabinet* and the Voyantic *Tag Rotation System* to provide fully automated measurements.

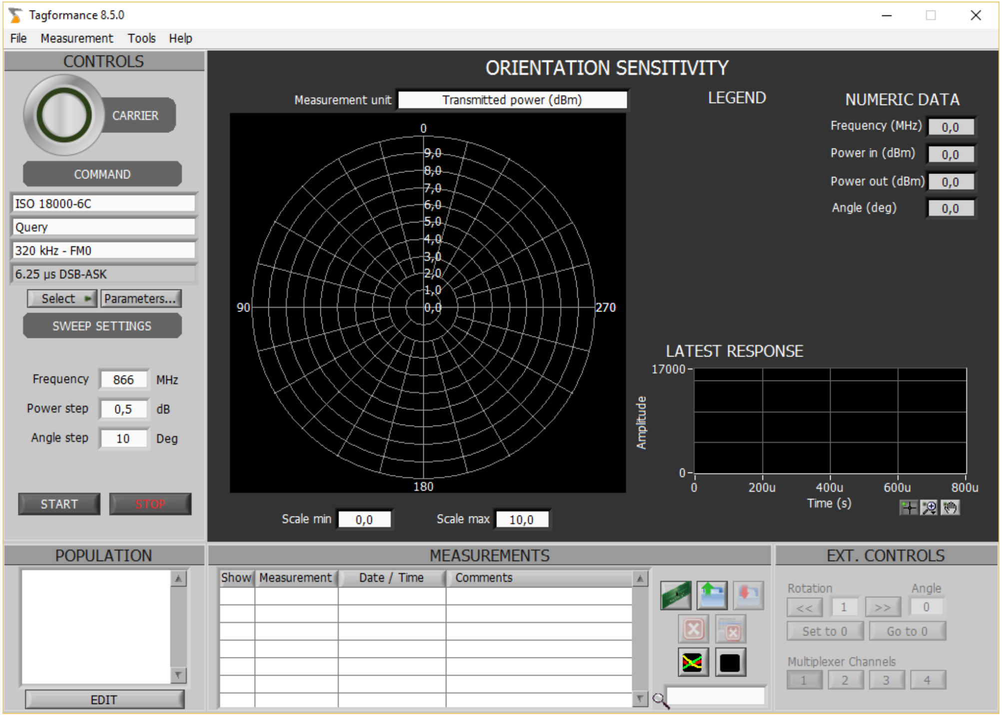


Figure 77.Orientation Sensitivity Measurement software

- **Command** – The protocol and command that is used in the measurement. See chapter 7.19 for detailed information.
- **Select** – The control for setting the select command feature on/off.
- **Selection Parameters** – Change the selection parameters.
- **Sweep settings**
  - **Frequency** – A control for the frequency used in the measurement.
  - **Power step** – Indicates how much the power increases with each measurement point. The power step can be changed from the drop-down menu. Possible values are 0.1 dB, 0.5 dB, and 1.0 dB.
  - **Angle step** – Indicates how much the angle increases with each measurement point. The angle step can be changed from the drop-down menu. Possible values are 1, 5, 10, 15, and 30 degrees.
- **Start** – Starts the measurement.
- **Stop** – Stops the measurement.

The Measurement Unit can be changed from the drop-down menu above the polar plot graph. The possible values are:

- Transmitted power (dBm)
- Backscattered power (dBm)
- Electric field strength (V/m)
- Power on tag forward (dBm)
- Power on tag reverse (dBm)
- Theoretical read range forward (m/ft)
- Theoretical read range reverse (m/ft)
- Normalized radiation pattern (dB)

8.4 Read Range

The *Read Range* measurement is basically a *Backscatter* measurement initiated with multiple frequencies. The read range and link budget are measured for each frequency. Afterward, the user may inspect how altering the transmitter power, receiver sensitivity, and antenna gain affects the tag's read range. In addition to the *Read Range*, *Link Details*, and *Raw Data* graphs, a backscatter graph exists to inspect the raw data at either single transmitter powers or frequencies.

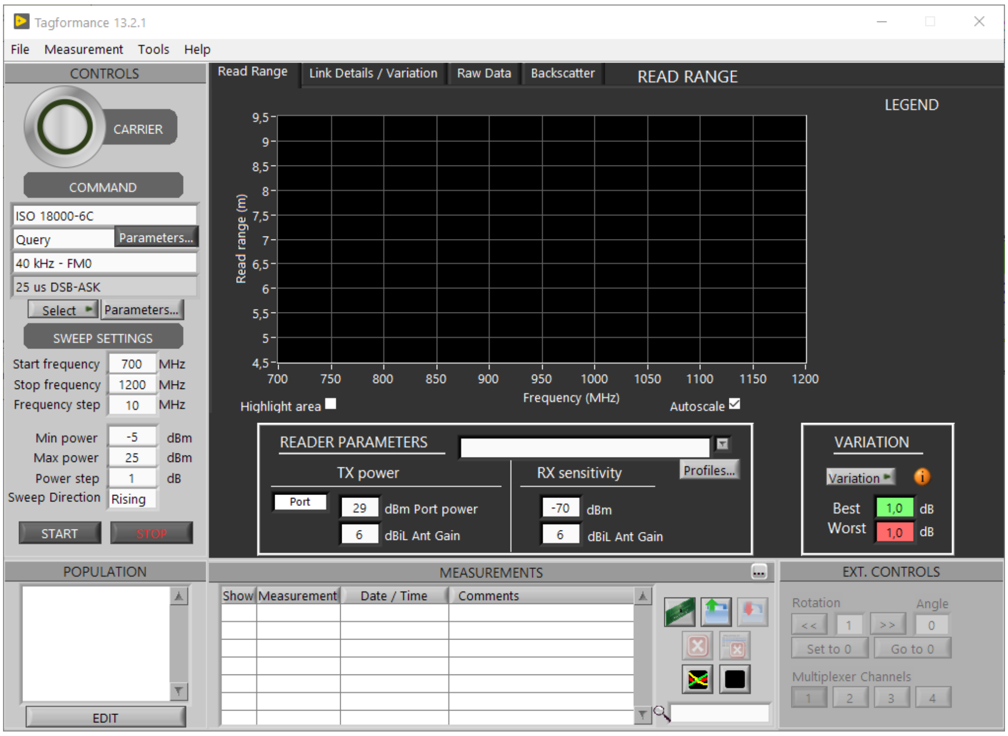


Figure 78.Read Range Measurement software

The **control panel** comprises the following controls.

- **Command** – The protocol and command that is used in the measurement. See chapter 7.19 for detailed information.
- **Select** – The control for setting the select command feature on/off.
- **Selection Parameters** – Change the selection parameters.
- **Sweep settings**
  - **Start frequency** – Sweep measurement start frequency (MHz).
  - **Stop frequency** – Sweep measurement stop frequency (MHz).
  - **Frequency step** – Indicates how much the frequency increases with each measurement point. Possible values are from 0.1 MHz to 100 MHz.
  - **Min power** – Lowest carrier power at each test frequency in dBm. The minimum value is -20 dBm, and the maximum is +30 dBm (or maximum attainable power).
  - **Max power** – Highest carrier power at each test frequency in dBm. The minimum value is -20 dBm, and the maximum is +30 dBm (or maximum attainable power).
  - **Power step** – Indicates how much the power increases with each measurement point. The power step can be changed from the drop-down menu. Possible values are 0.1 dB, 0.5 dB, and 1.0 dB.
  - **Sweep Direction** – Decides whether to start iterating each frequency from min power (Rising) or max power (Falling).
- **Start sweep** – Starts the sweep.
- **Stop sweep** – Stops the sweep.

Start and Stop frequencies are coerced if they are either above or below threshold values to their nearest limits. If the Stop frequency is smaller than the Start frequency, the Stop frequency is coerced to the maximum frequency.

The start power should be chosen below the tag's threshold level. Otherwise, the read range and link detail calculations will be invalid and not presented.

In the Raw Data graph, the intensity color (z-axis) can be changed to show the Response Data instead of backscatter power. This feature can be used especially with sensor tags.

8.4.1 Reader Parameters

After the tag is characterized by a read range measurement, the user may simulate the effect of reader parameters on the theoretical maximum operating range. This information can be used to compare the performance of different tags in a specific reader setup or to analyze the effect of reader parameters on the read range of a certain tag. Although the application environment will affect the performance in a real use case, simulations can help provide insight into which parameters are critical and how components compare to each other.

A reader profile includes transmit power (power at port), receiver backscatter sensitivity, and antenna gain for RX and TX ports (they're the same in a normal monostatic setup). The user can choose the simulated reader among the readily available profiles, define a custom one, and save it for later use. The profiles are saved to the temporary file in the Data folder (C:\Tagformance\Data\reader_profiles_temp.txt) and can be later edited by the Reader Profile Editor.

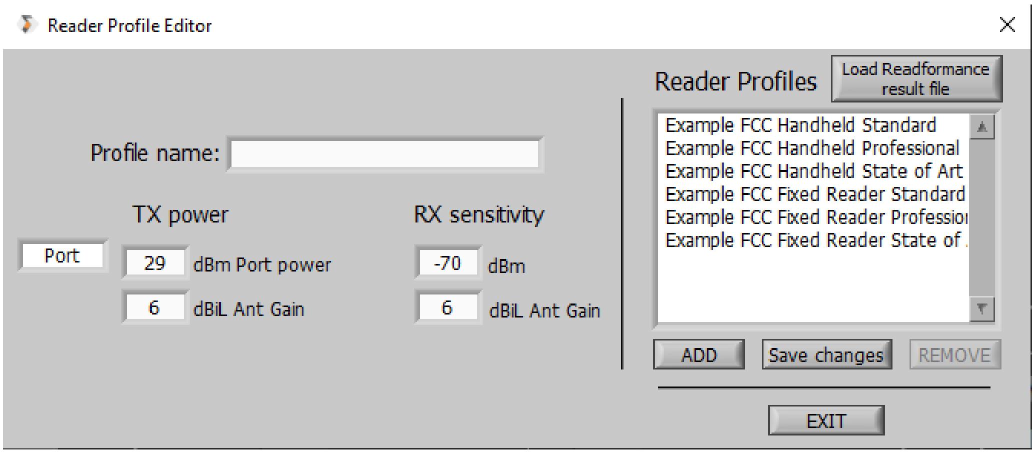


Figure 79.Reader Profile Editor

8.4.2 Variation

Variation is a tool for inspecting how the variation of power on tag, threshold power, affects to the tag read range. Variation is most useful when the measured tag represents the median tag or the golden sample of the group of tags, e.g. production batch.

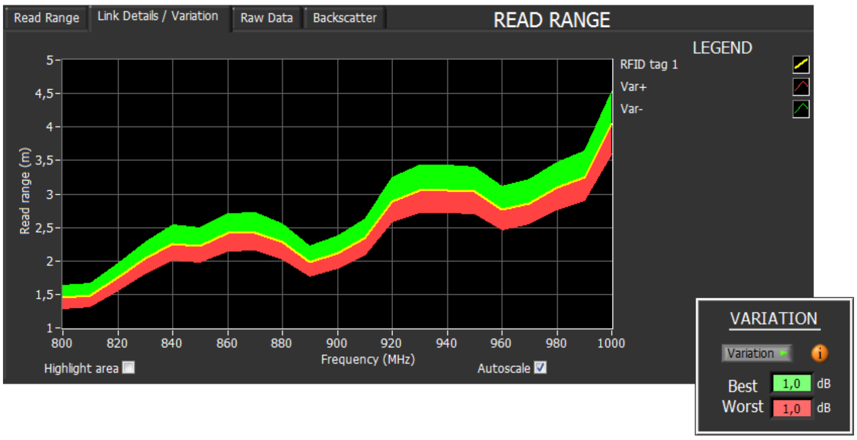


Figure 80.Variation tool in Read Range measurement software

In variation controls, the extremities of the group of tags can be set by best value and worst value. The best defines how much less power the most sensitive tag needs to be powered up compared with the median tag. Respectively, the worst defines how much more power the least sensitive tag needs to be powered up.

9 Application Development Suite

9.1 Population Management

Population Management is a tool for addressing individual tags in the presence of multiple tags. This allows the user to measure the performance of a single tag in a population, e.g., in order to evaluate how tags placed close to one another affect each other's performance or how the tags shadow each other from the radiated power generated by a reader.

The Population Management Panel in the lower left corner of the Tagformance window is automatically activated when the Software license includes this tool. If the Tagformance system includes both the Application Development and the Tag Designer Suite, then the population management can be used with Threshold, Backscatter, and Orientation Sensitivity measurement features. Population Management can also be purchased separately for Tag Designer Suite.

The usage of the Population Management Panel and Population Editor are discussed in Chapters 7.3 and 7.4. A measurement use case is illustrated in Chapter 17.7.

9.2 Response Test

A response test is a measurement function designed to test whether or not a tag responds to a chosen frequency and power.

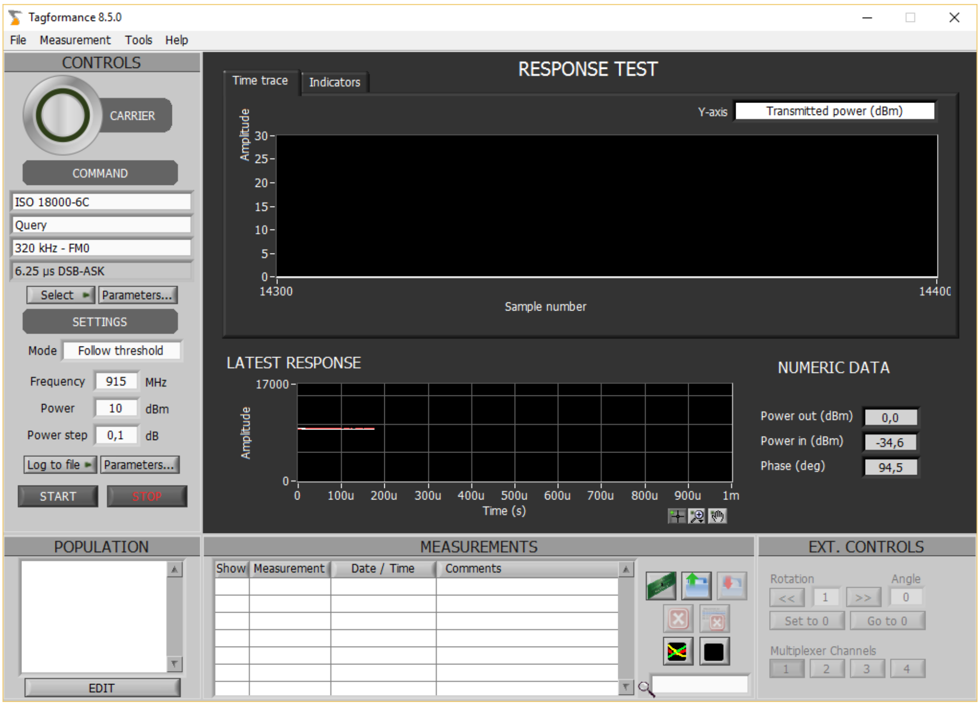


Figure 81.Response Test Measurement program – Time trace view

The elements of the **Response Test's** control panel are:

- **Command** – The protocol and command that is used in the measurement. See chapter 7.19 for detailed information.
- **Select** – The control for setting the select command feature on/off.
- **Selection Parameters** – Change the selection parameters.
- **Sweep settings**
    - **Frequency** – The frequency used in the measurement
    - **Power** – Power in dBm. Minimum value is -20 dBm, maximum +30 dBm (or maximum attainable power).
- **Mode**
    - **Constant power –** The measurement is repeated with default power.
    - **Follow threshold – T**he transmit power is adjusted by the required power which is needed to activate the tag.
- **Log to file** – The control for setting the logging feature on/off.
- **Data logging parameters** – Define the file to log data and the time interval for how often data will be logged.
- **Start** – Starts the test.
- **Stop** – Stops the test.

The Measurement Unit can be changed from the drop-down menu above the polar plot graph in the **time trace view**. The possible values are:

- Transmitted power (dBm)
- Backscattered power (dBm)
- Backscattered signal phase (deg)

In the **indicators view,** a LED indicates whether there was a valid tag response. When it lights up, a response has been received from a tag.

Transmitted power (dBm) indicates the transmitted power at the port, Backscattered power (dBm) indicates the backscatter signal level at the port, and Backscattered signal phase (deg) is the tag backscatter signal phase.

The yield of x latest samples can be monitored with the yield indicator. Change Yield History to set the desired history length for the yield calculation.

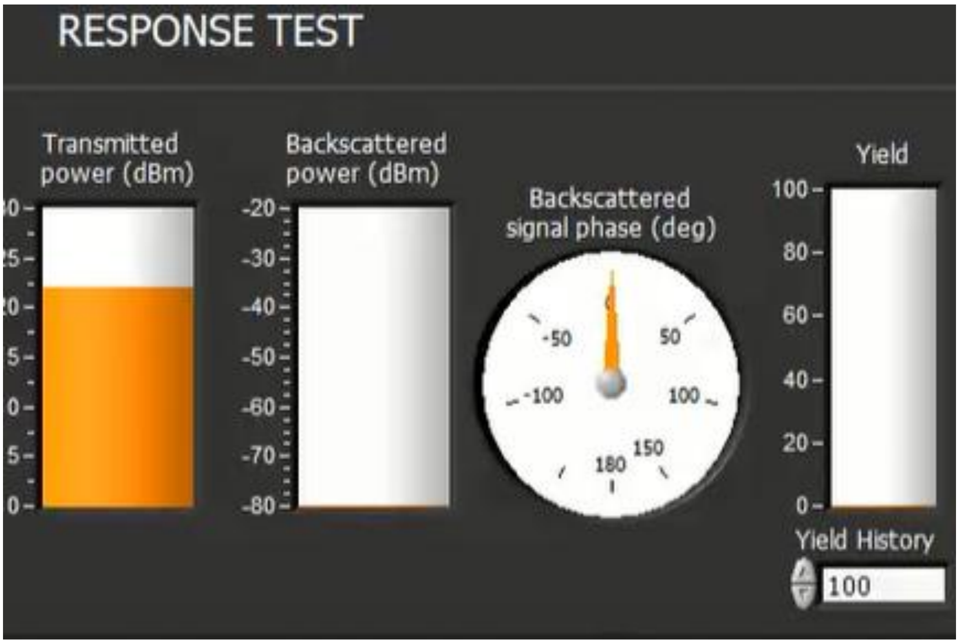


Figure 82. Response Test Measurement program – Indicators view shows Transmitted power, backscatter power and phase, and yield of the consecutive tests according to yield history length.

Data logging to a file is available in the modes 'Constant Power' and 'Follow Threshold'. The response result data: timestamp, command (+parameters), frequency, transmitted power, backscattered power, backscattered signal phase, and read/write result (in relevant case) will be written to the defined .txt file. The file will be overwritten in case of consecutive measurements.

The "Test every Xs" option applies an interval for each transmit in Constant power mode, while the Follow threshold mode applies the delay only once the threshold has been found.

9.3 Population Analysis

Population Analysis is a tool for identifying the tags' performance in a population.

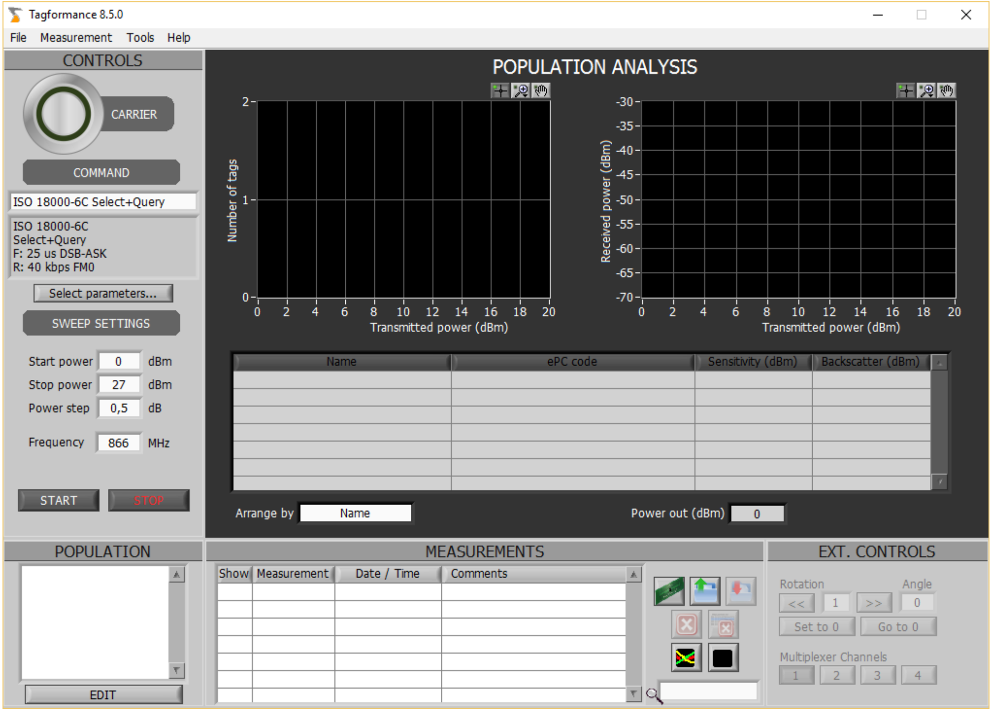


Figure 83.Population Analysis Measurement software

The elements of the **Population Analysis** control panel are:

- **Command –** Population analysis is done by using ISO 18000-6C Select+Query.
- **Select parameters** – Change the selection parameters.
- **Sweep settings**
  - **Start power –** Sweep start power in dBm. The minimum value is -20 dBm, and the maximum is +30 dBm (or maximum attainable power).
  - **Stop power –** Sweep stop power in dBm. The minimum value is -20 dBm, and the maximum is +30 dBm (or maximum attainable power).
  - **Power step –** Indicates how much the power increases with each measurement point. The power step can be changed from the drop-down menu. Possible values are 0.1 dB, 0.5 dB, 1.0 dB, 2.0 dB, and 4.0 dB.
  - **Frequency** – The frequency used in the measurement.
- **Start sweep –** Starts the population sweep.
- **Stop sweep –** Stops the population sweep.

The *Population Analysis* measures the transmitted and backscattered power on the threshold level for every tag listed in the population list. It also counts the number of tags answering on each transmitted power level. Tags must be identified before starting the measurement (please see chapter 7.4).

The graph window on the left shows how many tags are answering at a certain power level (dBm). The graph window on the right shows the amounts of received and transmitted power (dBm) for each measured tag.
When the START button is pressed, every tag on the population list appears in the list box. The list can be organized by name, EPC, sensitivity (dBm), and backscatter (dBm).

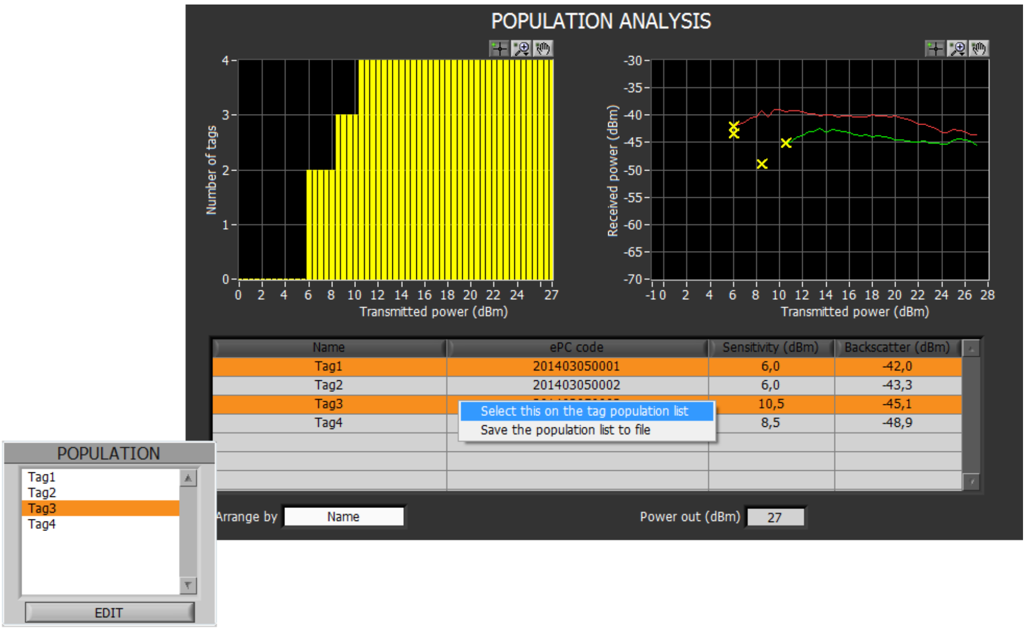


Figure 84.Tag selection and shown backscatter sweeps in Population Analysis

By selecting tags in the Population Analysis list box, the graph window on the right also shows the received power graph of the selected tags. The selection ways are listed in Chapter 7.1.1.

The corresponding tag will be selected by clicking a single cross with a cursor tool in the graph window. The right-click menu in the list box offers the possibility to choose the clicked tag also in the Population List (discussed in Chapter 7.3 and a use case is illustrated in Chapter 17.7).

9.4 Interference

The Interference tool is for measuring RFID activity and allocating channel traffic.

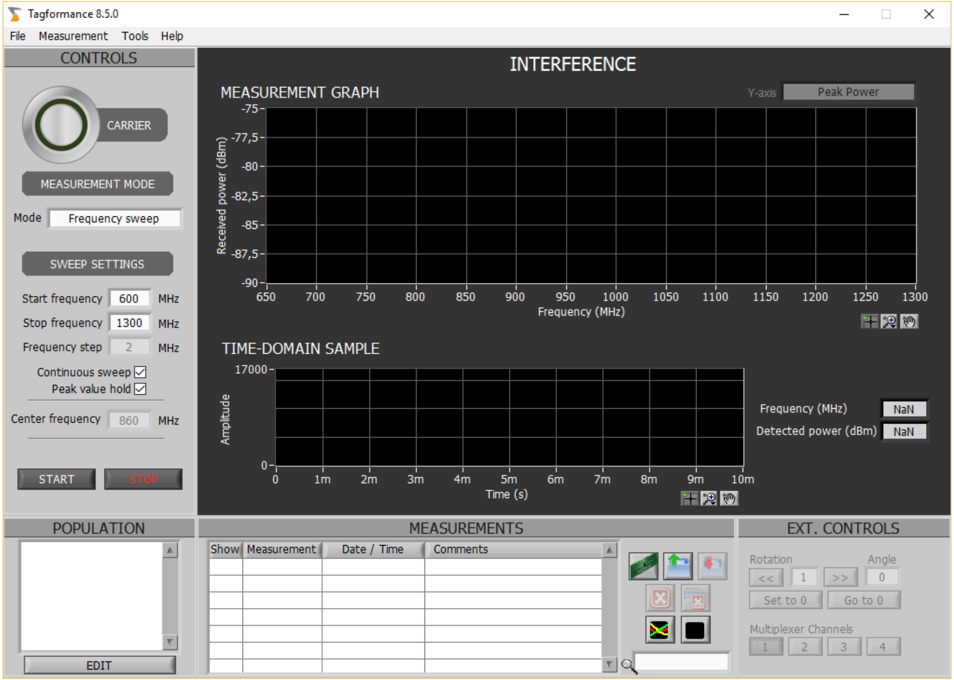


Figure 85.Interference Measurement software

The elements of **Interference's** control panel are:

- **Mode**
  - **Frequency sweep** – Measures the defined frequency band.
  - **Constant frequency** – Measures a defined constant frequency.
- **Sweep settings**
- **Frequency sweep:**
  - **Start frequency** – Sweep start frequency (MHz).
  - **Stop frequency** – Sweep stop frequency (MHz).
  - **Frequency step** - Indicates how much the frequency increases with each measurement point.
  - **Continuous sweep** – Starts automatically a new frequency sweep after the previous one is finished.
  - **Peak value hold** – Keeps the highest received power value in each frequency point during the continuous sweep.
- **Constant frequency:**
  - **Center frequency** – The frequency used in the measurement.
  - **Start –** Starts the measurement.
  - **Stop –** Stops the measurement.

The way how the measurement results are shown can be selected from the *Y-axis* menu. *Peak Power* shows the highest measured values. *Average Power* shows averaged values.

