MAKING MEASUREMENTS FROM 50 GHz TO 100 GHz

APPLICATION

There is a growing trend world-wide to use increasingly higher frequencies for many applications of high power RF energy. Certainly, it is the military that has led the way in using the millimeter band. MILSTAR communications systems operate from 43.5 GHz to 45.5 GHz and at a similar narrow band around 94 GHz. Millimeter band radars, fire control systems, and numerous other systems are in use around the world. The frequencies are largely classified. There are also several commercial applications either in-use or being planned.

DETECTION AT MILLIMETER FREQUENCIES

Narda's 8600 series probes were originally designed to operate up to 18 GHz and later to 26.5 GHz. These probes all use thermocouple detectors that function as dipoles. The sensitivity starts to decrease above 26 GHz, which limits the useful frequency range.

Narda made a patented breakthrough with the introduction of the models 8621D and 8623D in 1983 that dramatically increased the upper frequency range. This new design was carried forward into the 8700 series.

The ultra broadband characteristics of these probes are obtained by distributing resistive dipoles along the length of detector elements.

The spacing of the dipoles is less than a quarter wavelength of the highest rated frequency. This eliminates the possibility of any resonance within the rated frequency range. Technically, one of these probes may be viewed as a group of series connected small resistive dipoles or as a very low Q resonate circuit. The dipoles are oriented along the Poynting Vector which results in a traveling wave effect beginning to occur above 26 GHz. The traveling wave effect increases with frequency which offsets the natural loss in sensitivity from the dipoles. This results in a probe with an extremely flat frequency response throughout most of the millimeter region.

FREQUENCY RESPONSE

The theoretical, useful measurement range of the models 8721D and 8723D probes extends up to about 140 GHz. The rated frequency response of these models is 300 MHz to 50 GHz . However, these probes have a virtually flat frequency response from 700 MHz to 100 GHz. Narda has long theorized that the useful frequency range was far above the 40 GHz rating of the earlier models but lacked the test capability to confirm the calculations.

VERIFICATION

A U.S. Department of Defense (DoD) funded calibration effort undertaken several years ago indicated that these probes were usable at 94 GHz. Questions concerning the accuracy of the method used still left some doubts. A DoD funded program in 1994 verified accuracy from 40 GHz to 46 GHz to answer questions concerning measurements of MILSTAR systems. The probes proved to be flat (± 0.25 dB) in this region. Narda has now acquired a high power source to calibrate at 45.5 GHz (the upper end of the lower MILSTAR band) and has increased the frequency range of several probe models to 50 GHz.

The United States Air Force and Narda combined efforts to check the frequency response of several Narda probes and monitors at 94 GHz in late 1994. The results were published in a USAF sponsored *RF Radiation and Ultra Wide Band Measurements Symposium* in February 1995. A major U.S. defense contractor verified the results of this test program using their own facilities in 1996.

This 94 GHz measurement program was undertaken at the Air Force's Armstrong Laboratory located on Brooks AFB in San Antonio, Texas, the USAF's center for non-ionizing radiation research. The U.S. Navy and the U.S. Army have now re-located their non-ionizing radiation research facilities to Brooks. The experiments were carried out in an anechoic chamber fed by a 45 W tunable Klystron transmitter located just outside the chamber. The antenna

narda Safety Test Solutions
an L3 communications company

USA TEL: (1) 631 231-1700 • FAX: (1) 631 231-1711 • E-MAIL: NardaSTS@L-3COM.com • www.narda-sts.com
GERMANY TEL: 49-7121-9732-0 • FAX: 49-7121-9732-90 • E-MAIL: support@narda-sts.de • www.narda-sts.de

was a 2.54 cm diameter horn and all experiments were carried out in the far field. The accuracy of the facility had recently been verified by two separate outside organizations.

The probes were positioned precisely and the electric field was established to be equal to a five percent of the full scale measurement range of the probe.* This is standard practice for calibrating Narda probes because it results in a minimal linearity error. As expected, models 8621D, 8623D, 8721 and 8723 had virtually no loss in sensitivity at 94 GHz. The ultra-broadband models 8741 and 8722 plus the very high power model 8725 did show a loss of sensitivity. This was expected due to the somewhat different design of the detectors. Two personal monitors and one area monitor were also checked for accuracy.

* The model 8725, which is rated at 1000mW/cm², was checked at 0.5% of rated power. One of the model 8721 probes was checked at half power to verify that there were no linearity problems.

MODEL	S/N	CORRECTION FACTOR	ELLIPSE RATIO
8723	8010	1.06	±0.2 dB
8723	8011	1.06	±0.8 dB
8721	13037	1.07	±0.4 dB
8721	13031	0.96	±0.8 dB
8725	07004	1.6	±0.4 dB
8725	07003	1.4	±0.8 dB
8623D	35044	0.96	±0.6 dB
8623D	32029	1.26	±0.3 dB
8623D	36009	1.06	±0.4 dB
8741	11021	2.4	±0.2 dB
8722	10005	2.3	±0.2 dB

APPLICATION:

Probe models 8621D, 8623D, 8721, 8723, 8721D, and 8723D can be used with confidence to make accurate measurements up to 100 GHz. This assumes that the probe has been recently calibrated over its normal rated frequency range. These probes have extremely close unit-to-unit frequency response characteristics which is largely determined by the dimensions of the thermocouples. They are manufactured using a sputtering technique that results in virtually identical detectors.

There is only a single gain adjustment on the probe amplifier. Therefore, if a probe is properly adjusted at the lower frequencies and is within its rated frequency response at all frequencies, accuracy at frequencies up to 100 GHz is virtually guaranteed. A failure of any component that could alter the frequency response characteristics of the probe would certainly be evident during calibration at frequencies below 40 GHz.

The ultra-broadband models 8741 and the shaped frequency response 8722 series have two sets of sensors. Microwave frequencies are measured with thermocouple detectors but these detectors lose 3-4 dB in sensitivity at 94 GHz. They are quite accurate up to 50 GHz. Again, these characteristics are quite repeatable unit-to-unit so that by applying a 4 dB correction factor at 94 GHz, these models can be used to provide an approximate field strength reading.

The 8840 and 8841 series of Nardalert personal monitors indicated a 2-4dB loss in sensitivity. Narda now rates the model 8840D-1 up to 100 GHz because even a 6 dB loss of sensitivity would result in the monitor sounding the alarm at levels no higher than 4mW/cm². The vast majority of the standards in the world limit exposure in the millimeter range to either 5mW/cm² or 10mW/cm².

The model 8825 SMARTS area monitor indicates a loss of less than 2dB at 94 GHz. Given the many variations of monitor location, personnel location, and the site of the leak, this loss in sensitivity should not be critical.

TOC