RF Measurement Sample Point – Its Importance in Making Accurate AM Noise Measurements and Other Types of Measurements in an FM Transmission System

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Abstract

This paper will discuss the importance of a properly designed transmission line coupler for making synchronous AM noise measurements. In addition, this same type of sample port can be used to drive a modulation monitor with excellent results

AM Noise in FM Transmission Systems

There are two types of AM noise signals present in FM transmission systems. One type is caused within the transmitter itself usually due to poor power supply regulation and/or filtering. A second type of noise is synchronous AM noise which is caused by the band width limitations inherent in any FM system. A perfectly tuned system will have the carrier centered symmetrically about the band pass of the tuned elements of the system including tuning stages within the transmitter and various other transmission path components including filters and the antenna system itself. Rarely are things perfect and too narrow a bandpass or an asymmetry in the pass band can cause the amplitude of the FM carrier to vary due to the change in frequency of the carrier with modulation. As the carrier rides upon the skirt of the pass band the amplitude will vary as the carrier comes in and out of the pass band.

According to leading transmitter manufacturers a figure of -40 dB or better should be obtained for good system performance. In order to tune a transmitter for minimum synchronous AM noise it is necessary to properly set up a test fixture to do this. Not doing so could cause the transmitter to be mistuned because the AM noise figure is being impaired by the measurement setup. There are various methods for measuring AM noise and the actual techniques are beyond the scope of this paper. There are references in the reference section that describe these methods. The point of this paper is to illustrate the proper signal take off point for this measurement. The RF sample port that is used for this type of measurement needs to present only a signal to the detector that is representative of what is coming from the transmitter. In order to do this the coupler must have good directivity. Poor directivity in the coupling system will result in summation of the incident and reflected signals which can cause erroneous data to be collected. This is due to the fact that the incident and reflected signals will be summed at a random phase angle due to the round trip time of the reflected signal relative to the incident signal. Summing these two signals together creates a vector of resultant phase angle. Because the signal is being modulated, AM modulation synchronized to the audio modulating the FM carrier results due to the instantaneous phase shift of the two signals. In order to minimize this error it is important to use a directional coupler with directivity exceeding 30 dB. A balanced type of coupler can provide this kind of directivity because the reflected signal is absorbed in a termination where it is prevented from influencing the incident wave being measured. This coupler can also be used to measure forward and reflected power as long as both ports of the coupler are terminated in their characteristic impedance.

In general, voltage type probes often provided with new transmitter installations should be avoided for test purposes due to the fact that they offer very poor directivity. A voltage probe will pick up signals coming from both directions of a transmission line. In some cases it may be adequate as long as the voltage standing wave ratio is extremely low to begin with and that there are no other interfering signals present near the antenna connected to the line. It is recommended that these types of samples not be used to drive a modulation monitor/test set because erroneous measurements may result.

There are several modulation monitors on the market that incorporate AM noise measurement capability. A suitable balanced directional coupler can be used to drive the monitor for modulation measurements and for test measurements such as static and synchronous AM noise measurements. Dual versions of this type of coupler are available whereby one side of the coupler can be used to measure forward and reflected power and the other to drive test equipment including modulation monitors and spectrum analyzers.

Harmonic Measurement of an FM broadcast Transmitter

There are several methods for measuring harmonics and spurious emissions from an FM broadcast transmitter. FCC rules require that all emissions outside of the FM mask be -80 dB or better below carrier level. The proper way to measure an FM transmitter's RF purity is to sample the signal from a directional coupler in the transmission line to the antenna of the transmitter in question. Care should be taken to have sufficient amount of coupling to allow harmonic energy and spurious emissions to be displayed on the measurement device. At the same time the level of signal coming from the coupler for on carrier measurements should be within the headroom range of the measurement device. Sometimes a pad will be required but often it is not if the coupler has been sized properly for the transmitter output power. Here is an example to illustrate this:

