FCC Proof of Performance Measurements with a Real-Time Spectrum Analyzer (RTA) with QAM Vector Signal Analysis

This handout was developed in conjunction with my *Testing in Progress Column* in the Broadband Library, Winter 2018 Edition.

My intent in this exercise was to see how many of the required FCC NTSC analog (and optional QAM) measurements can be taken with a standard, factory issue RTA-VSA analyzer. My primary concerns, which I'll comment on throughout this document are (a) measurement accuracy and (b) measurement speed.

The modern 'real-time spectrum analyzer – vector signal analyzer' (RTA-VSA) is completely digital in terms of signal processing. This allows for varied measurements, options and displays; such as a digital display often termed DPX (the name is dependent on the spectrum analyzer manufacturer) in which the display makes use of various colors to indicate three measurement values rather than the normal two. The vertical axis {still} indicates signal power amplitude and the horizontal axis {still} indicates frequency. What is different is the range of colors assigned to each pixel. This color range indicates how often the signal is present over time (whether the signal is there 100% or only a portion of the monitoring time frame selected by the operator). A color 'scale' is selected by the operator depending on their preference. In my screenshots, a 'thermal' color scale is utilized similar to that employed in thermal imagery. Red pixels indicate a signal that is present 100% of the time (at a given [pixel] amplitude & frequency), while at the opposite end of the thermal scale blue to violet pixels indicate spectrum that is active around ≤10% of the time. And most RTA units (including mine) offer options including 'vector signal analysis'. A *vector signal analyzer* is an instrument that measures the magnitude and phase of the input signal at a single frequency within the IF bandwidth specified by the operator. Its primary use is to make in-channel measurements, such as error vector magnitude, code domain power, and spectral flatness on known signals. This VSA feature adds many new capabilities including QAM analysis & amplitude versus phase measurements to name several.

In general, speed of measurement as compared to a spectrum/QAM analyzer customized for cable television measurements is always an issue. It simply takes longer to make the measurements with a general purpose analyzer, however there are things one can do to speed the process up. Most RTA-VSA units allow for the 'settings' for any given test to be saved to the unit or an attached laptop. So, for example, once I have the unit set correctly to measure ICR on Channel 13, I can save those settings to my laptop to be recalled at any time. That speeds the testing process considerably, however, one is still faced with recording measurements on paper and then entering them into a spreadsheet or document file later.

