

Application Note #63

Field Analyzers in EMC Radiated Immunity Testing

By Jason Galluppi, Supervisor Systems Control Software

In radiated immunity testing, it is common practice to utilize a radio frequency (RF) field probe to measure the electric field at the location of the unit under test (UUT). Most RF field probes are designed to measure the root mean square (RMS) of a continuous wave (CW) electric field over a broad range of frequencies and amplitudes.

RF field probes are also commonly used to measure modulated fields. In general, this is not a good practice if the RF field probe is diode based. Depending on the analog response time and the sample rate, measuring a modulated field with a diode based RF field probe will be unpredictable and could yield erroneous results.

In some modulated field measurements, such as those found in MIL-STD 461, calibration factors can be obtained to relate modulation amplitude to CW amplitude. These calibration factors will only be good for the specific amplitude and modulation scheme that was used to obtain them. In addition, this will only work well with a slow modulated field where the analog response time of the RF field probe is also slow. Unfortunately, most modern diode based RF field probes have a reasonably fast analog response time. This coupled with a slow sample rate will cause measurements to be unstable. In this case, averaging many readings over time can be used to obtain a stable reading.

In applications where a narrow pulsed field is to be measured, most diode based RF field probes cannot be used. These RF field probes will see the pulses, but not sample fast enough to consistently measure them.

Thermocouple RF field probes offer a solution to some of the above listed problems, however they can only provide an average field measurement. Since the maximum RMS field level is what is typically desired, an additional computation is required. In order to perform this computation, prior knowledge of the modulation is necessary. Additionally, this type of RF field probe does not allow the user to see a visual representation of the modulation envelope. This leaves questions about the validity of the modulation as seen by the UUT.

Being able to see the modulation envelope is extremely useful for verification of the waveform or uncovering any distortion that may be caused by items in the signal generation path. For example, distortion can occur with pulsed RF signals that are amplified by an amplifier that is driven into saturation or into a poor load. As a result, overshoot, droop, or ringing can be introduced.

To address the problems and inconsistencies listed above, devices called Field Analyzers were developed. Field Analyzers are a relatively new type of RF field probe. These patent pending

devices have the ability to measure modulated electric fields in addition to CW electric fields. They allow the user to view and measure the electric field in the time domain using an oscilloscope-type display and interface. Table 1 shows a comparison between Field Analyzers and the above listed conventional RF field probes.

	Field Probe (Diode)	Field Probe (Thermocouple)	Field Analyzers (Diode)
CW Field (RMS)	✓	✓	✓
CW Field (Peak)	Calculable from RMS value	Calculable from RMS value	Calculable from RMS value
AM Field (Average RMS)		✓	✓
AM Field (Maximum RMS)			✓
AM Field (Minimum RMS)			✓
AM Field (Peak)			Calculable from Maximum RMS value
Pulsed Field (Average RMS)		✓	✓
Pulsed Field (Maximum RMS)		Calculable from Average RMS value*	✓
Pulsed Field (Minimum RMS)			✓
Pulsed Field (Peak)		Calculable from Maximum RMS value*	Calculable from Maximum RMS value
Pulsed Field (Rise Time)			Measureable from displayed waveform
Pulsed Field (Period)			Measureable from displayed waveform
Pulsed Field (% Duty)			Measureable from displayed waveform

* Only if % duty is known

Table 1. Comparison of RF Field Probe Measurement Capabilities

The AR designed and manufactured FA7000 series of Field Analyzers (see Figure 1) utilize an isotropic field sensor to sample the composite field and transmit its amplitude digitally over optical fiber to a processor unit. The sample rate of these devices is significantly faster than conventional RF field probes allowing them to accurately measure pulsed electric fields in the micro-second range. Table 2 lists some common modulations per various standards that can be measured with the FA7000 series of Field Analyzers.

