Application note 107:
Measuring high power RF pulse field levels

Purpose -

The information supplied in this application note is to provide a better understanding of how measurements can be determined for high power pulse field levels. Although not for every case, customer's specification, and/or requirement, these high power pulse field levels are largely defined and determined by or from the DO-160 standard. Many of these requirements are due to the increased applications of pulse modulation technologies that are being employed for communications and other high technology applications and are therefore being incorporated into commercial and military Radiated Susceptibility (RS) test standards. It is then a necessity to be able to test with common available lab equipment if you are performing testing at high power pulse field levels. This application note explains and illustrates how the field levels are determined. It also illustrates the relationship of amplifier power to antenna gain. (See our application note 105 "antenna terms and related formulas" for more detailed information.)

Introduction -

The DO-160 Standard requires two basic types of pulse modulations, SW or Square Wave Modulation and PM or Pulse Modulation. The purpose and function of this application note will be to describe and discuss the high power pulse field levels as required by many applications including category L of the DO-160 standard related to Pulse Modulation.

Pulse modulation "PM" requires that the pre-calibrated carrier be modulated to 100% depth with an on-off ratio of 40 dB. The key issue with the 100% modulation pulse or "PM" is that the measurement of the peak pulse field is considerably more complex to measure as compared to the "SW" modulation. The basic techniques and associated test equipment will be the principal focus of this application note.

Pulse field terms and characteristics -

For Pulse Modulation (Reference Figs. 1 and 2, pg. 2)

- **Carrier Level** - The pre-calibrated RF/microwave field producing signal
- **Modulation Depth** - The level or amplitude of the pulse modulation signal.
- **Pulse Repetition Frequency (PRF)** - The number of pulses per second (ON and OFF time included.)
- **Pulse Width** - The length or duration of an RF pulse "ON" time
- **Duty Cycle** – The ratio of the "ON" to "OFF" time of a pulse modulated signal

Pulse parameters –

In addition to understanding the amplitude aspects, working with pulsed fields require the user understand the key pulse characteristics of pulse width, pulse repetition frequency or rate, and duty-cycle. By the application of basic mathematics, any third parameter can be calculated from the other two.
(see figs 1-2, pg. 2)

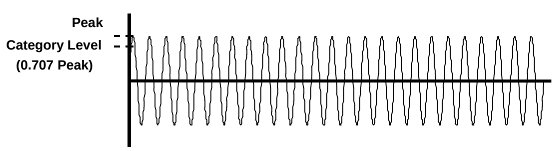
Pulse Width - Pulse width refers to the period of time that a pulse is actually on.

Pulse Repetition frequency - Pulse repetition frequency is the number of pulses in a measurement period, typically referred to as "pulses per second." The pulse repetition rate - **(PRR=1/PRF)** is the time period between the pulses which is the inverse of the frequency. The total time period is the sum of the ON and OFF periods of each pulse.

Duty Cycle = PW/PRF - Duty cycle is the proportion of ON to OFF time during the pulse period.

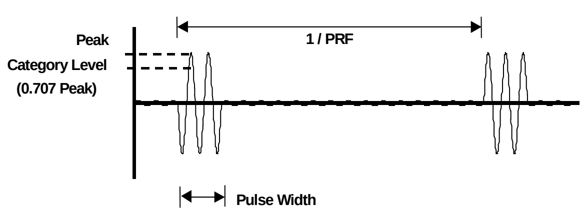
Pulsed field levels and average power -

Upon pulse modulating a CW signal, the average power is determined by the signal pulse width, pulse repetition rate and subsequent duty cycle.



Unmodulated (CW) Waveform

Figure 1 - Unmodulated (CW) waveform (100% duty)



Pulse Modulated Waveform

Figure 2 - Pulse modulated waveform (PM)

Pulse/Average power examples:

A pulse modulated signal with a PRF of 1 KHz (1ms PRR) and a 500us pulse width will have a 50% duty cycle. This is the type of signal that will be used when performing the SW test. The average power resulting from a 50% duty cycle signal is half of the CW level. A 100 watt peak, 50% duty cycle signal will produce 50 watts of average power. The converse is also true; a 50% duty cycle signal with 50 watts of average power will have a peak power of 100 watts.

