APPLICATION BULLETIN NO. 10

AN INTRODUCTION TO THE AM SPLATTER MONITOR

AND

THE SPLATTER MONITOR AND THE SPECTRUM ANALYZER: MEASUREMENT COMPARISONS

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THE AM SPLATTER MONITOR

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INTRODUCTION

The AM Splatter Monitor is designed to evaluate a transmitter's level of AM interference while avoiding some of the limitations of existing measurement techniques[1]. The development of the AM Splatter Monitor is a result of the National Radio System Committee's (NRSC) desire to more effectively measure the performance of radio stations in evaluating the NRSC preemphasis standard (NRSC standard)[2]. One goal of this committee is the reduction of AM interference[3] (splatter), particularly second adjacent channel interference, using a high performance, 10 kHz low pass filter[4]. The AM Splatter Monitor is ideally suited to evaluate the effects of this filter on transmitted interference.

This paper discusses the nature and effects of splatter and describes the uses of the AM Splatter Monitor compared to other spectrum measurement techniques.

SPLATTER DEFINITION

Splatter is one of those intuitive but ill defined concepts with which every broadcast engineer is acquainted. To the author's knowledge, no technical reference dictionary defines the term. For the purposes of this paper, let splatter be defined as the undesired portion of a station's output spectrum caused by modulation. Using this definition, power supply hum sidebands and carrier harmonics along with co-channel and adjacent channel interference are not splatter. Second adjacent channel interference is splatter. Also, note that the exact definition depends upon the engineer's opinion about which parts of the transmitter output spectrum are desirable. This is natural because the engineer's expectations are partly determined by regulation and partly by existing technology both of which may change. Finally, splatter is defined for the station's output spectrum which includes both the transmitter's output spectrum and the far field spectrum.

THE SPLATTER PROBLEM

Splatter is a problem because it interferes with reception of other stations. Nearly everyone has experienced the steam-locomotive-like sound of second adjacent channel interference while trying to receive a weak AM radio signal, especially at night. This effect is due to splatter from another radio station. The presence of such splatter does not necessarily indicate a violation of FCC emission limitations rules[5] because the receiver's automatic gain control brings up the splatter along with the weak signal.

Several secondary effects of splatter are harmful to the AM broadcaster. The existence of splatter from thousands of radio stations raises the general noise level of the AM band and thereby reduces the quality of AM broadcast programming. Also, splatter is energy wasted because the splatter sidebands are never audible to the station's listeners. In fact, the signals which cause splatter may intermodulate in the transmitter to produce distortion components within the desired portion of the spectrum and, therefore, distortion in the received signal.

SPLATTER SOURCES

The primary cause of splatter is higher frequency audio components at the transmitter's modulator input[6]. These higher frequency audio signals are translated directly into splatter by the normal process of modulation. A typical source of these audio signals is an improperly filtered clipper in the audio processor. Fortunately, the better audio processors incorporate a low overshoot filter to eliminate these clipping products.

Other sources of splatter are overmodulation, improper use of the transmitter's protective clippers, distortion and noise in the modulator, incidental phase modulation (IPM), and improperly operated AM stereo. In the case of incidental phase modulation, the resulting phase modulation sideband pairs would not, if left undisturbed, affect receiver envelope detectors. However, these sidebands are disturbed by every tuned circuit all the way through to the detector, especially the asymmetrical skirts of the IF bandpass. So some of this sideband energy is converted to AM sidebands which are detected as distortion. This is why reduction of IPM by proper transmitter neutralization improves the sound of AM stations.

MEASUREMENT TECHNIQUES

The regulations governing emission limitations[7] do not specify the monitoring equipment to be used or the frequency of measurement but specify only that the broadcaster must not violate the internationally agreed upon spectrum limits. Thus, strictly speaking, the broadcaster must guarantee at all times that he is not violating these limits. In practice, however, the spectrum is checked only periodically, perhaps once a year, using a rented or borrowed spectrum analyzer or wave analyzer and the assumption is made that the spectrum is acceptable at all other times. Until now, this was the only practical recourse available to the broadcaster due to the high cost of the necessary measurement equipment and the requirement for competent technical people to operate the complex equipment.

Other equipment readily available, such as communication receivers and field strength meters, are not suitable for close-in spectrum measurements because they lack the necessary dynamic range and selectivity. Even a high quality spectrum analyzer has the limitation that as it sweeps through the measurement band, it looks at only a small segment of the spectrum at any given time. Thus, the spectrum analyzer would not record the existence of a burst of splatter at other segments of the measurement band[8].

THE AM SPLATTER MONITOR

The AM Splatter Monitor is a dedicated, specialty device primarily intended for full time measurement of the spectrum segments between 11 kHz and 100 kHz away from the carrier on both sides of the carrier. The AM Splatter Monitor measures splatter level and any spurious emissions which fall within this spectrum segment. The AM Splatter Monitor is an economical device designed to fit within the budget of an AM broadcast station. Figure 1 is a front panel view of the AM Splatter Monitor.

Because splatter level normally decreases with frequency away from the carrier, the AM Splatter Monitor measures the most important segment of spectrum associated with splatter. This same segment of spectrum is where the changes in splatter level occur. These changes are due to factors such as shifts in modulation level, changes in program material, audio processor adjustments, and tube aging. The AM Splatter Monitor has an alarm that may be set to detect such changes. The station can use this alarm through a remote control system to immediately signal the occurrence of a splatter problem.