10 Protocol Testing Suite

10.1 Protocol Testing

Protocol Testing is a tool for testing the functionality of EPC Class1 Gen2 tags with all the mandatory and optional commands and custom and proprietary commands.

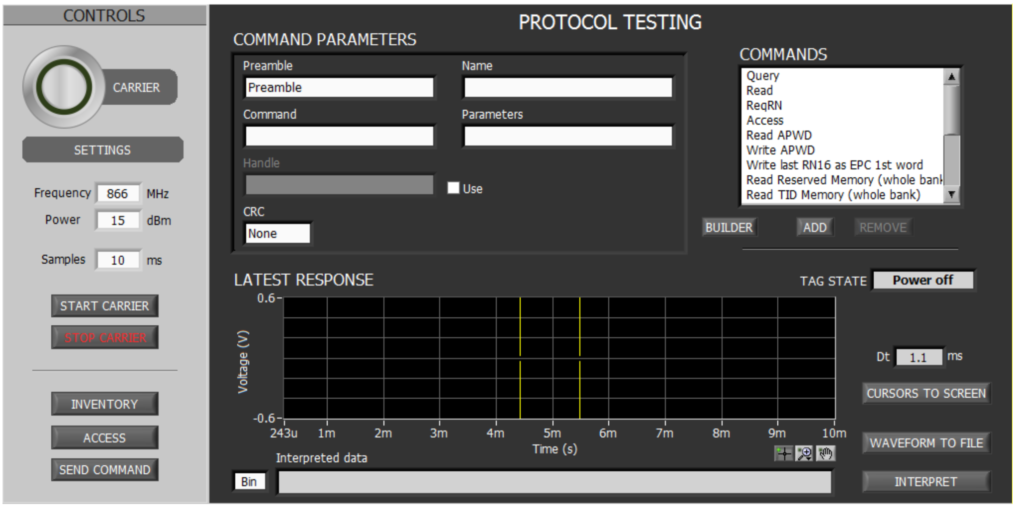


Figure 86.Protocol Testing Measurement software

The elements of the **Protocol Testing's** control panel are:

- **Sweep settings**
  - **Frequency –** The frequency used in the measurement.
  - **Power –** Power in dBm. The minimum value is -20 dBm, and the maximum is +30 dBm (or maximum attainable power).
  - **Samples –** The length of samples in µs. The minimum value is 0 ms, maximum is 1000 ms.
- **Start Carrier –** Starts the carrier signal.
- **Stop Carrier –** Stops the carrier signal.
- **Inventory –** Performs the Gen2 inventory.
- **Access –** Performs the access command sequence.
- **Send Command –** Sends the defined command to the tag.
- **Command parameters –** The parameters that form the command.
- **Commands –** A list of commands.
- **Interpret –** Interprets the bits from the part of the waveform that is in between the yellow cursors. The interpreted bits are shown in the Interpreted data field. Cursors can be moved anywhere in the waveform window. With the Bin/Hex/Ascii selection, the interpreted bits can be shown in different formats
- **Tag state –** Indicates the current tag state.
- **Cursors to screen –** Brings the interpret cursors to the current view of the latest response window.
- **Waveform to file –** Saves the latest response data to a user-defined file.

Adding custom commands to the command list

- Fill the command parameters and name your command
- Press the *ADD* button below the commands list

Removing custom commands from the command list

- Select the command you want to remove
- Press the *REMOVE* button below the command list
- The default commands cannot be removed from the list.

The commands are stored in a file called *pts_commands.dat* which can be found from the *Data* folder.

10.2 Memory Management

Memory Management is a tool for analyzing the memory of EPC Class1 Gen2 tags. The software reads EPC, TID Reserved, User and possible Custom memory banks.

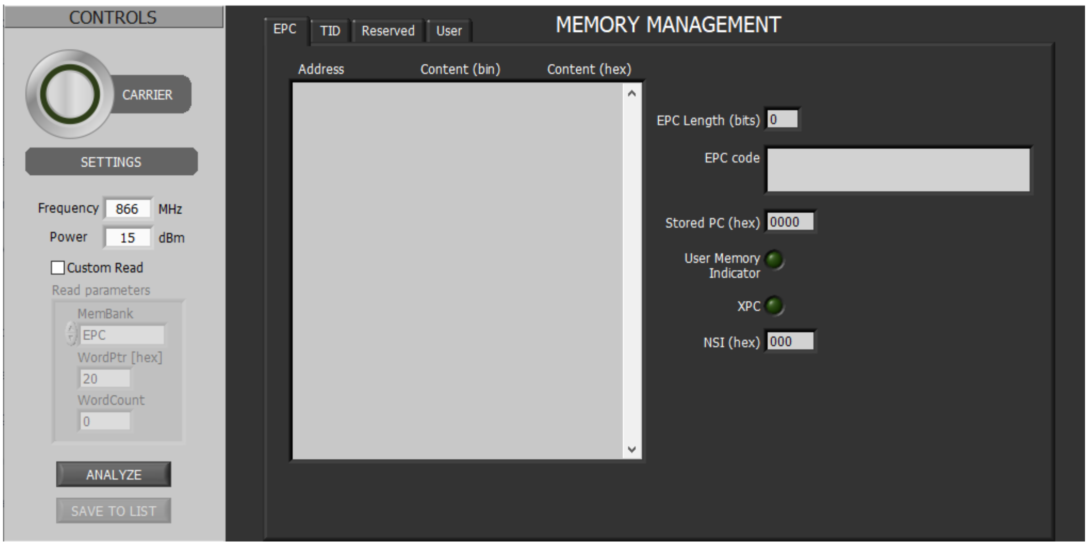


Figure 87.Memory Management Software

The elements of the **Memory Management's** control panel are:

- **Settings**
  - **Frequency –** The frequency used in the analysis.
  - **Power –** Power in dBm. The minimum value is -20 dBm, and the maximum is +30 dBm (or maximum attainable power).
  - **Custom Read –** Selection for reading custom-defined memory bank
    - **MemBank –** Memory bank to be read
    - **WordPtr (hex) –** first word to be read
    - **WordCount–** amount of words to be read

The results of Memory Management are:

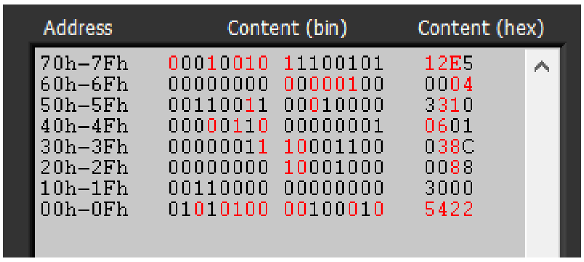
- **All memory banks**
  - **Address –** Address of memory bank section
  - **Content (bin) –** Contents of the memory bank section in binary
  - **Content (hex) –** Contents of the memory bank section in hexadecimal
- **EPC memory bank**
  - **EPC length (bits) –** length of EPC code as indicated by the PC bits
  - **EPC code –** EPC code as hexadecimal
  - **Stored PC (hex) –** Contents of the protocol Control bits
  - **User Memory indicator –** Indicates the availability of user memory
  - **XPC –** Indicates availability of eXtended Protocol Control bits
  - **NSI (hex) –** Contents of the Numbering System Identifier – indicates if the tag is coded with an EPC global code or ISO15961 code
- **TID memory bank**
  - **Class identifier (hex) –** Contents of Class Identifier in hexadecimal

  - **XTID –** Indication of availability of Extended TID
  - **Mask Designer ID (hex) –** Contents of Mask Designer ID (MDID) defined by GS1's EPC Tag Data Standard (TDS) in hexadecimal
  - **Tag Model Number (hex) –** Tag Model Number (TMN) defined by GS1's EPC Tag Data Standard (TDS) in hexadecimal
  - **Chip manufacturer –** Name of Chip manufacturer based on TID
  - **Model name –** Chip model name based on TID
- **Reserved memory bank**
  - **Kill Password (hex) –** Kill Password in hexadecimal
  - **Access password (hex) –** Access Password in hexadecimal
- **User memory bank**
  - **User memory Bank Block Size (bits) –** Size of user memory
- **Custom memory bank**
  - No memory bank-specific results

10.2.1 Analysis

No results are shown if multiple tags are in the tester's antenna field.

When tag or tags are read consecutively, differences in memory contents of the consecutive reads are highlighted with red color

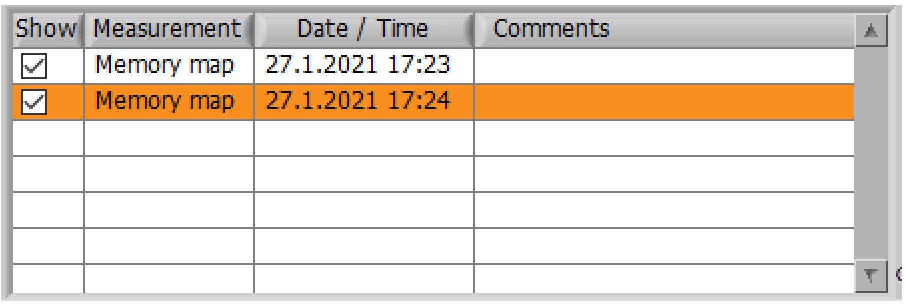


Address	Content (bin)	Content (hex)
70h-7Fh	00010010 11100101	12E5
60h-6Fh	00000000 00000100	0004
50h-5Fh	00110011 00010000	3310
40h-4Fh	00000110 00000001	0601
30h-3Fh	00000011 10001100	038C
20h-2Fh	00000000 10001000	0088
10h-1Fh	00110000 00000000	3000
00h-0Fh	01010100 00100010	5422

Figure 88.Differences in consecutive memory reads are highlighted in red

10.2.2 Saving results

Click 'Save to list' to save data. Results now appear on the measurement list.



Show	Measurement	Date / Time	Comments
☑	Memory map	27.1.2021 17:23	
☑	Memory map	27.1.2021 17:24	

11 Tagged Item Grading Suite

11.1 TIPP measurement program

The tagged Item Grading measurement function implements the GS1 Tagged-Item Performance Protocol (TIPP) according to the ***Release in Nov 2017.***

As of Tagformance 10.1, the backscatter results measured in TIPP are not comparable with backscatter measurements performed before this update or by other measurement functions of this software. The TIPP measurements return 4dB weaker results compared to other measurement functions. This discrepancy is due to the different definition of backscatter strength adopted by GS1. 'Tagged Item Grading' result files with 1.4 TFF will be converted upon loading to correspond to the GS1 definition and may be saved as 1.5 TFF.

Tagged Item Grading is a tool for grading tagged-item UHF RFID performance as defined in *the GS1 Tagged-Item Performance Protocol (TIPP) guideline.* The software can also verify whether a tagged item performs according to a grade.

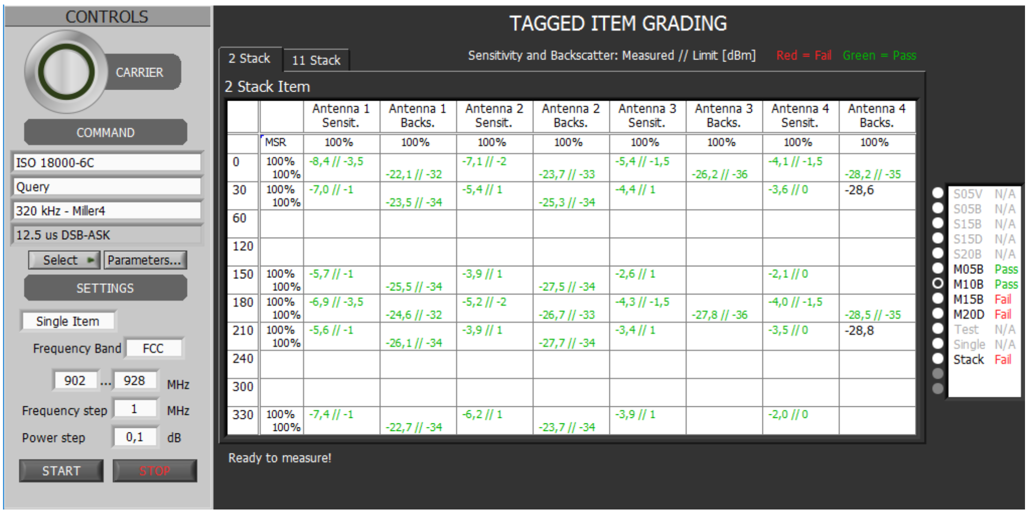


Figure 89.Tagged-Item Grading software

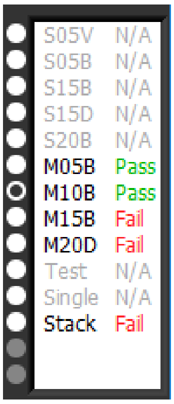
The elements of the **Tagged Item Grading's** control panel are:

- **Command –** The type of command used in the grading test. The default command is ISO18000-6C Query+ACK, 320 kHz, Miller 4, as specified in the TIPP guideline.
- **Settings**
  - Selection of a test type
    - **Single Item –** Test used for grading a single item
    - **Stacked Item –** Test used for grading a stacked item
    - **Verify Grade –** Test used for verifying if an item passes or fails a grade
      - **Grade selection** – Selection of which grade is verified
    - **Stack 2 –** Part of Stacked item test, 2 items in stack

    - **Stack 11 –** Part of Stacked item test, 11 items in stack
    - **J-Grade Test –** Test used for grading a population of 7 tags in a stack
  - **Frequency Band**
    - FCC – Sets frequency range to FCC range (902-928MHz), frequency step to 1Mhz and power Step to 1dB
    - ETSI - Sets frequency range to ETSI range (865-868MHz), frequency step to 1Mhz and power Step to 1dB
    - FCC + ETSI – Sets frequency range to sample the ETSI range (865-868 MHz) and FCC range (902-928MHz), frequency step to 1MHz and power step to 1dB
    - Custom – Allows custom setting of the frequency band, frequency step, and power step
  - **Frequency range –** The frequency range used in the test
  - **Frequency Step –** The frequency step used in the test
  - **Power step –** The power step used in the test

Test results show:

- Pass/fail information of each grade that are relevant to the selected test type. The list also shows defined custom grades.
- Measured sensitivity and backscatter results, limits according to the grade selected in the pass/fail list, and minimum success rate limits defined for grades. If no grade is selected, the shown result in each cell corresponds to the worst measured result. Selecting a grade shows the worst result for the given grade.



		Antenna 1 Sensit.	Antenna 1 Backs.	Antenna 2 Sensit.	Antenna 2 Backs.	Antenna 3 Sensit.	Antenna 3 Backs.	Antenna 4 Sensit.	Antenna 4 Backs.
	MSR	100%	100%	100%	100%	100%	100%	100%	100%
0	100% 100%	-8,4 // -3,5	-22,1 // -32	-7,1 // -2	-23,7 // -33	-5,4 // -1,5	-26,2 // -36	-4,1 // -1,5	-28,2 // -35
30	100% 100%	-7,0 // -1	-23,5 // -34	-5,4 // 1	-25,3 // -34	-4,4 // 1		-3,6 // 0	-28,6
60									
120									
150	100% 100%	-5,7 // -1	-25,5 // -34	-3,9 // 1	-27,5 // -34	-2,6 // 1		-2,1 // 0	
180	100% 100%	-6,9 // -3,5	-24,6 // -32	-5,2 // -2	-26,7 // -33	-4,3 // -1,5	-27,8 // -36	-4,0 // -1,5	-28,5 // -35
210	100% 100%	-5,6 // -1	-26,1 // -34	-3,9 // 1	-27,7 // -34	-3,4 // 1		-3,5 // 0	-28,8
240									
300									
330	100% 100%	-7,4 // -1	-22,7 // -34	-6,2 // 1	-23,7 // -34	-3,9 // 1		-2,0 // 0	

Figure 90.The green color indicates the passed result, and the red color indicates the failed result

The cells in the result table can be selected and exported to the clipboard with a menu that appears when you right-click.

The result table can be saved as an image with a menu from the right mouse click.

11.2 Performing the test

During the test indicators below, the result table shows the progress of the test.

Some tests require user actions; these are noted with pop-up windows.

J-Grade results indicate the number of tags in the population that pass the grade. This is displayed in the following format: (# of passed tags/# of tags in measurement).

The number of tags in J-Grade measurement is specified to be 7 in the GS1 TIPP measurement protocol. It is possible to carry out J-Grade measurement with a number of tags that is not equal to 7, but consequently, all grades will be marked as 'Fail,' even if all specified measurements are within the limit. This information can also be accessed within the software by selecting the information button highlighted in red in Figure 91.

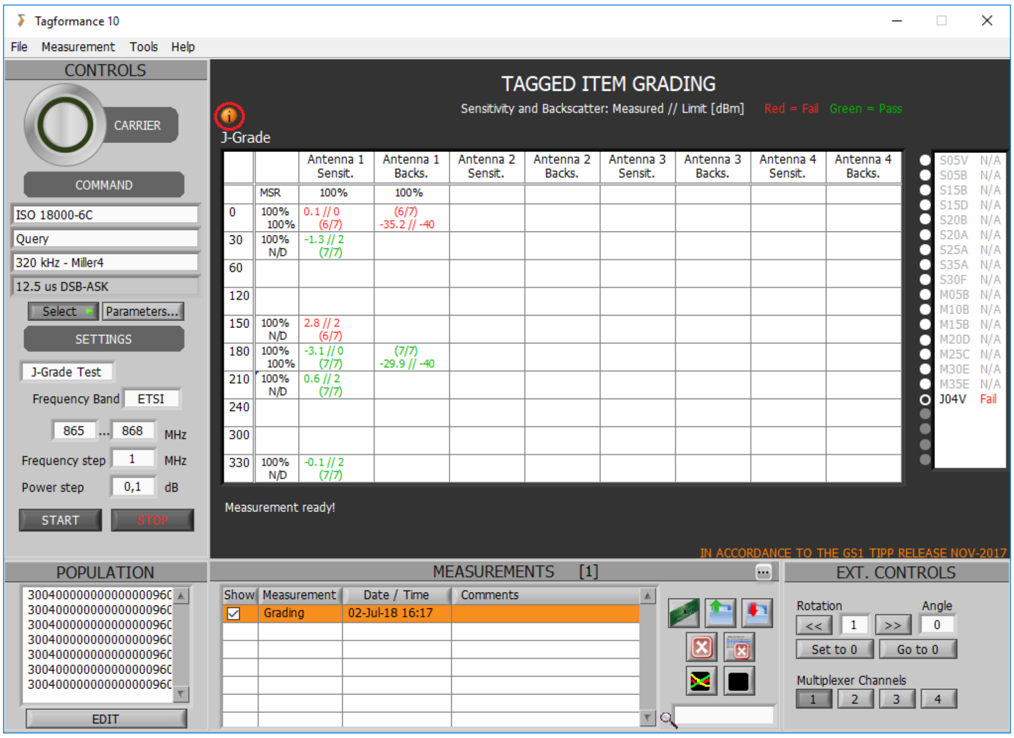


Figure 91.Sample J-Grade measurement. The tag counts are indicated below for sensitivity and above for backscatter measurements, respectively. The information button is highlighted in red (shown only when a J-Grade measurement is selected).

11.3 Optimization of the test flow

The fail-fast runtime option provides a means to reduce time, especially when running a test against all grades. In fast-fail mode, remaining tests in the cell are skipped when they're known to fail based on the prepending test results. See **Chapter 7.11.2** for instructions on how to enable fast fail mode for the TIPP test.

11.4 Creating a New Grade or a Custom Grade

A custom grade can be defined with a .txt file in a Tagformance/data folder.

- File name shall start with Tagged_item_custom_grade_...
- File format is .txt
- Sample files are included in the Tagformance SW: (remove “sample_” from the front of the file name to take the file into use.)

```
Custom Grade definition file
Version 1.0

// Grade Types
// 0 = Single item
// 1 = 2 stack
// 2 = 11 stack
// 3 = J-Grade

Grade Name:     Single
Grade Type:     0
[Sensitivity]
-3,5    -3.5    -2,5    -2.5
1       2       4       2
NaN     NaN     NaN     NaN
NaN     NaN     NaN     NaN
1       2       4       2
-3,5    -3.5    -2,5    -2.5
1       2       4       2
NaN     NaN     NaN     NaN
NaN     NaN     NaN     NaN
1       2       4       2
[Antenna success rates for Sensitivity]
100     100     100     100
[Angle success rates for Sensitivity]
100     100     NaN     NaN     100     100     100     NaN     NaN     100
[Backscatter]
-29     -30     -30     -29
NaN     NaN     NaN     NaN
NaN     NaN     NaN     NaN
NaN     NaN     NaN     NaN
NaN     NaN     NaN     NaN
-29     -30     -30     -29
NaN     NaN     NaN     NaN
NaN     NaN     NaN     NaN
NaN     NaN     NaN     NaN
NaN     NaN     NaN     NaN
[Antenna success rates for Backscatter]
100     100     100     100
[Angle success rates for Backscatter]
100     NaN     NaN     NaN     NaN     100     NaN     NaN     NaN     NaN
```

- Grade definition file
    - Grade name: Name displayed in pass fail list
    - Grade type: 0= single item, 1= 2 item stack test, 2=11 item stack test, 3=J-Grade test
    - Limits are specified as a matrix (if no limits are specified for an angle “NaN” shall be used instead of a number)

After a grade has been defined, it can be measured in the measurement program, either with the other grades of the associated type or verified against the set limits.

12 ARC Test

12.1 ARC measurement program

ARC Test is a tool for creating RFID tag performance benchmark in accordance with the ARC Program driven by the RFID Lab of Auburn University. Its main use case is to pre-test the tags before submitting them to official tests.

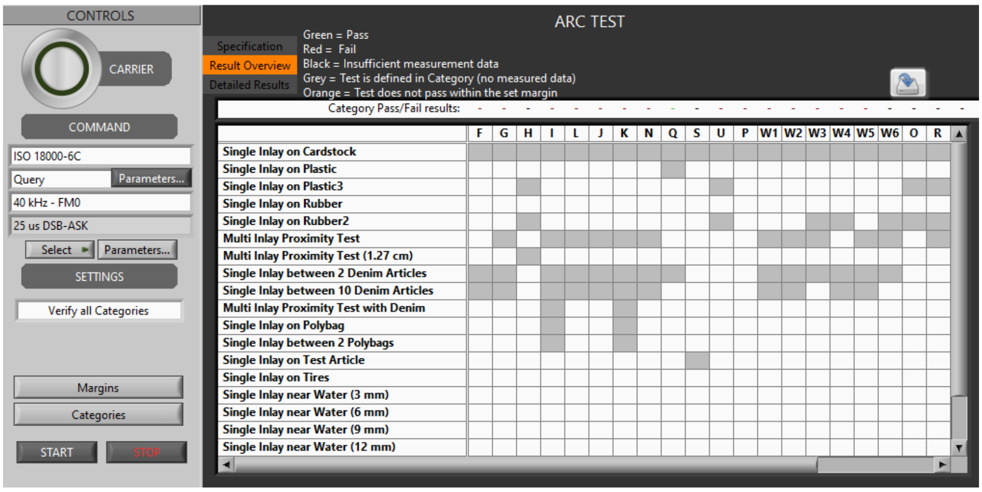


Figure 92.ARC Test Specifications

The elements of the **ARC Test's** control panel are:

- **Command**
- **Settings**
    - Selection of a test type
        - **Verify all Categories –** Measure complete tag performance benchmark.
        - **Verify selected Categories –** Measure the tag's performance with only the Test setups defined in the selected Categories. Measurement will be done over the frequency band and with sensitivity levels defined in selected categories.
        - **Run selected Tests –** Measure the tag performance using all frequencies and sensitivities defined in any Categories related to the selected Tests.
        - **Verify single Test in Category** – Perform only one Test of any Category where the Test is defined.
    - **Margins –** Opens a menu where the user may set worst-case scenarios for different test types.
    - **Categories –** Opens a menu where the user may select active categories.
    - **Category-Test table -** Depending on the test type selection, select/remove selection of the Categories (columns) or Tests (rows) by clicking the table area.

Note: The software uses the write command settings that the user has selected in the Write Command Parameters.
Before the test starts, an information window appears showing the current write setting, confirming which settings will be used for the measurement.
To change these parameters, it can be done via the Command → Write Command Parameters menu. (See Chapter 7.19.1 for instructions)

12.2 ARC test result

Result Overview shows pass/fail results for each Category-Test pair which are covered in the selected measurement results in *Measurement List*. The cell will be black if only part of the results is available, e.g., backscatter results for certain Categories are missing. Orange cells indicate that the test result exceeds the criteria but less than the given margin. For any category/test combination with results, click on the cell to switch to 'Detailed Results' to view that category/test combination. Please note that only active categories are visible.

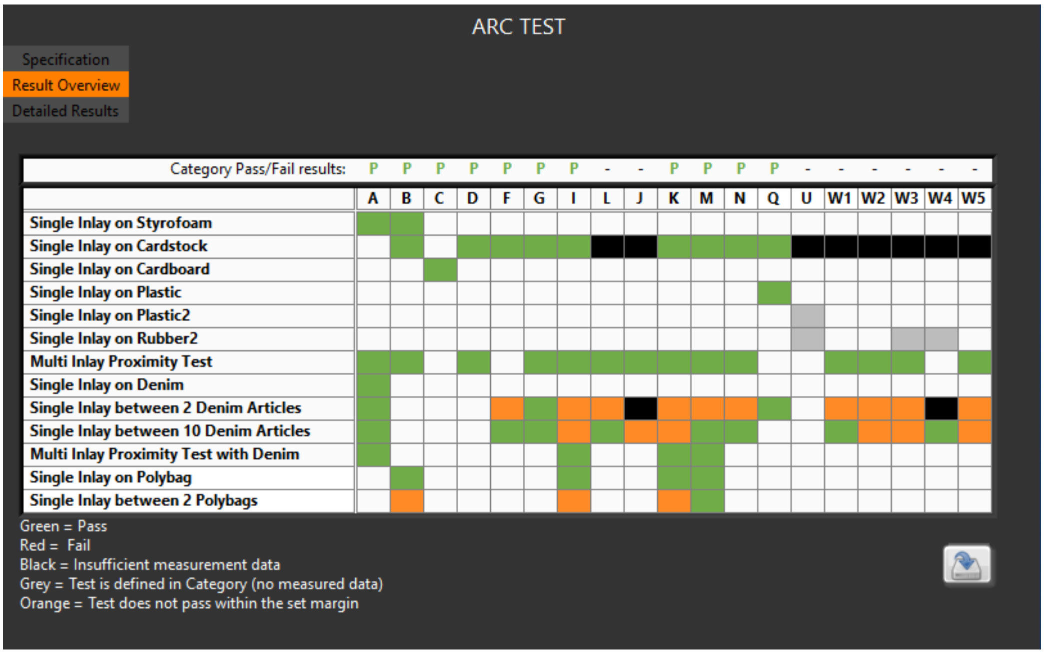


Figure 93.ARC Test Result Overview

Detailed Results show the Test specific results covered by the selected measurement results in *Measurement List*. Click on the 3x3 cell result area for any antenna/channel combination to view the raw data (sensitivity sweep) measured for the test.

Note: In the case of a test that includes the measurement of multiple tags, the detailed results display a summarized 'worst case' performance of the set of tags. On each measurement point, the result of the worst-performing tag is chosen.

Backscatter and Write sensitivity switches are enabled only when results are available in the selected measurement type.

The Frequency band control (ETSI, FCC, 970-980 MHz, 980 MHz) shows the frequency band in which the category was measured. This control allows switching between category definitions with multiple frequency band limits.

