Dual Site Measurements

The two types of measurement sites that make up a DSM process are much less expensive than a single semi-anechoic chamber.

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INTRODUCTION

The measurement of radiated signals as specified by current EMC regulations is commonly accomplished at two distinct sites. The term *Dual Site Measurements (DSM)* is applied to this process.

The first of the two measurements is made in some type of shielded room or enclosure in which ambient signals are attenuated below the limit level. Thus, this first part of the process measures only signals radiated from the item under test (EUT). Since the amplitude accuracy of any signal measured in a shielded enclosure is compromised by reflected waves, the objective is to obtain a frequency list of those signals radiated from the EUT.

The second measurement is made at a different site, usually an open area test site (OATS), which should be located in an area of low ambient signal density (Figure 1). The signals from the EUT frequency list taken at the first site are measured a second time. When a qualified or certified OATS is used, the second measurement will result in acceptable amplitude accuracy.[1]

ADVANTAGES OF DSM

This process at first seems redundant. However, upon further analysis, the reasons for the existence and the continued use of the DSM become obvious. Much of the justification for the DSM process relates to the costs of the measurement sites. The two types of measurement sites described above are much less expensive than a single semi-anechoic chamber. The first site can be made by lining nearly any room with a metallic screen or conductive cloth. The OATS will have much better site attenuation characteristics than a semi-anechoic chamber since the OATS has no off-wall or ceiling reflections.[1]

The advantage of the OATS becomes even greater as the measurement distance increases. The OATS ground plane can be extended to 30 meters and beyond at only a small additional cost, while the cost of a semi-anechoic chamber increases dynamically as the size of the chamber increases. The sheltered OATS also offers the possibility of unrestricted use during inclement weather.

DSM SOFTWARE

The actual implementation of the DSM process is more complex than a similar measurement in a semi-anechoic chamber. An EMI measurement software program features a DSM option that aids in the implementation of the DSM process. In brief, this program uses a unique multi-part measurement process.[2]

The measurement process has three basic parts:

- Part One is a number of peak, max hold sweeps over a fixed measurement band.
- Part Two makes a signal selection from the Part One trace data by means of a cutoff. The cutoff is an offset from the limit. Part Two automatically measures each signal exceeding the cutoff in a narrow frequency span using a peak detector.
- Part Three measures signals identified in Part Two with a quasi-peak (Q/P) and/or average detector. Part Three may be omitted entirely in cases where only the peak data is desired.

ADVANTAGES OF A MULTI-PART PROCESS

One of the numerous advantages of a multi-part measurement process is the capability to interrupt the measurement process at specified points. When the measurement process is interrupted in Part Two, it is possible to optimize the turntable azimuth and/or antenna height. Current regulations require that each signal measured be optimized for maximum amplitude. In the case of radiated signals, this means that the turntable azimuth and antenna height must be positioned to optimize the signal amplitude. In the multi-part process, this is accomplished in Part Two. After an initial set of several sweeps, the program will provide queues to optimize either or both the turntable azimuth or the antenna height, depending on selected options. The sweeps are taken with one trace in the max hold mode and the second trace in the normal mode.

The optimization process requires that the operator scan the variable to be optimized over its entire range. This will result in the max hold trace being displayed at a maximum level. The operator must then incrementally scan the variable a second time until the normal and max hold traces are approximately equivalent, at which point the variable is optimized.

Since it can be shown mathematically that the probability of maximum signal level is at the highest elevation for horizontal polarization and at the lowest elevation for vertical polarization, one strategy is to move the antenna to these positions while doing the azimuth scan and then scanning the antenna height.

THE FIRST MEASUREMENT

The first measurement using the program is made in what would be considered the usual manner. The required options from the main measurement menu are individual signals, record data, and print tabular data. A printout of the graphic data display is useful and can be made from the PC display at the completion of the data recording. There is no requirement to make a Q/P or average measurement, so these options are not selected.