The AM Splatter Monitor is normally installed in a rack at the transmitter site to continuously monitor the transmitter's output

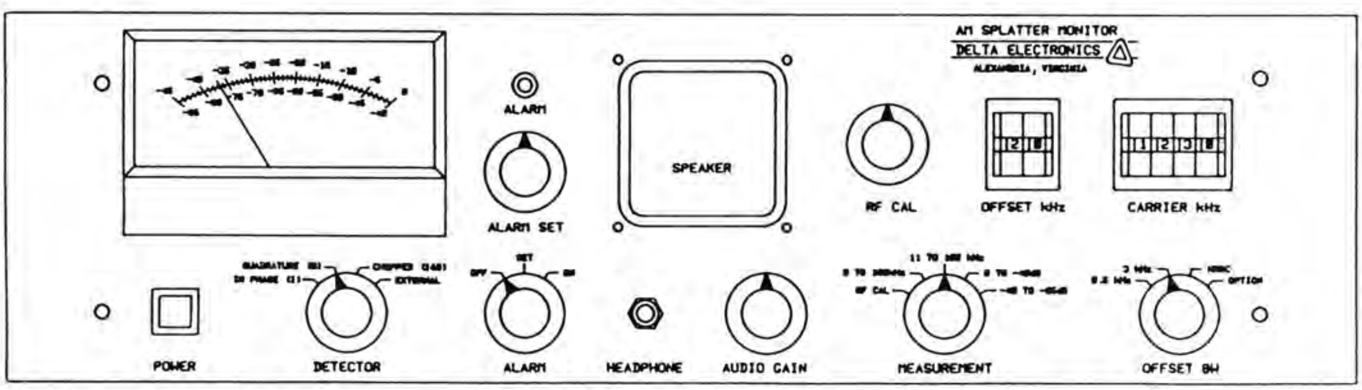

FIGURE 1

spectrum. Although the regulations regarding emission limitations require field measurement to assure compliance[9], the intervening elements between the transmitter's output and the far field are usually quite linear so continuous monitoring of transmitter's output is a reasonable indication of operational compliance. The AM Splatter Monitor is portable, and may be removed from the rack for field monitoring to assess compliance of the close-in spectrum (within 100 kHz) to emission limitations rules[10]. The unit may also be used for field monitoring in the strong signal areas of other AM stations to investigate interference complaints. For these purposes, the AM Splatter Monitor derives power from an automobile's cigarette lighter jack (+12V) and receives its RF input signal from an optional, active antenna.

Figure 2 is a simplified, functional block diagram of the AM Splatter Monitor. The reader is encouraged to refer to this figure while reading the following description.

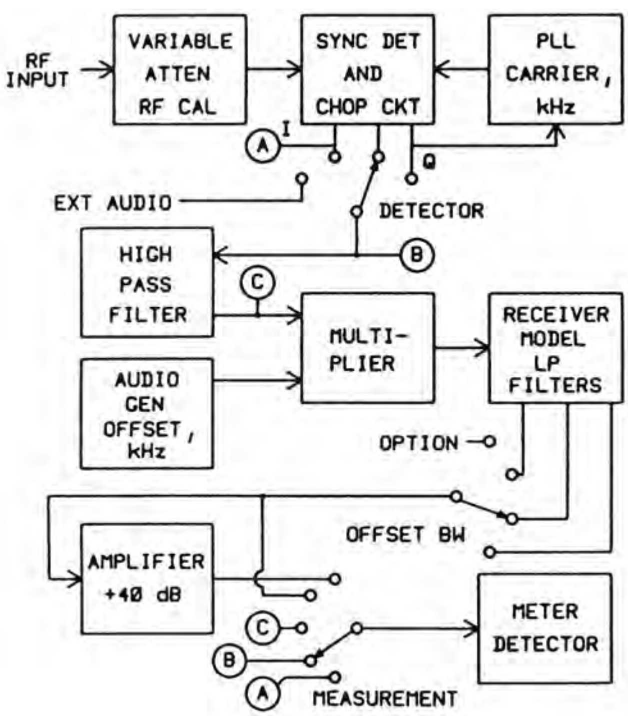

FIGURE 2

A 3 1/2 digit thumbwheel switch labeled CARRIER kHz adjusts the operating frequency of the AM Splatter Monitor from 450 kHz to 1700 kHz. Simple crystal and jumper changes allow operation at either 9 kHz or 10 kHz channel spacing. When tuned to 450 kHz, the AM Splatter Monitor can be connected to the 450 kHz IF output of a synthesized receiving, taking advantage of the AM Splatter Monitor's synchronous detectors either to evaluate receiver performance or for off the air monitoring. In monitoring applications, first evaluate the receiver using an amplitude modulated, signal generator and also evaluate the signal generator directly with the AM Splatter Monitor.

The AM Splatter Monitor uses high performance in-phase and quadrature synchronous detectors. The output of each synchronous detector is available on the rear panel. When used to measure splatter, the in-phase synchronous detector measures the splatter due to distortion and clipper products and the quadrature synchronous detector measures splatter due to incidental quadrature modulation which is related to incidental phase modulation. A measure of the overall splatter level requires a combination of the in-phase splatter and the quadrature splatter. A low frequency chopper circuit performs this function. The engineer uses the DETECTOR switch to select the in-phase detector, the quadrature detector, the chopped combination of these two detectors, or an external audio input depending upon his measurement needs. The external audio input is used to analyze the audio source material fed to the transmitter's modulator.

