BROADBAND NOTE

Dual Directional Couplers

We often overlook the contribution of the ubiquitous Dual Directional Coupler in modern EMC immunity test set-ups. While seasoned EMC test veterans have voluntarily used directional couplers for years, they are now required by many EMC standards when conducting a fully compliant test.

A generalized test procedure for radiated immunity requires that the test chamber be "calibrated" for an arbitrary test level. This calibration generally entails monitoring the forward power required to generate an arbitrary field level at a number of frequencies across the test frequency spectrum. This test is repeated at a number of points over a predetermined area and variance criteria are applied to insure that the test chamber provides the necessary field uniformity. Finally, the device under test (DUT) is substituted for the field probe and the previously measured forward power (scaled up or down accordingly) is applied to the antenna to test the DUT. This approach is referred to as the "Substitution Method". For those unfamiliar with this procedure, a reading of "IEC 61000-4-3, Electromagnetic compatibility (EMC)-Testing and measurement techniques-Radiated, radio-frequency, electromagnetic field immunity test" is very enlightening.

The system diagram used to conduct this test is shown in Figure 1.

FULL COMPLIANCE SUSCEPTIBILITY TEST SYSTEM

(Use in applications that call for "Substitution Method" testing)

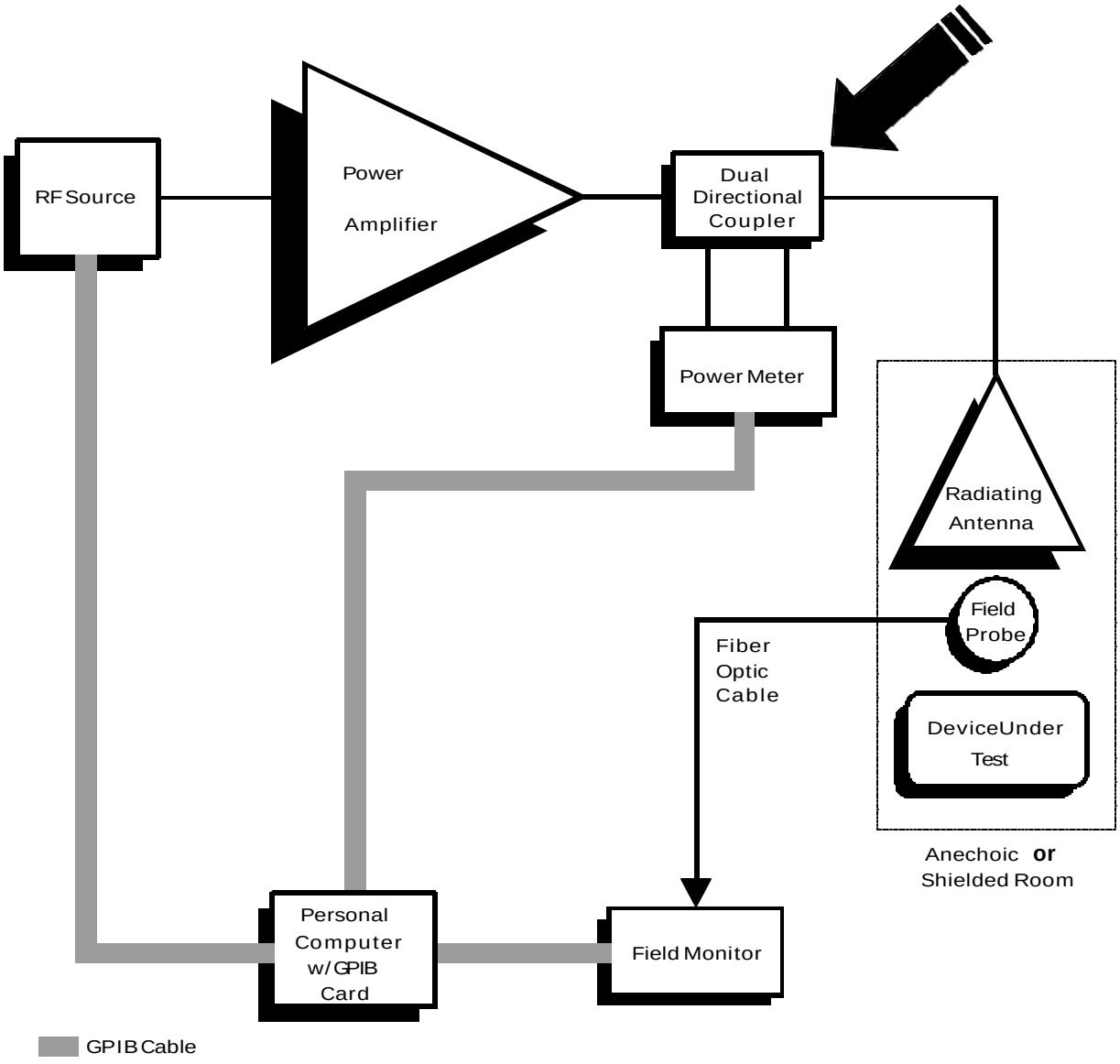
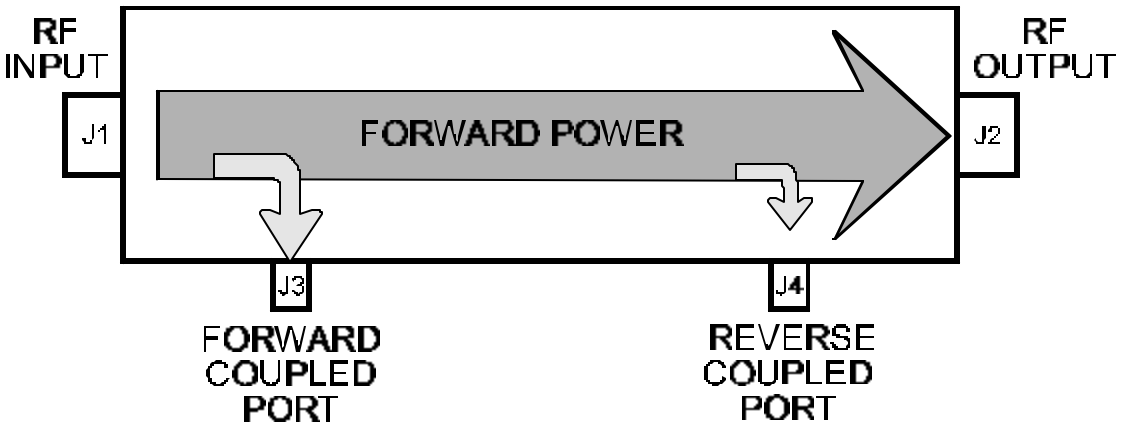