A modulation signal with a PRF of 1 KHz (1ms PRR) and a 100 µs pulse width will have a 10% duty cycle. The average power resulting from a 10% duty cycle signal is one-tenth of the CW level. A 100 watt peak, 10% duty cycle signal will produce 10 watts of average power. Thinking in terms of duty cycle is probably the easiest to mentally calculate average power.

The Duty Factor is mathematically expressed as:

Duty Factor = PW/PRR = 100us/1ms = 1E-4/1E-3 = 1E-1 or 0.1 Duty Factor (10% duty cycle)
Correction factor in dB = 10 x Log (duty cycle)

Knowing the Duty Factor or duty cycle allows simple multiplication or division to arrive at a peak power level given an average level or vice versa. For example, a pulse signal with a duty cycle of 10% and an average power indication of 50 watts would be multiplied by 10 to arrive at a 500 watts peak power. The same 10% duty pulse train is $1/10^{th}$ or the total time period so the average power level would be 10 times less than the peak or -10 dB. The same process would hold true for a 1% duty cycle signal, but the average power would be multiplied or divided by a factor of 100 or 20 dB.
Table 1 shows a list of duty percentages and multipliers.

Duty Cycle Percentage	Correction factor in dB to correlate average power to peak power	Examples			
		Average Power in dBm/watts	+ correction factor in dB	Peak Power (dBm)	Peak Power (watts)
1%	Add 20	40dBm/10 W	20	60dBm	1000 watts
2%	Add 17	43dBm/20 W	17	60dBm	1000 watts
4%	Add 14	46dBm/40 W	14	60dBm	1000 watts
6%	Add 12.2	47.8dBm/60 W	12.2	60dBm	1000 watts
10%	Add 10	50dBm/100 W	10	60dBm	1000 watts

Table 1 – Duty percentages and multipliers

RF power and field level examples:

As a quick review, these are the calculations of the RF input power required to produce a field level of 20 V/m at a distance of 1 m using an antenna with a linear or numerical gain of 4.0. A 3.3 W RF signal will be required to produce a 20 V/m field at a 1 m distance from the antenna. A 333.3 W RF signal will be required to produce a 200 V/m field at a 1M distance from the antenna. (See our application note 105 "antenna terms and related formulas" for more detailed information.)

CW field calculations:

20 V/m at 1M

Antenna parameters:

Antenna Gain - G(dBi) = 6 dB
Antenna Gain - G(linear) = **4.0**

Variables:

E(V/m) - E field level - **20 V/m**
R(m) - Distance in meters - **1M**
Pt(w) - RF power input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

$Pt=E^2 x R^2/30 x G(linear)$ = *RF power at antenna*

Calculation

$Pt=((20.0)^2 x (1)^2)/(30 \times 4)$ = ***3.3 watts***

200 V/m at 1M

Antenna parameters:

Antenna Gain - G(dBi) = 6 dB
Antenna Gain - G(linear) = **4.0**

Variables:

E(V/m) - E field level - **200 V/m**
R(m) - Distance in meters - **1M**
Pt(w) - RF power input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

$Pt=E^2 x R^2/30 x G(linear)$ = *RF power at antenna*

Calculation

$Pt=((200.0)^2 x (1)^2)/(30 \times 4)$ = ***333.3 watts***

Important Note:

These examples indicate a field produced using the same antenna and distance from the EUT. The difference is that the field is 10 times greater requiring that the RF power be increased by a factor of 100 times or 20 dB. Alternatively, increasing the antenna gain will cause a proportional reduction in the required antenna RF input power level.

Field level measurement -

The direct measurement of a CW or a low level pulse field is basically straightforward. The test system must be assembled in accordance with the standard for the specific Equipment Under Test (EUT) and then the field sensing device located in the correct proximity to the (EUT). Assuming that E-Field probes have the necessary dynamic range and can react/respond to pulse RF Power, then the pulse field level can be measured and system drive levels determined as if it were a CW field. Then a drive table can be constructed as explained on (pg. 6) "Constructing the drive table".