A five position switch labeled MEASUREMENT selects the function of the AM Splatter Monitor. In the first switch position, the AM Splatter Monitor measures the DC portion of the in-phase synchronous detector for calibration of the RF input level (carrier level). The second switch position selects measurement of all signals within 100 kHz of the carrier. The meter, when reading the in-phase detector or the chopper circuit, will typically read several dB down as it measures the desired modulation and splatter. The demodulated signal is audible from the front panel speaker or by use of headphones. In this switch position, the external synchronous detector outputs are used for receiver evaluation or off the air monitoring as mentioned above or are used with an FFT spectrum analyzer[11].

In the third switch position, a sharp high pass filter[12] is inserted so that the meter reads only that portion of the spectrum between 11 kHz and 100 kHz on either side of the carrier. This is a measure of the total splatter produced by the radio station and, unlike a swept spectrum analyzer, all spectrum components of interest are always available for measurement.

In the last two switch positions, the AM Splatter Monitor measures a selected spectrum segment of the total splatter signal in two ranges. The top meter range is elected by the fourth switch position and measures down to 45 dB below the calibration reference. The fifth and last switch position selects the bottom meter range which measures between 40 dB and 85 dB below the calibration reference. The segment of the spectrum selected is determined by a thumbwheel switch labeled OFFSET kHz and by a bandwidth switch labeled OFFSET BW. The OFFSET BW switch selects an equivalent receiver model and the OFFSET kHz thumbwheel determines how far that equivalent receiver is tuned away from the carrier on both sides of the carrier. For spectrum analyzer like applications, the OFFSET BW switch is set to the 0.5 kHz position yielding an RF bandwidth of 1 kHz which matches the step size of the OFFSET kHz thumbwheel. In the 3 kHz switch position, the AM Splatter Monitor responds like a typical narrow band radio. In the NRSC position, a wide band receiver is modeled with NRSC deemphasis. The switch position labeled OPTION allows selection of a customer determined receiver model contained on an optional plug in assembly.

A typical example of the use of the AM Splatter Monitor is monitoring the splatter produced on the second adjacent channels, 20 kHz away from, and on both sides of, the carrier. The OFFSET kHz switch is set to 20 for the required 20 kHz frequency offset. The OFFSET BW switch might be set to the 3 kHz position to measure the level of total splatter energy received by a typical narrow band receiver. According to the emission limitation rules[13], the maximum acceptable splatter level for this frequency is 25 dB below the carrier reference so the MEASUREMENT switch is set to the fourth position for measurements down to 45 dB below the carrier reference. The AM Splatter Monitor's meter must not read above the 25 mark on the top scale (-25 dBc).

The ballistics of the meter's detector circuit are set to match the integration factors of the human ear. Therefore, the meter reading for the example given above is equivalent to the interference level perceived by a listener. This is, of course, exactly the desired measurement if we assume that the purpose of the whole exercise is reduction of objectionable interference. The question may arise, however, of whether this measurement will agree with a measurement derived from some other measurement method. Will a spectrum analyzer, for instance, read the same as the AM Splatter Monitor? The answer is a qualified yes.

In the case of fixed sidebands due to test tone modulation, the peak detector of the spectrum analyzer responds the same as the quasi-peak detector of the AM Splatter Monitor. This is how the AM Splatter Monitor is calibrated. Modulation using the pulsed USASI noise source as recommended in the NRSC standard[14] yields the same readings provided that the spectrum analyzer is used either in the fixed frequency mode or with peak hold over a long time period. The same situation occurs with real modulation so that the qualification mentioned above is that the AM Splatter Monitor produces conservative readings, that is, if anything, higher readings than a sweep spectrum analyzer. Therefore, the AM Splatter Monitor is, in some ways, superior to a spectrum analyzer for this special application.

SUMMARY

Splatter is unwanted spectrum components due to modulation which interfere with other stations and cause distortion of the desired signal. The AM Splatter Monitor measures the level of splatter and can be used to identify and correct the sources of splatter. The AM Splatter Monitor is primarily intended for continuous monitoring of the transmitter output to indicate operational compliance to the regulations governing spectrum limitations[15]. It is also useful for field measurements in strong signal areas. The AM Splatter Monitor's alarm can be used to remotely alert the occurrence of splatter problems. The high performance, synchronous detectors in the AM Splatter Monitor make this unit useful for a variety of other applications.

REFERENCES

[1]Harrison J. Klein, P.E., Modulation, Overmodulation, and Occupied Bandwidth: Recommendations for the AM Broadcast Industry, (NAB September 1986) p. 22

[2]National Radio Systems Committee (a joint National Association of Broadcasters and Electronic Industries Association group), Interim Voluntary National Standard, (January 1987)

[3]op. cit. NRSC p. 1

[4]Ibid p. 7

[5]Federal Communications Commission, Rules and Regulations, Part 73, #73.44

[6]op. cit. Klein p. 23

[7]op. cit. FCC

[8]op. cit. Klein p. 22

[9]op. cit. FCC
[10]Ibid

[11]op. cit. Klein p. 23

[12]Courtesy of Bob Orban, Orban Associates, Inc., 645 Bryant Street, San Francisco, CA 94107

[13]op. cit. FCC

[14]op. cit. NRSC p. 9

[15]op. cit. FCC

Bibliography

Interim Voluntary National Standard, National Radio Systems Committee (a joint National Association of Broadcasters and Electronic Industries Association group), (January 1987) available through National Association of Broadcasters, 1771 N Street, NW, Washington, DC 20036

Klein, Harrison J., P. E.; Modulation, Overmodulation, and Occupied Bandwidth: Recommendations for the AM Broadcast Industry, (NAB September 1986)

Rules and Regulations, Federal Communications Commission, Government Printing Office, Washington, DC

THE SPLATTER MONITOR AND THE SPECTRUM ANALYZER: MEASUREMENT COMPARISONS

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Introduction

Can spectrum measurements made with a Splatter Monitor compare favorably with measurements made with a much more expensive spectrum analyzer? The short answer to this question is yes; comparison of spectrum measurements between the Splatter Monitor and the spectrum analyzer agree well.

