Testing RxMER at the output of nodes and amplifiers

Letter to the Editor prepared for SCTE•ISBE by

Brad Niems, Amphenol Broadband Solutions, Director of Business Development, SCTE•ISBE Member
2935 Golf Course Drive
Ventura, CA 93003
bradn@hollandelectronics.com
805-339-9060

Over the years it has been accepted that there must be transmit equalization (slope) compensation at the output of all analog nodes and distribution amplifiers. This is to counter the roll-off of both the hardline coaxial cable and the roll-off created by the insertion of multiple hardline taps and other passives in line with the coax cable run. It is further understood that the vast majority of nodes were originally designed for a maximum upper frequency limit ranging from 550 MHz to 750 MHz or higher. The end result of these designs is that the span between the node and the first amplifier, or between amplifiers, represents a length that was reasonably engineered in many cases for a 750 MHz bandwidth.

With the creation of DOCSIS 3.1, FDX and the upcoming DOCSIS 4.0, a new upper frequency limit of up to 1218 MHz (ultimately growing to 1794 MHz) that all DOCSIS 3.1 devices (I-CMTS or I-CCAP, R-PHY or R-MACPHY) operate to, and also realizing that the coaxial network is at a fixed length from previous design decisions, it is clear to all that up to 22 dB of positive slope (tilt) must be transmitted from either the traditional analog node or from the R-PHY or R-MACPHY (digital node) in order to satisfy the higher frequency losses due to the extended bandwidth.

The main point here is not to criticize older design decisions, but rather to point out the reality that the output from 100 MHz to 1218 MHz will more than likely need up to 22 dB of slope (tilt). The 22 dB slope presents the very real and difficult task of measuring the node or amplifier output for receive modulation error ratio (RxMER) performance accurately.

The CATV analyzer that the RF technician has been given for measurements in the field and, more importantly, that is also used for establishing performance objectives, likely will have serious dynamic range limitations.

By way of example, for measuring DOCSIS 3.1 accurately, it is important to understand that the RF power being measured has grown from DOCSIS 3.0 that is used today everywhere in the world and the analyzers have not adapted in kind. The situation is confirmed by the fact that the RF technician is armed with a CATV analyzer that is barely capable of measuring equalized RxMER = 47 dB.

For purposes of this scenario, assume that the system in question is a 1005 MHz EURO-DOCSIS 3.0 R-PHY or D-CCAP device installed in the CATV plant, replacing the analog node that was there previously. Further assume the use of a field meter capable of measuring up to about 47 dB RxMER on a flat spectrum from 100 MHz to 1 GHz.

So, now the reality. Standard practices result in the D-CCAP or R-PHY having to transmit approximately 65 dBmV total power, with a positive slope of 18 dB, to ensure that the signal reaches the input to the next amplifier in cascade with acceptable levels and tilt. The output positive slope requirement holds true for an N+0 as well, in order to provide a reasonable tilt and level for either the set-top box (STB) or DOCSIS cable modem at the end-of-line to operate in a satisfactory manner.

Figure 1 reflects these standard practices as produced by the R-PHY or D-CCAP (R-MACPHY) node.

The end result is that one ends up attempting to measure the following transmit spectrum at the output of the node.