SECOND MEASUREMENT

The second measurement requires that the DSM options be selected and that a disk with the data set from the first measurement site be inserted into the specified drive. When the DSM option is selected, a queue will request a data set number that refers to the data set that was measured at the first site. This data set number is simply a number that indicates the order in which the data sets were recorded. This number is automatically assigned to the data set file name when it is recorded and provides the unique file name required by DOS, so that the data set recording is automatic. The data set number is included on both the tabular data printout and the graphic data printout. When the data set number from the first site is entered, the program will use the data from the individual signal measurement at the first site to compile an EUT signal frequency list.

Proceeding with the second measurement, the required measurement options will be identical to those of the first measurement with one exception. The Q/P or average option would now be required, depending on the frequency range of the measurement and the requirements of the subject regulation. The effect of the DSM option will be apparent in Part Two of the measurement process.

First, a vertical line representing both the frequency and amplitude of each EUT signal is included on the graphic data display of the trace data taken in Part One of the measurement process. As each selected signal is measured, the program will determine if the signal being measured is within ± one-half the initial frequency span of one of the signals on the EUT frequency list. The signals selected at the second measurement site include both EUT signals and ambient signals. If no signal on the EUT list is within ± one-half the initial frequency span, then the signal being measured is an ambient, the measurement process is truncated, and the signal is not measured. If a signal on the EUT frequency list is within ± one-half the initial frequency span, there are two possibilities: the signal being measured is on the EUT frequency list, or the signal being measured is an ambient signal located within ± one-half the initial frequency span of a signal on the EUT frequency list. Part of the signal processing in Part Two of the measurement process ensures that signals selected by the cutoff are separated by ± one-half of the initial frequency span. This prevents duplicate measurements of the same signal.

At this point the spectrum analyzer will have scanned the initial "normal" frequency span a number of times so that the operator can use the spectrum analyzer display to evaluate the situation. The operator must now intervene and determine which signal on the spectrum analyzer display is to be measured. Menus are provided to give the operator several options to facilitate this decision. If the signal being measured is on the EUT frequency list and there is no other larger signal present on the spectrum analyzer display, then an option permits the program to continue and measure the signal being processed in the normal way. The process will measure the highest signal in the spectrum analyzer display.

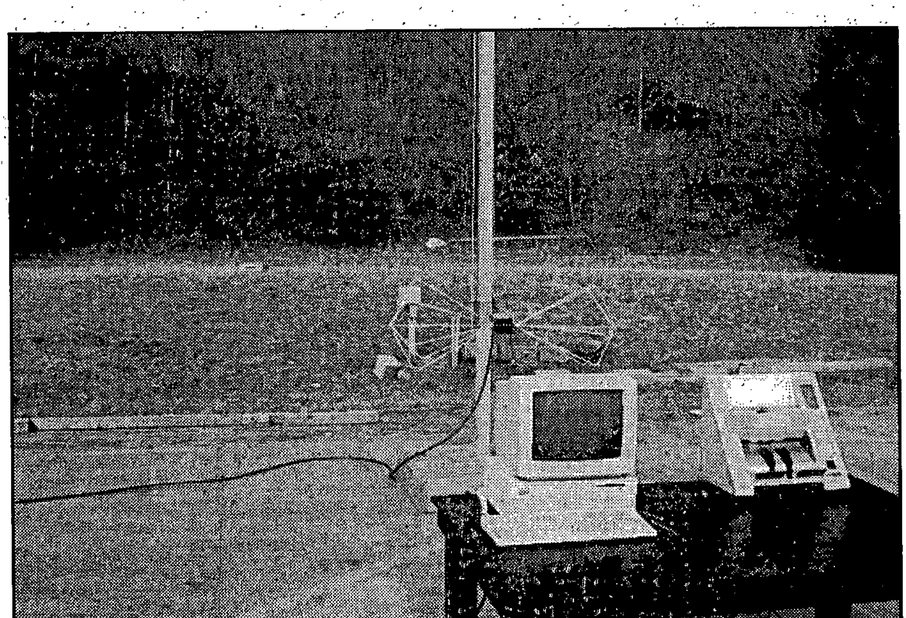

Figure 1. Open Area Test Site.