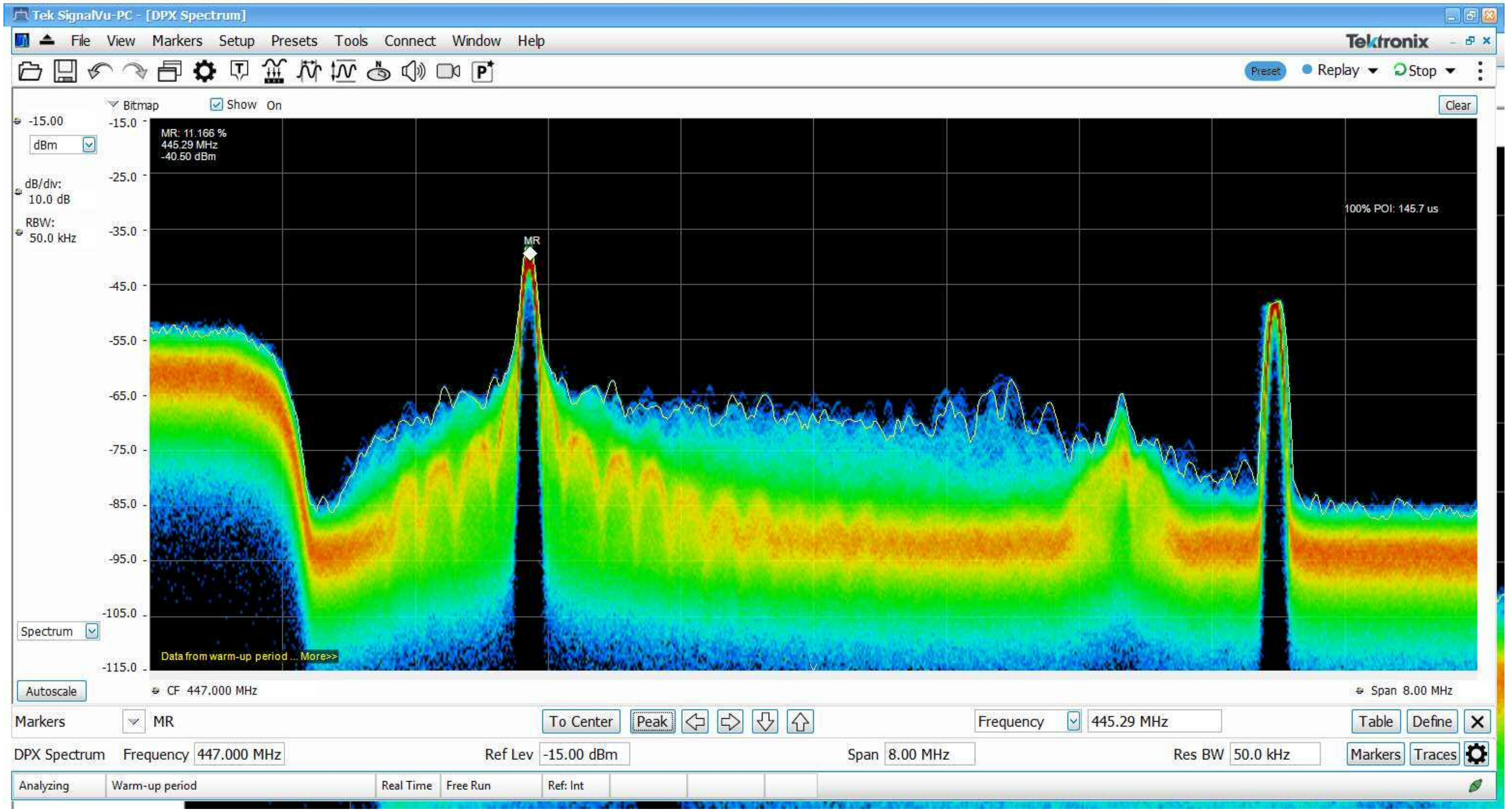
In terms of accuracy I would state, in general, the general purpose RTA has the upper hand. I've found through making hundreds of comparisons between a popular customized analyzer and my general purpose RTA that there was greater accuracy and repeatability of the results with the RTA.

Finally, several tests are difficult or impossible with the RTA unless other test equipment is added. In general, it is those tests where we commonly use 'gated testing' on the customized unit to select a certain line in the vertical interval for access to a required video test signal, with subsequent measurements made with the unit 'gating' (turning on to make its measurement) during that vertical interval scan line only. For example, in modern headends IP-to-analog modulators are becoming the norm as compared to stand along modulators, and with those units selected test patterns can be made available in the vertical interval of the NTSC signal on all channels (for example: multiburst on line 18 odd & FCC or NTC7 composite on line 19 odd). While the modern RTA-VSA does have the ability to gate on the vertical and horizontal sync, there's no easy way to select the particular horizontal scan line with the desired test signal. In the case of ICR, as you'll see in the following waveforms, it is possible to make this measurement by substituting a multiburst video test signal on *all scan lines*, thus allowing one to get around the gating issue. Of course this creates a short term video outage on the channel under test which I avoid if at all possible.

Finally, the so called 'color tests' (CLDI, differential gain, differential phase) are not possible with the RTA unless several additional test equipment items are added., and I did not have access to either of them during the writing of this article.

Now, on to some waveforms and measurements…

Ch61 in DPX view.



This first waveform, strictly speaking, is not an FCC related test. The waveform is included to demonstrate the capabilities of the modern DPX (digital persistence) view. Refer to page one in this addendum for an explanation of DPX. As you can see, intermodulation and other signal impairments would be very easy to locate and measure in this analysis mode. There are no such impairments in this waveform.