Calibration methods -

The key issue with the calibration of a high power pulse field test is to validate the field level in a manner consistent with the test standard and acceptable to the customer. The DO-160 standard states that both SW and PM signals should be developed in a manner which produces the same forward power into the transmitting antennas as the calibration level. This is rational at lower field levels, but far more difficult at the higher field levels. Fortunately, the standard provides for the use of "appropriate scale factors" if the reference CW calibration was performed at a different level than the desired square wave or pulse category field strength. This means that the system can be calibrated at a level that your field probes can respond to and then you can modify the calibrated drive table by applying a multiplication factor to them. Then running the modified drive table into the RF test system will produce the calculated/correlated high field levels.

This approach produces valid results but some customers may insist on the use of receive antennas and appropriate signal level measurement devices to validate the pulse fields in real time. Keep in mind this is only practical if receive antennas are available. When using antennas, antenna factors must be applied to the receive data to obtain accurate results. A spectrum analyzer can be used as a receiver, but care must be exercised to ensure that the readings produced are normalized and acceptably accurate. Spectrum analyzers are typically best for differential measurements, power meters are best for absolute measurements. For pulse power measurements pulse RF power meters and sensors would be required but many labs do not have this type of measurement equipment so this method is not common. Other measurement alternatives are possibly using an EMI receiver system or pulse field detectors which are not readily available for the full frequency range that is normally tested in accordance to the DO160 standard.

The most practical approach for measuring radiated field strength is by the use of an E-Field Sensor. These sensors are relatively small, lightweight and utilize a fiber optic cable to transmit the level information to the remote test system. They are designed to be co-located with the EUT providing a direct reading and real-time field level measurement. It is imperative that the sensors used be rated for the field type and level that is to be measured. High field level pulse sensors are not readily available which is why the DO-160 provides for the use of a correlation/scaling factor for testing at higher field levels.

Exceptional care must be taken to make absolutely certain that the test system components are compatible with the expected power signal levels and exceptionally high field levels that will be produced! All equipment must be rated and then derated for a reasonable safety margin. This includes all RF cables, connectors, Antennas, couplers and any sensing equipment that will be exposed to the high field and the high power pulsed RF signals.

CAUTION: RF/microwave measurement equipment and E-field sensors (CW and peak reading) can be seriously damaged by excessive peak power and E-field levels. Great care must be taken when developing a manual or an automated drive table to ensure that the system output power levels do not excessively exceed the level expected for the test equipment being used. Most software packages provide for maximum signal generator limits and they should be used. It is far better to restart a constructed test scan because a preset drive safety level was reached than to replace damaged hardware.

Constructing the drive table -

The drive table is a list of drive levels, by frequency, that will be produced by the system signal generator. These signals, when applied to the RF power amplifier system, will produce the output power required to obtain the desired field level at all of the frequencies contained in the list.

The drive table can be constructed manually or automatically under software control. Either way, the table is constructed one frequency at a time by successively increasing the signal generator output level (driving the RF amplifier system) until the correct field level is indicated on the field measuring device. The resultant drive level can then be recorded manually or by the software. This process is done repeatedly for each frequency until the list is completed.

Modifying and running the drive table -

A drive table can be modified manually or by the test software to alter the RF output to meet the high field pulse requirements. DO-160 category L for PW modulated signal levels are required to reach 7,200 V/m for some frequency bands.

The DO-160 standard provides for a test to be run using a lower level calibration. This means that one may calibrate the system at a more convenient level like 50 V/m, 100V/m or otherwise and then modify the drive table with a multiplication or scaling factor to consistently increase the drive levels to support a higher field test. This approach assumes that the RF power amplifier system and transmit antennas can support the increased power for the specific test. Again, great care must be taken to confirm that all system components are properly rated to withstand the extremely high pulse power levels required to produce the intended field levels. An example for lower level calibration is shown on page 13.

Once constructed and modified the drive table can then be "played back" by the test system either manually or under software control to run the RS test at field levels far in excess of the level used to calibrate the system.