This paper will present field measurement comparisons between the Delta Electronics Model SM-1 Splatter Monitor and the popular Tektronix Model 7L5 spectrum analyzer. The measurement techniques are described along with a theoretical discussion of spectrum measurements.

The Splatter Monitor

Since the Splatter Monitor employs a fundamentally different measurement scheme than that used in spectrum analyzers, a brief review of Splatter Monitor operation is necessary for the theoretical discussion.

Figure 1 is a simplified block diagram of the Splatter Monitor operating in the offset mode, the mode used in spectrum measurements. The local oscillator is phase locked to the input carrier frequency. Both in-phase (I) and quadrature (Q) mixers directly convert the RF input to baseband. Carrier and up converted products are removed by a 100 kHz low pass filter. This circuit is called a direct conversion or homodyne receiver.

Two important characteristics of this receiver should be noted. One, the in-phase (I) and quadrature (Q) mixers recover all of the available RF energy. Two, this homodyne receiver looks at both sides of the carrier simultaneously. The only practical disadvantage of this circuit occurs when an interfering signal corrupts the measurement. The spectrum analyzer shows each sideband independently so that the uncorrupted sideband can be used to estimate the level of the corrupted sideband. The Splatter Monitor cannot do this. Unfortunately, the ability to view both sidebands independently accounts for much of the cost of a spectrum analyzer.

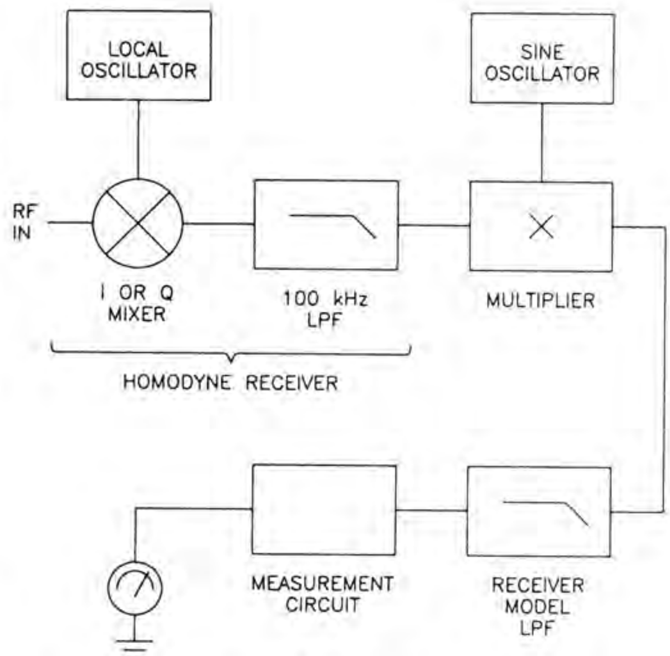

Figure 1

One might think that since both sidebands are viewed simultaneously by the Splatter Monitor, an imbalance in the sidebands would result in an erroneous Splatter Monitor reading. This is not the case as a simple example illustrates. Starting with a 100% amplitude modulated signal, the in-phase (I) detector will have a one volt peak demodulated signal and the quadrature (Q) detector will have zero volts output. If all of the energy from the lower sideband were added to the upper sideband, a single sideband signal would result. An examination of the appropriate vector modulation diagram reveals that the output of the in-phase detector would decrease by 3 dB and that the output of the quadrature (Q) detector would increase to this same level. Thus the recovered energy is simply redistributed between the two detectors.

The instantaneous magnitude of the baseband signal is the vector sum of the in-phase (I) and quadrature (Q) detector outputs. If one detector's output is 10 dB or more above the other detector's output, the lower level detector output can be ignored. A 10 dB level difference results in a maximum error of only 0.4 dB. For Splatter Monitor measurements, the in-phase detector usually dominates by at least 10 dB.

The output of the homodyne receiver is multiplied by a pure sine wave. The sine wave frequency is the frequency offset from the carrier. Thus, if we wish to examine spectrum components 20 kHz removed from the carrier, the sine wave frequency would be set to 20 kHz. A receiver model low pass filter isolates the spectrum components of interest. This is equivalent to tuning the modelled receiver to the two spectrum regions above and below the carrier.

A measurement circuit consisting of an absolute value circuit, a peak detector, and a logarithmic amplifier drives the meter. The splatter indications are displayed in decibels referenced to the carrier level (dBc).

Bandwidth Effects

The obvious, underlying reason for spectrum emission limitations is reduction of interference to other radio stations. This interference is perceived by people listening to their radio receivers. Thus, a sensible approach might be modelling the real world interference condition by using measurement bandwidths analogous to real radio receivers and by using meter ballistics that approximate the psychoacoustic response of the human ear.