MARKER FREQUENCY

If there is more than one signal on the spectrum analyzer display, the operator will be required to move a marker to the signal to be measured. The program provides queues with the frequencies of the EUT signal being measured and the marker frequency to aid the operator in selecting the EUT signal. The marker frequency is updated with each incremental move of the marker. It is therefore only necessary to match the marker frequency with the EUT frequency, both of which are provided as queues. An option will then measure the signal amplitude and frequency at the point of the marker. There will also be options to change the frequency span within pre-specified limits. Decreasing the frequency span increases the frequency resolution of the marker. There is also an option to center the spectrum on the frequency of the marker. These options all facilitate the process of distinguishing between signals. The initial "normal" frequency spans in the 30 to 200 MHz measurement band is 1.5 MHz.

The end result is that the ambient signals will not be measured in Parts Two and Three of the measurement process but the signals of the EUT frequency list will be measured.

One additional case to be considered is when an ambient signal and a signal from the EUT frequency list are separated in frequency by less than ± one-half the Q/P 120 kHz or average 100 kHz bandwidth.[3] This case can be addressed by reducing the frequency span width to its narrowest setting and observing the signal being measured. If the ambient signal and the EUT signal spectrums overlap, the ambient signal may affect the accuracy of the Q/P or average measurement. In other words, the ambient signal is within either the Q/P or average bandwidths and the resultant measurement would be corrupted by the ambient signal.

The Q/P and the average measurement are both made in the zero span mode at the frequency of the signal being measured. When the marker signal option is used, the measurement is made at the marker frequency. By setting the marker off center from the signal being measured so that the bandwidth will include the EUT signal while excluding the ambient signal, the effect of the ambient can be minimized. However, if this step cannot be performed because the ambient and EUT signals are too close together, signal canceling methods will have to be applied.[3] Any such method is an additional step in the measurement process, making the entire measurement less efficient and more expensive. Locating the second measurement site in a low ambient signal density environment reduces the probability of this situation.

IMPROVED DSM MEASUREMENTS

The program has another feature that will improve the implementation of the DSM. This feature involves the initial frequency span in Part Two of the measurement process. It was stated earlier that the "normal" span was used. From the Measurement Utility menu, an option to select a wide, normal or narrow span is available. The value of the frequency span determines the resolution, or frequency separation, of the measurement process. By selecting the narrow span, which is one-half the normal span width, the possibility of the initial frequency span containing a single signal is increased. This is a desirable result because less operator intervention would be required.

The program calculates an estimate of the frequency of every signal that is to be measured individually in Part Two of the measurement process. This calculation is based on the trace data. When the signal is actually measured, the difference between this estimate and the actual measured frequency is saved as a frequency error correction factor. When the same signal, same frequency, is measured again, this error correction factor is used to reduce the frequency estimate error to nearly zero. The reduced frequency estimate error permits the use of the narrow span. Therefore, an improved DSM measurement process would include repeating the first measurement using the narrow span, resulting in greater frequency resolution in the EUT frequency list. This repetition is only required once for any specific spectrum because the error correction data is saved. The measurement at the second site would then also use the narrow span, which requires less operator intervention.

CONCLUSION

In conclusion it can be seen that the DSM has several advantages over conventional single measurement site methods. One advantage is the lower initial investment in measurement sites. The accuracy advantage of the OATS is also a consideration. Lastly, the use of the EMI commercial measurement program can greatly increase the efficiency and the accuracy of the DSM measurement process.[4-5]

REFERENCES

1. R. Southwick and S. Bennett, "Comparative Site Attenuation of Open Field Test Sites," Proceedings of the 1984 EMC Symposium, Tokyo, Japan, October 1984.
2. R. Southwick and G. Runger, "A Theory to Optimize the Detection of EMI Signal Measurement," *IEEE EMC Transactions*, November 1989.
3. R. Southwick, "EMI Signal Measurements at Open Area Test Sites," *EMC Test & Design*, July/August 1992.
4. R. Southwick, "Accuracy Considerations for Automated EMI Measurements," *ITEM UPDATE*, 1994.
5. R. Southwick, "Automated Compliance Testing" *ITEM*, 1992.

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