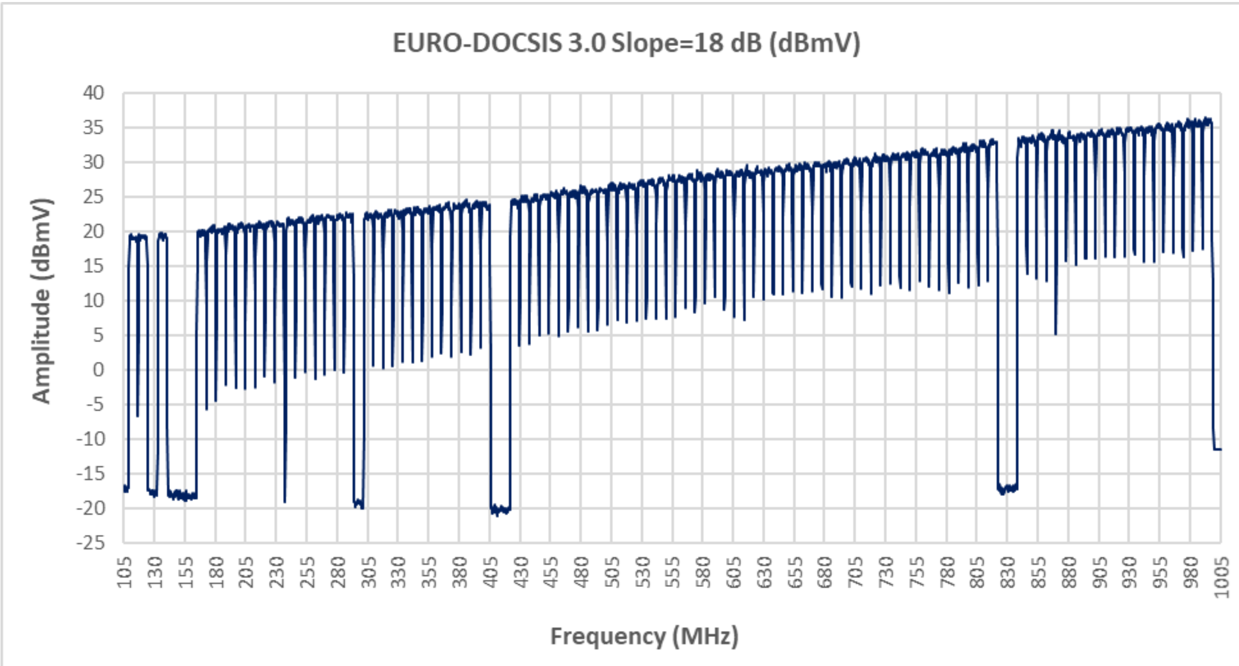

Figure 1 - R-PHY or R-MACPHY (Digital Node) - Typical Output Spectrum

Total Power (105 MHz to 1005 MHz)	=	**64.5 dBmV**
Required RxMER per carrier	=	43 dB
Power - (105 – 300) MHz	=	48.1 dBmV
Power - (300 – 500) MHz	=	52.2 dBmV
Power – (500 - 1005) MHz	=	64.1 dBmV

To further complicate the matter, the RF technician is instructed to verify the RxMER in the 300 MHz to 500 MHz region which means the CATV analyzer is being used to assess RxMER in the presence of the entire transmitted spectrum.

One can clearly see that the power from 500 MHz to 1005 MHz contains most of the total power while the RF technician must attempt to estimate or measure the RxMER in the 300 MHz to 500 MHz region which is several dB lower than the total power, and in particular the power above 500 MHz

Given that there is roughly 18 dB of slope or tilt in the node's output spectrum the RF technician must perform one of the following adjustments:

- Adjustment Option 1 – Lower the sensitivity on the CATV analyzer by adding attenuation so the instrument is not driven non-linearly by the higher-powered spectrum above 500 MHz. This would work, but by increasing attenuation, the signal being measured would be lowered to a level where it is degraded by the noise floor of the analyzer. The end result is one gets a stable RxMER estimate; however, the RxMER estimate does not reflect the node's RxMER output capability at all. Instead, the RxMER being reported is the direct result of the CATV analyzer noise floor now being part of the measurement. Therefore, the measurement is not accurate.

- Adjustment Option 2 – Playing with the attenuation (decreasing it somewhat from the adjustment in Option 1). Ironically this option is a veiled attempt at trying to determine how much of the Option 1 safe measurement approach was merely reflecting the CATV analyzer limitations and not the actual RxMER of the node. The irony is the RF technician will usually be instructed to push the linearity limits a little to see how much the RxMER estimate can improve. If the instrument has an overload light and it is only flashing a little rather than constantly on, the CATV analyzer is going to report the best RxMER possible. Of course, the uncorrectable codeword errors may actually increase during this measurement procedure. As with Adjustment Option 1, the measurements are not accurate.

So now the RF technician has what they feel is the best RxMER estimate possible given the circumstances since they cannot get a true accurate measurement. Let's say for sake of argument that the estimate was 41.5 dB. So, as is the case now, the RF technician doesn't know whether to report the RxMER estimate as a failure or assume it is good enough and move on to the next node or amplifier.

What has just been described goes on every single day in the field and is widely known throughout our industry. In fact, some have even come up with calibration estimates on how to determine what the real RxMER measurement should be!

In reality, however, there is no need to have to go through this procedure of overdriving the front end of the test equipment and playing with the input attenuation in an effort to see if the CATV analyzer can report a 43 dB or higher RxMER.

This is why the author and his colleagues spent considerable time working closely with industry experts such as Jack Moran and others to define a better, more accurate, approach. The fundamental concept is to simply connect a bandpass filter in series with the analyzer. This will accomplish the important function of significantly limiting the total power to the CATV analyzer input.