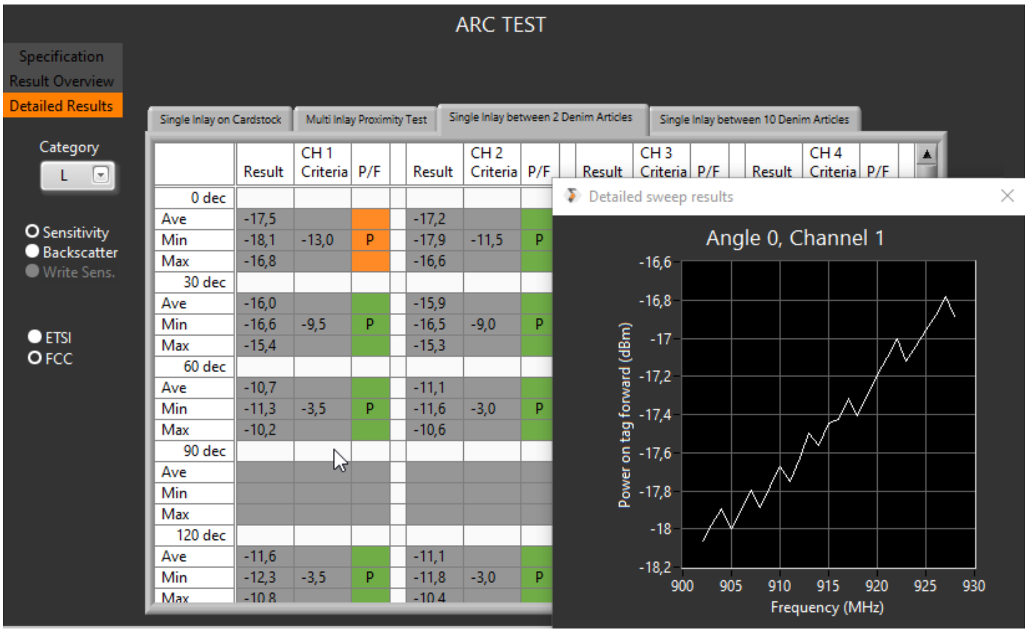


Figure 94.ARC Test's Detailed Results with Sweep Result

Result Export is available in the bottom right corner of the *Result Overview* table, see Figure 93The results may be exported as CSV files or pictures. The CSV option groups the results by category and includes an overview image. The picture option saves test-specific detailed result tables in the given file folder. The export will only contain the active categories. Margins are used in the GUI only for viewing purposes and, thus, are not applied to the exported data.

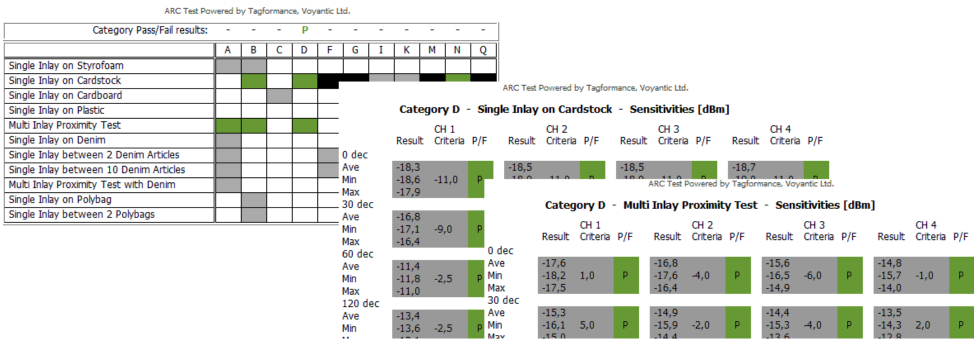


Figure 95.ARC result pictures

12.3 Optimization of the test flow

The fail-fast runtime option provides a means to reduce time, especially when running a test against all grades. In fast-fail mode, remaining tests in the cell are skipped when they're known to fail based on the prepending test results. See **Chapter 7.11.2** for instructions on how to enable fast fail mode for the ARC test.

12.4 List of supported categories

- A
- B
- B2 - version 0.5
- B3 – version 0.5
- C
- C2 - version 1
- D
- E1 - version 0.5
- E2 - version 0.5
- E3 - version 0.5
- E4 – version 0.5
- F - version 1.1
- G - version 1
- H – version 1.1
- H2 – version 0.6
- I - version 2.1
- J – version 2
- K
- L - version 1.1
- M - version 2
- N - version 1
- O – version 2.0
- P – version 0.9

- Q – version 2
- R – version 3.1
- S – version 1.1*
- T – version 0.8
- U – version 2
- W1 – version 1.1
- W2 – version 1.1
- W3 – version 1.1
- W4 – version 1.1
- W5 – version 1.1
- W6 – version 1.1
- Y – version 2.0
- Y2 – version 1.1
- Z – version 3.1

* S-category tests require up to +12dBm power-on-tag forward. Measurement is typically feasible up to 50cm without power amplified and up to 100cm with a power amplifier.

13 Tag Emission Test

13.1 Overview

Tag Emission Test is a tool for determining whether the RFID tag backscatter strength and frequency spectrum complies with *ETSI EN 302 208 v.3.4.1*. The purpose of the measurement is to determine that neither the tag reply's backscatter nor any other emissions exceed the limits set in the standard.

To perform the measurement, the tag should be positioned at a known distance from the antenna at an angle that maximizes the radiated backscatter from the tag. Backscatter strength can be tested using backscatter measurement described earlier in the chapter 8.2. In detail, spectrum, harmonics, and other emission components are tested with Emissions test measurement. Alternative emission test methods are described in the following chapters, and a practical, detailed measurement example is presented in chapter 17.

13.2 Measurements

Tag emission test measurement provides two analysis methods. The "Simulated harmonics" method offers a quick means of assessing the backscatter mask with Tagformance Pro alone. In contrast, the "Query spectrum" method enables a more in-depth investigation of the emission components with a separately purchasable real-time spectrum analyzer.

Method 1: Quick simulated harmonics measurement with Tagformance Pro

The measurement involves testing the tag with a single command using a selected frequency and power. The requested modulation frequency is 320 kHz for the lower ETSI band and 640 kHz for the upper ETSI band. The backscatter strength is measured from the tag reply, the BLF verified, and based on these parameters, a waveform is reconstructed to simulate the tag backscatter spectrum. For the simulation, the tag is assumed to modulate between two discrete and stable states and change the state instantaneously.

Since the EN 302 308 standard does not specify what kind of backscatter signal should be used for the test, the measurement offers two modes that the user can select.

The default mode is labeled as the *"typical"* backscatter mode. This assumes a random distribution of ones and zeroes in the data packet and a Miller-4 modulation type, one of the most common types preferred by RFID readers and, thus, a very representative case of a real-world tag data packet. The simulation is done with a 1ms long data packet to fulfill the resolution bandwidth requirements requested by the test standard. The actual binary content of the test packet was also fixed and chosen to be as average as possible, halfway between a "forgiving" and "unfortunate" bit pattern.

The second mode, labeled “worst case,” assumes the tag to modulate backscatter tone, equivalent to sending a sequence of consecutive zeroes in FM0, a continuous 50% duty square-wave modulation effectively. This will produce a Fourier-series type of spectrum with all power concentrated on the fundamental and odd harmonic components. This is the theoretically most difficult type of backscatter signal, with the most spectrally concentrated power. If the tag passes this mode, all other modulation types and data patterns will also pass with a more evenly distributed power spectrum.

Method 2: Spectrum measurement with a real-time spectrum analyzer

Important notice: The spectrum analyzer requires an additional installation to be completed before use. Please refer to *Appendix H* : RSA306B - Spectrum analyzer information for more details.

The Query spectrum measurement is performed with an external real-time spectrum analyzer synchronized to Tagformance Pro. Tagformance Pro provides a wakeup command for the tag and a trigger for the spectrum analyzer. The Spectrum analyzer records the response spectrum shown to the user in the Tagformance GUI.

The measurement is conducted in two parts: with and without a tag in the interrogator field, the latter being recorded as a reference. The user is shown the spectrum of both measurements and their difference, which is then judged against the limits given in ETSI EN 302 208. The requested modulation frequency is 320 kHz for the lower ETSI band and 640 kHz for the upper ETSI band.

The measurement is made in the spirit of official test standard. ETSI EN 302 208 suggests recording the spectrum measurement from either a continuous tag’s modulation along EN 302 208 5.7.1.1 mode a) *“worst case”* or mode b) “typical”. Since the EPC Class 1 Gen 2 protocol does not support infinitely continuous backscatter modes, the measurement method uses Miller-8 modulation to generate a long, continuously modulated waveform for the *“worst case”* (leading zeros in the extended preamble). A Miller-4 Query is used to provide a RN16 random number packet for the *“typical”* mode respectively. Also, as the tag replies are not infinitely long but limited in length, the exact resolution bandwidths requested by the test standard are not accurately met, and the spectrum is recorded with a slightly greater res-BW, making it a little stricter to pass.

Please also note that as the *“typical”* mode uses the tag’s random number generator to create replies, every measurement spectrum will be slightly different depending on the actual data content of the backscatter reply.

Note: Query spectrum measurement requires a separate spectrum analyzer unit and license option.

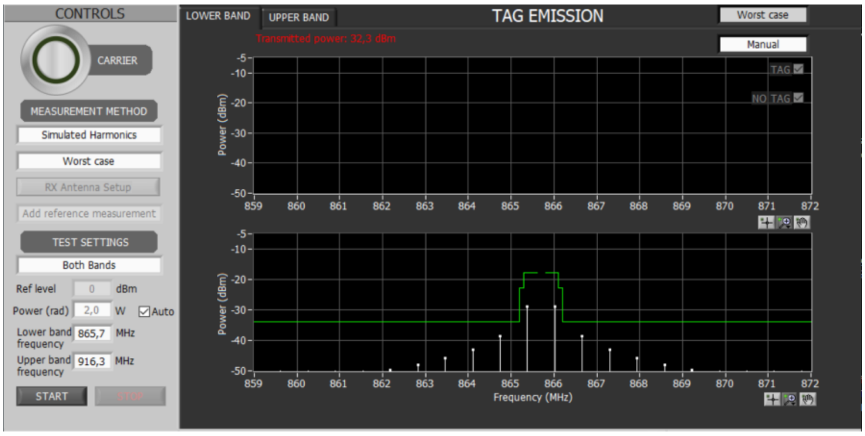


Figure 96.Simulated harmonics measurement shows the main spectrum component calculated from the backscatter signal.

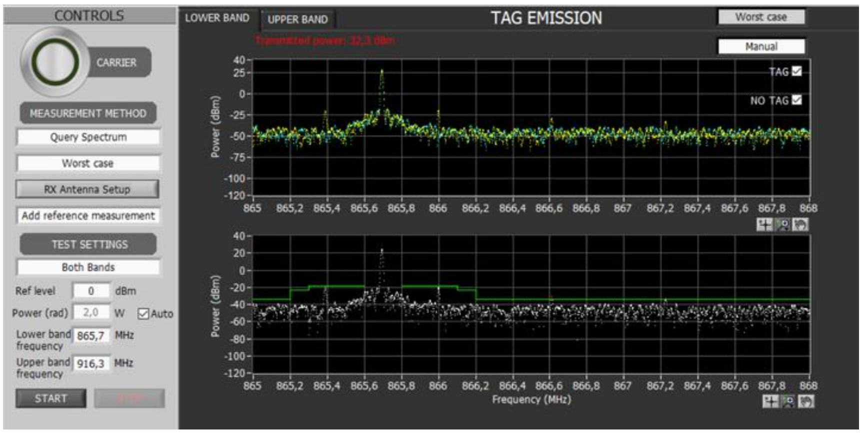


Figure 97.Using a real-time spectrum analyzer with Tagformance enables measurement of the backscatter spectrum and investigation of unwanted emission on a broad frequency band.

13.3 User Interface

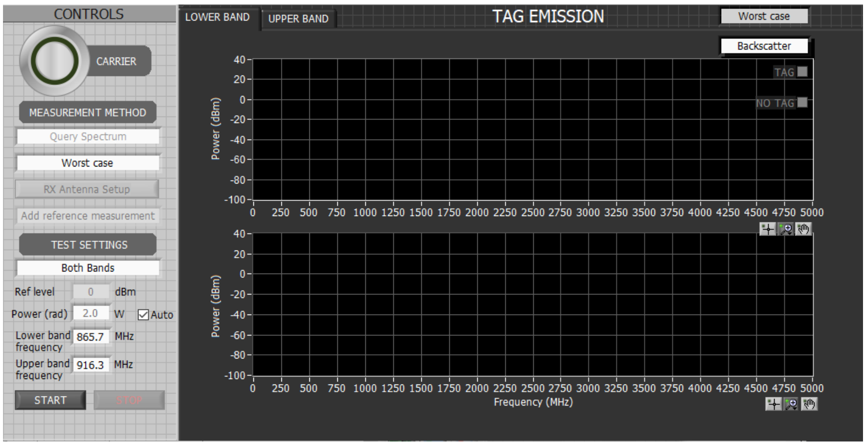


Figure 98.Tag emission test interface.

The elements of the **Tag Emission Test**'s control panel are:

- **Measurement Method**
  - Selection of measurement method
    - **Simulated harmonics** – Measure a tag's backscatter strength and extrapolate its odd harmonics
    - **Query spectrum** – Measure a tag's backscatter using a spectrum analyzer
  - Selection of measurement type. For more information, refer to 13.2
    - **Worst case –** Sample continuous 0s, the only measurement type up until Tagformance 13.5
    - **Typical –** Sample the whole response
  - **RX Antenna Setup** – Opens dialog for defining the reception path losses for spectrum analyzer measurement (see chapter 13.4).
  - **Reference Method**
    - **Add reference measurement** – After the spectrum analyzer sweep, the user is prompted to remove the tag from the interrogator field to measure the reference
    - **Use static reference** – After selecting this option, the user will be prompted to remove any tags from the interrogator field, after which the reference measurement will be performed. This measurement result will be automatically appended to any "**Query spectrum**" measurement performed after this point.
- **Test Settings**
  - **Frequency Band**
    - Both Bands – Perform both lower and upper band measurements
    - Lower Band (865-868) MHz – Perform only the lower band measurement
    - Upper Band (915-921) MHz – Perform only the upper band measurement
  - **Ref level** – Set the spectrum analyzer's reference level in dBm. If the signal level is unknown, starting with a higher rather than a lower ref level is recommended since a suboptimal value can distort the measurement results. Use the **Power at Port** indicator for a starting point. In a sound measurement result, the spectrum is symmetrical around the carrier. Setting the ref level too high decreases the signal-to-noise ratio, and the spectrum of the tag's response is not as clearly visible.

  - **Auto** – Enables/disables carrier power setting for the measurement
    - When selected, the software calculates Transmitted power so that radiated power matches the standard (i.e., power on tag forward equals 2W ERP transmitted at 20cm distance). The Transmitted power text will appear red if the current setup cannot achieve a strong enough carrier level.
    - When unselected, the user may select Transmitted power manually. Red warning text is shown on the top of the result graph in case the radiated carrier level is not as strong as defined in the test standard.
  - **Power (rad)** – Radiated power and carrier power levels are used according to the standard. Shown when "**Auto**" is selected.
  - **Power (tx)** – Transmitted power used for the measurement. Shown when "**Auto**" is unselected.

  - **Lower band Frequency** – Carrier frequency used for the lower band measurement. It may contain any value within the lower ETSI Band (see **Frequency Band**)
  - **Upper band Frequency** – Carrier frequency used for the upper band measurement. It may contain any value within the upper ETSI Band (see **Frequency Band**)
  - **Start** – Starts the measurement
  - **Stop** – Stops the measurement

The elements of the **Tag Emission Test**'s measurement window are:

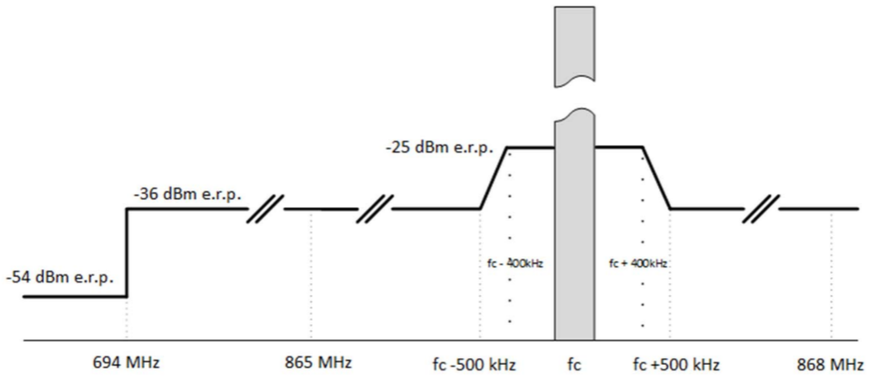
- **Result view** – Toggle view between lower and upper band results
- **Measurement type**
  - **Query Spectrum –** The measurement mode used for the selected result
  - **Simulated harmonics –** Current "**Measurement type**" selection in Tag Emission Test's control panel
- **Predefined graph view selection** – Adjusts the graph limits according to the selection. It is located in the upper right corner of the window.
  - Manual – Set when manually adjusting the graph view
  - Backscatter – Sets the graph limits to Fc +/- 400 kHz for the lower band and +/- 800 kHz for the upper band
  - ETSI band – Sets the graph limits to [865;868] MHz for the lower band and to [915;921] MHz for the upper band
  - Whole Band – Sets the graph limits to show all measurement results
- **Upper Graph** – Shows the result for "Query spectrum" measurements and its tagless reference result.
  - **TAG –** Shows/hides the measurement result
  - **NO TAG –** Shows/hides the tagless reference result
- **Lower Graph** – Shows the result of the Simulated harmonics measurement relative to the Unwanted Emissions limit. Shows the difference between the measurement and tagless reference measurement for "Query spectrum" measurements.
- **Transmitted** power – Indicates the transmitted power used for the test. The indicator's text will be shown in white if the power can be generated and automatic Transmitted power calculation is enabled. If the power cannot be generated or automatic Transmitted power calculation is disabled, the text will be red to indicate that the measurement is not compliant with the standard. If the requested power is too high, the largest power that could be generated will be used instead.
- **Power at Port** – Indicates the maximum power recorded during the measurement at the spectrum analyzer. If the measured power approaches or exceeds the spectrum analyzer's measurement range, the text will be shown in red. This information can be used to adjust the reference level to perform accurate measurements.

The required carrier power level set in ETSI EN 302 208 is 2W ERP, which is equivalent to 35.16 dBm EIRP. The distance between the transmitting antenna and the tag is set to be 20cm. The used Transmitted power is calculated as follows:

$$Transmitted\ power = Power\ (rad)[dB] - FSPL\ at\ 20cm[dB] + Setup\ Forward\ Path\ Loss$$

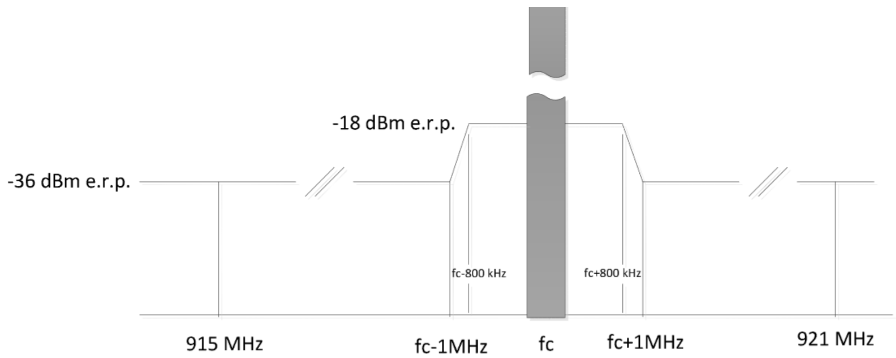
Essentially the setup's forward path loss is compared to FSPL at 20cm ([17.21;17.75] [dB] depending on frequency). The difference is then added or subtracted from the requested Transmitted power to achieve standard equivalent measurement conditions with different measurement configurations.

The green graph in the lower graph of the measurement window shows the power limit at a given frequency. Any results that are greater than the limit will be shown in red in the lower graph. The area Fc +/- 100 for the lower band and Fc +/- 200 for the upper band is excluded. The limit values may be found in Figure 99 for the lower band and Figure 100 for the upper band, respectively. For the frequency area Fc +/- 400 kHz for the lower band and Fc +/- 800 kHz for the upper band, the limit is described in 8.2.1. Furthermore, the limit values given as ERP must be transformed into EIRP. For more information, please refer to heading *B.3* under *Appendix B*: Tagformance Measurement Units.



NOTE 1: fc is the centre frequency of the carrier transmitted by the interrogator.
NOTE 2: The transmit channel occupied by the interrogator is shown in grey.

Figure 99.Lower ETSI band unwanted emissions limits



NOTE 1: fc is the centre frequency of the carrier transmitted by the interrogator.
NOTE 2: The transmit channel occupied by the interrogator is shown in grey.

Figure 100.Upper ETSI band unwanted emissions limits

13.4 RX Antenna Setup Dialog

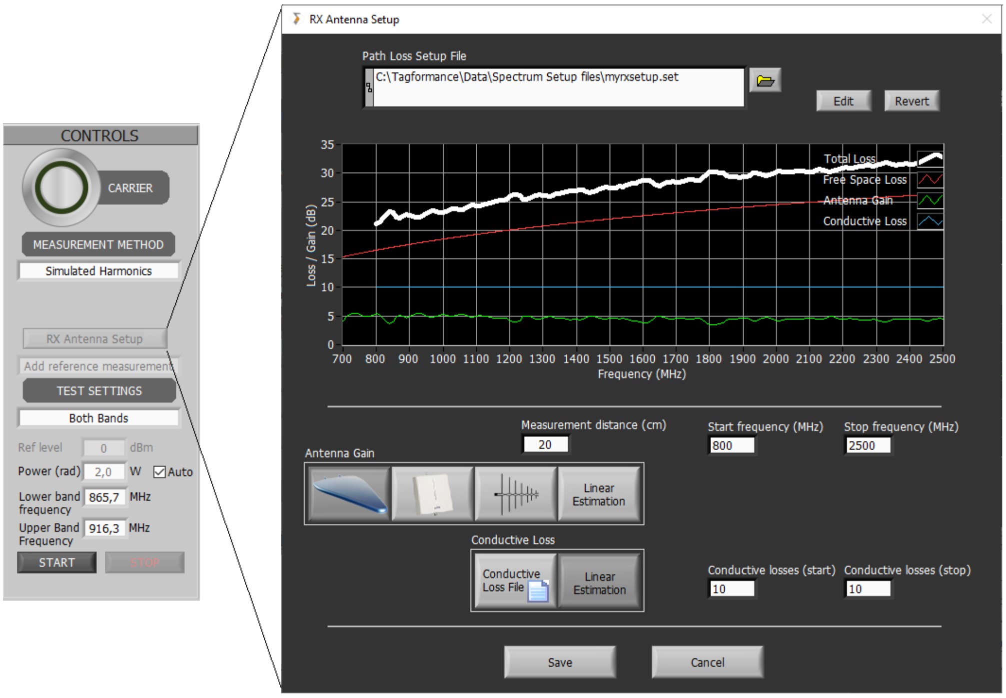


Figure 101.RX antenna setup dialog for setting up reverse link setup for **spectrum analyzer** measurement and calculate Power on Tag Reverse from Power at Port.

To perform a "**Query spectrum**" measurement, the reverse link loss to the spectrum analyzer has to be determined. To do this, the following options are available:

1) Measure the entire path loss from the tag to the spectrum analyzer's port for the desired frequency band. Enter the results into a file and point to it in "RX Antenna Setup". The path loss file is a text file with file identifier ".set" including headers according to the example below. Frequencies and the respective path loss values are provided on their own tab-separated columns. When this option is selected, only the setup loss graph shows the total setup loss.

```
[Path Loss]
Frequency (MHz) Path Loss (dB)
800 21.130
810 21.538
820 22.045
830 22.850
840 23.354
850 23.057
```

2) Enter the distance between the tag and the receiving antenna, give the receiving antenna's gain profile, and give the conductive losses (cables, coupler) to compute the reverse path loss that is used to calculate Power on Tag Reverse. The individual components (FSPL, Antenna gain, and Conductive loss) are drawn on the graph in addition to the total setup loss.

Measurement distance

This value determines the Free Space Loss between the tag and the receiving antenna. The official test distance defined in ETSI EN 302 208 is 20cm. Using a smaller distance to keep the tag in the far field is not recommended. Longer distances can be used, but the maximum transmit power available from Tagformance Pro may limit the available radiated carrier below the level defined in the official test protocol at longer distances.

Start and stop frequency

User-entered start and stop frequencies define the frequency range of the measurement and frequency values for the user-entered linear gain and loss estimates.

Antenna gain

Voyantic provides two test antenna options, but it is also possible to use other antenna types.

The frequency response data of Voyantic patch (800-1000 MHz) and wideband (700-2500 MHz) antennas are built with the software, and the user can include that data with the setup by clicking their respective icons. The patch antenna has more gain but comes with a narrower frequency response. Due to this, it is suitable if the user is only interested in the backscatter spectrum components. The Wideband antenna's calibration data is defined up to 2500MHz and can be used to investigate unwanted emissions outside the official ETSI bands.

To utilize other antenna models, the user must define the gain information manually. When choosing a custom antenna, the user will be prompted to select an antenna file that defines the antenna gain over the operating frequencies. The antenna gain file is a tab-delimited text file with frequencies in the first column and the matching gain in the second (see example below). Alternatively, the user may also enter a start and stop frequency and the corresponding gain values for these frequencies (Linear estimation). The gain values are linearly interpolated from the entered gain values for the band between the start and stop frequencies.

Conductive losses

Conductive losses can be defined as a linear estimation (the user establishes an estimation for conductive losses from the antenna to the spectrum analyzer port at start and stop frequencies) or using a file that enables the user to enter more detailed loss information. When linear estimation is used, the losses at a specific frequency are linearly interpolated from the entered loss values. When using a custom loss file, the user will be prompted to select a loss file. The conductive losses definition file is a tab-delimited text file with frequencies in the first column and respective gain in the second (see example below).

(a)

```
700	5,01
800	4,97
1100	4,90
1200	4,85
```

(b)

```
700	10,2
800	10,3
1100	10,4
1200	10,5
```

Figure 102.(a) Antenna gain and (b) conductive loss definition files are tab-delimited lists with frequency on the first column and gain/attenuation on the second.

Tag emission setup file

Once the user has finished adjusting the RX setup, the data is saved to a human-readable setup file. The file includes information on the user choices and can be loaded to restore settings later.

```
Tag Emission Setup File
Version 1.0
Date:   2019-06-11
Time:   14:51

[Settings]
Antenna Gain [STRING] = "Voyantic Wideband Antenna"
Conductive Loss [STRING] = "Manually Defined Conductive Loss"
Conductive loss estimation start [Float] = 0.000000
Conductive loss estimation end [Float] = 0.000000
Start frequency [U32] = 700
Stop frequency [U32] = 2500
Measurement distance [Float] = 20.000000

[Path Loss]
Frequency (MHz) Path Loss (dB)
800     21.130
810     21.538
820     22.045
830     22.850
840     23.354
850     23.057
860     22.358
870     22.159
880     22.458
```

Figure 103.Tag emission setup file generated in the RX setup dialog.

14 Support for Additional Protocols and Commands

Appendices A.9 (UHF RFID) and A.10 (HF RFID/NFC) list readily available protocols and commands.

In addition to the ready implementations, the Tagformance system has three methods for adding new custom commands. These are described below and can be used with the custom command license.

14.1 Inventory-Based Custom Commands for EPC g2v2 (UHF)

With Gen 2 Custom command mode, it is possible to create commands that can be used in TDS and ADS software suites. The commands are created as text files in the data folder. The authenticate AES command file is provided as an example (see Figure 104).

In the command file:

- Fields are separated with tabs
- File name must start with gen2_custom
- The first two rows of the file must be:
  - *Custom Command File*
  - *Version* 2
- *"Name"*: "name to appear in the command menu"
- The binary command structure is in the format (Bits1) (+Handle) (+Bits2) (+CRC-16)
- *"Bits1"* field is mandatory, "*Bits2"* field is optional (leave the field blank if not used)
- *"Handle"*: 1 if the handle is used, 0 if the handle is not used
- *"CRC"*: 1 if CRC is used, 0 if CRC is not used
- *"Length"*: Time [µs] from the end of the reader command to the expected end of the tag response
- *"Condition"*: Conditions for accepting the response. Possible choices
  - *CRC_OK*
  - *BIT_EQUALS N X*
    , where *N* is the bit number, and *X* is 0 or 1
  - *ENVELOPE XXX ZZZ*
    , where *XXX* is the response start time in µs, and *ZZZ* is the response length in µs
- *"Preamble"*: Selects the prepended preamble. If this field is missing, framesync is used
  - *Preamble*
  - *Framesync*

The commands appear as new commands under ISO18000-6C.

```
gen2_custom_authenticate - Notepad
File  Edit  Format  View  Help
Custom Command File
Version	2
Name	Authenticate AES
Bits1	110101010011000000000000001100000000000000000000001111111101011
Bits2	
Handle	1
CRC-16	1
Length	15000
Condition	CRC_OK	BIT_EQUALS	8	0
```

Figure 104.Custom command description file for EPC g2v2 Authenticate command with AES cryptosuite

14.2 Custom Command Sequences for EPC g2v2 (UHF)

With the Gen2 Custom Command Sequence mode, creating command sequences for TDS and ADS software suites is possible.