Figure 1

Note the key role played by the directional coupler. While most EMC standards require that only the forward power be monitored, some standards call for the monitoring of “net power”. Net power is the difference between forward and reverse power. Our dual directional couplers can accommodate either requirement.

If you are new to directional couplers, you might wonder why they are required? Why not just measure the power with a power meter? The reason is that power meters use very sensitive power heads to measure power. Any appreciable amount of power would burn out most power heads, especially those that employ very sensitive diode sensors. Take for example our popular PH2000 diode power head. The dynamic range of this power sensor is –60 to +20dBm. While at first glance +20dBm may appear like a sizable number, it is only 100mW (recall that 0dBm equals 1mW). A directional coupler is used to "shunt" a small amount of the forward power to a forward power coupled port and likewise "shunt" a small amount of reverse power to a reverse power coupled port while passing most of the energy from the power amplifier to the antenna. In other words, a good directional coupler will have very little insertion loss. Figure 2 provides a graphical overview as well as a practical example of how to apply a directional coupler in an actual EMC test. Notice that the majority of the energy flows from J1 to J2, with very little insertion loss. Small amounts of power are siphoned off and appear at J3 and J4.

DUAL DIRECTIONAL COUPLER



INSERTION LOSS =	Pwr J1 – Pwr J2	(Typically 0.15 to 0.6 dB)
COUPLING FACTOR =	Pwr J1 – Pwr J3	(Typically 40 to 60 dB)
DIRECTIVITY =	Pwr J3 – Pwr J4	(Typically 20 to 25 dB)

Figure 2

Example: Assume that the amplifier frequency range is 1-1000MHz, and the rf output power is 30 watts. Convert the output power to dBm: $dBm=10\log(P_o/1mW)=10\log(30W/1mW)=10\log(30x10^3)=44.77dBm$ or ≈ 45dBm.

If the PM2002 / PH2000 combination is used, the power meter sensitivity is –60 to +20 dBm. Clearly, 45dBm would destroy the sensitive diode head. This is where the attenuation of the directional coupler comes in. A coupler that has a frequency response of at least 1 to 1000MHz and a power handling capability of at least 30 watts is needed. In addition, the attenuation to the coupled ports (coupling factor) must be at least 25dB to get within the sensitivity range of the power head. Allowing for a 10dB safety factor to insure that the power head will not be destroyed, a coupling factor of at least 35dB is necessary.

A quick scan of the available directional couplers results in the choice of the DC3001A. With a frequency range of 100kHz to 1GHz, power handling capability of 50 watts, and a coupling factor of 40dB, this is a good choice. The power applied to the power head is 5dBm. This is well within the safe operating range of the diode sensor.

The above exercise applies to the 30W1000B. As you might imagine, one could work the numbers for each amplifier on our Price Schedule. To save you the trouble, we have done the math and have listed the recommended dual directional couplers in Table 1.