The Standard test levels and parameters –

The DO-160 standard requires that the test signal be pulsed at 4 µs from 400 MHz to 4 GHz and 1 µs from 4 GHz to 18 GHz and both at a 1 kHz PRR. The resultant average power is relatively low allowing a pulsed amplifier source to be utilized that is capable of producing the required high peak power. This concept is the key in being able to produce high power pulse field levels. A CW rated amplifier producing the same peak level would be tremendous in size and of course a very costly amplifier system. Pulse amplifiers are more economical for generating high power pulse field levels.

Example DO-160 Pulsed field calculations:

730 V/m at 1M (CW)

Antenna parameters:

Antenna Gain - G(dBi) = **10 dB**
Antenna Gain - G(linear) = **10.0**

Variables:

E(V/m) - E field level - **730 V/m**
R(m) - Distance in meters - **1M**
Pt(CW) - RF input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

$Pt=(E^2 x R^2/30 x G(linear))$ = RF power at antenna

Calculation

$Pt(peak)=((E(V/m)^2 \times (1)^2)/(30 \times 10)) = Pt(CW)$
$Pt(peak)=((730)^2 x (1)^2)/(30 x 10)) =$ **1,776 watts (CW)**

730 V/m at 1M (PULSED)

Antenna parameters:

Antenna Gain - G(dBi) = **10 dB**
Antenna Gain - G(linear) = **10.0**

Variables:

E(V/m) - E field level - **730 V/m**
R(m) - Distance in meters - **1M**
Pt(peak) - RF input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

$Pt=(E^2 x R^2/30 x G(linear))$ = RF power at antenna

Calculation

$Pt(peak)=((E(V/m)^2 \times (1)^2)/(30 \times 10))= Pt(peak)$
$Pt(peak)=((730)^2 x (1)^2)/(30 x 10)) =$ **1,776 watts (peak)**

1400 V/m at 1M (PULSED)

Antenna parameters:

Antenna Gain - G(dBi) = **14.8 dB**
Antenna Gain - G(linear) = **30**

Variables:

E(V/m) - E field level - **1400 V/m**
R(m) - Distance in meters - **1M**
Pt(peak) - RF input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

$Pt=(E^2 x R^2/30xG(linear))$= RF power at antenna

Calculation

$Pt(peak)=((E(V/m)^2 \times (1)^2)/(30 \times 30))$= Pt(peak)
*$Pt(peak)=((1400)^2 \times (1)^2)/(30 \times 30))$= **2177.8 watts (peak)***

5000 V/m at 1M (PULSED)

Antenna parameters:

Antenna Gain - G(dBi) = **24 dB**
Antenna Gain - G(linear) = **251**

Variables:

E(V/m) - E field level - **5000 V/m**
R(m) - Distance in meters - **1M**
Pt(peak) - RF input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

$Pt=(E^2 x R^2/30xG(linear))$= RF power at antenna

Calculation

$Pt(peak)=((E(V/m)^2 \times (1)^2)/(30 \times 251))$= Pt(peak)
*$Pt(peak)=((5000)^2 \times (1)^2)/(30 \times 251))$= **3320 watts (peak)***

6000 V/m at 1M (PULSED)

Antenna parameters:

Antenna Gain - G(dBi) = **24 dB**
Antenna Gain - G(linear) = **251**

Variables:

E(V/m) - E field level - **6000 V/m**
R(m) - Distance in meters - **1M**
Pt(peak) - RF input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

$Pt=(E^2 x R^2/30xG(linear))$= RF power at antenna

Calculation

$Pt(peak)=((E(V/m)^2 \times (1)^2)/(30 \times 251))$= Pt(peak)
*$Pt(peak)=((6000)^2 \times (1)^2)/(30 \times 251))$= **4780 watts (peak)***

7200 V/m at 1M (PULSED)

Antenna parameters:

Antenna Gain - G(dBi) = **27 dB**
Antenna Gain - G(linear) = **501**

Variables:

E(V/m) - E field level - **7200 V/m**
R(m) - Distance in meters - **1M**
Pt(peak) - RF input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