The commands are created as text files and saved to “Tagformance\Data,” where they’re loaded at Software startup or when the ISO 18000-6C protocol is selected.

An example of a custom command sequence file is shown in Figure 105. The file consists of a header, command order, and command definitions. In addition, the user can define commands at the bit level. Ready commands are available to enable more advanced sequences.

```
Custom Command File
Version	3
Name	Custom Sequence Example

[Cmd Order]
1 = PopSelect
2 = Wait
3 = Inventory
4 = Req_RN
5 = custom_built_BlockWrite
6 = Req_RN
7 = custom_built_Read

[Inventory]
Sel = 4
Session = 0
Target = B

[Wait]
Time = 5

[custom_built_Read]
Bits1 = 11000010010000000000000000
Bits2
Handle = 1
CRC-16 = 1
Length = 6000
Condition = CRC_OK	BIT_EQUALS	0	0
ResponseDataMask = 9	8

[custom_built_BlockWrite]
Bits1 = 110001110100000001000000000111111111111111111
Bits2
Handle = 1
CRC-16 = 1
Length = 8000
Condition = CRC_OK
```

Figure 105. Custom Command Sequence description file

In the command file:

- Headers are between brackets
- Values follow the keyword and the equal sign
- File name must start with “Gen2_custom”
- The first two rows of the file must be:
  - *Custom Command File*
  - *Version 3*
- *Name:* “name to appear in the command menu”

Custom Command definition parameters

- The binary command structure is in the format *Bits1* (+*Handle*) (+*Bits2*) (+*CRC-16*)
- *“Bits1”* field is mandatory, *“Bits2”* field is optional (leave the field blank if not used)
- *“Handle”:* 1 if the handle is used, 0 if the handle is not used
- *“CRC-16”:* 1 if CRC-16 is used, 0 if it is not used
- *“Length”:* Time [μs] from the end of the command to the expected end of the response
- *“Condition”:* Conditions for accepting the response. Possible choice:
  - *CRC_OK*
  - *BIT_EQUALS N X*
    - where *N* is the bit index, and *X* is 0 or 1
  - *ENVELOPE XXX ZZZ*
    - where *XXX* is the response start time in μs and *ZZZ* the response length in μs
- *“ResponseDataMask”: (optional)* By defining the data mask, it is possible to plot the response data to the graph as an integer. The preamble is already filtered out before the data mask. Thus, the index of *0* is the first bit after the preamble.
  - *parameters A B*
    - where A is the bit index, and B is the number of bits
- “*Preamble*”*:* Selects the prepended preamble. If this field is missing, framesync is used
  - *Preamble*
  - *Framesync*

Ready Commands and parameters for the Sequence

- *“PopSelect”:* The same functionality as the “Select” button under the command selection in the Control Panel. The selection parameters are applied, and the selection is done for the tag selected in the Population list.
- *“Carrier_down”:* turns off the carrier signal
- *“Wait”:* A delay for defining, for example, the carrier downtime. Defined time is the minimum waiting time because the OS is not a real-time system.
  - *Time [ms]* is a mandatory parameter
- *“Inventory”* performs the inventory process (Query+ACK+Req_RN) according to the selected command parameters in the Control Panel. Three of the Query parameters must be given as a parameter.
  - *Sel (0…4):* Values 0…3 are according to the EPC Gen2 protocol. With *4*, the “*Sel”* is automatically set after the *“PopSelect”,* no matter if the select

is defined in the custom command file or is it selected in the Tagformance Software Control Panel.
    - *“Session” (0…3)*
    - *“Target” (A or B)*
- *“Req_RN”*

Before the very first command and before the first command after “Carrier_down”, the amount of carrier, defined in *Options,* is being sent to the tag.

Handle, the part of some commands, e.g. *Read* and *BlockWrite*, is taken automatically from the response of previous *Inventory* or “Req_RN”.

There are built-in commands as functions: “PopSelect”, “Carrier_down”, “Wait”, “Inventory”, and “Req_RN”.

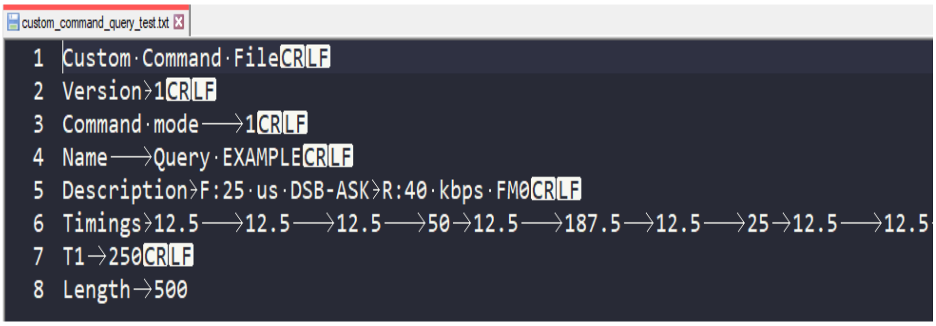
14.3 Custom Command Waveforms (UHF)

14.3.1 Command definition

The custom command is described as a txt file, saved to the Data folder. The set of commands is loaded at Tagformance software startup, and when the Custom command protocol is selected.

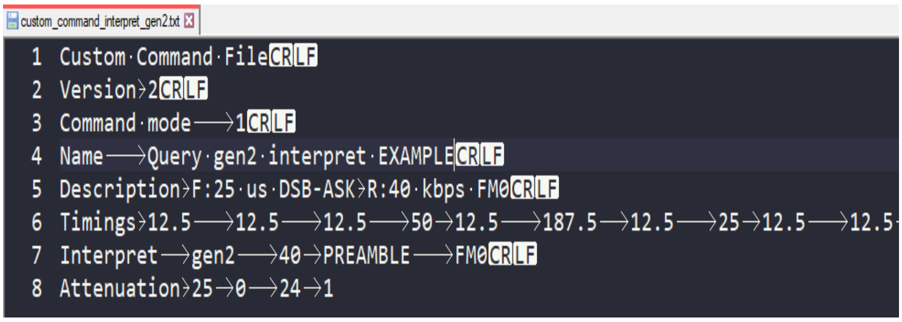
- File name must contain “custom_command” or “custom-command”
- The first three rows must contain the items listed in the example, “Version” may use 1 or 2
- *“Name”* and *“Description”* are the information that appears in the command menu
- “*Timings*” is the command to be sent after the inventory sequence described as a timing sequence
- Version 1
    - *“T1”* is the expected delay [µs] between command and reply
    - *“Length”* is the expected reply length [µs]
- Version 2
    - The items are read as keys, should duplicate entries exist, the lower row index will be used
    - *“Interpret”* accepts either *“envelope”* or *“gen2”*
        - *“envelope”* expects 2 tab-delimited values, *“T1”* and “*Length”*
        - *“gen2”* expects 3 tab-delimited values, *“BLF”*,*”preamble”* and *“modulation type”.* These values are case-sensitive.
            - *“BLF”* is either 40, 320 or 640, Miller4 supports only 320
            - *“preamble”* is EXT-PREAMBLE or PREAMBLE
            - *“modulation type”* is FM0 or Miller4, Miller4 supports only EXT-PREAMBLE for *“preamble”*
    - *“Attenuation”* is an optional parameter. Each value corresponds to a *“Timings”* value and is an offset from the high-level. All *“Timings”* without a corresponding *“Attenuation”* are not offset. Valid values [0;25].

The commands appear as new commands under the Custom command protocol.



```
custom_command_query_test.txt
Custom Command File
Version	1
Command mode	1
Name	Query EXAMPLE
Description	F:25 us DSB-ASK	R:40 kbps FM0
Timings	12.5	12.5	12.5	50	12.5	187.5	12.5	25	12.5	12.5
T1	250
Length	500
```

Figure 106.Custom command description file for query command version 1 (part of the timing sequence)



```
custom_command_interpret_gen2.txt
Custom Command File
Version	2
Command mode	1
Name	Query gen2 interpret EXAMPLE
Description	F:25 us DSB-ASK	R:40 kbps FM0
Timings	12.5	12.5	12.5	50	12.5	187.5	12.5	25	12.5	12.5
Interpret	gen2	40	PREAMBLE	FM0
Attenuation	25	0	24	1
```

Figure 107.Custom command description file version 2 (gen 2 interpret)

14.3.2 Limitations

When defining a command, the following limitations apply:

- Continuous timings may not be shorter than 0.2 µs
    - For short periods of time, this limit may be exceeded; however continuous shorter timings will result in a buffer overflow and cause an incorrect waveform
- The shortest possible timing is 12.5 ns
    - Should not be used continuously
- The maximum number of timings is 50000
    - If this limit is exceeded, the software will crash and require a reboot of the device

14.3.3 Custom command waveform preview

Select the Custom command protocol in the Tagformance software to view the generated command waveform. Right-click on any field under COMMAND, and a preview window will open. Exporting the waveform for further analysis is available via right-click options.

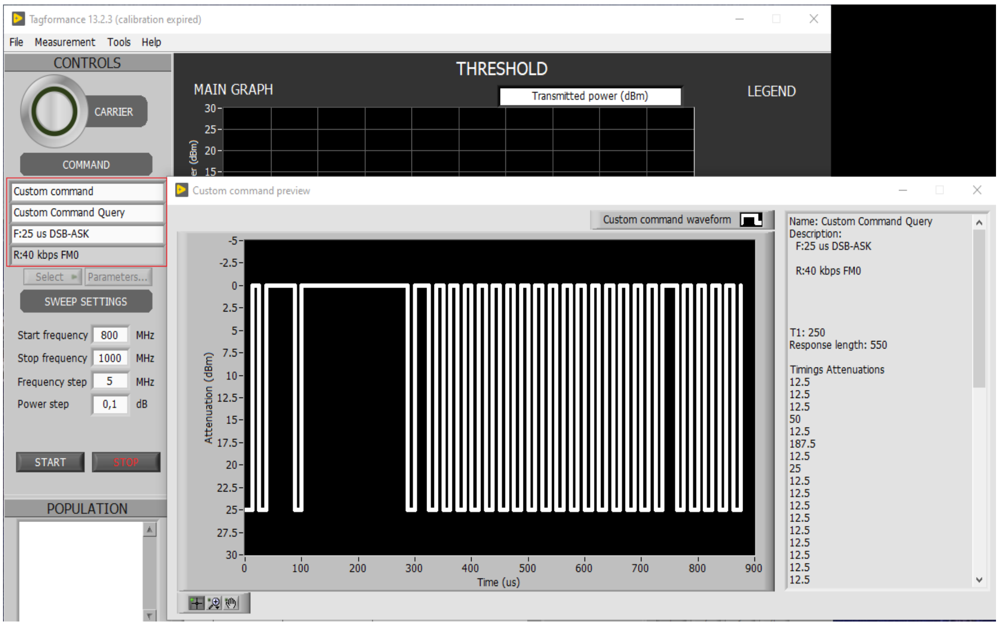


Figure 108.Custom command waveform preview

15 Accessory Controls

15.1 Multiplexer Unit

Figure 109.Multiplexer Unit – front panel

The Multiplexer requires a USB connection and power to work. The TX cable is connected to the C connector, and antennas 1-4 are connected to connectors 1-4.

Figure 110.RF-channel controls

When using the Multiplexer, four different Measurement Setup files must be defined, and each channel has its own set-file (Figure 111). The same file can be used for all four channels if the measurement setups are identical. Empty setups can also be chosen, for example, when initiating near-field measurements with coupling elements.

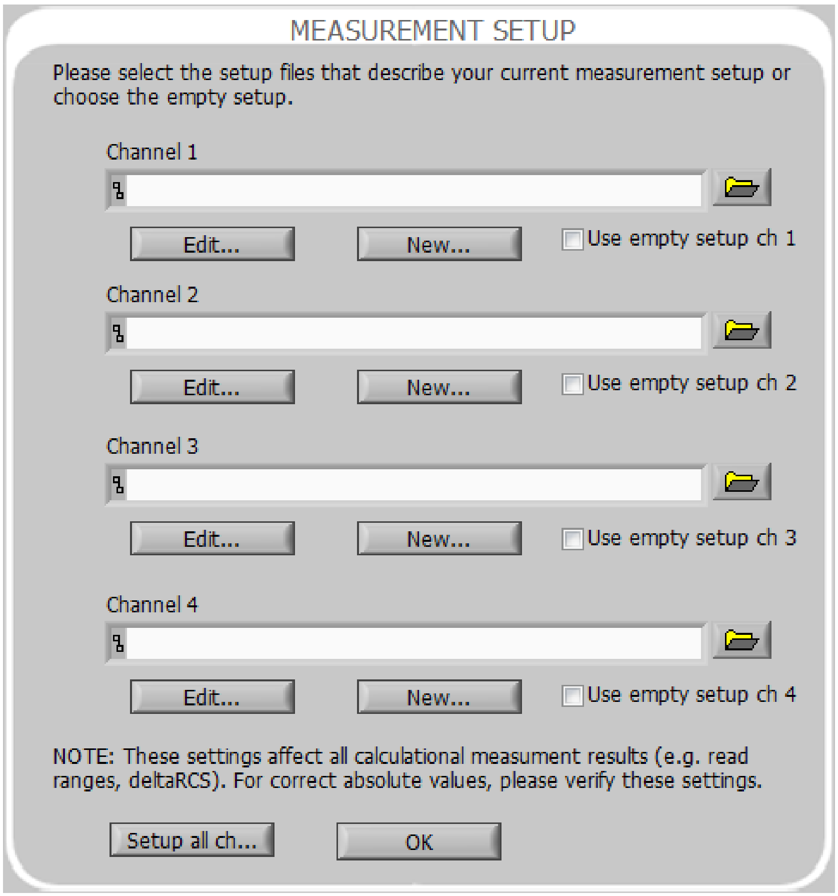


Figure 111.Measurement setup when using the Multiplexer unit.

The setups can be edited or created one by one, as described in the UHF RFID Measurement Setup section. There is also the option to run an automated measured setup of 4 channels by pressing the “Setup all ch…” button.

15.2 Rotation Control

Figure 112.Rotation table controls

The rotation table controls are shown when the rotation module is connected to the PC.

- **<< –** Rotate counter-clockwise
- **Step –** Angle step, degrees
- **>> –** Rotate clockwise
- **Angle –** Current angle in degrees
- **Set to 0 –** Make the current rotation table position 0º angle.
- **Go to 0 –** Rotate the rotation table to 0º angle.

16 HF RFID Testing Suite

16.1 Threshold

The Threshold measurement function is designed for tag characterization as a function of the carrier frequency. This function will analyze the tag's sensitivity and tuning.

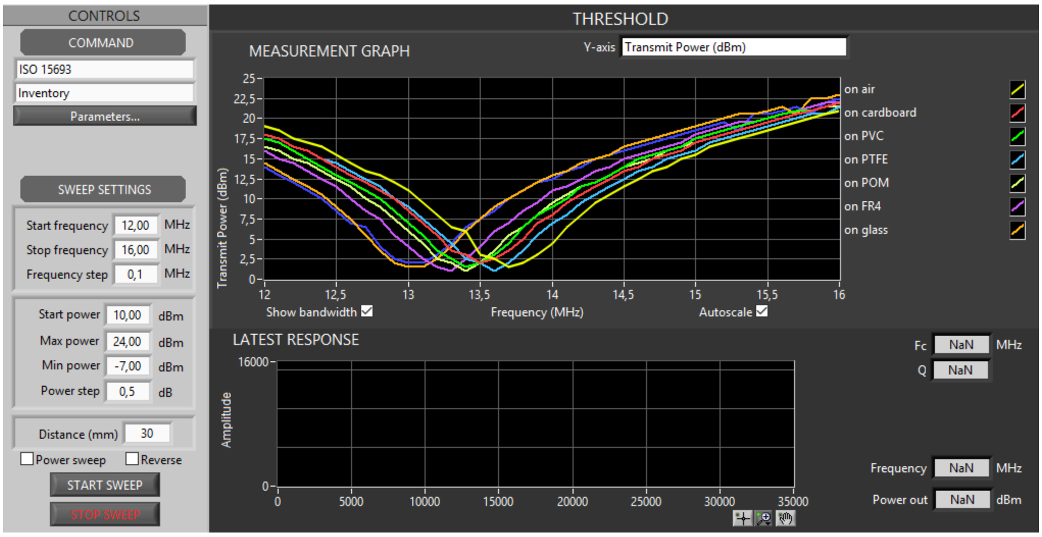


Figure 113.Threshold Measurement software

The **control panel** contains the following controls:

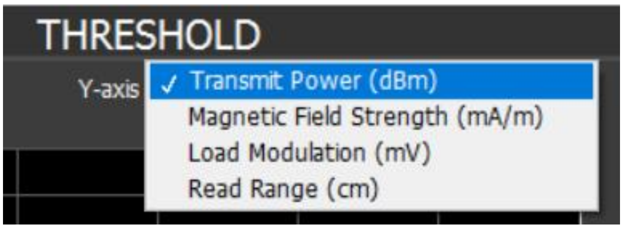
- **Command** – The protocol and command that is used in the measurement.
- **Parameters** – Each command has some parameters.
  See chapter 0 for detailed information.

Sweep settings:

- **Start frequency** – Sweep start frequency (MHz).
- **Stop frequency** – Sweep stop frequency (MHz).
- **Frequency step** – Indicates how much the frequency increases with each measurement point. Possible values are from 0.01 MHz to 10 MHz.
- **Start Power** – Sweep start power (dBm).
- **Max Power** – Sweep maximum power (dBm).
- **Min Power** – Sweep minimum power (dBm).
- **Power step** – Power resolution. The power step can be changed from the drop-down menu. Possible values are 0.1 dB, 0.5 dB, and 1.0 dB.
- **Distance (mm)** – The measurement distance between the antenna and tag. This setting calculates the magnetic field strength and controls the Distance Control Kit if it is connected.
- **Start sweep** – Starts the sweep.
- **Stop sweep** – Stops the sweep.

The Y-axis unit can be selected from the drop-down menu above the measurement graph. The possible values are:

- Transmit power (dBm)
- Magnetic Field Strength (mA/m)
- Load modulation (mV)
- Read Range (cm)



In the lower-left corner of the measurement graph, there is a checkbox to display the calculated bandwidth of the currently selected measurement. This bandwidth is calculated using the measurement's Magnetic Field Strength data.

Indicators for displaying the center frequency (Fc) and the Q factor (Q) for the currently selected measurement are in the lower right corner. If no Fc or Q factor can be calculated for the measurement, a “NaN” will be displayed.

See Appendix F: HF Threshold for more information on Fc and Q calculations.

16.2 Passive

Passive measurement is primarily meant for measuring RFID tags without using the protocol in a manner similar to using a vector network analyzer. It can also be utilized to measure other components, e.g., reader antennas.

Before attempting any passive measurement, an S11 calibration must be performed. The calibration is done by pressing the calibrate button and following the software instructions. The instructions will ask you to place a 50 Ohm termination (supplied with the system) at the measurement cable's end and then leave the cable empty for open load calibration. After the calibration procedure, the device is ready for S11 measurements. A new passive calibration should occur whenever the setup components are changed.

A reference measurement should also be carried out to measure a tag. This will make a single S11 measurement of the test antenna without a tag to record its frequency response. The measurement will be used to display the normalized Y-axis units where the effect of the test antenna is subtracted.

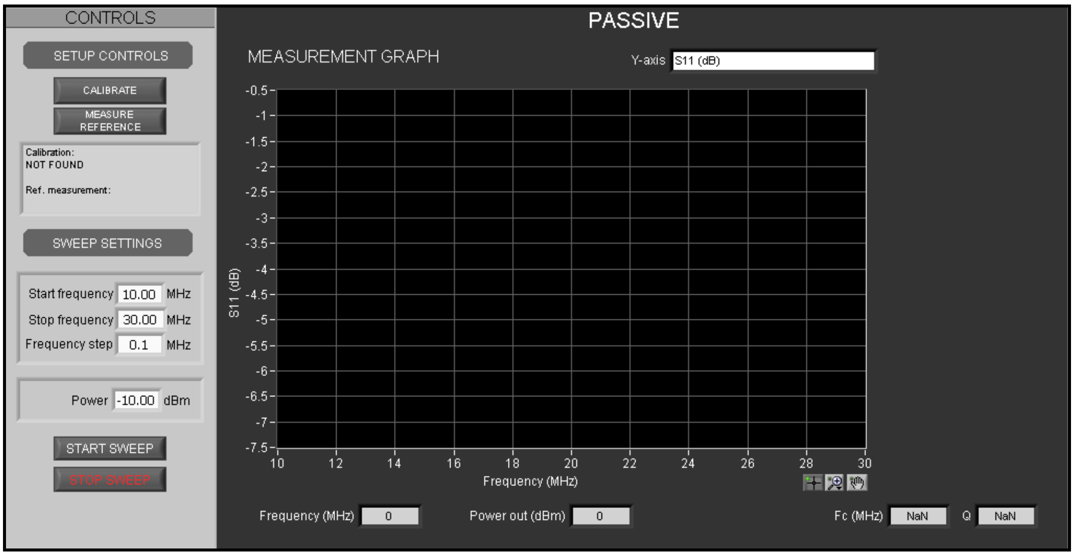


Figure 114.Passive Measurement software

The **Setup Controls** panel contains:

- **Calibrate –** Opens the calibration dialog.
- **Measure Reference** – Opens the Reference measurement dialog.

For more information about the Calibration procedure or the Reference Measurement, please see chapter 17.12.

The **control panel** contains the following controls:

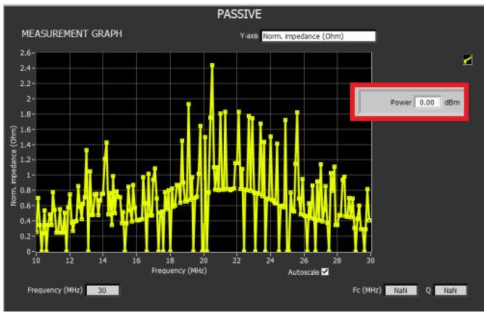
Sweep settings:

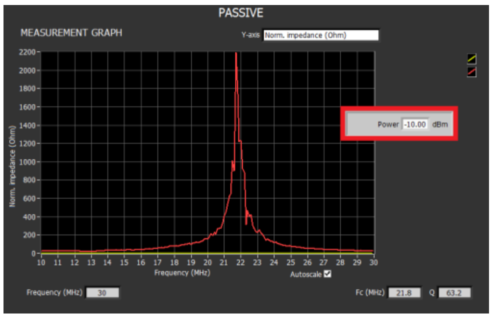
- **Start frequency** – Sweep start frequency (MHz).
- **Stop frequency** – Sweep stop frequency (MHz).
- **Frequency step** – Indicates how much the frequency increases with each measurement point. Possible values are from 0.01 MHz to 10 MHz.
- **Power** –The transmit power (dBm).
- **Start sweep** – Starts the sweep.
- **Stop sweep** – Stops the sweep.

The Y-axis unit can be selected from the drop-down menu above the measurement graph. Possible values are:

- S11 (dB)
- Impedance (Ohm)
- Resistance (Ohm)
- Reactance (Ohm)
- Normalized Impedance (Ohm)
- Normalized Resistance (Ohm)
- Normalized Reactance (Ohm)
- Reflection coefficient Magnitude
- Reflection coefficient Phase

Note that the power level should be set low when using the passive test with the chip attached so the chip does not activate. The pictures below show a sample with the same test setup. The first image with a yellow curve shows the result with 0dBm power (too much), and the second with a red curve with low enough power.





16.3 Load Modulation

The Load Modulation measurement plots load modulation as a function of transmit power (or Magnetic Field Strength).

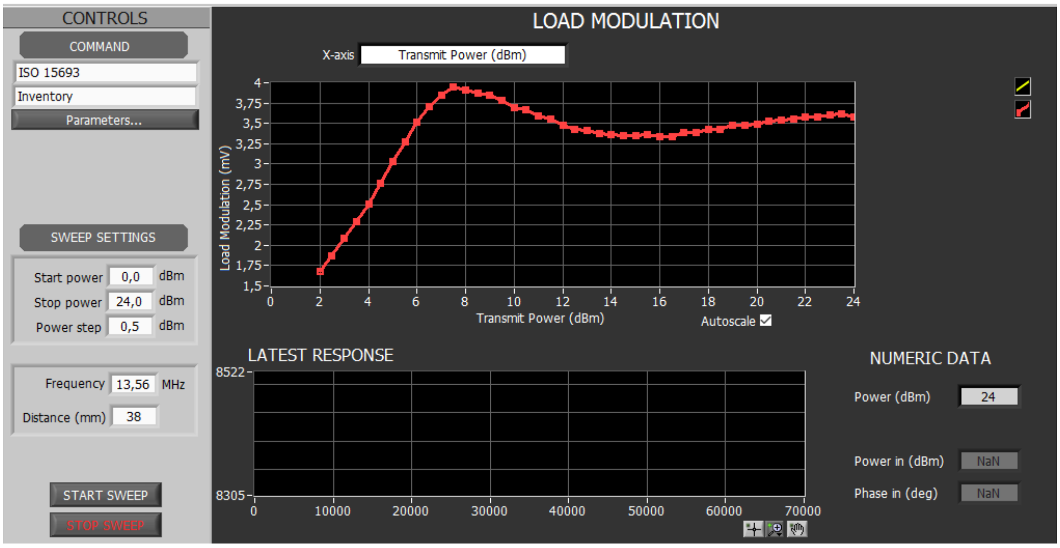


Figure 115.Load Modulation Measurement software

The **control panel** contains the following controls:

- **Command** – The protocol and command that is used in the measurement. See chapter 0 for detailed information.

Sweep settings:

- **Start power** – The lowest power with which the test is made.
- **Stop Power** – The highest power with which the test is made.
- **Power step** – Measurement resolution.
- **Frequency** – Sweep start frequency (MHz).
- **Distance** – Distance used in the test.

16.4 Working Range

Working Range measurement uses the Distance Control Kit to adjust the measurement distance automatically. At each distance point, the software measures the *Load Modulation.* The plotted *Load modulation* is the strength of the received tag signal from the measured tag.

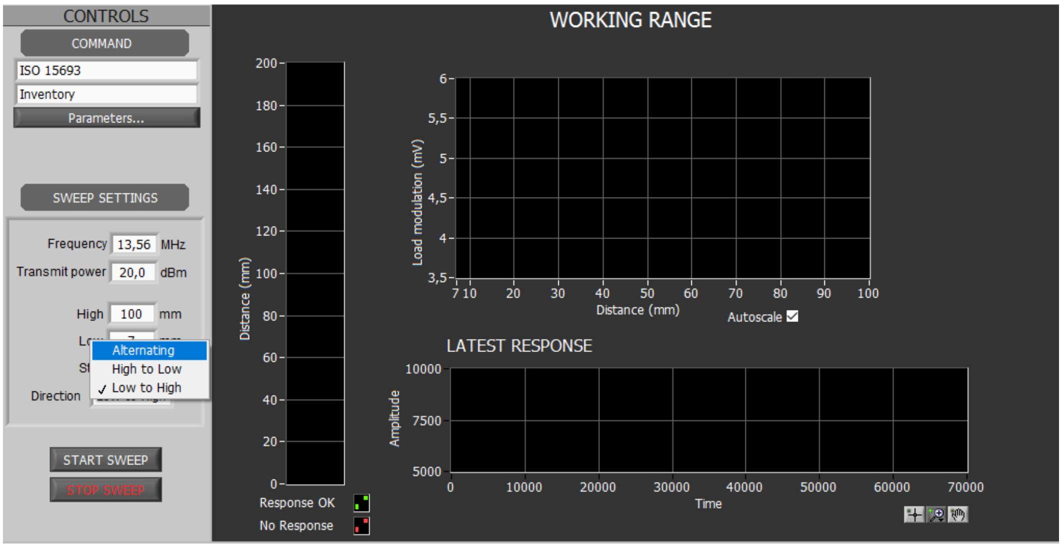


Figure 116. Working Range Measurement software

The **control panel** contains the following controls:

- **Command** – The protocol and command that is used in the measurement. See chapter 0 for detailed information.