This is done in the Splatter Monitor in two of the four selectable receiver model low pass filters. A 3 kHz low pass filter models the bandwidth of a low cost, narrow bandwidth receiver and an 8 kHz low pass filter with NRSC deemphasis models a high performance receiver. When either of these filters is selected, the peak detector in the measurement circuit is switched to slower attack and faster decay times for the required meter ballistics.

The National Radio Systems Committee (NRSC) recommends 300 Hz resolution bandwidth for spectrum analyzer measurements of emission spectrum. This is, of course, much narrower than the bandwidth of a typical radio receiver. Consequently, the spectrum analyzer will intercept a much smaller fraction of the RF energy in a splatter burst than a typical radio receiver. One might surmise that such spectrum analyzer readings are, somehow, invalid since the readings would not reflect real world receiver interference levels.

The 300 Hz resolution bandwidth, however, permits measurement of the expected attenuation slope of the spectrum at 10 kHz from the carrier when using a NRSC cutoff filter. A wider resolution bandwidth would smear and shift this slope showing the spectrum analyzer IF filter skirts rather than the desired measurement. The maximum spectrum emission levels specified by the National Radio Systems Committee are based upon the use of 300 Hz resolution bandwidth. A wider resolution bandwidth would simply require higher maximum permissible emission levels. If, for example, a 10 kHz resolution bandwidth were employed in an effort to model a typical radio receiver, few radio stations would comply with today's FCC emission regulations.

One of the selectable receiver model low pass filters in the Splatter Monitor has 0.5 kHz audio bandwidth. This is equivalent to a 1 kHz RF bandwidth. Since the frequency offset from the carrier is selectable in 1 kHz steps, the use of the 0.5 kHz receiver model neatly divides the spectrum into 1 kHz segments and guarantees that no transmitter spurious output is overlooked. When this receiver model is selected, the peak detector is switched to a very fast attack time with a very slow decay time. Thus, the Splatter Monitor meter shows the highest peaks with little decay between peaks. This makes the meter easier to read and corresponds with the fast peak readings of the spectrum analyzer.

Field Measurement Technique

Delta conducted field tests and made observations of stations broadcasting in the Washington, D.C. vicinity. These measurements were made without the knowledge of the stations. A mobile van was equipped with an AC generator, a Tektronix oscilloscope with a 7L5 plug-in spectrum analyzer module, a Delta Splatter Monitor, a Delta Model AWA-1 Active Whip Antenna, a Potomac Instruments Model QA-100 Quantaural Audio Program Analyzer, and an oscilloscope camera. Figure 2 is a block diagram of the test setup.

Using the active antenna, the van was positioned near the transmitting site of the AM station. The RF spectrum was then simultaneously measured with the spectrum analyzer and the Splatter Monitor. The Model QA-100 permitted monitoring of the audio processing characteristics of each

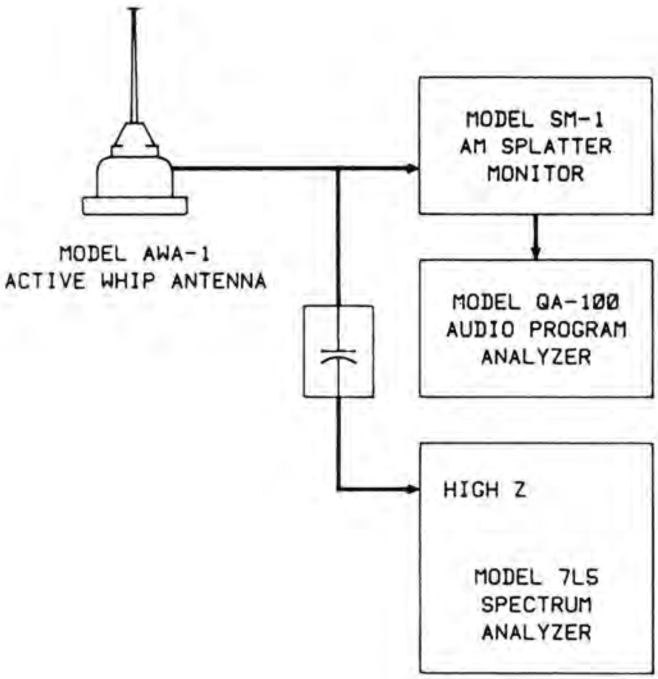

Figure 2

station measured. The spectrum analyzer was set for operation in accordance with the recommendations of NRSC-2. That is, the spectrum analyzer was set for a resolution bandwidth of 300 Hz, span of 20 kHz per horizontal division, peak hold with no video filtering, and sweep measurement for 10 minutes. During this 10 minute measurement period, Splatter Monitor readings were taken at 0.5 kHz, 3 kHz and NRSC bandwidths using both the in-phase (I) and quadrature (Q) detectors. For this paper, only the 0.5 kHz readings will be presented since these readings most closely approximate spectrum analyzer measurements.

The Splatter Monitor readings were taken by observing the "peaks of frequent occurrence" similar to the method used in modulation monitor measurements where an occasional overmodulation condition is tolerated. Since the spectrum analyzer is sweeping the band of interest and only observing any given frequency segment a fraction of the measurement time, the spectrum analyzer is likely to miss the rare maximum peak and observe the more frequent peaks in any given spectrum segment. In essence, the Splatter Monitor operator and the sweeping spectrum analyzer are exercising similar judgement.