Power Amplifier	Dual Directional Coupler	Load Resistor or Load Attenuator	Power Amplifier	Dual Directional Coupler	Load Resistor or Load Attenuator
25A250A	DC3010A	LA150	1S1G4A	DC7144A	LA150
40AD1	DC3010A	LA150	1S4G11	DC7420 *	LR0050
75A250	DC2600A	LA150	5S1G4	DC7144A	LA150
75A250A	DC2600A	LA150	5S4G11	DC7420 *	LR0050
75AP250	DC2600A	LA150	10S1G4A	DC7144A	LA150
75A400	DC3400A	LA150	15S1G3	DC7144A	LA150
100A250A	DC2600A	LA250	25S1G4A	DC7144A	LA150
100A400	DC3400A	LA250	30S1G3	DC7144A	LA150
150A100B	DC2600A	LA500	50S1G4A	DC7144A	LA150
150A220	DC2600A	LA500	60S1G3	DC7144A	LA150
150A250	DC2600A	LA250	100S1G4	DC7144A	LA250
150A400	DC3400A	LA250	120S1G3	DC7144A	LA250
250A250A	DC2600A	LA500	200S1G4	DC7144A	LA500
250AP250A	DC2600A	LA500	240S1G3	DC7144A	LA500
500A100A	DC2600A	LA1000	10ST1G18	DC7420	LR0050 **
1000A100	DC2500M5	LA4000	20ST1G18	DC7420	LR0050 **
2500A250	DC2035M4	LA4000	15T4G18	DC7435	LA100 **
3500A100	DC2035M4	LR10000	20T4G18	DC7435	LA100 **
5000A250	DC4250	LR10000	40T18G26A	DC7530	LR142
10,000A250	DC4250	LR20000	40T26G40A	DC7620	LR128
1000L	DC2500M5	LA4000	200T1G2	DC7144A	LA500
2500L	DC2035M1	LA4000	200T1G3A	DC7144A	LA500
5000LP	DC2035M1	LA1000	200T2G4	DC7144A	LA500
10,000L	DC4000M2	LR20000	200T2G8A	DC7280A	LR0500
10,000LM45	DC4000M2	LR20000	200T4G8	DC7350A	LR0500
10,000LP	DC2035M1	LR2500	200T8G18A	DC7450M1	LR1000
1W1000B	DC3001A	LR0050	250T1G3	DC7144A	LA500
10W1000C	DC3001A	LR0050	250T8G18	DC7450M1	LR1000
10WD1000	DC3010A	LA150	300T2G8	DC7276M1	LR1250+AD1104
30W1000B	DC3001A	LR0050	500T1G2	DC7128A	LA1000
50W1000B	DC3002A	LA150	500T2G8	DC7275A	LR1250+AD1101
50WD1000	DC3010A	LA150	500T8G18	DC7450M1	LR1000
100W1000B	DC3510A	LA150	1000T1G2B	DC7128A	LR2500
150W1000	DC6180A	LA250	1000T2G8B	DC7276M1	LR2000M1
250W1000A	DC6180A	LA500	1000T8G18B	DC7450M1	LR1500M1
500W1000A	DC6180A	LA1000	1000 & 2000TP1G2A	DC7144A	LA500
1000W1000C	DC6280AM1	LA4000	1000 & 2000TP2G8A	DC7280A	LR500
2000W1000A	DC6380	LR5000	2000TP8G12	DC7450M1	LR1000
3000W1000	DC6380M1	LR5000	1000 &2000TP8G18	DC7450M1	LR1000
4000W1000	DC6380M1	LR5000	1000TP1G3	DC7144A	LA500

* Note: Suggest Pastornak PE9433 SMA (M) to Precision N (F) adapters for the coupled ports and J2 (output port) and a Pastornak PE9431 SMA (M) to Precision N (M) adapter for J1 (input port).

** Suggest Pastornak PE9447 TNC (M) to Precision N (F) adapter

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Table 1

You most likely have noted that there are many “A” version directional couplers and may wonder where they came from. The “A” couplers are a result of our attempt to match our couplers with our amplifiers, as well as our power heads. Typically, “A” couplers have male input connectors to mate directly with female amplifier output connectors and female output connectors to mate directly with the male coaxial connectors found on coax cables. Furthermore, the coupled ports are Type N female to mate with our Type N male power heads. This all makes sense if you assume that the directional coupler is connected to the output of the amplifier, which is generally the case. What about the situation where the coupler is connected to a bulkhead feedthrough or an antenna? No problem! Just reverse the coupler and hook it up directly. We can do this since J1 and J2 are interchangeable. While most applications find the coupler connected directly to the output of the amplifier, it must be noted that directional couplers of any significant size and/or weight must be supported. Rather than rig up a support system, some customers choose to connect the coupler to the amplifier output via a short run of coax. Again, no problem! We still have all of the “old” style directional couplers. The chances are very good that given the new “A” couplers plus the full complement of couplers with various input and output connectors, we can satisfy almost any application. Regardless, if we don’t currently have the correct configuration, chances are we can modify one of the existing couplers to accommodate your customer’s needs.

When in doubt, give us a call.