Sweep settings:

- **Frequency** – Sweep start frequency (MHz).
- **Transmit Power** – Transmit power (dBm).
- **High –** The longest measurement distance (mm).
- **Low –** The shortest measurement distance (mm).
- **Step –** Measurement resolution.
- **Direction** – Direction of the distance sweep.
    - **High to Low –** movement starts at a high position.
    - **Low to High –** movement starts at a low position.
    - **Alternating –** movement starts at a position closest to the current position.
- **Start sweep** – Starts the sweep.
- **Stop sweep** – Stops the sweep.

17 Measurement Examples

To perform the basic measurement functions, the hardware and software must be configured according to the instructions in the Chapter “Hardware installation.” Ensure the cables are connected, turn on the Measurement Unit, and run the Tagformance measurement program.

Next, place the tag in front of the antennas and select the desired measurement function from the Measurements menu. At this point, ensure that only one *TAG* is in the measurement field. Multiple tags may give false readings and greatly affect the measurement results.

17.1 Switching Between UHF and HF Testing

When switching between UHF and HF RFID testing

- Close the measurement software
- Open the other measurement software.

17.2 UHF Threshold

Make sure that the protocol settings correspond to the *TAG*. Then define the sweep range and the frequency step. Set the power level step. The frequency step and the power level steps affect the speed of the measurement cycle.

Once you have made these settings, click the *START SWEEP* button, and the Carrier indicator will be lit on both the Measurement Software and the Measurement Unit. TX and RX LEDs on the Measurement Unit indicate how the measurement proceeds and the graph is plotted at each frequency point as the function proceeds.

Once the sweep is finished, the carrier LED will turn off. You can also stop the function anytime by clicking the *STOP SWEEP* button.

17.3 Backscatter

Make sure that the protocol settings correspond to the *TAG*. Define the frequency at which you want to run the backscatter measurement and set the power limits and steps. Then click *START SWEEP*.

Again, the LED indicators give you a feel for how the measurement is proceeding. Once the sweep is finished, the carrier LED will turn off. You can also stop the function anytime by clicking the *STOP SWEEP* button.

17.4 Response Test

Make sure that the protocol settings correspond to the *TAG*. If you wish to repeat the measurement with constant power, define the frequency and power with which you want to run the measurement. If you wish to measure by maintaining the threshold power, define the frequency and the power step. If you wish to use the fast mode, just define the wanted frequency. Then click *START*.

The Software indicators show the transmitted and backscattered power and the backscattered signal phase in real time. The measurement can be stopped by clicking the *STOP* button.

17.5 Population Analysis

When using *Population Analysis,* you must have the tags learned first (tags can be seen down in the left-hand corner of the Tagformance Software).

Set your population in front of the antenna, and be sure that you are using tags that correspond to the ISO 18000-6C Class1 Gen2 protocol. Set the Start and Stop powers, the Power step, and the Frequency you want. Press START SWEEP to perform the measurement. You can stop the measurement at any time by pressing *STOP SWEEP*.

17.6 Interference

Frequency sweep performs analysis over a sweep of a certain frequency band. It’s useful for e.g., gaining an overview of which frequencies have the most interference.

1. Select Frequency sweep test mode
2. Define start frequency, stop frequency, and frequency step
3. Click START to initiate the test
4. Clicking STOP will stop the test during measurement

The constant frequency test performs an analysis at a single frequency. It’s useful for investigating and analyzing interference levels over time.

1. Select Constant frequency test mode
2. Define center frequency
3. Click START to initiate the test
4. Stop the test by clicking STOP

Measurement results are displayed on the *SPECTRUM* window.

1. The higher the value at a certain frequency, the more activity there is.

2. Peaks standing out from the noise floor indicate that there's more activity at those frequencies, which may potentially interfere with Tagformance measurements. Typical sources of interference are other RFID systems and cell phone signals.

3. The effect of interference depends on the tests made and the strength of the test signal investigated. If the interference strength is close to the same level as the tag backscatter or stronger, the test result might get distorted. Typically, tag backscatter level varies from -30dBm to -60dBm, but it may even decrease to -80dBm.

4. To reduce external interference, testing inside an anechoic chamber and, if possible, avoiding crowded channels are recommended. Utilizing high-quality RF cables can also reduce interference leaking to the receiver.

17.7 Using Population Management with Threshold

If your system includes both the Tag Designer and Application Development Suites or you have purchased the Population Management option separately for your Tag Designer Suite, you can measure an individual tag within a population of tags.

Start by making a tag population list according to the instructions in Chapter 7.4To make a Threshold Sensitivity plot for an individual tag, select the tag from the population list, use the Select + Query command, define sweep settings, and press *START.*

Similarly, you can use Population Management with the Backscatter, Orientation Sensitivity, and Response Test functions.

17.8 Protocol Testing

This is an example of performing the Gen2 read command.

Define the frequency at which you want to test the protocol and set the power. Then click *START CARRIER*. The next step is to click *INVENTORY* to achieve the *open* state of the tag. Select *READ* from the commands list and press *SEND COMMAND.* Now you should see the waveform in the *latest response* window (tag answer). Press the *CURSORS TO SCREEN* button. The cursors appear in the *latest response* window. Define the tag answer as shown in the picture below. Press *INTERPRET* and read the interpreted data from the *interpreted data* area.

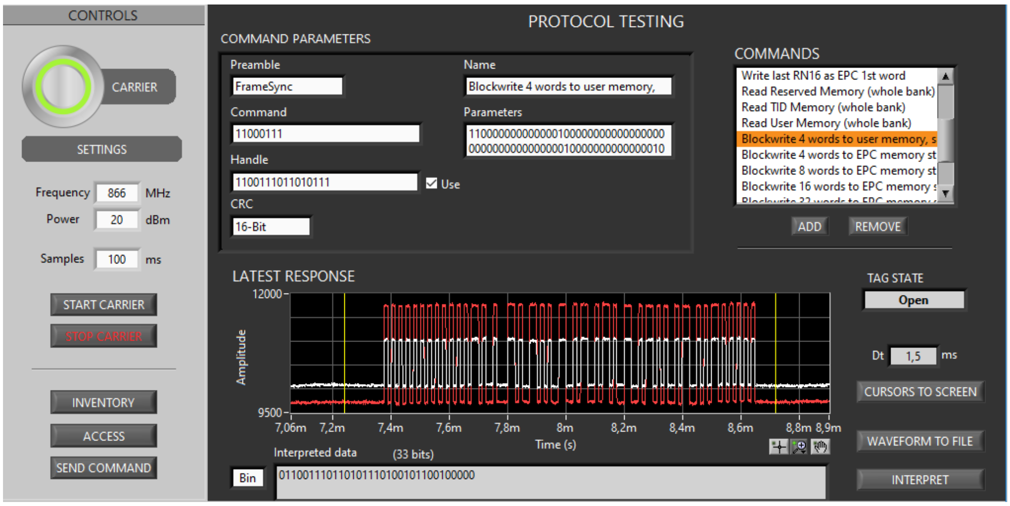


Figure 117.Defining the interpret area with cursors (tag answer)

17.9 Tagged Item Grading

Tagged item Grading enables the user to verify if the tagged item under the test passes the grades set in the TIPP standard.

A grade type determines the test configuration, e.g., how many items are placed for testing and their orientation. Grades are also associated with a family, denoted by the last letter in a grade's name. For more information on families, please refer to GS1 TIPP documentation.

There are measurement two approaches:

1. Check the tagged item(s) against all the grades of a type
2. Verify the tagged items(s) against a single grade

Checking against all grades of a type gives an overview of the item's performance and can help narrow down what grade(s) should be used as a passing criterion.

Verifying against a single grade is useful once you have a specification or baseline against which to compare. The test is also faster to complete as only the grade-specific angles, channels, and backscatters, if applicable, are measured.

A rough check can be done even faster by changing the frequency range, frequency, and/or power step and selecting "custom" as the Frequency range. Please bear in mind using this setting will make the test configuration non-compliant with the TIPP standard.

17.10 Tag Emission Test

To perform the measurement according to the ETSI EN 302 208 standard, the user must complete the following steps:

1. Find the optimal orientation for the tag with respect to the antenna so that the backscatter strength is maximized. For dipole-type labels, this might be self-evident, but for on-metal tags and source-tagged items, some experimenting and double-checking might be necessary.

2. Place the tag at the correct test distance from the antenna. The official protocol defines a test distance of 20cm. Slightly longer distances can be used, but significantly longer distances will require the use of a separate power amplifier to reach the specified field strength at the tag.

3. Test backscatter strength with Backscatter measurement.

4. Test the backscatter mask and emission spectrum with Tag emission measurement.

17.10.1 Finding out the direction of the strongest radiation from the tag

For the purposes of the emission test, the tag needs to be oriented to provide optimum coupling to the transmitting antenna.

To determine the tag's optimum orientation, perform the orientation measurement at the smallest step size. Switch the Measurement unit to Backscattered power (dBm) and note the angle value for which the backscatter is greatest.

Moreover, if a 4-antenna setup is available, measuring in 4 channels will provide more information on the optimal elevation angles. This might be necessary for special tag antenna designs and on-metal tags.

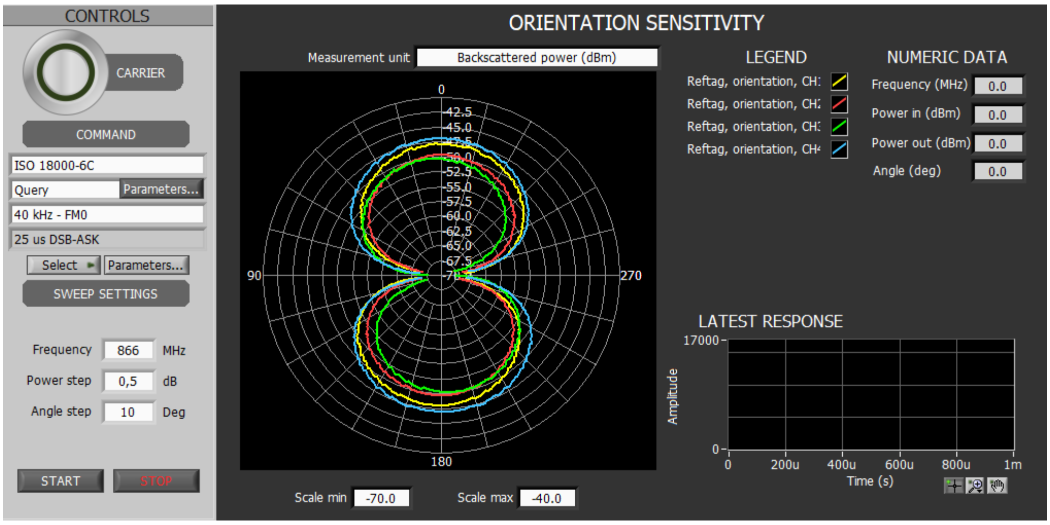


Figure 118.4 Antenna rotation measurements. The strongest coupling is achieved at channel 1 and channel 4, at 0- and 180-degree orientation.

17.10.2 Measurement of the backscatter strength

Orient the tag according to the previous step(s) results and perform backscatter measurements. In the measurement program, the user has first to enable the ETSI emission limit indicator, which is then shown if the selected measurement frequency is within either the lower (865-868 MHz) or upper (915-921) ETSI band. The axis selections must be ‘Power on tag forward (dBm)’ on the X-axis and ‘Power on tag reverse’ on the Y-axis.

The indicator for the backscatter criterion is a red cross located at ~+18dBm on the x-axis and -10,85dBm (lower band) or -0,85dBm (upper band) on the y-axis (see figure below). The Power on the tag forward level equals 2W (e.r.p) transmission at 20cm from the reader antenna. The Y-axis values are the result of converting original units in e.r.p first to e.i.r.p (i.e. +2,15dBm), and then scaled to match with backscatter definition used in Tagformance (+7dBm).

In addition to the official criterion point, the user can also compare backscatter at other activation fields. They might be stronger if the tag backscatter gets saturated at the higher carrier levels. This informative limit is indicated with a white dotted line.

Note: Tagformance setup must be re-calibrated between measurements if measurement setup is reconfigured, e.g. if test distance is changed.

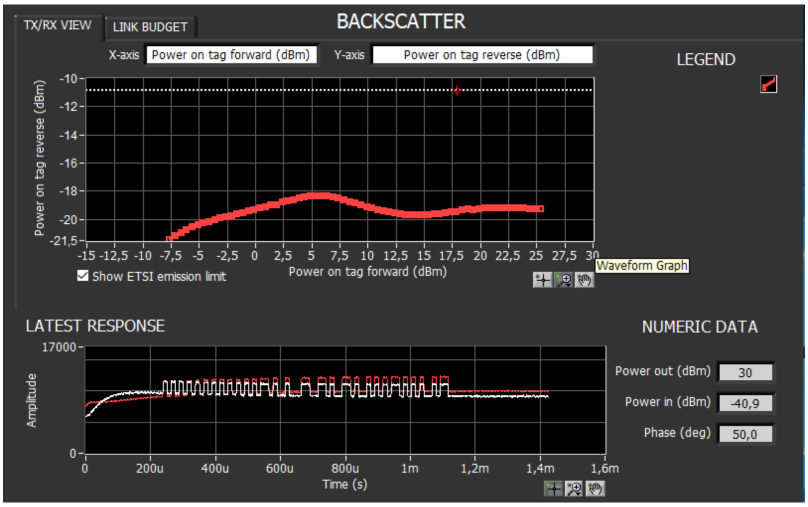


Figure 119.Backscatter measurement indicates whether response strength is below the limit set by the official test standard. It also indicates if the tag behaves differently at different carrier levels.

17.10.3 Measurement of the backscatter mask and unwanted emissions

Tagformance Pro enables two measurement modes for analyzing the backscatter spectral mask and emissions from the tag.

Simulated harmonics measurement mode enables quick testing of the backscatter spectrum based on measuring the tag backscatter strength and calculating the associated spectrum components from a recreated signal model matching the measured signal strength. The simulation assumes the tag backscatter to be between two discrete levels, and it also assumes the tag state will change instantaneously. This is usually relatively close to how tags work and will provide a benchmark of how much backscatter power spectrum a tag can produce. The simulated harmonics measurement will assume the tag backscatter waveform to be completely unfiltered, and thus, a tag that passes the test will also typically pass an actual full spectrum measurement. For the test, the user can choose between two modulation cases. The *typical* scenario uses a fixed random data packet in Miller-4 coding, whereas the worst-case scenario uses a tag response consisting of only zeroes in FM0 coding, giving the atypical and most spectrally focused power spectrum. The EN 302 208 standard does not specify what kind of data content or modulation type the tag should use, so this selection between the typical and worst-case scenarios is left for the user to decide which is more suitable.

To conduct the measurement, the user should put the tag at the desired distance from the test antenna, choose “Simulated Harmonics” measurement mode, set the carrier parameters (power and frequency), and click “Start” to run the measurement. Results are displayed in the lower graph with the official ETSI test limits. Approved results are indicated with white bars, and results exceeding the emission limits are indicated in red.

Query spectrum -measurement enables the investigation of the spectral features on a wider bandwidth. The measurement makes use of an additional real-time spectrum analyzer which is connected with the system as explained in chapter 5.12: ETSI RED Kit (ERK). Before starting the measurement, the user should put the tag at the selected distance from the test antenna and define the RX antenna setup parameters (see chapter 13.4: RX Antenna Setup Dialog).

The measurement is performed in two parts, first with a tag and then without a tag. Results from the two measurements are shown in the first graph, and their difference is to be judged against test criteria in the second. Approved results are indicated with white dots, and results exceeding the emission limits are indicated in red. For the *Query spectrum* measurement, the user, like vice, can choose between the more forgiving typical M4 random backscatter and the worst-case train of FM0 zeroes.

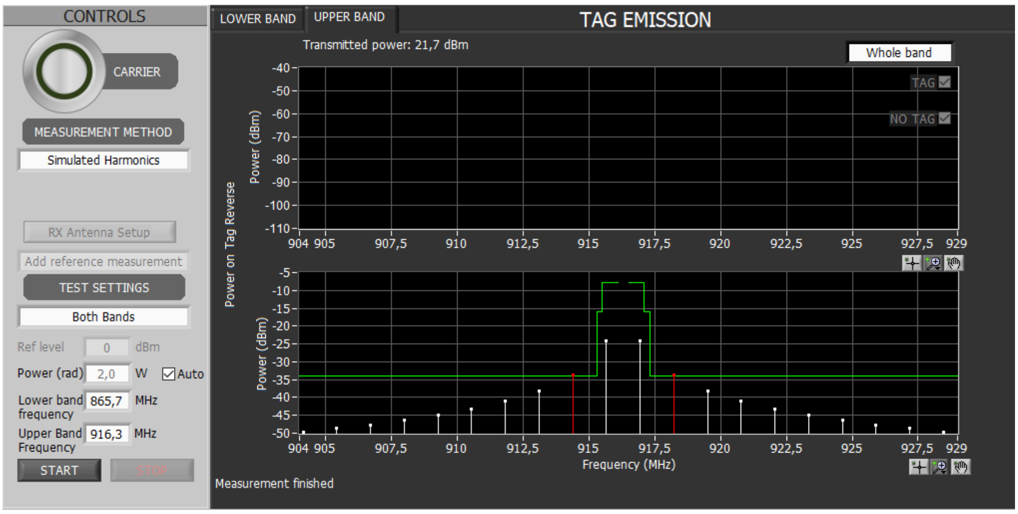


Figure 120.Simulated harmonics measurement shows the ideal calculated main components of the tag backscatter spectrum.

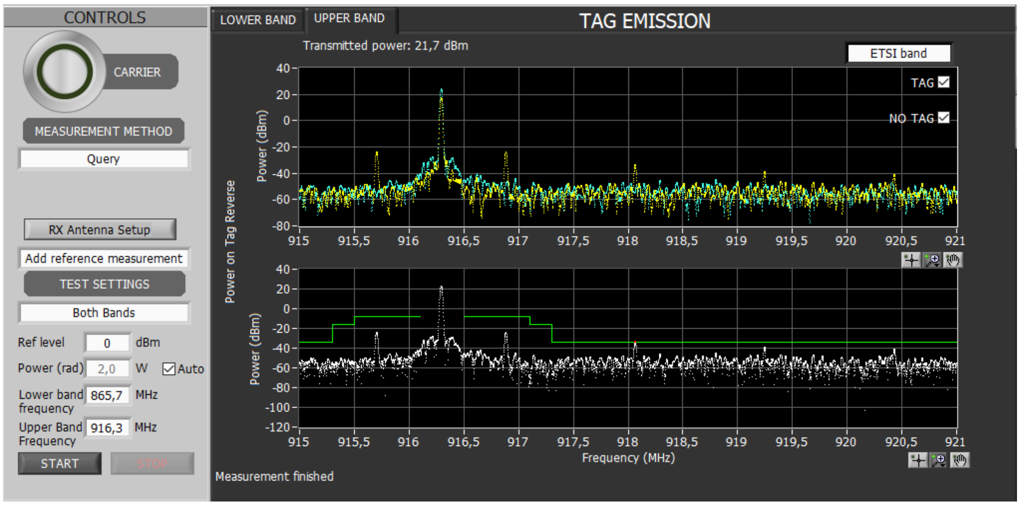


Figure 121.Real-time spectrum analyzer enables investigation of tag backscatter spectrum and unwanted emissions on a wider frequency band.

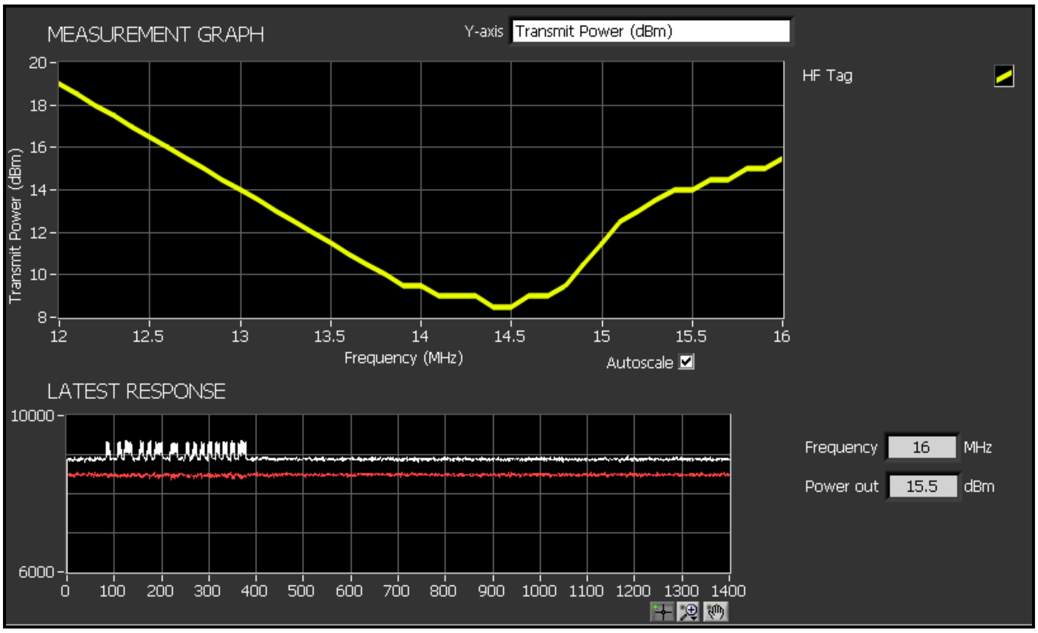
17.11 HF RFID Threshold

Ensure the selected protocol is supported by the tag you are using. Then define the sweep settings. The frequency step and the power level steps affect the speed of the measurement cycle.

Once you have made these settings, click the *START SWEEP* button, and the Carrier LED will be lit on the measurement unit. TX and RX LEDs indicate how the tag responds to the sent command. The graph is plotted at each frequency point as the function proceeds.

Once the sweep is finished, the Carrier LED will turn off. You can interrupt the measurement anytime by clicking the *STOP SWEEP* button.

Below you can see an example of a successful Working Range measurement result.



17.12 Passive

Before you can start using the Passive measurement tool, a few important things need to be done: The Calibration and the Reference Measurement. The measurement flow can be seen in Figure 122.

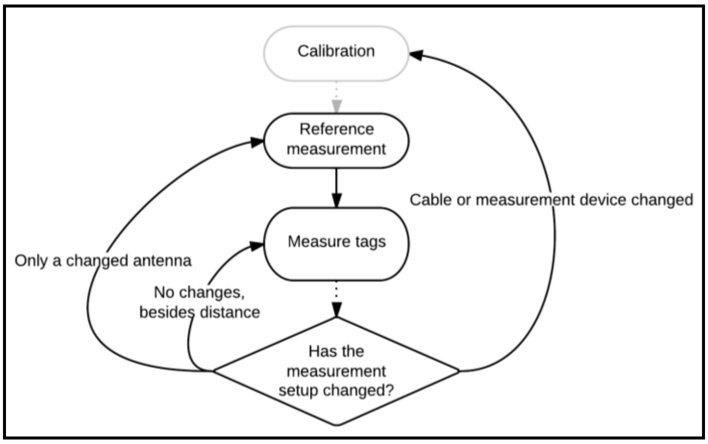


Figure 122.HF RFID Passive measurement flow

17.12.1 Calibration

System calibration is required to account for the effect of the connected cables and connections between the measurement unit and the measurement antenna. Therefore, calibration is needed only when an RF cable, adapters connected to it, or the measurement unit itself are changed. Please use the 50 Ohm terminator included in the Tagformance Pro HF kit for correct calibration. Disconnect the RF cable from the RX port of the device and connect the 50 Ohm terminator to the other end of the RF cable.

1. Select the Passive measurement from the Measurement menu.
2. If a “Reference Measurement” window pops up, click *CANCEL*.
3. Click *CALIBRATE*. The *Passive Calibration* dialog will appear; please follow the instructions.
4. Once the calibration has finished, the dialog will be closed.

17.12.2 Reference Measurement

The reference measurement is required to characterize the measurement antenna. It is suggested to run the reference measurement always after the measurement antenna has been changed or before you start measuring for the first time in a while. The reference data is used to calculate the normalized units where the effect of the test antenna has been subtracted. Connect the RF cable to the measurement antenna.

1. Click *MEASURE REFERENCE*.
2. The *Reference Measurement* dialog appears. Give a name to the reference data, click OK, and follow the instructions.
3. The dialog will be closed once the Reference Measurement has finished.

It is recommended to verify the HF RFID Measurement Setup with the reference tag as a final step.

17.12.3 Passive Measurement

Make sure that the Calibration and the Reference Measurement have been done. Then, place your tag on top of the measurement antenna or a tag holder. Align the tag so that it is in the middle of the alignment marks. Define the Sweep Settings and click *START SWEEP*.

When the measurement starts, the Carrier LED will light, and the TX and RX LEDs will indicate how the tag responds to the sent command.

Once the measurement is completed, the Carrier LED will turn off, and the result can be read on the graph. You can interrupt the measurement anytime by clicking the *STOP SWEEP* button.

In Figure 123 is an example of a successful passive measurement result. This measurement used an ID1-size HF Tag with the Voyantic C145 antenna.

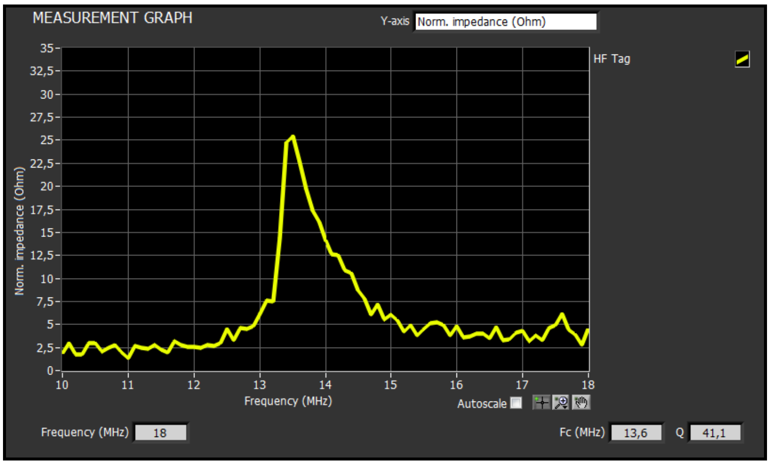


Figure 123.Successful passive measurement result

The Y-axis unit can be changed from the drop-down menu labeled *Y-axis.*

When the *Norm. Impedance (Ohm)* unit is selected, and the software automatically calculates the resonance frequency, Fc, and Q-factor and indicates them below the main graph.

The most commonly used Y-axis units	
S11	Depicts the matching seen at the end of the measurement cable. It includes the measurement antenna and the effect that the measured tag has on the system.
Impedance (Ohm)	Impedance at the end of the measurement cable.
Norm.impedance	It is “normalized impedance” and depicts the impedance

(Ohm)	effect that the measured tag influences. Normalized impedance utilizes the Reference Measurement data (reference point) to deduct the effect of the measurement antenna from the overall measured impedance, thus resulting in the effect that the tag influences.

17.13 Working Range

Using the Working Range measurement requires that you have the Distance Control Kit (Chapter 5.11).

Make sure that the tag you are using supports the selected protocol. Then, define the sweep settings. The frequency step and the power level step affect the speed of the measurement cycle. Click *START SWEEP*.

When the measurement starts, the Carrier LED will light up, and the TX and RX LEDs will indicate how the tag responds to the sent command. The measurement distance will be automatically adjusted during the measurement.

Once the measurement has reached its final measurement distance, the actuator will return to the start distance, and the Carrier LED will turn off.

Below you can see an example of a successful Working Range measurement result.