Figures 3, 4 and 5 are digitized versions of the oscilloscope pictures taken at three of the stations visited. Tables 1,

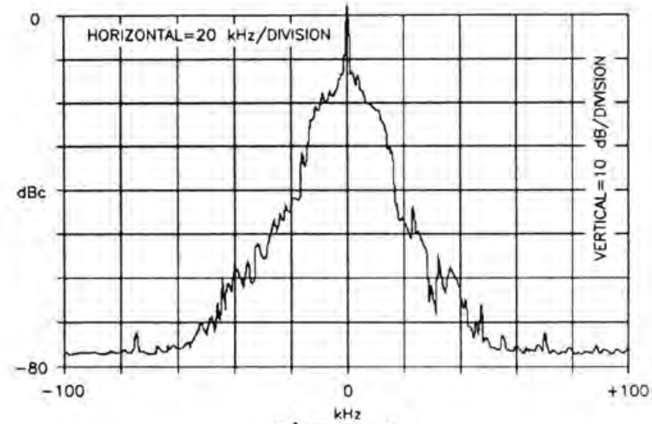

Figure 3

Table 1

Offset kHz	0.5 kHz I, dBc	0.5 kHz Q, dBc
15	-30	-49
20	-40	-58
30	-65	-78
40	-65	-72
50	-71	<-85
60	-80	<-85
70	-85	<-85
80	<-85	<-85
90	<-85	<-85
99	<-85	<-85

2 and 3 are the corresponding Splatter Monitor readings, respectively, for the same stations. Observe that the carrier peak of each spectrum picture appears to lie above the reference level. This is due to low frequency modulation energy falling within the 300 Hz resolution bandwidth around the carrier. The carrier reference was obtained with the 10 Hz resolution bandwidth to overcome this problem.

Figure 3 is a typical spectrum picture for a non-NRSC, monophonic station. Note in Table 1 that all of the quadrature modulation readings by the Splatter Monitor are well below the in-phase readings at the same offset frequencies, so that we may ignore the quadrature readings. The first data point, 15 kHz from the carrier, shows -30 dBc. Judging from the spectrum picture, the upper sideband appears to cross +15 kHz at about -30 dBc and the lower sideband appears to cross -15 kHz at about -28 dBc. Although this is in good agreement with the corresponding Splatter Monitor measurement, the picture illustrates one of the difficulties with making spectrum analyzer measurements. The slope of the spectrum is falling so fast at 15 kHz from the carrier that it is difficult to judge the exact spectrum level.

The second measurement point at 20 kHz from the carrier reads -40 dBc on the Splatter Monitor. The spectrum analyzer picture shows about -47 dBc on the upper sideband and somewhere between -42 and -46 dBc on the lower sideband. Thus, the jagged line on the lower sideband produces uncertainty in the measurement. Do we interpret the spectrum analyzer as the highest peak or as the average slope of the trace? A good case can be made that the highest peak should be used since every point on the display is, presumably, a valid measurement. This highest peak at -42 dBc agrees well with the Splatter Monitor.

The third measurement point at 30 kHz from the carrier illustrates another spectrum analyzer measurement problem. We know from the Splatter Monitor that this transmitter is a good AM source because the quadrature modulation (IPM) level is low. The upper and lower sidebands should, therefore, be symmetrical. However, the spectrum analyzer readings of the upper and lower sidebands at 30 kHz from the carrier are dramatically different. The lower sideband is between -52 dBc and -56 dBc whereas the upper sideband reads between -62 dBc and -67 dBc. Clearly, this is not just a case of reading interpretation.

The explanation of this phenomenon lies with the sweep measurement technique. The upper sideband reads less than the lower sideband because the bursts of splatter energy were absent whenever the spectrum analyzer was sweeping the upper sideband. When sweeping the lower sideband, the spectrum analyzer did catch one or more stronger splatter bursts. Of course, the same phenomenon applies to the Splatter Monitor as shown by the data. Neither instrument will measure where they are not looking. The Splatter Monitor measurement was, evidently, taken when the spectrum analyzer was recording the splatter levels of the upper sideband since these measurements agree.

Figure 4 is the spectrum analyzer measurement of monophonic station using NRSC preemphasis and filtering with a mostly talk format. First, notice the presence of two carriers from other radio stations which invalidate our Splatter Monitor's field antenna measurements at 40 kHz and 99 kHz offset from the carrier. The presence of these other stations is revealed by the appearance of the other stations' programming in the Splatter Monitor's speaker. As discussed above, the spectrum analyzer easily handles this problem. When using the Splatter Monitor, this difficulty may be overcome by taking readings on both sides of the invalid offset frequency and interpolating to the correct reading.

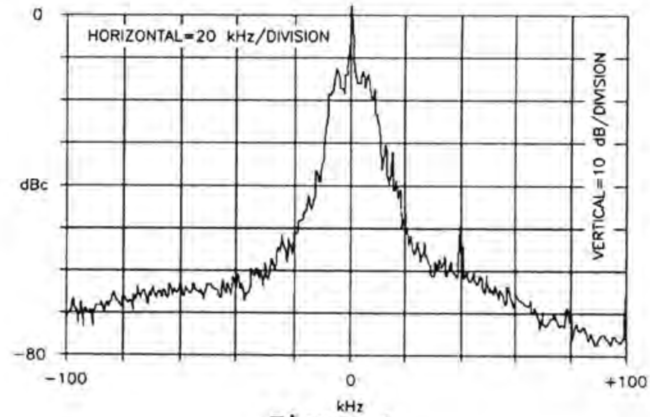

Figure 4

Table 2

Offset kHz	0.5 kHz I, dBc	0.5 kHz Q, dBc	Vector Sum, dBc
15	-40	-42	-38
20	-49	-52	-47
30	-62	-56	-55
40	-55	-53	-51
50	-70	-64	-63
60	-70	-66	-64
70	-70	-67	-65
80	-73	-69	-67
90	-76	-74	-72
99	-79	-78	-75