With this in mind, let's revisit the scenario displayed in Figure 1 but examine what the same CATV analyzer experiences when a 400 MHz bandpass filter (center frequency) with an approximately 200 MHz-wide passband is connected in series with the CATV analyzer.

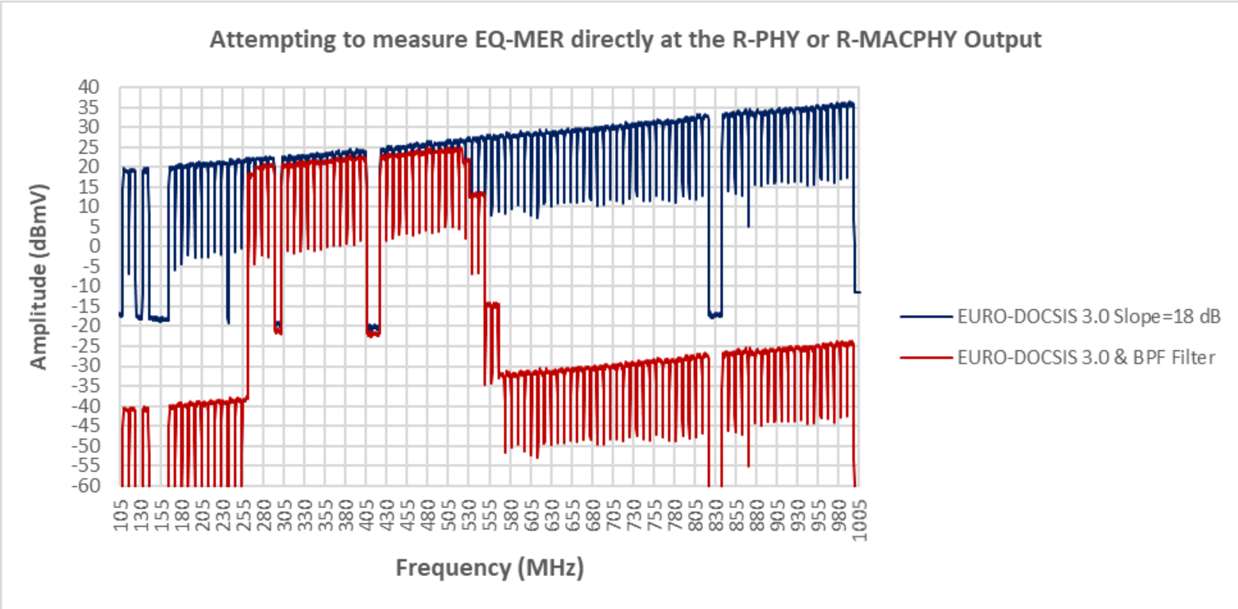

Figure 2 - CATV analyzer connected to R-PHY or R-MACPHY node output via a bandpass filter

Examining Figure 2, one can observe the following:

- The CATV analyzer only sees the energy in depicted in red and the total power = 51.7 dBmV. This value is a very long way from the total power of 64.5 dBmV that would be seen without the filter.
- Besides the obvious reduction in total power, all the higher signal power that required attenuation to be added no longer exists.
- It can also be observed that the filter itself does not eliminate the slope in the filter passband
- Finally, the original signal power in the approximately 300 MHz to 500MHz bandwidth is lowered by 1.8 dB, which is the passive filter insertion loss, so the only calibration required for accurate RX level recording is to add 1.8 dB to the level.

In summary, with the use of the bandpass filter and with very little attenuation being needed to perform the RxMER estimates, one would expect to easily report the RxMER estimate at the limits of the CATV analyzer (say 45 dB to 47 dB) rather than the 37 dB to 39 dB that Jack Moran had indicated he had to deal with in the field. This was tested in the field with a bandpass filter in series with a laboratory grade instrument (Keysight UXA Series N9040B) to measure a node's output RxMER. The results ranged between 48 dB and 50 dB as opposed to the 37 dB to 39 dB that had been reported using the cable operator'ss CATV analyzer without a bandpass filter. The CATV analyzer also reported higher RxMER with the bandpass filter than without.

The bottom line is that a suitable bandpass filter kit should be used in conjunction with test equipment – whether laboratory grade or the more common field-grade meters used by technicians – when measuring RxMER performance at the output of nodes and amplifiers.