One method to measure harmonic energy is to use a calibrate receiver such as the Potomac Instruments FIM-71 VHF Field Intensity Meter. According to the specifications for the product the unit can measure from 10 V to 1 uV RMS. This is a 140 dB dynamic range and is well within the range of most measurements of this type. If we use 10 KW transmitter power as an example and a directional coupler with a 45 dB coupling loss the signal out of the coupler will be 0.32 watts or approximately 4 VRMS assuming a 50 ohm termination. This is well within the top end range of the meter whereby a pad is not necessary. This leaves us with 132 dB of resolution to the theoretical noise floor of the instrument. The normal procedure is to calibrate the receiver on the carrier frequency and then measure it for a reference. Then either a notch filter tuned to the carrier frequency or a band pass filter tuned to the desired harmonic frequency is inserted between the measurement port and the meter. In either case the insertion loss of the filter and cabling needs to be taken into account. A typical insertion loss for this type of filter is generally on the order of 1 dB or less but this can be measured using the FIM-71 calibrating oscillator. The insertion loss must be subtracted from the noise floor so now you can resolve to approximately -131 dB below carrier. The filter must be used or receiver induced inter modulation distortion can result in erroneous readings.

For this use the balanced coupler also serves another important function. Because the directivity is on the order of 30 dB or better you are insured that only the desired signals coming from the transmitter are being measured. At crowded sites it is not unusual for there to be mutual coupling between antennas resulting in undesired signals being present at the measurement port. When using a balanced coupler it is important that the reflected port be terminated in its characteristic impedance as the termination acts to absorb the energy that would otherwise appear at the forward port.

Return Loss Measurements

Return loss can be measured using a balanced directional coupler owing to the design's inherent directivity. The Potomac FIM-71 or similar meter can be used in conjunction with a suitable directional coupler such as the Electronics Research, Inc. CD series precision couplers for this purpose. Other instruments appropriate for these measurements include RF power meters manufactured by HP/Agilent and others.

Return loss expressed in dB can be measured quickly and accurately as long as certain guidelines are observed. To make such a measurement with a field intensity meter or power meter the same guidelines for maximum level presented to the meter should be observed as discussed above. To take advantage of the coupler directivity make certain that the opposite port from that which is being observed is properly terminated in the port's characteristic impedance. Connect the meter after calibration to the desired port and take the measurement as instructed by the manufacturer of the meter. Reverse the coupler port termination and meter to measure the other port and the return loss will be the difference between the two readings. A rule of thumb for return loss accuracy vs. directivity is that you need to have 10 dB more directivity than you will likely resolve in return loss.

Another important note about return loss and power measurement with wide band directional couplers is that care must be taken with the type of detector used to make the measurement. If single carrier measurements of return loss or power are desired a diode type detector is suitable and will provide accurate measurements provided that the meter and probe system has been properly calibrated and operated within its power ranges. If multiple carriers exist on a coupler such as in master antenna situations diode detector use should be avoided as they can create inter modulation products which will cause the measurements to be erroneous. A thermal detector or an RMS detector can be used for this purpose. It is also possible to use a diode type detector if a suitable band pass filter is used ahead of probe. The filter should be center tuned for the carrier under observation. Of course the insertion loss of the filter should be taken into account.

Recommended Coupler loss values referenced to Power for Modulation Monitor/Test Equipment Usage

Based on the Belar Laboratories FMM-2 data sheet the input sensitivity of this equipment is 1 – 10 V RMS. Consult your modulation indicator manufacturer's specifications before attempting to connect equipment. In the example of the Belar monitor – 45dB coupling loss will provide approximately 4 V RMS at 10 KW transmitter power output It may be necessary to add padding to stay within the maximum power level for the monitor in use so size accordingly. Directivity should be 30 dB or better. P Cube, Inc. directional couplers for example can be provided with -40 to -60 dB coupling loss and still provide 30 dB or better directivity.

Summary

Consideration of test set up is important for qualitative measurements of FM broadcast transmitters. Use of balanced directional couplers provides good isolation and is generally free of error when sized appropriately and padding is used when appropriate. AM noise measurements under modulation conditions can benefit from use of balanced couplers because they reduce the number of unwanted artifacts from being introduced in the signal to be measured. For spurious and harmonic measurements can be made with a high degree of confidence using a balanced directional coupler again due to the fact that a coupler with high directivity provides a clean signal source free of unwanted emissions from other sources. For general purpose modulation monitor take off the balanced coupler makes an excellent choice because the residual incidental AM modulation apparent to the monitor can be minimized due to high directivity.

References

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The author would like to thank Dean Casciola of P Cube, Inc. Raymond Maine for assistance with preparation of this manuscript.