$Pt=(E^2 x R^2/30 x G(linear))$ = RF power at antenna

Calculation

$Pt(peak)=((E(V/m))^2 \times (1)^2)/(30 \times 501))$= Pt(peak)
$Pt(peak)=((7200)^2 \times (1)^2)/(30 \times 501))$= **3449.1 watts (peak)**

1100 V/m at 1M (PULSED)

Antenna parameters:

Antenna Gain - G(dBi) = **20 dB**
Antenna Gain - G(linear) = **100**

Variables:

E(V/m) - E field level - **1100 V/m**
R(m) - Distance in meters - **1M**
Pt(peak) - RF input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

$Pt=(E^2 x R^2/30 x G(linear))$ = RF power at antenna

Calculation

$Pt(peak)=((E(V/m))^2 \times (1)^2)/(30 \times 100))$= Pt(peak)
$Pt(peak)=((1100)^2 \times (1)^2)/(30 \times 100))$= **403.3 watts (peak)**

2000 V/m at 1M (PULSED)

Antenna parameters:

Antenna Gain - G(dBi) = **24 dB**
Antenna Gain - G(linear) = **251**

Variables:

E(V/m) - E field level - **2000 V/m**
R(m) - Distance in meters - **1M**
Pt(peak) - RF input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

$Pt=(E^2 x R^2/30 x G(linear))$ = RF power at antenna

Calculation

$Pt(peak)=((E(V/m))^2 \times (1)^2)/(30 \times 251))$= Pt(peak)
$Pt(peak)=((2000)^2 \times (1)^2)/(30 \times 251))$= **531.2 watts (peak)**

Scaling a drive table –

The DO-160 standard requires pulsed fields up to 7,200 V/m which are far more difficult to validate for calibration purposes. Scaling means that a 72 V/m field can be used as the calibration for a 7,200 V/m test. Available probes have frequency and level limitations and will at some point be no longer useful. This leaves the receiving antenna approach or drive table scaling to produce the high levels required to run the pulse tests. Or, simply run the calibration at a range you can record and use correlation/scaling factors to determine what peak/pulse power is required to achieve the desired field level.

In the example below the power level required to produce a 72 V/m CW field is 3.267 watts. The test system can be far more easily calibrated at 72 V/m as compared to 7,200 V/m. After the lower level calibration the drive table can be scaled by adding +40 dB to each individual drive levels to achieve the multiplication and obtain the 7,200 V/m level.

The PM pulse modulation must be set for the appropriate pulse with and repetition rate. This will ensure that the average power requirement is set correctly so components and equipment are not over-loaded. The results should be tested at reduced power using a power measuring device prior to bringing the system up to full peak power under manual or software control.

The peak antenna input power for this test would be **3.45KW!** After the application of the modulation, running the scaled drive table will produce a 7,200 V/m peak power pulsed field. This of course assumes that the RF power amplifier and the test system have been rated and designed to safely produce the required power levels across the bands of interest.

The fields produced in this type of testing are extremely hazardous and can quickly cause severe physical damage to humans exposed to the radiation. Safety is Imperative!

See examples next page-

Note: The RF Power Levels identified are at the antenna. The Amplifier power level will need to be higher for system RF losses from the Amplifier RF output connector to the Antenna RF input.

7,200 V/m at 1M (PULSED)

Antenna parameters:

Antenna Gain - G(dBi) = **27 dB**
Antenna Gain - G(linear) = **501**

Variables:

E(V/m) - E field level - **7,200 V/m**
R(m) - Distance in meters - **1 M**
DF - Duty Factor - 0.4% (**0.04**)
Pt(peak) - RF input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

$Pt=(E^2 x R^2/30 x G(linear)) x$ Duty Factor = RF power at antenna

Calculation

$Pt(peak)=((E(v/m)^2 \times (1)^2)/(30 \times 501)) \times DF = Pt(peak)$
$Pt(peak)=((7{,}200)^2 \times (1)^2)/(30 \times 501)) \times 1.0$ = **3,449 watts (CW/peak)**
$Pt(ave)=((7{,}200)^2 \times (1)^2)/(30 \times 501)) \times .04$ = **137.9 watts (average)**

720 V/m at 1M (CW for calibration)

Antenna parameters:

Antenna Gain - G(dBi) = **27 dB**
Antenna Gain - G(linear) = **501**

Variables:

E(V/m) - E field level - **720 V/m**
R(m) - Distance in meters - **1M**
DF - Duty Factor – 1.0
Pt(peak) - RF input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

$Pt=(E^2 x R^2/30 x G(linear)) x$ Duty Factor = RF power at antenna

Calculation

$Pt(peak)=((E(V/m)^2 \times (1)^2)/(30 \times 501)) X DF = Pt(CW)$
$Pt(peak)=((720)^2 \times (1)^2)/(30 \times 501)) \times 1.0$ = **34.49 watts (CW/peak)**

72 V/m at 1M (CW for calibration)

Antenna parameters:

Antenna Gain - G(dBi) = **27 dB**
Antenna Gain - G(linear) = **501**

Variables:

E(V/m) - E field level - **72 V/m**
R(m) - Distance in meters - **1M**
DF - Duty Factor – 1.0
Pt(peak) - RF input to antenna

Antenna Gain Conversions

G (dBi) = 10 Log G(linear)
G(linear) = Antilog [G(dBi)/10]

Field Strength

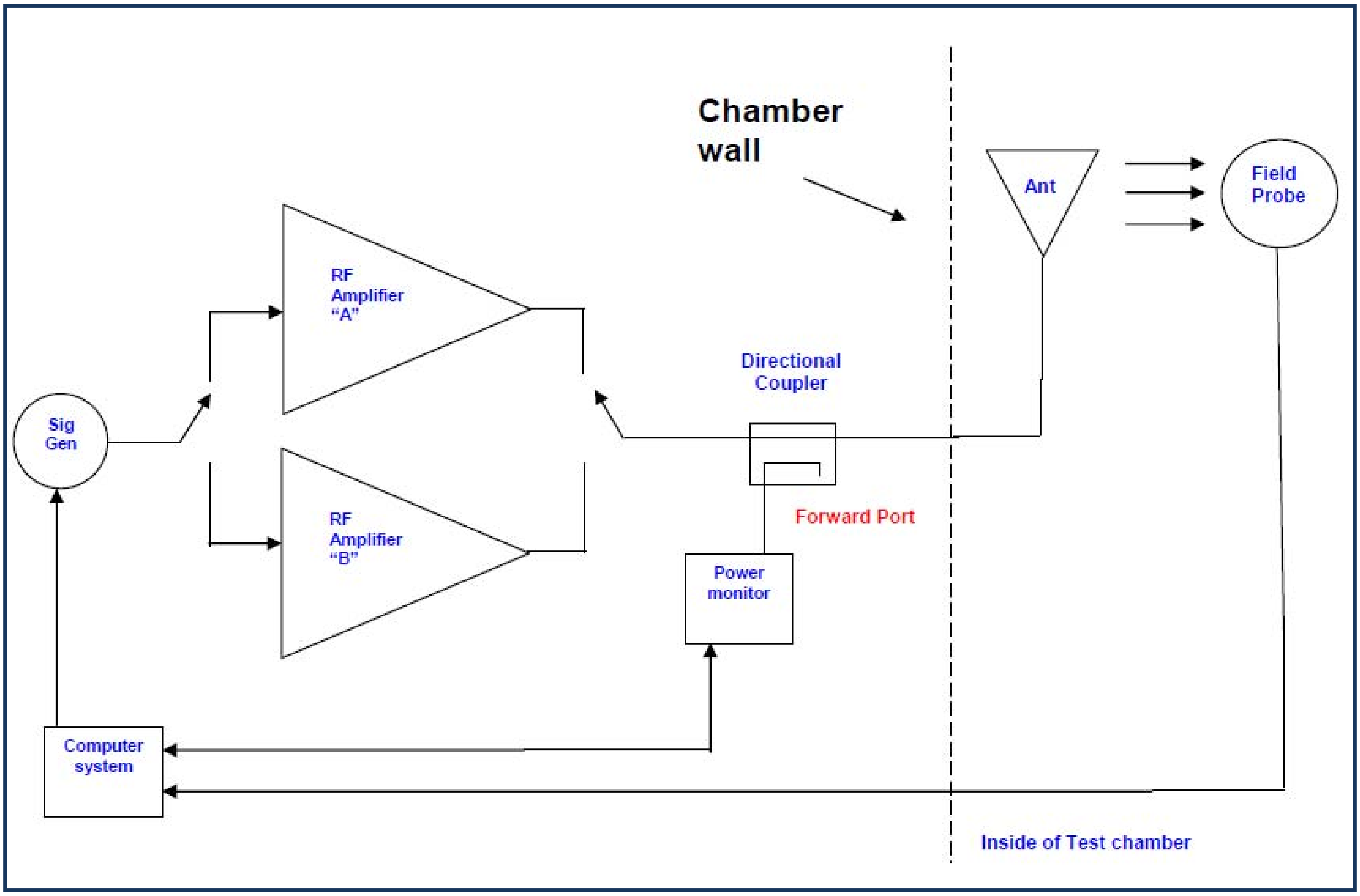
$Pt=(E^2 x R^2/30 x G(linear)) x$ Duty Factor = RF power at antenna