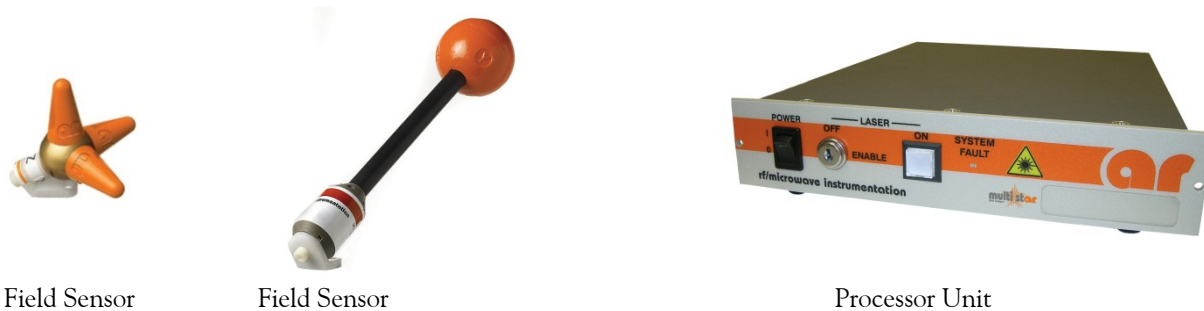


Figure 1. FA7000 Series of Field Analyzers (Photos not to scale)

EMC Standard	Modulation
DO-160	4% Duty 1kHz Pulse
DO-160	90% Depth Square Wave 1kHz
DO-160	4uS Pulse 1kHz Repetition Rate
IEC 610000-4-3	80% Depth 1kHz AM
ISO 11452	3uS Pulse
ISO 11452	80% Depth 1kHz AM Peak Conservation
MIL STD-461	50% Duty 1kHz Pulse
MIL STD-461	50% Duty 400Hz Pulse

Table 2. Common Modulations and their Associated EMC Standard

The processor unit is used to buffer the digital samples and host an embedded webpage where the samples can then be viewed in an oscilloscope-type display. The embedded webpage can be viewed on any web-enabled device such as a personal computer, tablet computer, or smart phone. This webpage contains a number of familiar controls that allow the user to adjust the way the modulation envelope is displayed. It also provides feedback about the Field Analyzer system and provides some useful calculations based on the displayed waveform.

Like the FL7000 and PL7000 series of field probes designed and manufactured by AR, all of the field sensors in the FA7000 series of Field Analyzers are laser powered. This allows for continuous testing without ever having to recharge or replace batteries.