Signal Level & Frequency Measurements including 24 Hr Level Variation

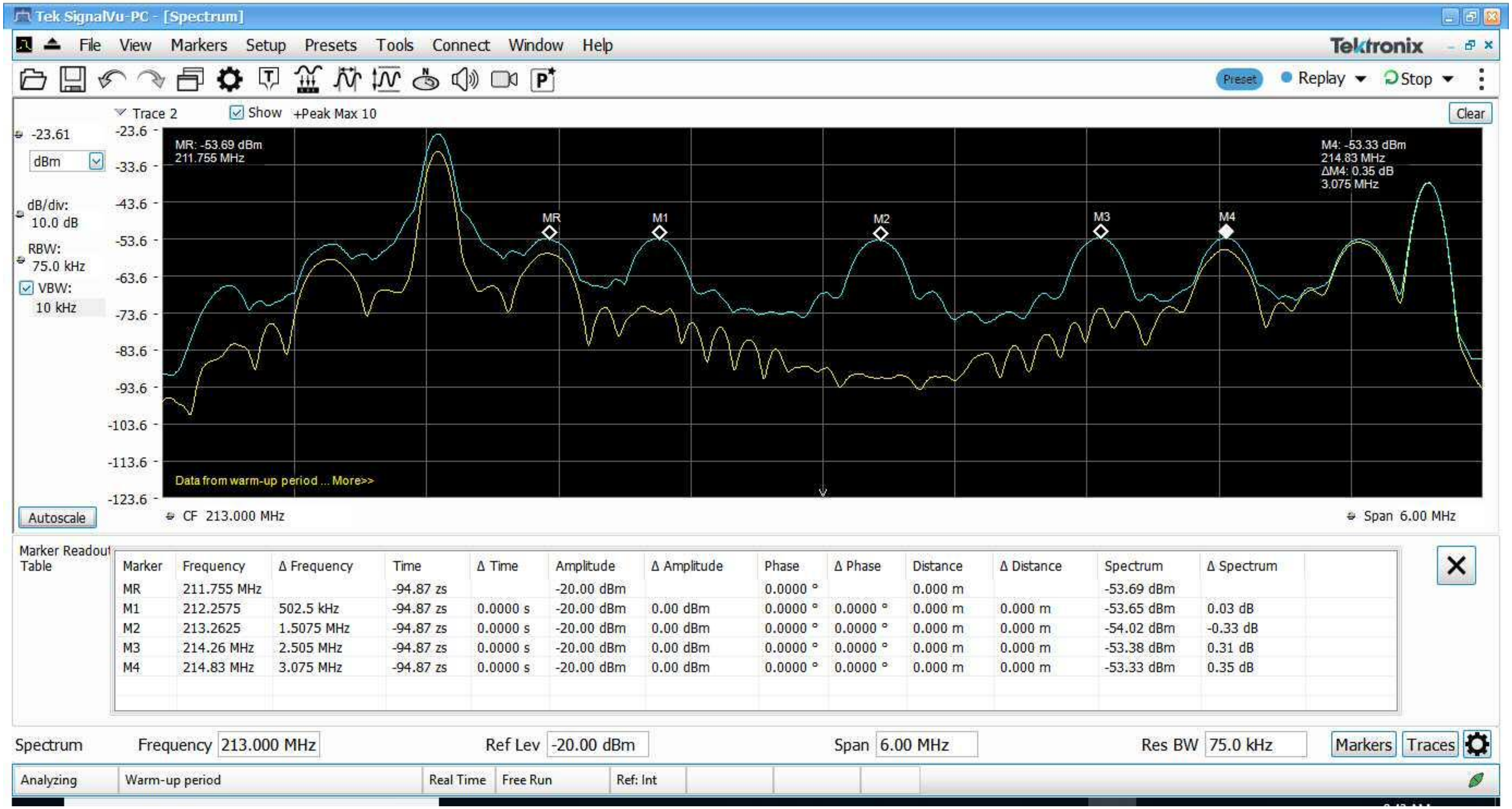
In general, using a RTA-VSA to make these measurements is unrealistic. RF levels can be measured accurately, however the process of capturing values for level variation analysis purposes would prove to be extremely time consuming.

And the marker system in a RTA-VSA, while reasonably accurate, does not meet FCC accuracy requirements to measure {the} frequency offset requirements outlined in 'FCC Part §76.612, Cable television frequency separation standards in the aeronautical bands'.