Calculation

$Pt(peak)=((E(V/m)^2 \times (1)^2)/(30 \times 501)) X DF = Pt(CW)$
$Pt(peak)=((72)^2 \times (1)^2)/(30 \times 501)) \times 1.0$ = **.35 watts (CW/peak)**

Illustration 1.0 –

Radiated Immunity block diagram and drive table construction



The basics of automated testing of a CW amplifier are straightforward. A file is loaded into the software test profile containing the target output power levels in dBm and then the system levels to those levels by successive approximation from frequency to frequency. This subsequently builds a drive table which can be used to derive other information including gain and drive level.

The testing of a pulse amplifier is similar with the exception that average power is available to close the loop. If you control and set the input duty cycle to 10% then an appropriate power meter similar to the HP 436 does a fine job of measuring the average power with a 10 dB offset. If you provide the average power output level targets then a leveling routine does the rest.

You may also setup system calibration routines that normalize the losses of the input chain and or system losses including the output cabling. This data is taken automatically (at the click of a mouse) and then the data is available to normalize the target drive table and to correct the signal generator drive level to provide an accurate indication of gain and drive level. All of the final output data is normalized and plotted automatically.

The system must have some additional input information including approximate gain to allow the loop to start in a safe level, the nominal attenuation value in the RF output, the frequency list and target output power level. All of this information is imported in the from comma delimited Excel files.

With that explained, we can proceed to the EMC testing! One method is to setup a calibration system as in illustration 1.0. The basic function is for the system to level from the field level information supplied by the probe output. Most software packages allows for the leveling input data to be taken from a field probe, power meter, SA or about anything.

The whole idea is to ratchet up the drive level to eventually obtain the correct field level one frequency at a time. This data is saved in a file that can be accessed by the software. The actual test data can not be altered directly, but can be manipulated using basic math functions supported by the software.

Since the DO-160 standard requires the user to record the output power level during the tests, a power level monitoring device must be connected to the output of the sample port on the amplifier. The levels can be “monitored” and recorded by the software. The coupler calibration data can be imported and then a math function applied to obtain the calculated RF level at the output of the amplifier. If desired, the antenna cable losses can be normalized to provide and calculate the antenna power input levels. That information could then be used to correlate the calculated antenna gain to the manufacturer’s published specifications.

The calibration amplifier (Low Level Amplifier) will be referred to as amplifier “A.” We will now replace amplifier “A” with amplifier “B” which will be capable of operating at the peak power levels required to generate the high field levels. The test setup is similar to the one shown above with the elimination of the probe feedback connection. Monitoring of the RF power levels will still be required by the standard and for the leveling system.

Since we have a normalized record of the output power produced by amplifier “A” during calibration, we can apply the correction factors from the sample coupler to that data set along with the high level scaling factors and use those results as leveling targets for the software to run the high level tests. This will allow the system to operate in closed loop mode and the signal generator level will increase during areas of amplifier compression, thereby producing an accurate leveled field.