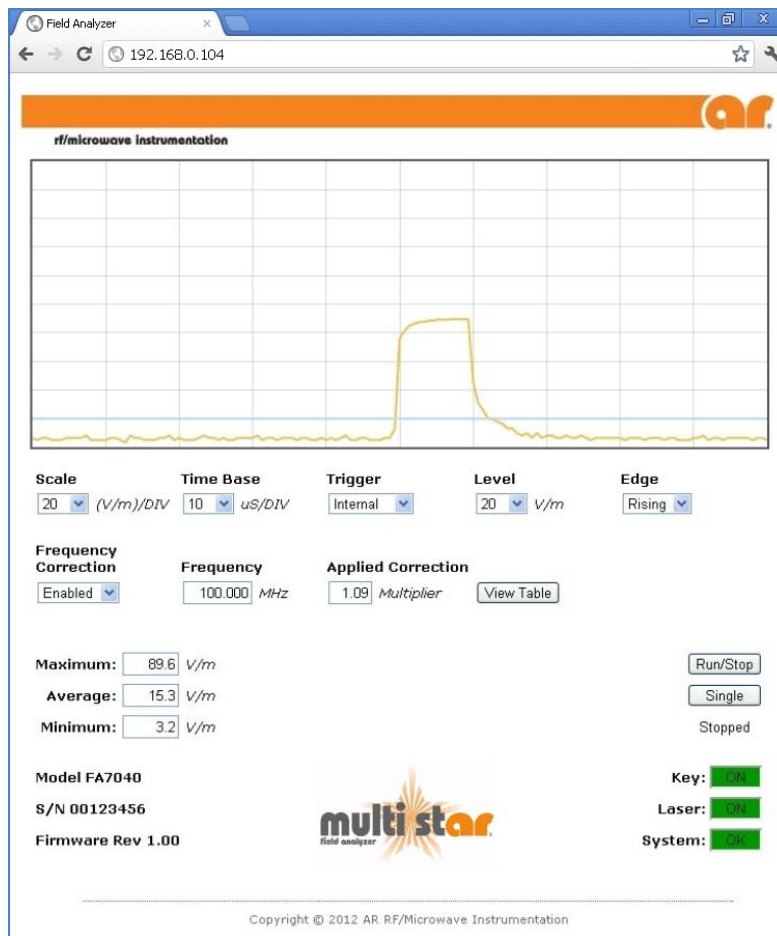


Figure 2. FA7000 Series Embedded Webpage

Figure 2 shows a screen shot of the embedded webpage for the FA7000 series of Field Analyzers. At the top of the page is the waveform display in a 10 by 10 grid configuration. Below the waveform display is a set of controls for adjusting how the modulation envelope is displayed. Similar to a standard oscilloscope, the two main controls are scale and time base. In addition, there is a control to select the trigger method. When internal trigger mode is selected, additional controls for threshold level and edge become available.

In free run trigger mode a trigger event is automatically set each time the waveform display refreshes. This is a good initial mode to obtain a quick view of the electric field if one does not know the specifics of the amplitude or modulation of the electric field being measured.

Internal trigger mode is essentially a conventional level trigger in which the user can select a threshold field level for which the refresh of the display will occur. The direction for the threshold trigger is also user selectable as either rising or falling edge. The waveform will appear with the threshold crossing event in the center of the waveform display window providing the user with 50% pre-trigger data and 50% post trigger data.

An external pulse signal can also be used to create a trigger event. This is particularly useful for single shot events or when synchronization with a signal generator is necessary. Most signal generators can provide a compatible trigger signal that can be connected to the external trigger input found on the rear panel of the processor unit.

To correct for deviation of the field sensor's frequency response from a flat response, the user can load a table of correction factors (found in the calibration report) for up to 30 different frequencies. This is done using the Table Loader program found on the AR website.

Once correction factors have been loaded, the embedded webpage can use them to correct the displayed waveform based on a user specified carrier frequency. The calculated multiplier correction factor is displayed so the user understands the amount of correction being applied. Linear interpolation is used between frequency points in the table. If the user specified carrier frequency is beyond the end points of the correction factor table, a warning message is displayed. The correction factor table can also be viewed directly from the embedded webpage by using the View Table button.

Below the waveform controls are indicators for the minimum, maximum and average field level. These are all calculated based on the waveform as it is displayed. To the right is a set of buttons that control the refresh of the display regardless of trigger events. One button is a simple Run/Stop button while the other allows the user to capture a single event. Both of these controls are useful for closer examination or printing of the waveform.

The bottom of the webpage contains useful information about the Field Analyzer system. This includes model, serial number, and firmware revision information along with the status of the processor unit's front panel controls and indicators.

Field Analyzers can also be used where automated software such as the AR emcware® (formerly the SW1007) controls all of the test equipment in an RF radiated immunity test setup. The minimum, maximum, and average field levels are easily obtained through any of the standard remote ports (USB, GPIB, and Ethernet) found on the rear panel of the processor unit. A set of backward-compatible remote queries are also available for easy substitution with any FL7000 or PL7000 conventional RF field probes. This allows for compatible connectivity with an AR FM7004 Field Monitor.

All of the waveform display controls are also accessible remotely which allows the user to setup to measure a specific type of modulation. When a Field Analyzer is used in this way, frequency correction factors must be applied by the automated software controlling the test.

The field sensors in the FA7000 series of Field Analyzers are designed to be isotropic. However, they each have a specified deviation from isotropic. This means that, like conventional RF field probes, the best accuracy is achieved by positioning the field sensor with a single antenna element aligned with the electric field. Each field sensor has indicators showing where the individual antenna elements are located. For example, the stalk style field sensors indicate the tips of each of the three dipole antenna elements.

Since Field Analyzers are relatively new devices, all of their potential applications have yet to be discovered. Their fast sampling allows them to provide more information and better accuracy than a conventional RF field probe, which in turn, allows for a better understanding of the amplitude of the electric field in the time domain.

This innovative instrument measures modulated electric fields that resemble actual real-world situations, thereby giving the user a more correct and more accurate measurement.