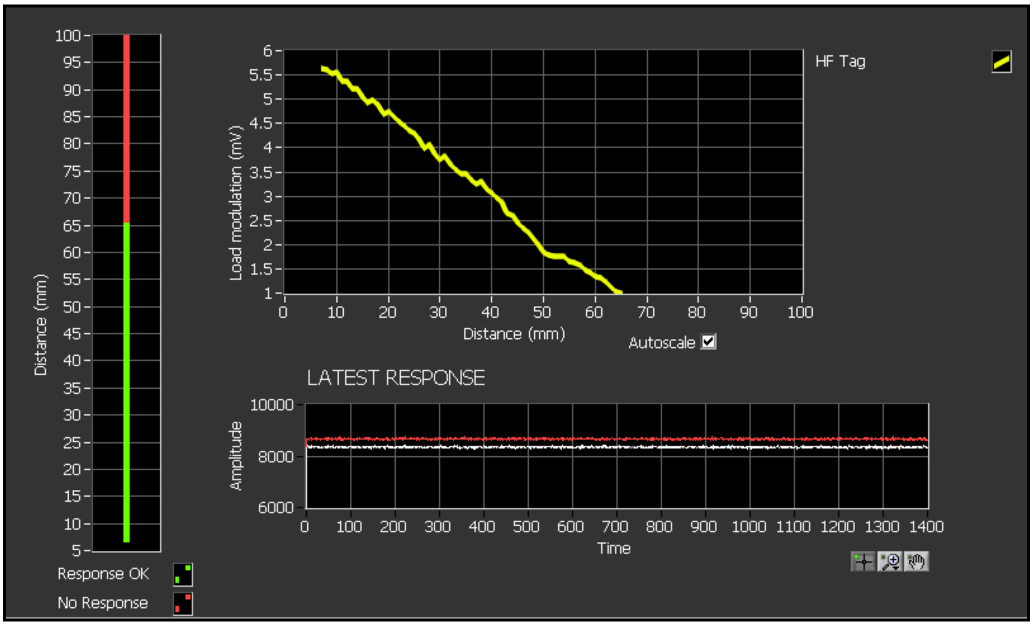


Figure 124.Example of successful Working Range measurement result

18 Tagformance System Information

18.1 Standard and Wideband Measurement Frequency Range

The standard UHF measurement range is 800–1000 MHz, and the wideband measurement range is 600–1300 MHz.

The HF measurement range is 10–30 MHz.

18.2 Extended Protocol Support

The standard UHF protocol the Tagformance Software supports is EPC Class1 Gen2 (ISO 18000-6C). However, other protocols are also offered as add-on options. The additional protocols currently include ISO 18000-6B, GB/T20678, Siniav, and Tag-Talks-Only.

The supported HF protocols are: IS015693, ISO14443 A/B, Sony Felica, ISO18000-6 and Tag-Talks-Only

18.3 Warnings and Errors

18.3.1 General Error Handling

The Software is designed to recover from most errors that may occur between and during measurements. However, if something unexpected happens, the Software will display one of the two warning dialogues below and enter demo mode. In the demo mode, measuring is disabled, but the user may still save the measurement results before restarting the Software. The Software also saves a description of the occurred error into a file named *error.log* in the *Data* folder of the Software. If the error repeats itself, please attach the generated *error.log* file to the email that you send to ***support@voyantic.com***. This will make troubleshooting significantly faster.

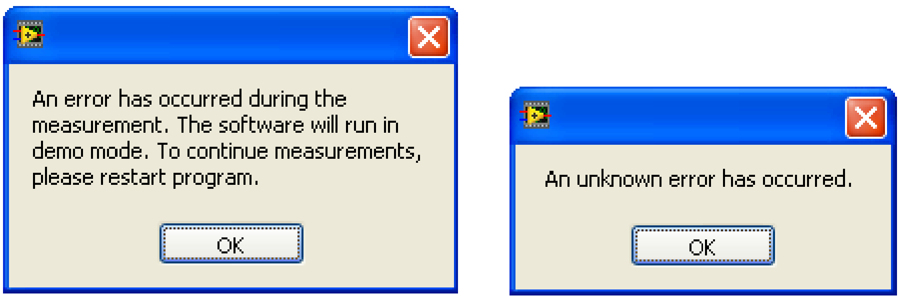


Figure 125.Error popups

18.4 System information in the About dialog

The About dialog can be found in the Help menu. It shows the current Tagformance software version, the firmware version installed on your Tagformance Pro device, the calibration date, and the options listing of the license in use.

If you're asked for the installation ID, you can make it visible by clicking Show ID. If the user has opted in with Voyantic services and provides this ID for Voyantic customer support, it can be used to associate telemetric data with the device.

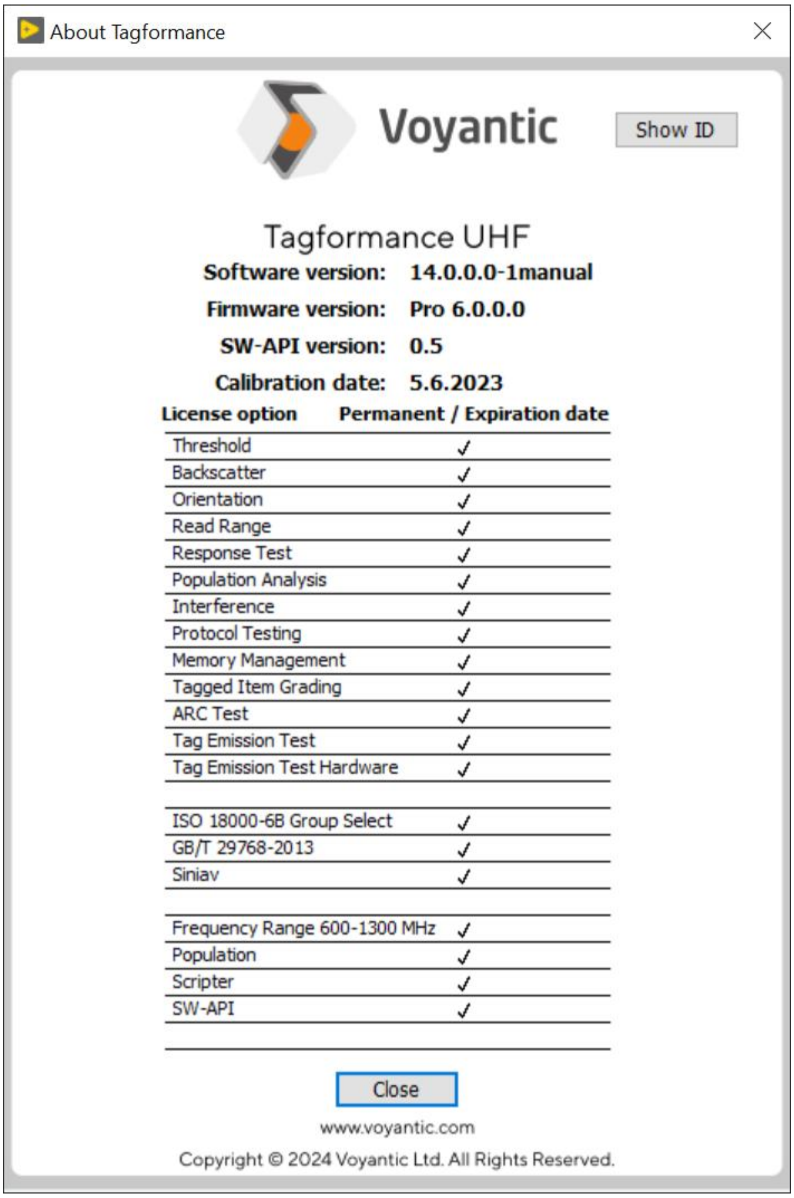


Figure 126.About Dialog

18.5 Demo Mode

When the Tagformance Pro Measurement Device is disconnected, the Tagformance Software operates in demo mode. In this state, measurement results and setup files may be handled.

18.6 Temporary Measurement File

The Tagformance Software stores all measurement results from the measurement list in a temporary data file named *temporary.dat* in the *Data* folder. The content of the temporary file is loaded every time you start up the Tagformance Software. The temporary file is cleared only when the measurement list is cleared.

18.7 Calibrating

Please contact the manufacturer for calibration procedure instructions.

19 Licensing

The manufacturer supplies a license file that activates the Measurement System. This file must be located in the Tagformance\Data –folder. The file name will include the word license, and it will have a .dat file extension. The file cannot be altered in any way.

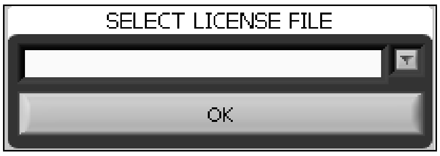


Figure 127. License file dialog for selecting a specific license file

If the *Data* folder contains multiple valid license files, a dialog will be displayed as the Tagformance program starts. All valid license files will be shown in the drop-down list.

Typically, the license file will contain the calibration data of the specific Device. If the license file does not include the calibration information, an external calibration.dat file from the *Tagformance\Data* folder will be used.

The license management in Tagformance Software monitors the date of the used computer. If the date is shifted backward, the license file will be locked. In this event, please contact your local distributor or Voyantic support to resolve the issue.

20 Troubleshooting

Tagformance Pro Measurement Unit Does Not Start

Check the power cord, the power supply, and all the connections.

Tagformance Program Does Not Start

Ensure the Measurement Unit is powered up (green round LED is illuminated) and connected to the computer. Check that the Tagformance\Data folder includes a license.dat file.

If Tagformance does not work properly and you are using NOD32 Anti-Virus Software, disable “Automatically detect HTTP communication on other ports” in the NOD32 IMON Setup, make sure port 3580 is not in the list of ports above the setting, and restart your computer.

This problem may arise with other Anti-Virus Software as well. Try disabling the Anti-Virus Software to check if it is causing unexpected runtime problems for the Software.

The software jumps into the viewer mode right after the start or during the measurement

If you are using a laptop computer on battery, check the advanced power options and turn the maximum power saving off. For example, having the PCI Express Link State in power-saving mode may cause problems.

WiFi connection may cause problems, so it is better to connect a computer directly to the device via crossover Ethernet cable.

There Are Large External Signals in the ‘Latest response’ Graph (See figure)

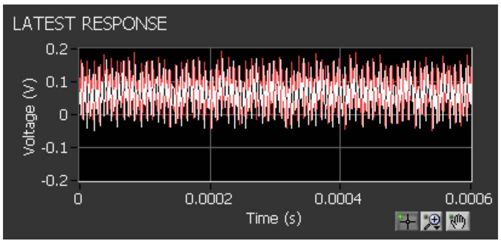


Figure 128.External signals in the response

There may be a transmitting RFID reader nearby. If this is the case, the external signals are present only in a frequency range of approximately 10 MHz. Try to change location, wait for the situation to change, disable the reader, or skip the affected frequencies.

There Is a Lot of Distortion in the ‘Latest response’ Graph (See figure)

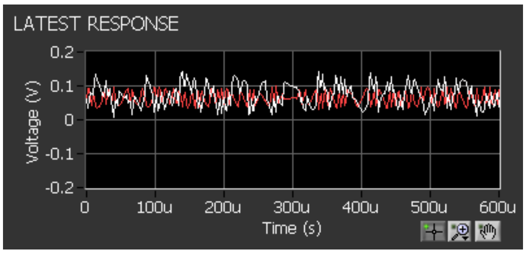


Figure 129.Distortion in the response signal

Other transmitters may be nearby. Typically, this is the case if a GSM base station is nearby and the measurement room is not adequately shielded against external interference. Try to change location or skip the affected frequencies.

There Are Multiple Responses in the ‘Latest Response’ Graph (See figure)

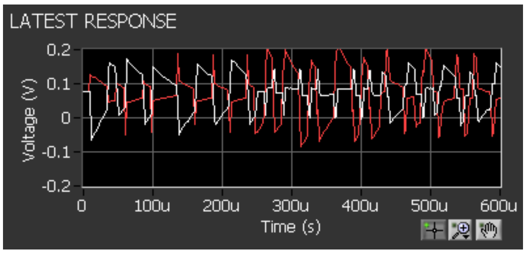


Figure 130.Multiple responses

At least two tags are powered and responding to the command. Try to locate the extra tag(s) and place them out of the measurement system's range or in another polarization angle. The population management toolkit can also access individual tags.

Backscatter Signal Strength Is Too High (See figure)

The problem is recognized from the signal being ”cut”. See the upper part of the red channel graph in the image below.

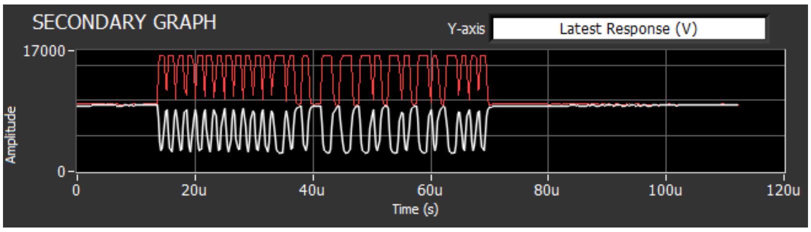


Figure 131.Multiple responses

The problem may occur with short measurement distances, especially if connectorized tags are used (no free air path loss).

To solve the problem, add attenuation either in front of the TX port or between the circulator and antenna (or connectorized tag).

Cannot Open Measurement File

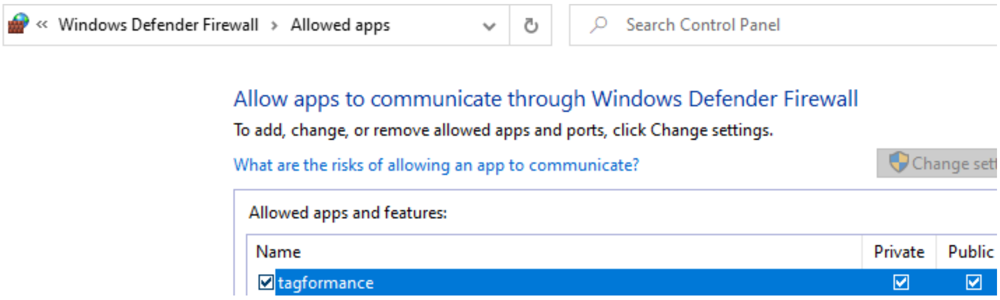
If a measurement file has been opened with MS Excel and resaved in a format other than tab-limited text, the file format is no longer recognized by the Tagformance Measurement Program. Make a copy of the files before opening them in Excel.

Fonts in Plot Legend etc. Are Black / Non Suitable Color

This problem occurs with certain Windows themes. Changing the Windows theme / font color form in the appearance section of Windows should help with this problem.

Tagformance software does not find or cannot connect to the device

First, check that the Ethernet cable is properly connected and the device is powered up. Then make sure the network settings are configured correctly (see Chapter 5.4 for details). Finally, device discovery may also be problematic if Windows Defender is blocking the software's operation. To fix that, the user must allow Tagformance in Windows Defender settings.



Appendix A: Technical Specifications

A.1 Environmental Conditions

The Tagformance Pro Measurement Unit is designed for indoor use only in typical office-like conditions. Specifications in this document apply under the environmental conditions specified in the table below.

Exceeding the given conditions may result in test accuracy degradation, shortened lifespan of the device, device malfunction, or permanent damage to the unit. Also, strong mechanical stress or vibration may affect the measurement results and even cause defects in the unit.

Parameter	Value	Unit
Ambient temperature range[1,2,3]	15 to 30 59 to 86	C F
Relative humidity[4,5]	Non-condensing 30 to 80	 %

[1] Measured at 5 cm distance from Tagformance Pro back panel.

[2] Altitude decreases natural heat convection and affects the cooling of the device. Maximum ambient temperature is reduced by 1 degree for each 300m at above 700m above sea level. E.g., at 1000m, the maximum ambient temperature during operation drops by 1°C.

[3] Tagformance Pro should never be installed or operated in an airtight container to avoid heat building up. The user is required to ensure adequate ventilation or enough free air space around the device to allow proper cooling of the device.

[4] Tagformance Pro is not tested for performance against extremes. The given range is considered typical in office-like environments. If only the humidity level stays non-condensing, it is not expected to create issues after the device has warmed up.

[5] Tagformance Pro should not be exposed to high humidity, water, or snow during operation, storage, or transportation to avoid damage to the device.

Device storage and transportation

Tagformance Pro should be stored in non-condensing conditions. The original plastic Tagformance Pro carrying case should be used to protect the unit from temperature variations, moisture, and damage caused by possible mechanical shocks, e.g., during transportation and storage.

Other remarks

The unit is not designed or type-approved for use in the medical or aerospace industries.

A.2 Mechanical Specifications

The Tagformance Pro Measurement Unit is enclosed in an aluminum enclosure.

The signal connectors and indicator LEDs are located at the front of the casing.

The backside of the casing includes the network connector, power connector, and IO connector.

A.2.1 Hardware version 2.x

A.2.1.1 Mechanics

Parameter	Typical value	Unit
Dimensions	190 x 90 x 222 7.5 x 3.6 x 8.8	mm inch
Weight	3.3 7.3	kg lbs

A.2.1.2 Connectors

Parameter	Connector type
RF connectors (UHF TX, UHF RX, HF TX, HF RX)	4 x N
PC interface (Ethernet)	RJ45
Digital Analog I/O	DA-15 (female)
Power connector, 18–24 VDC, 3A	5.5/2.1 mm

A.2.1.3 Buttons and LEDs

The power button on the front panel
The power LED on the front panel
Ready LED
Activity LED

A.2.2 Hardware version 1.x

A.2.2.1 Mechanics

Parameter	Typical value	Unit
Dimensions	185 x 90 x 225 7.3 x 3.6 x 8.9	mm inch
Weight	3.4 7.5	kg lbs

A.2.2.2 Connectors

Parameter	Connector type
RF connector (UHF TX, UHF RX, HF TX, HF RX)	4 x N
PC interface (Ethernet)	RJ45
Digital Analog I/O	DB-25 (female)
Serial port, RS232 (RFU)	DE-9 (female)
Power connector, 18 VDC, 5A	5.5/2.1 mm

A.2.2.3 Buttons and LEDs

The power button on the front panel
The power LED on the front panel
Carrier LED
Transmit LED
Receive LED
Status 1 LED (UHF mode)
Status 2 LED (HF mode)

A.3 Electrical Specifications

The electrical specifications are valid for the specified Environmental Conditions unless otherwise stated.

A.3.1 Power Supply

External Power Source

The Tagformance Pro Measurement Unit uses an external +18V power supply. The typically provided supply is Edacpower EA10951D by Edac Power Electronics Co., Ltd.

Other power supplies may be supplied to some countries, depending on the stock availability.

Power consumption

Parameter	Value
UHF mode, maximum power consumption	30W
HF mode, maximum power consumption	22W

Important notes

Interference coupled via external power supply can affect the performance of the device. Make sure to utilize a high-quality power supply with Tagformance Pro.

A.4 UHF RF Generator

The RF generator includes means for both creating a carrier signal and modulating it with an arbitrary waveform. The specifications for the carrier and modulation are presented below.

A.4.1 Carrier Specifications

Parameter	Typical value	Unit
Frequency range - RAIN RFID operation band - Standard - Wideband	 860 to 960 800 to 1000 600 to 1300	 MHz MHz MHz
Frequency resolution	100	kHz
Frequency accuracy	±50 [1]	ppm
Output power, max - RAIN RFID operation band - Standard - Wideband • 800…1000 MHz • 600…1200 MHz • 1200…1300 MHz	 +30 +30 +30 +27 +21	 dBm dBm dBm dBm dBm
Output power, min	-20	dBm
Output power resolution	0.1	dB
Output power absolute accuracy	±1	dB
Output impedance	50	Ω

[1] Omitted from component manufacturer's datasheet.

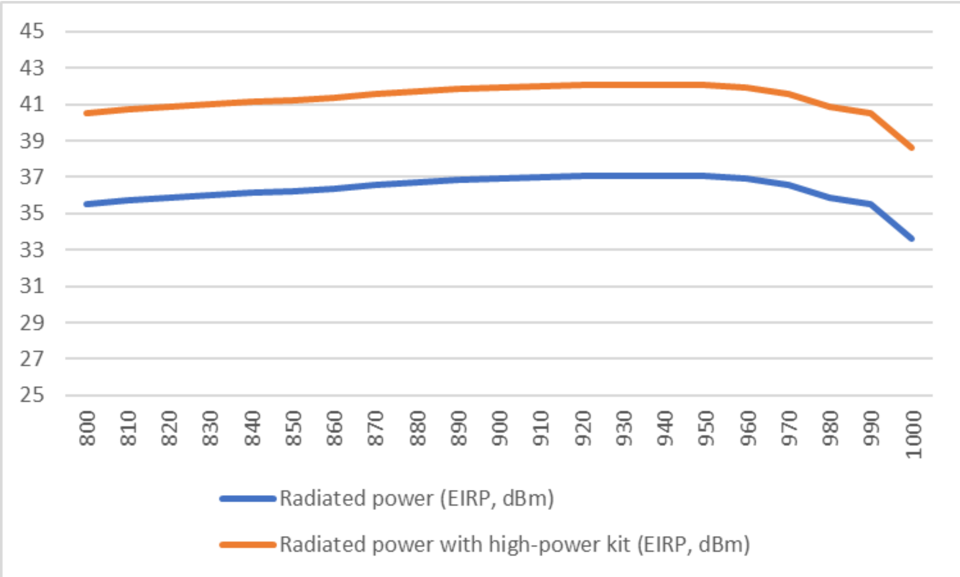
A.4.2 Modulator Specifications

Parameter	Typical value	Unit
Modulation modes	DSB-ASK	

A.4.3 Typical Power Output

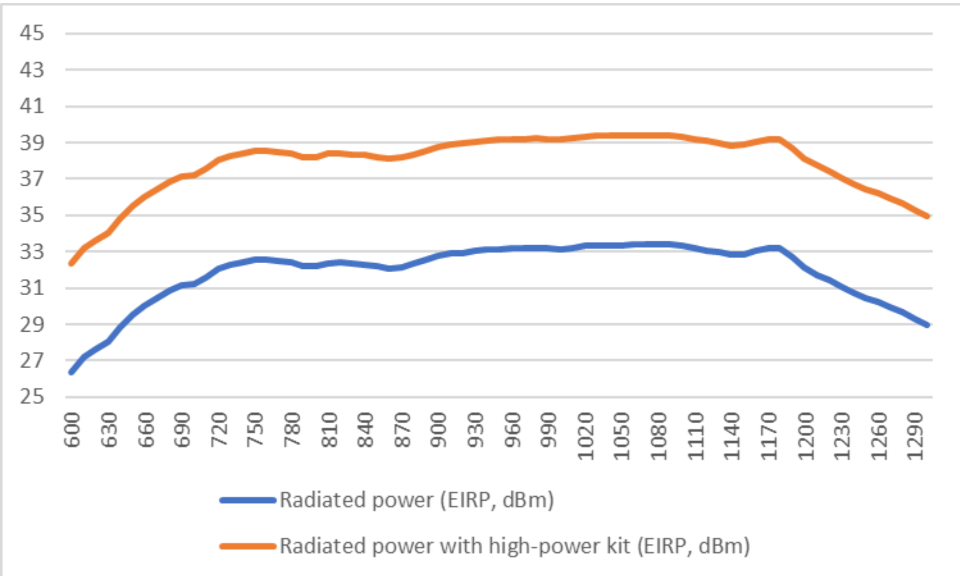
Maximum radiated power with Standard setup

Typical maximum radiated power with standard Tagformance Pro setup (TF-Pro v1.2.1) with and without a high-power amplifier. Cable losses are assumed to be 1,5dB, the circulator causing 0,1dB forward loss in the normal setup, and the coupler causing 1,1dB of forward loss in the high power setup. The gain of the amplifier setup is 6dB.



Maximum radiated power with Wideband setup

Typical maximum radiated power with wideband Tagformance Pro setup (TF-Pro v1.2.1) with and without a high-power amplifier. Cable losses are assumed to be 1,5dB, and coupler causes 1,1dB of forward loss. The gain of the amplifier setup is 6dB.



A.5 UHF RF Receiver

The UHF RF receiver includes means for retrieving the backscattered signal waveform from the reflected carrier. The detailed specifications are presented below.

Parameter	Value	Unit
Absolute maximum input power[1] - peak power - continuous	 +28 +18	 dBm dBm
Recommended maximum input power[2]	+12	dBm
Sensitivity - receiver noise floor[3] - minimum backscatter for Query-based tests[4,5] - minimum backscatter for Inventory-based tests[4,5]	 <-85 (typ.) -76 to -89 (typ.)[6] -62 to -70 (typ.)[7]	 dBm dBm dBm
Input impedance	50	Ω

[1] Exceeding the maximum port power affects device performance and may cause permanent damage in the worst case. Use caution when applying external instrumentation, such as a power amplifier, with the setup.

[2] The receiver's linear operation range is limited to +12dBm. Exceeding this range may affect the device's accuracy and performance. For optimal performance, an external 6dB attenuator is recommended at the receiver port when the transmit power is above +25dBm.

[3]. An anechoic chamber is recommended to reduce interference from other systems and reflections from the environment.

[4] The minimum backscatter level for successful detection and decoding of the tag response depends on the environment, test performed, communication protocol, test command used, and link speed.

[5] Query-based tests require less backscatter than Inventory-based tests since real-time decoding of the tag's response is not needed, which makes the test less susceptible to noise.

[6] Tested in a setup with standard Tagformance setup, in C50 measurement chamber, with +12dBm transmit power, using Query command with different modulation settings and link speeds.

[7] Tested in a setup with standard Tagformance setup, in C50 measurement chamber, with +12dBm transmit power, using Read command with different modulation settings and link speeds.

A.6 HF RF Generator

The RF generator includes means for creating a carrier signal and modulating it with an arbitrary waveform. The specifications for the carrier and modulation are presented below.

A.6.1 Typical Performance Values

Parameter	Typical value	Unit
Active meas. Frequency range	10 to 30	MHz
Passive meas. Frequency range	10 to 30	MHz
Frequency resolution	10	kHz
Frequency accuracy[1]	±25[1]	ppm
Output power	-10 to +25	dBm
Output power resolution	0.1	dB
Output power absolute accuracy	±1	dB
Output impedance	50	Ω

[1] Omitted from component manufacturer's datasheet.

A.6.2 Modulator Specifications

Parameter	Typical value	Unit
Modulation type	Vector I/Q Modulator	
Modulation depth	0 to 30	dB
Modulation waveform resolution	10-bit	
Modulation waveform sample rate	500 – 30 000	kS/s

A.7 HF RF Receiver

The RF receiver includes means for retrieving the backscattered signal waveform from the reflected carrier. The detailed specifications are presented below.

Parameter	Value	Unit
Absolute maximum input power[1] - peak power - continuous	 +26.5 +25	 dBm dBm
Recommended maximum input power[2]	+12	dBm
Waveform sampling resolution	14-bit	
Waveform sampling rate	500 - 4000	kS/s
Input impedance	50 typ.	Ω

[1]. Exceeding the maximum port power affects device performance and, in the worst case, may cause permanent damage. Use caution when applying external instrumentation with the setup.

[2] The receiver's linear operation range is limited to +12dBm. Exceeding this range may affect the device's accuracy and performance.

A.8 Suggested Measurement Antenna Operating Ranges

Antenna	Start Frequency (MHz)	Stop Frequency (MHz)
C60	12	16
C145	10	18

A.9 UHF RFID Protocol Support

The measurement system includes a basic version of the EPC Class1 Gen2 protocol described below. Different protocols and data rates can be introduced through Measurement Software. Current optional protocols are also described below.

ISO 18000-6C (EPC Class 1 Gen2)	**Forward link**	**Return link**
Query Read Write Custom commands Select (w. Command)	DSB-ASK, Tari: 25 µs	40kHz FM0
	DSB-ASK, Tari: 6,25 µs	320kHz FM0
	DSB-ASK, Tari: 6,25 µs	640kHz FM0
	DSB-ASK, Tari: 6,25 µs	320kHz Miller 4
Query+ACK Select (w. Command)	DSB-ASK, Tari: 12,5 µs	320kHz Miller 4

ISO 18000-6B	**Forward link**	**Return link**
Group Select	40 kbps Manchester	40kbps FM0

GB/T20768-2013	**Forward link**	**Return link**
Query Read Write	Tc: 6,25µs	64kHz FM0, pilot tone

Siniav (Uses ISO-18000-6C, 320 kBps FM0)	**Forward link**	**Return link**
Query	DSB-ASK, Tari: 6,25µs	320kHz FM0

Tag-talks-only (e.g., ISO18000-6D)	
Tagformance sets carrier on and seeks to detect a tag response at the receiver within a predefined time window. - Detection window size: 10-250ms (user-defined) - Response burst length: 0,2-100ms (user-defined, smaller than window size)	

A.10 HF Protocol Support

The measurement system supports the most commonly used HF RFID protocols. The different protocols and data rates can be selected from the measurement software.