Second, observe from Table 2 that the output of the quadrature (Q) detector is almost as strong as the output of the in-phase (I) detector. This is due to a high level of incidental phase modulation which has compromised the effectiveness of the NRSC filtering. These high quadrature readings must be taken into account. Since peaks of incidental phase modulation are associated with peaks of envelope modulation and since in-phase splatter is associated with peak clipping on the same modulation peaks, one is justified in assuming that in-phase (I) and quadrature (Q) peaks occur simultaneously. Thus, the magnitude of the resulting peak is the vector sum of the in-phase (I) and quadrature (Q) peaks. This calculation appears in the sum column of Table 2.

The vector sum of the first data point at 15 kHz offset is -38 dBc. The upper and lower sideband peaks of the spectrum analyzer display are -35 dBc and -38 dBc, respectively. The second data point has a vector sum of -47 dBc and the upper and lower sideband peaks are -48 dBc and -49 dBc respectively. For the third data point at 30 kHz offset, the numbers are -55 dBc versus -57 dBc and -58 dBc. On the surface, this vector sum approach appears to yield

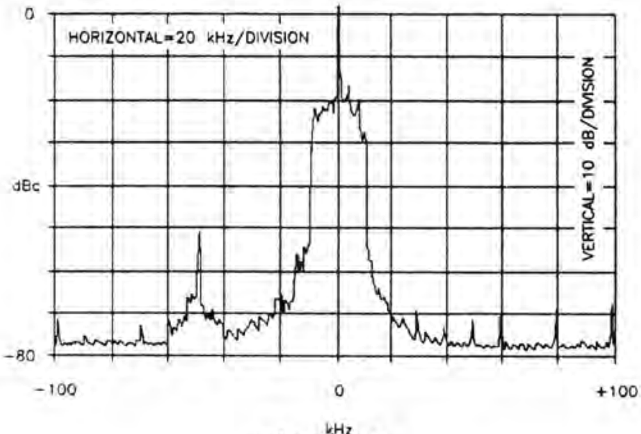

Figure 5

Table 3

Offset kHz	0.5 kHz I, dBc	0.5 kHz Q, dBc
15	-55	-70
20	-64	-80
30	-75	-80
40	-81	-82
50	-64	-65
60	-80	-80
70	-83	-82
80	-83	-79
90	-84	-82
99	-85	-83

close agreement between Splatter Monitor readings and the spectrum analyzer's highest peak readings. However, due to the fact that in-phase (I) and quadrature (Q) peaks do not necessarily occur at the same time as sideband peaks, this method is difficult to theoretically justify. Delta is pursuing this issue with special attention to AM stereo radio stations.

Figure 5 shows spectrum analyzer measurements of an exceptionally clean monophonic station employing NRSC preemphasis and filtering. This station's spectrum is so clean that the sidebands of another station only 50 kHz away are visible down to -75 dBc. This is attributable to the NRSC filtering, exceptionally low incidental phase modulation, and conservative modulation practices.

Again, the quadrature (Q) detector output is well below the level of the in-phase (I) detector and the quadrature contribution can be ignored. Examination of the first three data points shows that the Splatter Monitor's in-phase detector output agrees closely with the highest corresponding sideband peak observed on the spectrum analyzer.

The last observation about these field measurements is the level of the measurements far from the carrier. The spectrum analyzer readings at 90 kHz offset, for example, show a peak at about -75 dBc whereas the Splatter Monitor readings are in the -80 dBc range. This difference has not been fully explained except to note that the 7L5 spectrum analyzer is rated for -75 dB intermodulation products. Delta is still investigating this phenomenon.

Conclusion

Careful operation of the Splatter Monitor and the spectrum analyzer yield measurements in substantial agreement. In the presence of significant quadrature modulation or high levels of incidental phase modulation, the vector sum of the in-phase and quadrature peaks appears to yield good agreement with the highest corresponding spectrum analyzer sideband peak. In the presence of interfering signals from other stations, splatter levels at the interfering frequencies may be estimated by using an interpolation method.

Obviously the most careful means of determining peak splatter levels at any given frequency is to tune a measurement instrument to that frequency and observe the maximum peak. This avoids missing these maximum peaks in a sweeping frequency measurement and avoids judgement of "peaks of frequent occurrence." This is accomplished with a spectrum analyzer by setting the spectrum analyzer in zero span (i.e., zero Hz per horizontal division), tuning to the frequency of interest, and activating the peak hold function.

Delta has developed a digital peak hold circuit for long term retention of the maximum readings of the Splatter Monitor. Additionally, Delta has constructed a receiver model filter circuit for installation in the optional filter location of the Splatter Monitor. This filter closely matches the response of the synchronously tuned IF filter in the 7L5 spectrum analyzer with 300 Hz resolution bandwidth. With these new tools Delta hopes to develop even more accurate spectrum measurement techniques.

