Application Note
AN-6a

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MER - What is it ?

Jim Andrews, KH6HTV
www.kh6htv.com

When I first started working on digital televison (DTV) I did a lot of internet web research. It seemed that a key performance parameter for DTV was the Modulation Error Ratio (MER). It is a measure of the signal to noise ratio (S/N) in a digitally modulated signal. It is typically measured with a special test set which analyzes the I-Q constellation diagram.

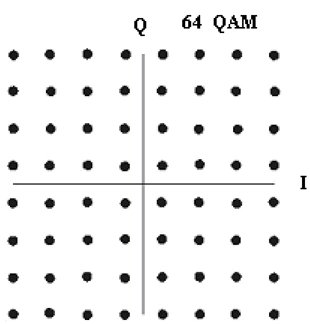


Fig. 1 Constellation Diagram

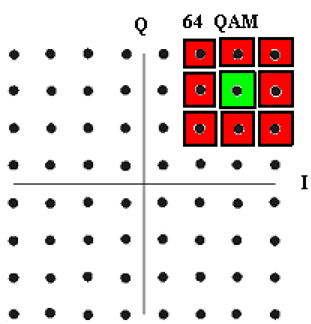


Fig. 2 Error Boxes

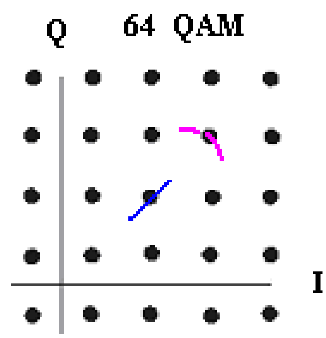
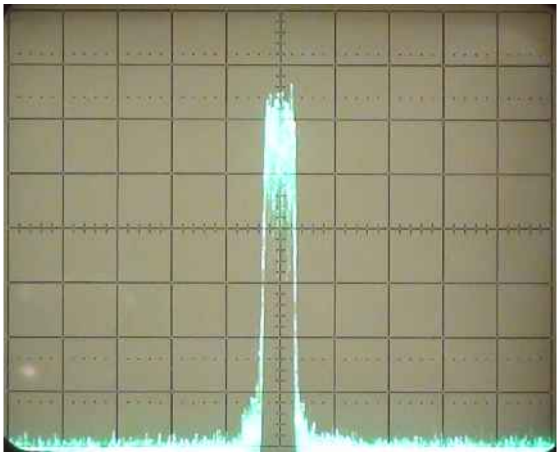


Fig 3. Amplitude & Phase Errors

The constellation diagram shows all of the possible logic states for a digitally modulated signal. This is a phasor plot showing amplitude and phase. The horizontal axis is called the In-Phase, or I axis. The vertical axis at 90 degrees to the horizontal axis is called the Quadrature, or Q axis. Fig. 1 shows a typical constellation, I-Q, plot for a 64 level Quadrature Amplitude Modulated, or QAM, signal.

So, how do errors occur in DTV ? Let's pick a particular data bit occupying a logic location such as I3-Q3. This is the green box in Fig. 2. The constellation "dot" is allowed to wander around in it's own green box and the DTV receiver will still decode it as a valid logic bit. However, if it wanders into a neighboring logic state box, indicated in red, the the DTV receiver will decode an error bit. Any impairments into the constellation will cause a data "dot" to move around in it's own allowed space, or "box". This could be outside interference, amplitude non-linearities, phase non-linearities, multi-path, etc. If the movement is radially this then is amplitude uncertainty. See the blue line in Fig. 3. If the movement is a rotation of the angle, then this is phase uncertainty as shown by the magenta curve.

So, how do we measure MER ? After a lot of internet research, I was unable to find out how the specialized test sets actually measure MER, but I did find a lot of companies offering to sell MER test sets. Was there any simple way for a ham to measure MER ? I turned to my spectrum analyzer and studied the spectrum of DTV signals.



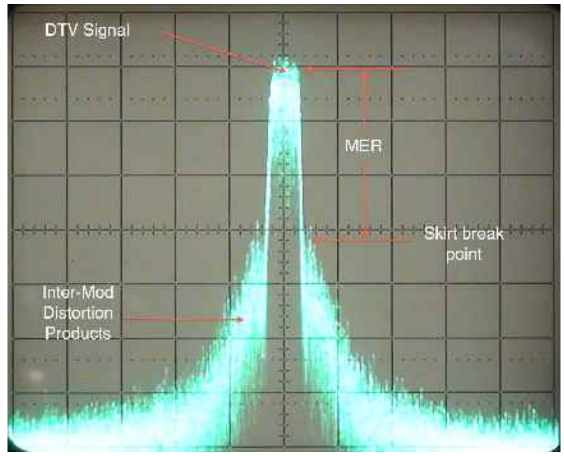


Fig. 4 64-QAM, DTV Spectrum Fig. 5 A measure of MER
10dB/div & 10 MHz/div

The ideal DTV signal spectrum appears like white noise sitting upon a tall pedestal above the background white noise. See Fig. 4 for an example. In cable TV (CATV) and USA broadcast TV, each DTV signal occupies a 6 MHz channel width. To avoid interference into adjacent channels there should be little or no energy present outside of the assigned 6 MHz channel.

I ran a series of tests driving the model 70-3, HDTV encoder and exciter signal, Fig. 4, into a linear amplifier. I deliberately drove the signal hard enough to cause the noise skirts to rise on the shoulders of the 64-QAM, 6 MHz rectangular box. See Fig. 5. These noise skirts were inter-modulation products as a result of amplfier non-linearites. I then ran this distorted signal into my Insignia, 22", HDTV receiver. I observed that if the ratio of the noise skirt break point level to the 64-QAM carrier power reached a level of about -28 dB, the TV set could no longer decode the signal, regardless of how strong the signal was. Numerous sources found on the internet all stated that the theoretical upper limit for MER was -27 dB for 64-QAM and - 31 dB for 256-QAM. **"Voila !"** My spectrum analyzer measurement of -28 dB gave excellent agreement with the theoretical MER limit of -27 dB. Thus, it appeared that I had discovered a simple, method for hams to measure the MER of a QAM signal using a spectrum analyzer. The bandwidth needs to be set to either 100 kHz, 300 kHz or 500 kHz for a valid measurement.

The FCC emission mask for ATSC, 8-VSB, broadcast DTV looks at the spectrum, see Fig. 5, and requires that the MER be > -37 dB. The FCC spec. specifies the use of a 500 kHz bandwidth. Thus, to be in compliance with the FCC emission mask, all KH6HTV VIDEO DTV transmitters maximum output power levels are set to have an MER = -40 dB as measured on a spectral plot such as Fig. 5.

NOTE: Since I wrote this original app. note in 2011, I have come to realize that this spectrum analyzer measurement was "fortunate" in giving an estimate of MER for CATV 64-QAM but doesn't really work for other DTV modulations. Observing the spectral re-growth as an amplifier is driven harder gives a measure of the amplifier linearity, but it is really not a true measurement of MER. ----------- Jim Andrews, KH6HTV, 30 Oct 2014