Parameter	Value
Supported protocol	ISO 15693
Forward link	fc/512 ASK; fc/8192
Return link	fc/2048 Manchester; fc/512
Modulation index	0% - 100%
Supported commands	Inventory, write single block, read single block

Parameter	Value
Supported protocol	ISO 14443A
Forward link	fc/128 ASK
Return link	fc/16 OOK Manchester
Modulation index	0% - 100%
Supported commands	REQA NFC Type 2 read NFC Type 2 write

Parameter	Value
Supported protocol	ISO 14443B
Forward link	fc/128 ASK
Return link	fc/16 OOK Manchester
Modulation index	0% - 100%
Supported commands	REQB ST25TB Read_Block

Parameter	Value
Supported protocol	FeliCa
Forward link	Fc/64 ASK Manchester
Return link	Fc/64 ASK Manchester
Modulation index	0% - 100%
Supported commands	Polling

Parameter	Value
Supported protocol	ISO 18000-3M3
Forward link	fc/339 ASK
Return link	fc/32 FM0
Modulation index	0% - 100%
Supported commands	BeginRound

Parameter	Value
Supported protocol	Tag-Talks-Only
Forward link	N/A
Return link	N/A
Modulation index	N/A
Supported tags	PR1101

Appendix B: Tagformance Measurement Units

B.1 Forward Link Units

Transmitted Power

This is the transmitted unmodulated RF carrier power at the Device *OUT* port.

Power On Tag Forward

$$P_{tag} = P_{EIRP}\left(\frac{c}{4\pi fR}\right)^2 = P_t\left[dBm\right] - L_{cable}\left[dB\right] + G_t\left[dB\right] - FSPL\left[dB\right]$$

R is the distance from the antenna to tag [m]

c is the speed of light at 299792458 m/s

FSPL is the free space loss

Electric Field Strength

$$E\ [V/m] = \frac{1}{R}\sqrt{\frac{P_{EIRP}R_0}{4\pi}}$$

R_0 is the impedance of free space at 377 Ω

Theoretical Read Range Forward

$$R_{\max} = \sqrt{\frac{P_{\max,EIRP}}{P_{tag}}}\cdot\frac{c}{4\pi f}$$

$P_{\max,EIRP}$ is the maximum allowed transmit power defined as EIRP power
The default value used is 3.28 W
For countries that allow 4.00 W EIRP, please add 11% to the results

Backscatter, Link Budget – Forward link

The forward link margin plot is calculated based on $P_{TF,TH}$ which is Power On Tag Forward threshold value. The value of $P_{TF,TH}$ remains the same regardless of the measurement distance.

Margin FL $\left[dB\right] = P_{tx} + G_{txAnt} - FSPL\left[d\right] - P_{TF,TH}$

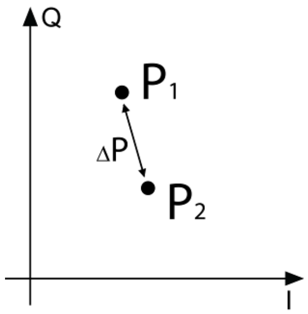
$$FSPL\left[dB\right] = 20\log_{10} R\left[m\right] + 20\log_{10} f\left[MHz\right] - 27.55$$

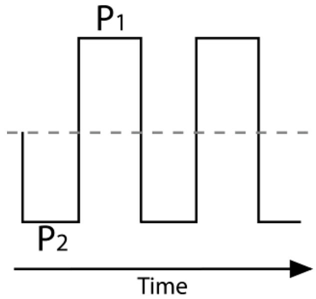
B.2 Reverse Link Units

Backscattered Power

This is the received RF signal power of the tag backscatter measured at the Device *IN* port. The unmodulated (bias) carrier power level at the IN port does not influence the reading.

The backscattered power is calculated from the two complex power levels P1 and P2 between which the backscatter modulation occurs. The backscattered power is the magnitude of the complex amplitude (P_{BS}=0.5*ΔP) of the receiver.





Backscatter, Link Budget – Reverse link

The forward link margin plot is calculated based on $P_{TR,TH}$, which is the Power On Tag Reverse threshold value. The value of P_{TR} depends on the measurement distance (*d*).

$$\text{Margin RL}\left[dB\right] = S_{RX} + G_{RX\ ANT} - FSPL\left[d\right] - P_{TR,TH}$$

$$FSPL\left[dB\right] = 20\log_{10} R\left[m\right] + 20\log_{10} f\left[MHz\right] - 27.55$$

Power on Tag Reverse

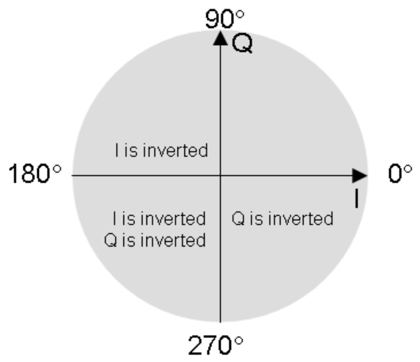
Power on Tag Reverse is the effective backscatter transmit power (EIRP) of the tag when answering to a reader command. It is calculated from the Backscatter Power:

$$P_{tag,BS}\left[dBm\right] = P_r\left[dBm\right] + L_{cable}\left[dB\right] - G_r\left[dB\right] + FSPL\left[dB\right]$$

$$FSPL\left[dB\right] = 20\log_{10} R\left[m\right] + 20\log_{10} f\left[MHz\right] - 27.55$$

Backscattered Signal Phase

This is the angle between the **I** and **Q** channels in the quadrature detector of the receiver.



DeltaRCS

$$\Delta RCS = \frac{2P_{EIRP,BS}}{P_{EIRP}} \cdot \frac{(4\pi)^3 f^2 R^4}{c^2}$$

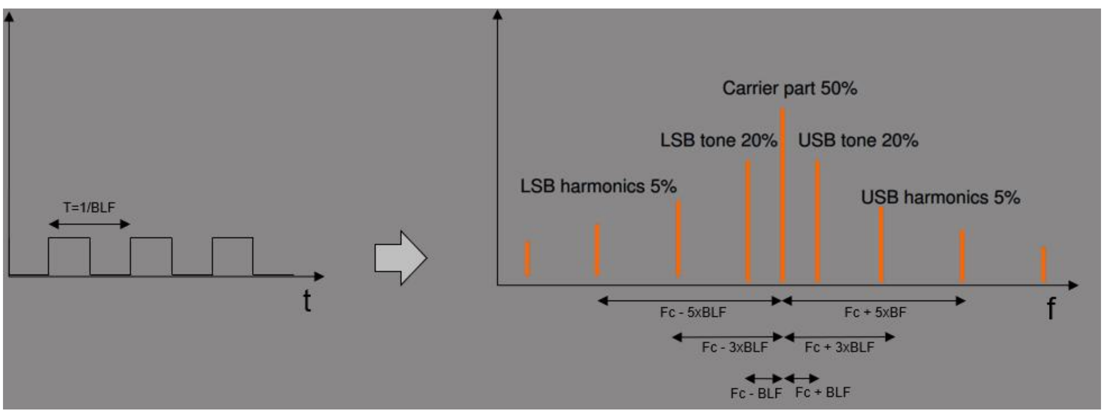
Theoretical Read Range Reverse

The *theoretical read range reverse* is a measurement specified by the EPC global. It can be easily understood in the following way; 1) Assume separate transmit and receive antennas. 2) Set the transmit power to the maximum allowed. 3) Move the transmit antenna as far away from the tag as possible while still activating the tag. 4) Move the receive antenna to the maximum distance where a reader with a receiver sensitivity of -70 dBm and an antenna gain of 4dBi will barely pick up the signal of the tag; this is the read range reverse.

$$R_{\max,BS} = \sqrt{\frac{P_{tag,BS}}{P_{EIRP,BS,limit}}} \cdot \frac{c}{4\pi f}, \qquad P_{EIRP,BS,limit} = -74dBm = 40pW$$

B.3 Backscatter Signal Power Spectrum and Definitions

Assuming the tag reply is an ideal square wave, its distribution into spectral components may be extrapolated from the carrier frequency and backlink frequency. From this distribution, the different backscatter definitions may be calculated.



The Voyantic backscatter definition sums the whole spectrum power, i.e., contains 100% of the power.

The GS1 definition for Backscatter considers only both side tones as the backscatter strength, i.e., 40% of the total power. According to the July 2017 release of the Tagged-Item Performance Protocol (TIPP) Tagged Item Grading: Testing Methodology Guideline, the backscatter power may calculated as follows:

$$P_{BS\,GS1}[dB] = P_{total}[dB] - 10\log 0.4\,[dB] \sim P_{total}[dB] - 4[dB]$$

The signal backscatter definition of ETSI EN 302 208 considers the stronger of the tones as the backscatter power. The backscatter power defined in ETSI EN 302 208 can be calculated as follows:

$$P_{BS\,ETSI}[dB] = P_{total}[dB] - 10\log 0.2\,[dB] \sim P_{total}[dB] - 7[dB]$$

Note: This calculation is valid if the assumption can be made that the side tones are symmetrical, as the stronger tones are considered for the calculation.

For the Tag Emission measurement's TX power and the ETSI limit in the Backscatter measurement, the conversion from ERP to EIRP needs to be made:

$$P_{EIRP}[dB] = P_{ERP}[dB] + 2.15$$

Example: $P_{EIRP}[dB] = 10 \times \log(2\,[W]) + 30 + 2.15 = 35.16\,[dBm]$

Appendix C: Scripter Commands

The scripter commands, their attributes, and script variable names are **not case-sensitive**.

C.1 Measurement Configuration Commands

MEASUREMENT - Change measurement program

MEASUREMENT THRESHOLD

MEASUREMENT BACKSCATTER

MEASUREMENT ORIENTATION

MEASUREMENT READRANGE

MEASUREMENT POPULATION

MEASUREMENT RESPONSETEST

MEASUREMENT MEMORYMANAGEMENT

COMMAND - Change measurement command (Query, Read, …)

COMMAND Query = [Query]

COMMAND QueryM4320 = [Query, M4 320k BLF]

COMMAND WriteTest = [Write]

COMMAND WriteTestM4320 = [Write, M4 320k BLF]

COMMAND ReadTest = [Read]

COMMAND ReadTestM4320 = [Read, M4 320k BLF]

COMMAND Query+ACKM4320 = [Query+ACK, M4 320k BLF]

COMMAND GroupSelect = [ISO 18000-6B Group Select]

COMMAND TagTalksOnly = [Tag-Talks-Only]

To change the backlink frequency, append 320 or 640 to the measurement command.

Commands that support BLF change: Query, WriteTest, and Readtest

QUERYCHECKANSWER – Verify that query answer contains 16 bits, applicable only to query command

QUERYCHECKANSWER TRUE

QUERYCHECKANSWER FALSE

QUERYAVERAGINGMODE – Set behavior for averaging

QUERYAVERAGINGMODE OFF

QUERYAVERAGINGMODE FIXED

QUERYAVERAGINGMODE ADAPTIVE

QUERYAVERAGINGCOUNT – Set number of repetitions for averaging [10;100], increments of 10

QUERYAVERAGINGCOUNT 10

QUERYAVERAGINGCOUNT 50

READTESTSETTINGSMEMORYBANK – Set the memory bank for the readtest.

READTESTSETTINGSMEMORYBANK Reserved

READTESTSETTINGSMEMORYBANK EPC

READTESTSETTINGSMEMORYBANK TID

READTESTSETTINGSMEMORYBANK User

READTESTSETTINGSWORDPOINTER – Set the read location in hex for readtest.

READTESTSETTINGSWORDPOINTER 0

READTESTSETTINGSWORDPOINTER A

READTESTSETTINGSWORDCOUNT – Set the number of words for the readtest to 0 to read the whole memory.

READTESTSETTINGSWORDCOUNT 0

READTESTSETTINGSWORDCOUNT 10

READTESTSETTINGSDATAPOINTER – Set the start location for the readtest result data in bits.

READTESTSETTINGSDATAPOINTER 0

READTESTSETTINGSDATAPOINTER 25

READTESTSETTINGSDATACOUNT – Set the length of readtest return data in bits.

READTESTSETTINGSDATACOUNT 16

READTESTSETTINGSDATACOUNT 96

READTESTSETTINGSDATALASTWORD – Set readtest return data to be the last word of the data, overrides *READTESTSETTINGSDATAPOINTER*, *READTESTSETTINGSDATACOUNT* if set to TRUE.

READTESTSETTINGSDATALASTWORD TRUE

READTESTSETTINGSDATALASTWORD FALSE

WRITETESTSETTINGSMEMORYBANK – Select the memory bank for the writetest.

WRITETESTSETTINGSMEMORYBANK Reserved

WRITETESTSETTINGSMEMORYBANK EPC

WRITETESTSETTINGSMEMORYBANK TID

WRITETESTSETTINGSMEMORYBANK User

WRITETESTSETTINGSWORDPOINTER – Set the read location in hex for writetest.

WRITETESTSETTINGSWORDPOINTER 0

WRITETESTSETTINGSWORDPOINTER A

WRITETESTSETTINGSADDRESSMODE – Select the way writetest uses *WRITETESTSETTINGSWORDPOINTER.* Incremental uses a step size of 1 word.

WRITETESTSETTINGSADDRESSMODE static

WRITETESTSETTINGSADDRESSMODE incremental

WRITETESTSETTINGSDATA – Set the data in hex to write for writetest; it must be 4 characters long.

WRITETESTSETTINGSDATA 1010

WRITETESTSETTINGSDATA ABEF

WRITETESTSETTINGSDATAMODE – Select how writetest uses *WRITETESTSETTINGSDATA.*

WRITETESTSETTINGSDATAMODE static

WRITETESTSETTINGSDATAMODE random

SELECT - Set the select ON/OFF and change the selection parameters. (ISO 18000-6C commands)

SELECT TID+EPC

SELECT TID

SELECT EPC

SELECT OFF

CARRIERBEFORECOMMAND – Set the carrier before command time in milliseconds

CARRIERBEFORECOMMAND 2.5

CARRIERBEFORECOMMAND 100

FREQUENCY - Set point frequency in MHz (Backscatter, Orientation, Response Test, Population)

FREQUENCY 866

FREQUENCY 915

STARTF - Set start frequency in MHz (Threshold, Read Range)

STARTF 860

STARTF 800

STOPF - Set stop frequency in MHz (Threshold, Read Range)

STOPF 960

STOPF 1000

STARTP - Set start power in dBm (Backscatter, Response Test, Population) or Min power (Read Range)

STARTP 0

STARTP 5

STOPP - Set stop power in dBm (Backscatter, Population) or Max power (Read Range)

STOPP 20

STOPP 30

POWER – Set transmit power in dBm (Memory Management)

POWER -10

POWER 25

FSTEP - Set frequency step in MHz (Threshold, Read Range)

FSTEP 0.1

FSTEP 1

FSTEP 5

PSTEP - Set power step in dB (Threshold, Backscatter, Orientation, Read Range, Population)

PSTEP 0.1

PSTEP 0.5

PSTEP 1

TESTMODE – Set the measurement mode

Response Test

TESTMODE CONSTANTPOWER

TESTMODE FOLLOWTHRESHOLD

Read Range

TESTMODE RISING

TESTMODE FALLING

TESTREPCOUNT – Set the number of iterations; a negative count will run until stopped (Response Test)

TESTREPCOUNT -1

TESTREPCOUNT 5

ASTEP - Set Angle step in degrees (Orientation)

ASTEP 1

ASTEP 5

ASTEP 10

ASTEP 30

CUSTOMREAD – Enable or disable custom read (Memory Management)

CUSTOMREAD TRUE

CUSTOMREAD FALSE

CUSTOMREADMEMORYBANK – Targeted memory bank for custom read (Memory Management)

CUSTOMREADMEMORYBANK TID

CUSTOMREADMEMORYBANK USER

CUSTOMREADWORDPOINTER – starting address for custom read in hex (Memory Management)

CUSTOMREADWORDWORDPOINTER 0

CUSTOMREADWORDWORDPOINTER A

CUSTOMREADWORDCOUNT – number of words to read for custom read in decimal (Memory Management)

CUSTOMREADWORDWORDCOUNT 1

CUSTOMREADWORDWORDPOINTER 15

DELAY - Set the delay before measurement starts in seconds (0-60s)

DELAY 0

DELAY 5

POPSELECT - Select a tag from the population list by the number on list 0...N

POPSELECT 0

POPSELECT 1

C.2 Measurement Commands

START - Start measurement

START

NAMELAST - Name the last measurement in the list

NAMELAST Measurement1

HIDELAST - Hide the graph of the last measurement in list

HIDELAST

SETUP1..4 - Select the setup file to be used on a channel

SETUP1 Setup - Hand Carry Kit

SETUP2 EMPTY

SETUP3 PRESET5

SETUP4 wideband600..1300

Three different cases apply

Use a preset defined in measurement setup (preset1..5)

Use an empty setup (empty)

Use a setup file located in ../Tagformance/Data/Setup files, without file ending

Further considerations

When not using a multichannel setup, setup1 refers to the measurement setup

Preset1, preset2, preset3, preset4, preset5 and empty are reserved names and will take precedence over a user defined setup file if there is a conflict.

C.3 External Hardware Control Commands

MULTIPLEXER - Select multiplexer channel

MULTIPLEXER 1

MULTIPLEXER 2

MULTIPLEXER 3

MULTIPLEXER 4

ROTATE - Rotate the table to an angle in degrees

ROTATE 0

ROTATE 90

C.4 Script Flow Commands

FOR [number of iterations; start value for loop variable; loop variable increment] – ENDFOR
- Loops through the structure N times and increments loop variable

FOR 10

ENDFOR

FOR 11 860 10

ENDFOR

Nested for loops are not supported.

POPUP - Generates a popup with the text specified by the user

POPUP Press here to continue

BEEP [frequency, duration]
– Generates a voice signal of defined frequency (500-30000 Hz) and duration (10-2000 ms).

BEEP 3000 800

WAIT [ms]
– Waits a defined time period [ms] before continuing to the next script line.

```
WAIT 2000
```

IF [condition] – ELSEIF [condition] – ELSE – ENDIF
– Checks if the condition is 0 (false) or true otherwise. Advances to the next statement until a true condition or an ELSE is encountered. IF and ENDIF are both mandatory, and multiple ELSEIF statements are allowed in a single IF structure.

```
IF 0

POPUP This text will not be displayed

ELSEIF 0

POPUP This text will not be displayed either

ELSEIF 1

POPUP This text will be displayed

ELSE

POPUP This text will not be displayed

ENDIF
```

Nested if structures are not supported.

COMPARELATEST [frequencies, power on tag forward values]

– Compares the “Power on tag forward” values of the previous measurement to a user-defined linearly interpolated reference limit. The response of the function will either be 0 (fail, the tag was less sensitive than the reference) or 1 (pass, the tag was more sensitive than the reference at every measured data point within the frequency range of the reference). The result will be saved into a parameter @comparelatest. This command performs correctly only with Threshold sweep (MEASUREMENT THRESHOLD). An equal amount of reference frequencies and powers are required.

COMPARELATEST 820 840 860 940 980 -9.5 -9.5 -8 -8 -9

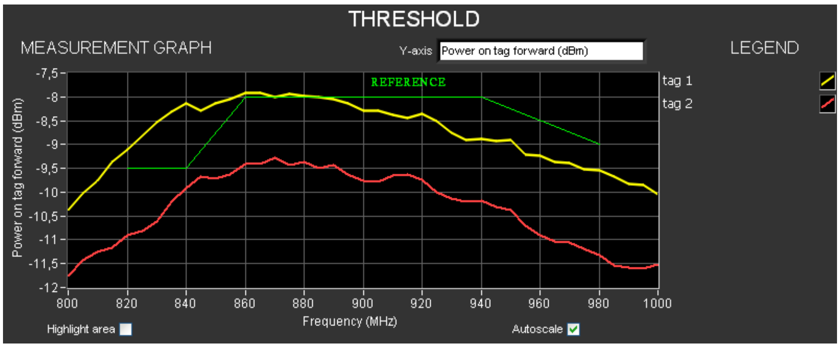
IF @comparelatest

POPUP Pass

ELSE

POPUP Fail

ENDIF



Creates a linearly interpolated reference from five frequency points and compares it to the previous measurement. Tag 1 would fail the test in the above figure because of the measurement points above the reference below 880 MHz.

C.5 Script Variables

Reserved Variables

@i – Index inside for loop

@VAR – Loop variable inside for loop

@TAGCOUNT – Number of tags in the population list

@comparelatest – Result of the COMPARELATEST command

User Defined Variables

SETVAR [variable name] [variable value]
– defines a variable; the variable name cannot contain spaces and is defined without @; when a variable is used, @ must be added as the first letter of the variable name; variable value can be changed by defining it again

Examples:

SETVAR text_for_popup Please put sample #3 on 4mm cardboard.

POPUP @text_for_popup

SETVAR start_frequency 800

SETVAR stop_frequency 1100

…

STARTF @start_frequency

STOPF @stop_frequency

Appendix D: Total System Accuracy Expectations

The system's most common task is to measure the tag sensitivity as a function of carrier frequency. For this, we are mainly interested in the uplink and its accuracy. The Tagformance Pro Measurement Unit is calibrated to the RF ports, and an absolute accuracy of 1 dB is given for the power at the OUT port. However, additional sources of error affect the tag sensitivity measurement accuracy.

In the following cases, two different typical measurement arrangements are considered, and the level of typical total error is evaluated for them.

In metrology, different error sources are typically calculated together using the RSS method (the root of the sum of squares). This method indicates the expected error level, which can, of course, be lower or higher.

D.1 Anechoic Measurement Room and Characterized Hardware Components

Here we consider a measurement scenario where:

- The Tagformance is used in an anechoic chamber

- The Standard Patch Antenna (800-1000 MHz) is used

- Measurement setup file is created with the calculated method

Error Source	Typical Magnitude
Tagformance Pro output power absolute level	0.6 dB
Cable losses	0.2 dB
Circulator loss	0.1 dB
Connectors x3	0.15 dB
Antenna gain (e.g., Voyantic standard 800-1000MHz patch antenna)	0.6 dB
Anechoic room (large high-end chamber)	0.5 dB
Distance measurement	0.15 dB
TOTAL (RSS)	**1.03 dB**
TOTAL (worst case: errors added together)	**2.30 dB**

D.2 Using the Reference Tag to Create the Setup File

Here we consider a measurement scenario where:

- The Tagformance is used in a non-ideal environment with reflections

- Measurement setup file is created with the measured method using a reference tag

Error Source	Typical Magnitude
Reference tag error (Total from previous case D1)	1.03 dB (2.30 dB)
Tagformance Pro output power repeatability (measure reference tag)	0.4 dB
Reference tag individual discrepancy*	0.5 dB
Tagformance Pro output power repeatability (measure DUT)	0.4 dB
TOTAL (root sum of squares)	**1.28 dB**
TOTAL (worst case: errors added together)	**3.60 dB**

*One identical reference tag result is distributed with all reference tags representing the median tag. All qualified reference tags are measured to ensure that they are within +/- 0.5 dB of the median tag.

When a reference tag is used to create a setup file, many different sources of error can be eliminated, such as inaccurately characterized or uncharacterized components, multipath propagation, inaccurate measurement distance, etc. Because of these properties, the measured path loss method is a very powerful tool for increasing the accuracy when measurements are carried out in a non-ideal environment.

However, if the user has access to an anechoic measurement chamber, the accuracy of the calculated path loss method will often be better.

Appendix E: Explanation of the Units in Read Range

E.1 Link Details - Forward Link

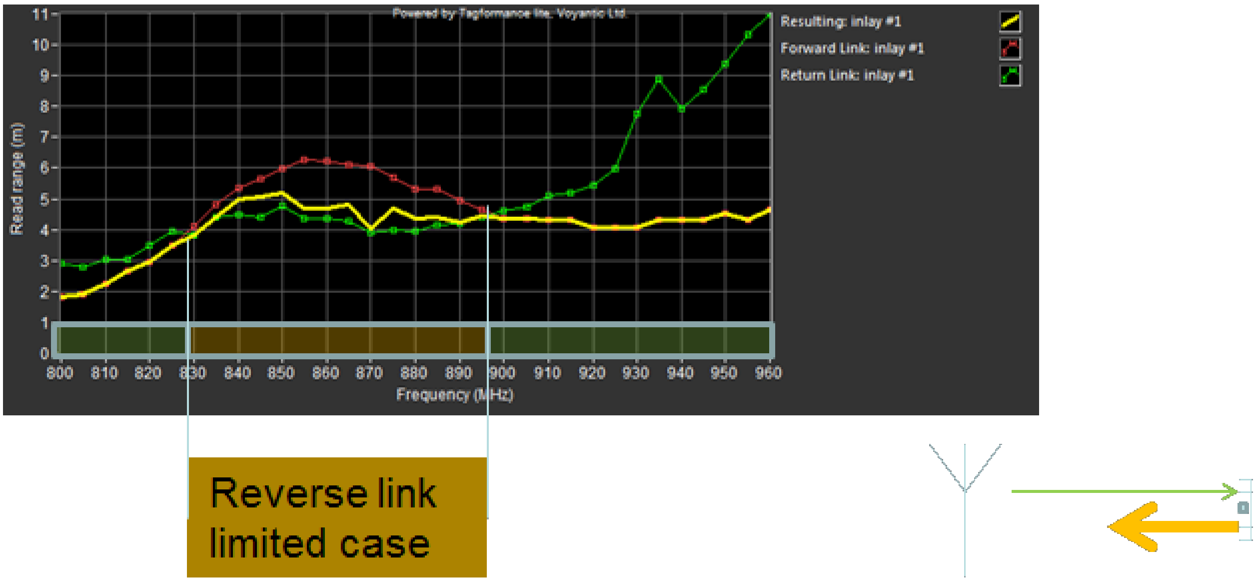
The red curve shows how far away the tag can be powered up; Radiated power and the tag's sensitivity limit this value.

When assuming that the reader can always “hear” the tag's response, this is how far the tag can be placed from the reader. This is true in “forward link limited cases”, which cover most of the cases with stationary readers and passive tags.

E.2 Link Details - Return Link

The green curve shows how far away the tag response can be heard at the threshold power (the minimum turn-on power of a tag)

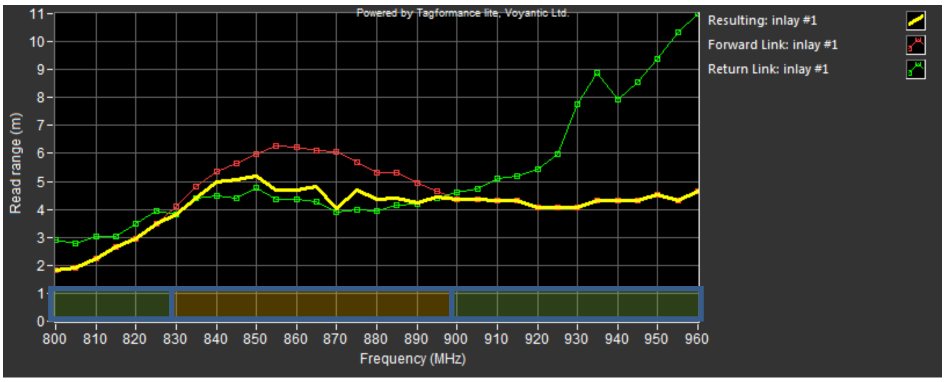
When assuming that the tag is as far from the reader’s transmit antenna as possible (Forward Link value, the red curve in the link detail graphs), the return link value is how far the receiver antenna can be taken from the tag to be still able to “hear” the response.



In the “reverse link limited cases”, the reader's receiver antenna must be closer to the tag than the transmit antenna.

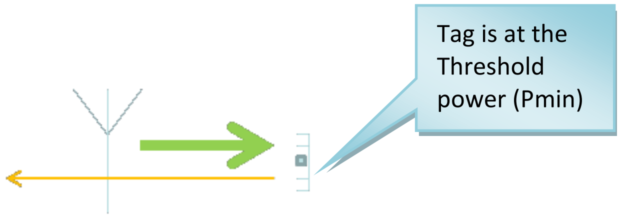
E.3 Link Details - Resulting

When the typical readers are considered, the transmitter and receiver antennas are the same. In these cases, the “resulting read range” typically best estimates the system-level read range.