Bibliography

National Radio Systems Committee:
Interim Voluntary National Standard
Emissions Limitations for AM Broadcast
Transmission (Voluntary Standard No.
NRSC-2)
April 7, 1988

Available through:
National Association of Broadcasters
1771 N. Street, N.W.
Washington, DC 20036

Electronics Industry Association:
NRSC AM Preemphasis/Deemphasis and
Broadcast Audio Transmission Bandwidth
Specifications (ANSI/EIA-549-1988)
June 24, 1988

Published by:
Electronics Industry Association
Engineering Department
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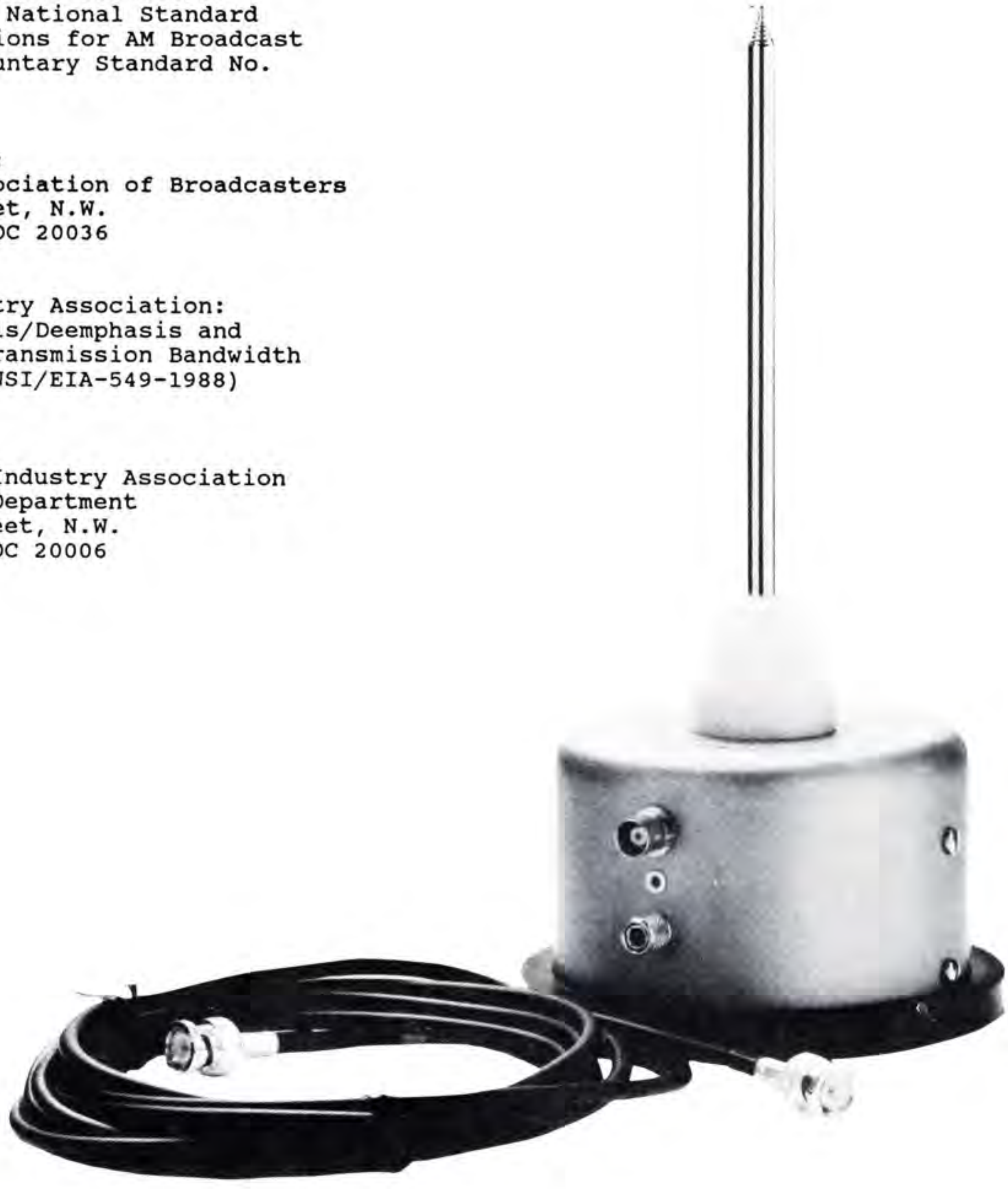

Delta's Optional AWA-1 Active Whip Antenna

The Optional Active Whip Antenna, Model AWA-1 permits field use of the AM Splatter Monitor. Splatter levels can be measured in fields of 1.0 volts/meter or higher. The AWA-1 is powered by the Splatter Monitor via a DC voltage carried by the RF coaxial cable. When used in fields above 1.0 volts/meter, the AWA-1 RF output is attenuated automatically. Using a low-distortion AGC technique, measurements can be made in very high signal strength locations without overloading the Splatter Monitor input. The ability to collapse the AWA-1 sectionalized antenna permits additional measurement range. A built-in test point, accessible from the side of the antenna, permits measurement of the AGC voltage. This voltage corresponds to field strength. The active antenna can be successfully operated in fields as low as 700 mV/M, however care must be taken so that splatter measurements at one frequency are not contaminated by other area stations. The antenna assembly is mounted to a recessed magnet for reliable mounting on a vehicle's roof. A separate ground lug is provided to reduce interference. The AWA-1 expands the uses of the Splatter Monitor, permitting investigation of splatter levels from neighboring stations, to field evaluation of directional system effects on audio sidebands.