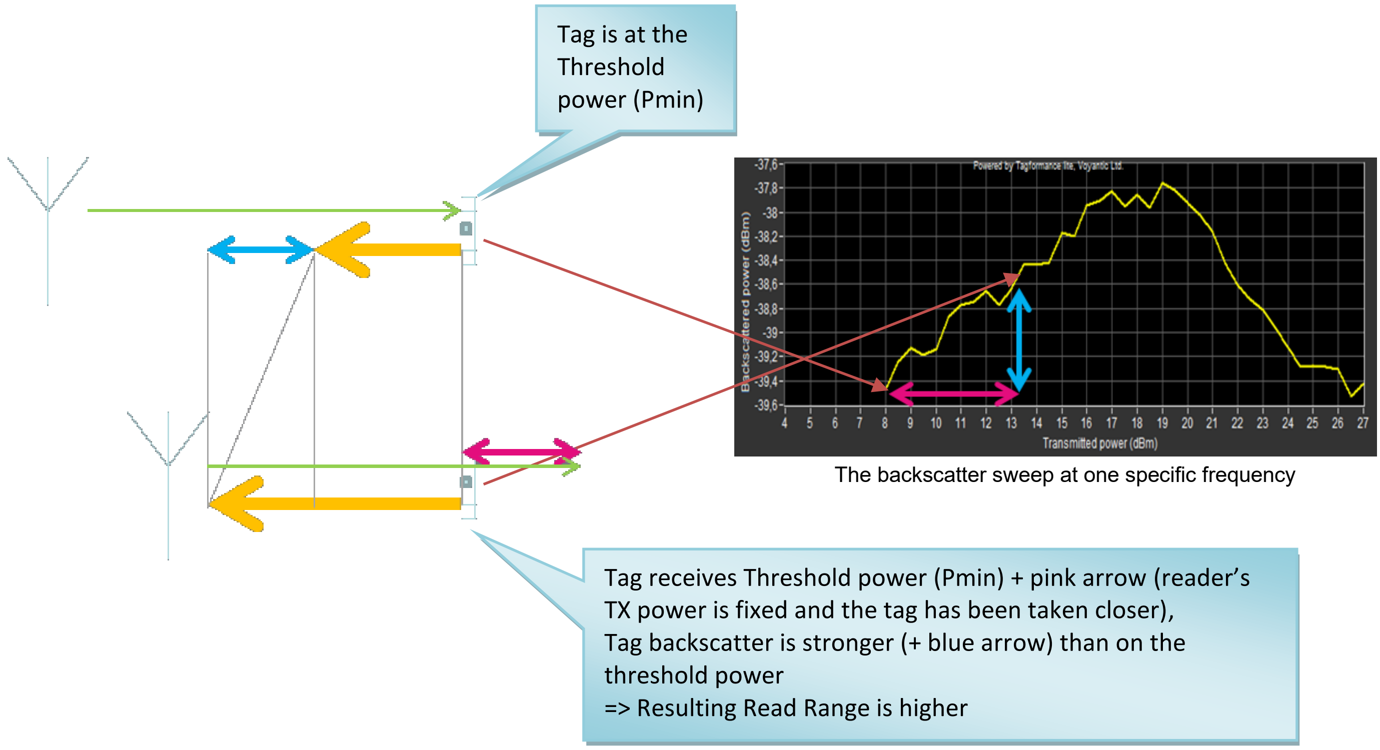


The yellow curve in the link details graphs shows the resulting read range when the transmitter and receiver antenna are in the same location.

- **In the forward link limited cases**, the yellow and red curve is the same.



- **In the reverse link limited cases**, the yellow curve is typically higher than the green curve as the tag receives more power than the threshold power, and, typically, the power response is positive, i.e., the tag's backscattered power is stronger if the tag receives more power. This is typically true at least near the threshold power level and the saturation typically occurs on higher power levels.

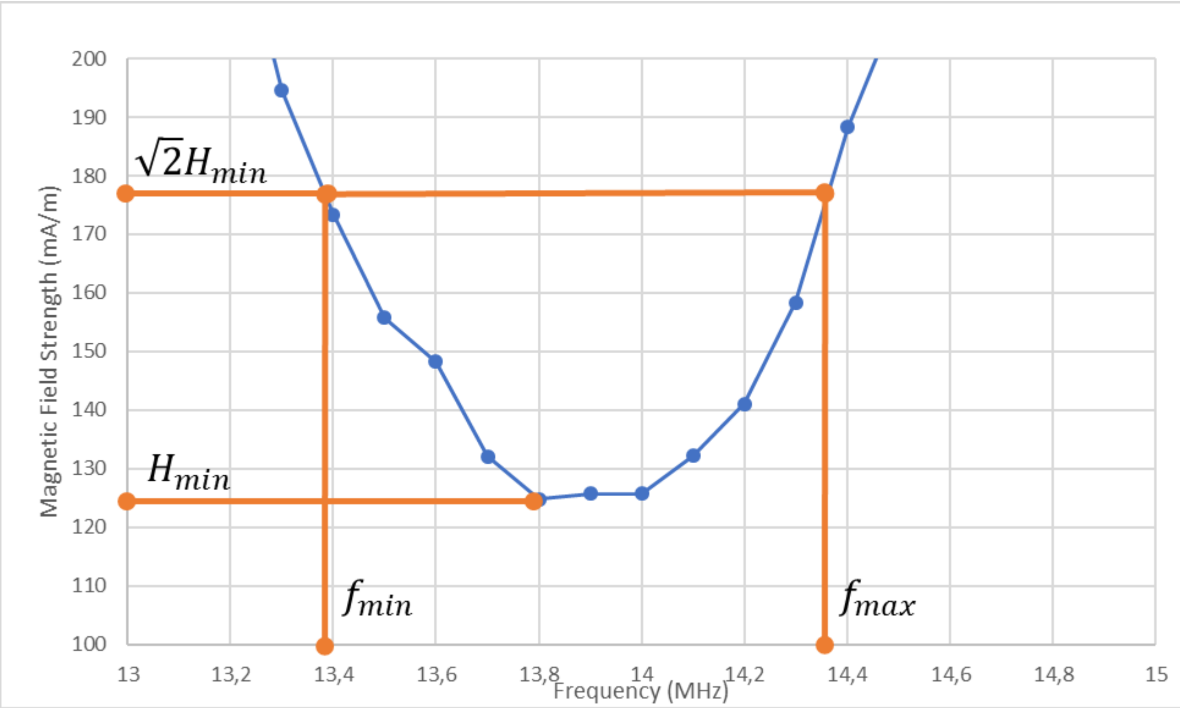


The backscatter sweep at one specific frequency

Appendix F: HF Threshold

F.1 Center Frequency and Q Value Measurements

The center frequency f_c and Q value is calculated from the magnetic field strength threshold curve as seen below



The algorithm finds the minimum field strength, $H_{\min}$, and calculates a threshold that responds to a 3dB higher power, which in this case means $\sqrt{2}$ higher magnetic field strength. This threshold is used to find $f_{\min}$ and $f_{\max}$ where the curve intersects the threshold. Linear interpolation is used to determine the frequencies of the intersections.

The center frequency is calculated as

$$f_c = \frac{f_{\min} + f_{\max}}{2}$$

The Q value is then

$$Q = \frac{fc}{bandwidth} = \frac{fc}{f_{\max} - f_{\min}}$$

Appendix G: Distance Control Kit Assembly Instructions

G.1 Assembling the Distance Control Kit

There are two supported tag lifter models. The V2 model is the device included in shipments from January 2019 onwards.

G.1.1 C60 and C145 Antennas

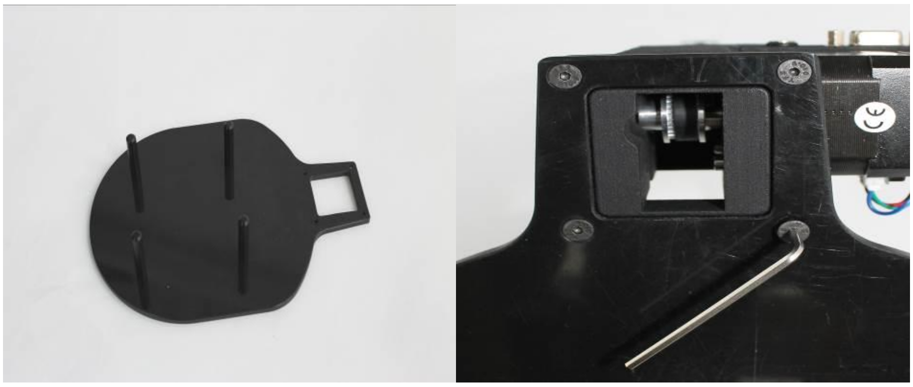
The Tagformance Pro HF antennas are delivered so that the C60 antenna fits inside the C145 antenna. If the antennas are packed into the carrying case, this is also the recommended way to store them.

When the antenna is used for measurements, it is important to remove the C60 antenna from the C145 antenna. If antennas are together during measurements, it will affect the measurement results.

C145 and C60 antennas

G.1.2 Fitting the Distance Control Lifter Shaft to the Base Plate

V2 Model



Base plate and tightening screws

Place the base on an even surface. Attach the actuator to the base plate by tightening the 4 screws on the base plate using a 2.5mm hex key. Make sure the screws are firmly attached to ensure that the actuator stands straight.

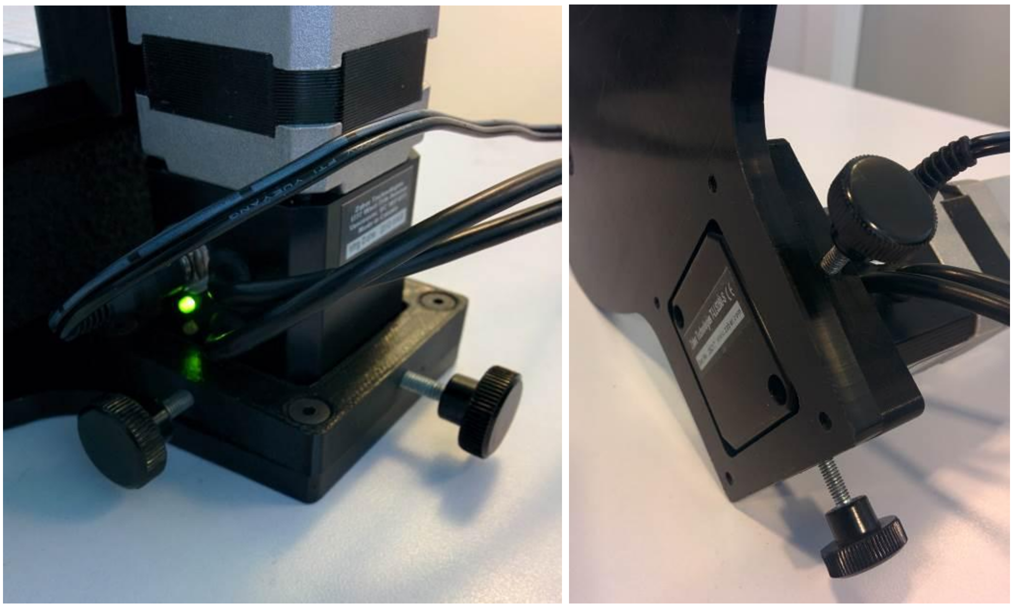
Cabling

Connect one end of the serial cable to the lifter and the other to the PC. Plug in the power supply and connect it to the lifter.

V1 Model

First, verify that the bottom of the lifter shaft is on the same level as the bottom of the base plate, i.e., both are against, e.g., the table surface. Make sure that the lifter shaft is straight while tightening the finger screws. If the shaft is tilted or is not on the same level as the base plate bottom, it will affect the accuracy of the distance control.

Connect the power cable to the connector above the LEDs, and the serial cable to the longer serial cable.



Shaft, base plate, and cables

G.1.3 Leveling the Tag Holder Platform

V2 Model

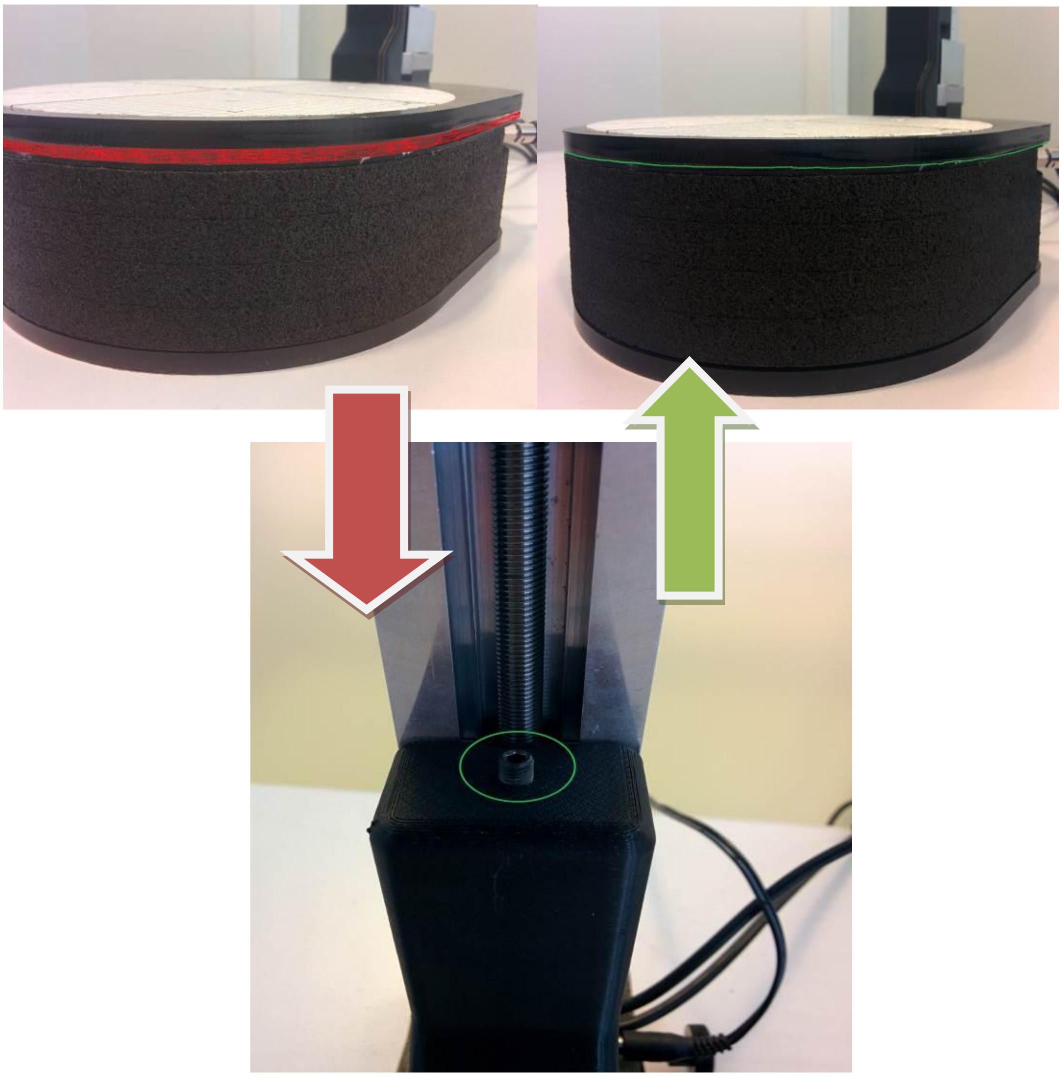
Connect the tag holder to the Distance Control Kit lifter and check that it goes to the bottom of the holder. Verify that there are no gaps between the antenna and the platform when the measurement distance is set to the lowest position (7mm). If there is a gap between the tag holder and the antenna, verify that the notch on the bottom of the tag holder is aligned with the RF antenna connector. If necessary, adjust the screw on the bottom of the tag holder attachment.

C145 antenna alignment

Tag holder height offset adjustment screw

V1 Model

Connect the tag holder to the Distance Control Kit lifter and check that it goes to the bottom of the holder. When the measurement distance is set to the lowest position (7mm), verify that there are no gaps between the antenna and the platform. If there is a gap between the antenna and the platform, try to minimize it by adjusting the level using the screws on top of the tag holder. The optimal position is that the tag holder and the antenna are on the same level and the gap between is as small as possible.



Adjust to remove the gap

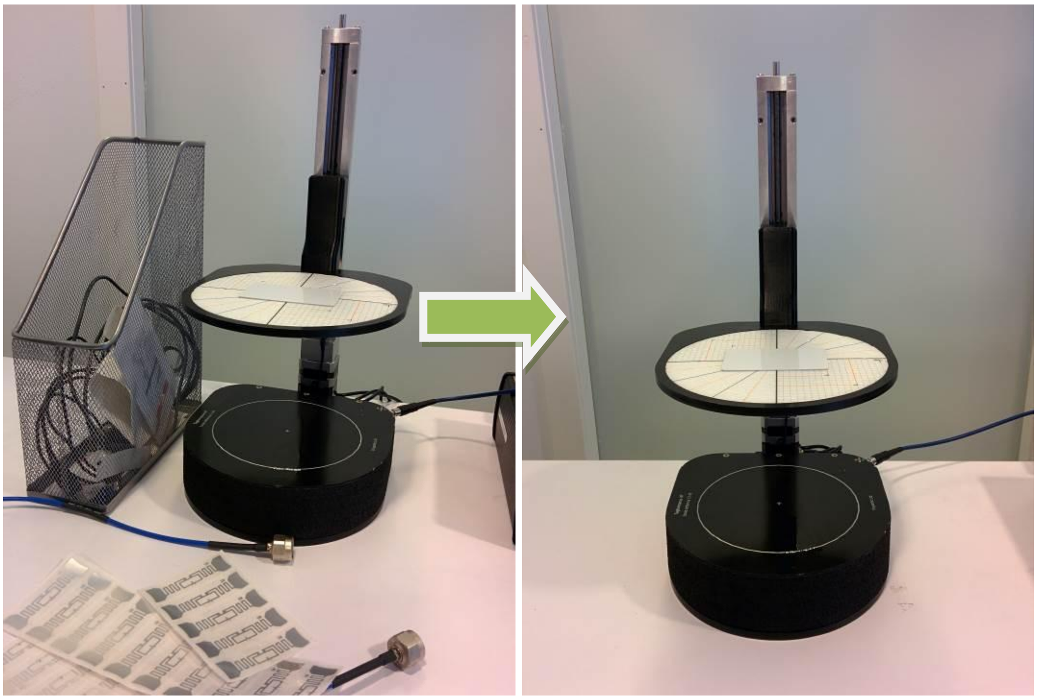
G.2 RF Cable Connectors

When the RF cable is connected, it is important to tighten the cable connectors properly. If the cable is loose on both or the other end, it will affect the measurement results. The optimal way to tighten the connectors is to use a torque wrench. For SMA connector 1Nm torque wrench is recommended.

SMA and N connectors

G.3 Environment

The Tagformance Pro measurement system is intended to be used in a laboratory environment. Verify that only one tag is in the measurement field. Multiple tags may give false readings and affect the measurement results significantly. Also, the antenna location may affect the measurement results, especially if there are large conductive or magnetic objects near the antenna. It is also good to avoid transmitting sources of interference.



The measurement environment

Appendix H : RSA306B - Spectrum analyzer information

H.1 Driver and .dll installation

Before using the spectrum analyzer unit, its drivers and dll have to be installed. These files are found in the Tagformance UHF software package. Please run “setup.exe” found in “RSA_API_USBDriver_x64”. Please note that only 64-bit operating systems are supported. The installer includes both the 64 and 32-bit APIs. Depending on the version of Tagformance software, follow the appropriate instructions. If using a non-default installation path, the path needs to be pointed to in Tagformance software.

From Tagformance 14.4 onwards

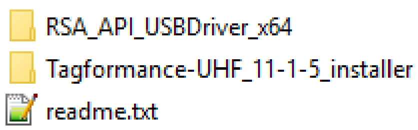
Use the 64-bit API found in the x64 folder of the installation.

Up to Tagformance 14.3.1

Use the 32-bit API found in the x86 folder of the installation.

Upgrading from 14.3.1 or before to 14.4 or after

Please run “setup.exe” and set the path to the installation location’s x64 dll. See *Configuration.cfg* for more details or point the new file location when prompted on Tag emission measurement program launch.



H.2 Understanding the indicator LED

The Indicator LED of the unit has four different states:

Unlit – The unit is not connected to power.

Red – The unit is in an error state or is starting up.

Green – The unit is ready for use.

Green, blinking – The unit is measuring.

Please make sure that the LED is green before starting a measurement.

H.3 Connecting the trigger cable

To use the spectrum analyzer in conjunction with Tagformance Pro, the trigger cable needs to be connected. Connect the straight SMA connector to the rightmost port and the other to the D-sub connector. Connect the D-sub to the I/O port of Tagformance Pro.

H.4 Maximum signal levels

Maximum RF input level without damage:

- Reference level ≥ –10 dBm: +23 dBm (continuous or peak)

- Reference level < –10 dBm: +15 dBm (continuous or peak)

Maximum RF input operating level, i.e., the maximum level at the RF input for which the instrument will meet its measurement specifications.

- +20 dBm, when center frequency ≥22 MHz (RF path)

For more information and up-to-date instructions, please visit the Manufacturer's product webpage: *https://www.tek.com/en/datasheet/spectrum-analyzer-0*

Appendix I: I/O Port

The I/O port on the back of the Tagformance Pro allows for additional interfacing with the device (only applicable in certain applications/modes). Note the difference between the device hardware versions.

I.1 15-Pin IO-connector on hardware version 2.x

DA-15 connector (female)

PIN	Description		
1	RFU (do not connect)	**9**	RFU (do not connect)
2	RFU (do not connect)	**10**	RFU (do not connect)
3	GND	**11**	+5 VDC out
4	GND	**12**	Signal ground
5	TRIG -	**13**	Logic high-level reference
6	TRIG +	**14**	Measurement trigger out
7	Digital output (RFU)	**15**	Digital output (RFU)
8	Digital output (RFU)	**Shield**	GND

PINS 3,4 Ground (GND)

PINS 5,6 Differential trigger signal input. Connect 5-24 V differential signal between pins 5 and 6 to provide a trigger for the device. If a unipolar signal is preferred, connect pin 5 to ground. The minimum trigger pulse length is 500 µs.

PIN 11 +5VDC output. Maximum output current is 20 mA. It can be used to provide logic high reference voltage for digital outputs.

PIN 12 Signal ground for output signals.

PIN 13 Logic high-level reference for the output signal. Can be connected to PIN11 to use the +5VDC output as reference level.

PIN 14 Measurement trigger output used in the Tag emission test to trigger an external spectrum analyzer. When the output signals are used, the signal ground should be connected to the ground, and the DC level at the high-level reference must be 0V or higher.

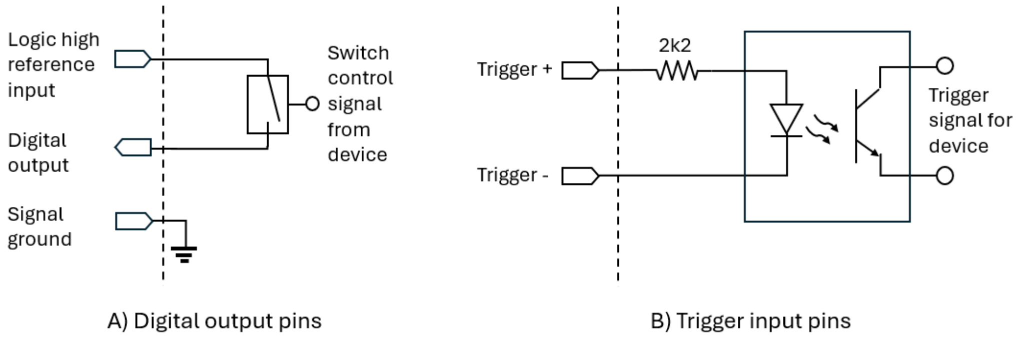


Figure 132. Electrical design of input and output pins of TF Pro version 2.x

I.1 25-Pin IO-connector on hardware version 1.x

DB-25 connector (female)

PIN	Description	PIN	Description
1	Power input (18-24VDC)	**14**	+5V out
2	Power input (18-24VDC)	**15**	Logic high reference input
3	Power GND	**16**	Trigger threshold level
4	Power GND	**17**	Trigger input
5	Ext Power enable (active low)	**18**	Busy/ready output (n/a for TF PRO)
6	Measurement trigger out	**19**	Pass/fail output (n/a for TF PRO)
7	Digital output (RFU)	**20**	Digital output (RFU)
8	Digital output (RFU)	**21**	Digital output (RFU)
9	Digital output (RFU)	**22**	Digital output (RFU)
10	Digital input (RFU)	**23**	Digital output (RFU)
11	Signal ground	**24**	Digital input (RFU)
12	Analog input positive (RFU)	**25**	Digital input (RFU)
13	Analog input negative (RFU)	**Shield**	GND

Pins 1-5 are related to the application of external power sources. Pin 5 is an external power enable pin that needs to be grounded when an external power source is applied. It can be connected to pins 1-4.

Pin 6 is a trigger signal controlled only in the Tag Emission Test to trigger an external spectrum analyzer.

Pins 7-10 are 3V3 compatible logic pins (reserved for future use).

Pin 11 is signal ground.

Pins 12-13 are differential analog input pins relative to the signal ground at Pin 11 (Reserved for future use).

Pin 14 is an isolated +5Vdc, 100mA voltage output.

Pin 15 is a logic high-level input pin relative to pin 11. It sets the high voltage level at output pins 18-23. When these pins are used, pin 11 should be connected to the ground, and the DC level at pin 15 must be 0V or higher.

Pin 17 is a unipolar trigger input compatible with voltages from 3.3V to 24V. The minimum trigger pulse length is 5μs.

Pin 16 is the trigger threshold adjustment pin. The default trigger threshold level is 38% (pin 16 is floating). It can be adjusted by adding a pull-up resistor to the +5V output (increasing the threshold) or a pull-down resistor to signal ground (lowering the threshold level). For details, please see the following schematics.

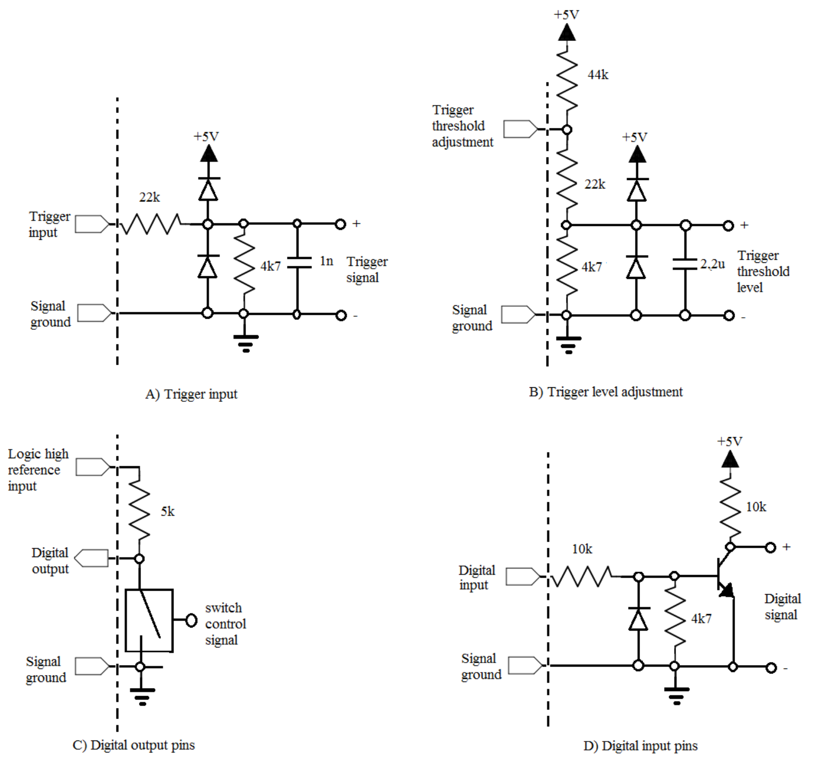


Figure 133.Electrical design of input and output pins of TF Pro version 1.x