Visual-to-aural level separation measurements can be made rapidly with a RTA, however, the values would again have to be recorded manually.

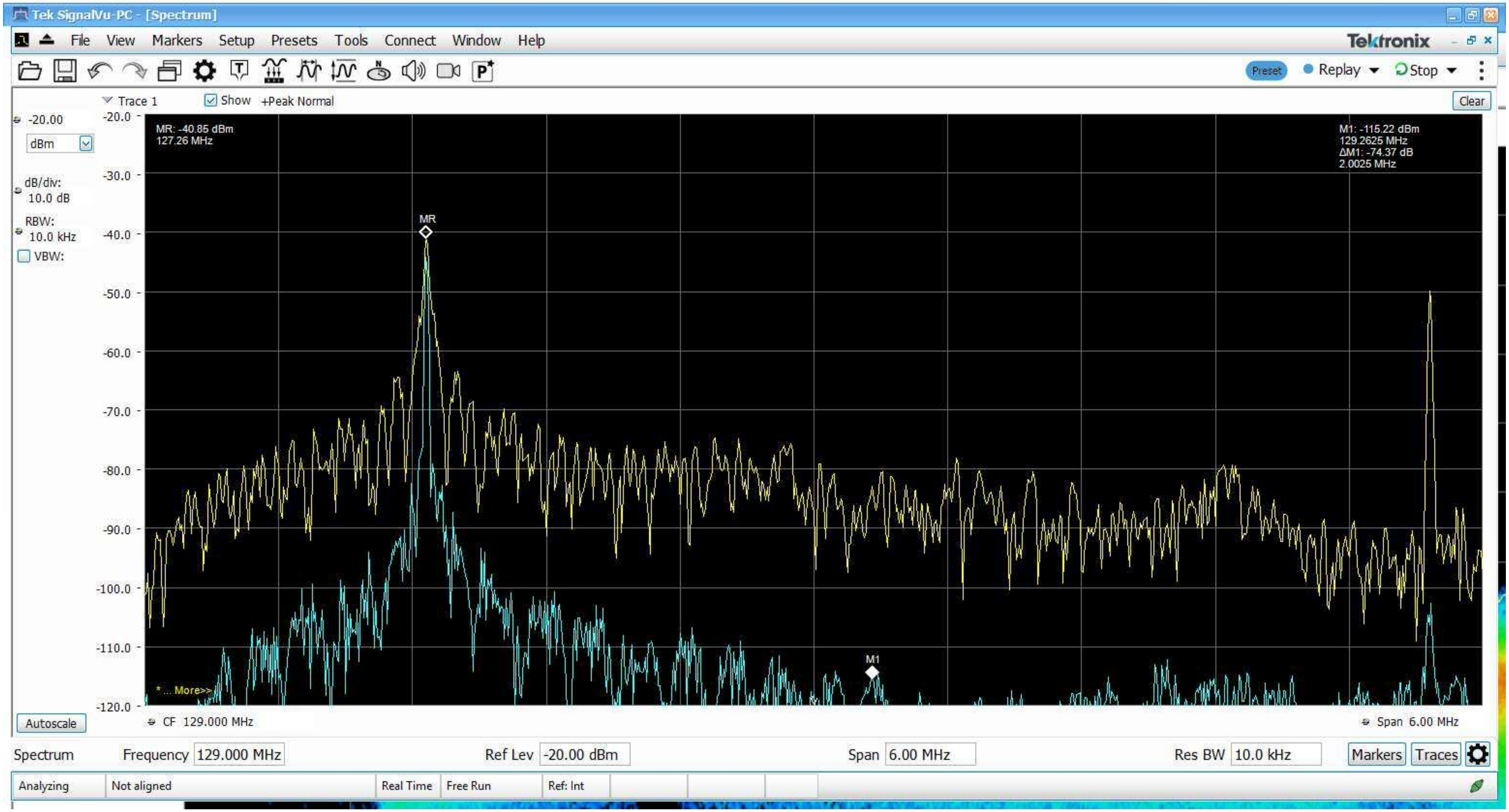
I did not record waveforms for any of the above examples since they were deemed an unrealistic approach for FCC POP related testing procedures.

In-Channel Response (ICR) on Ch13



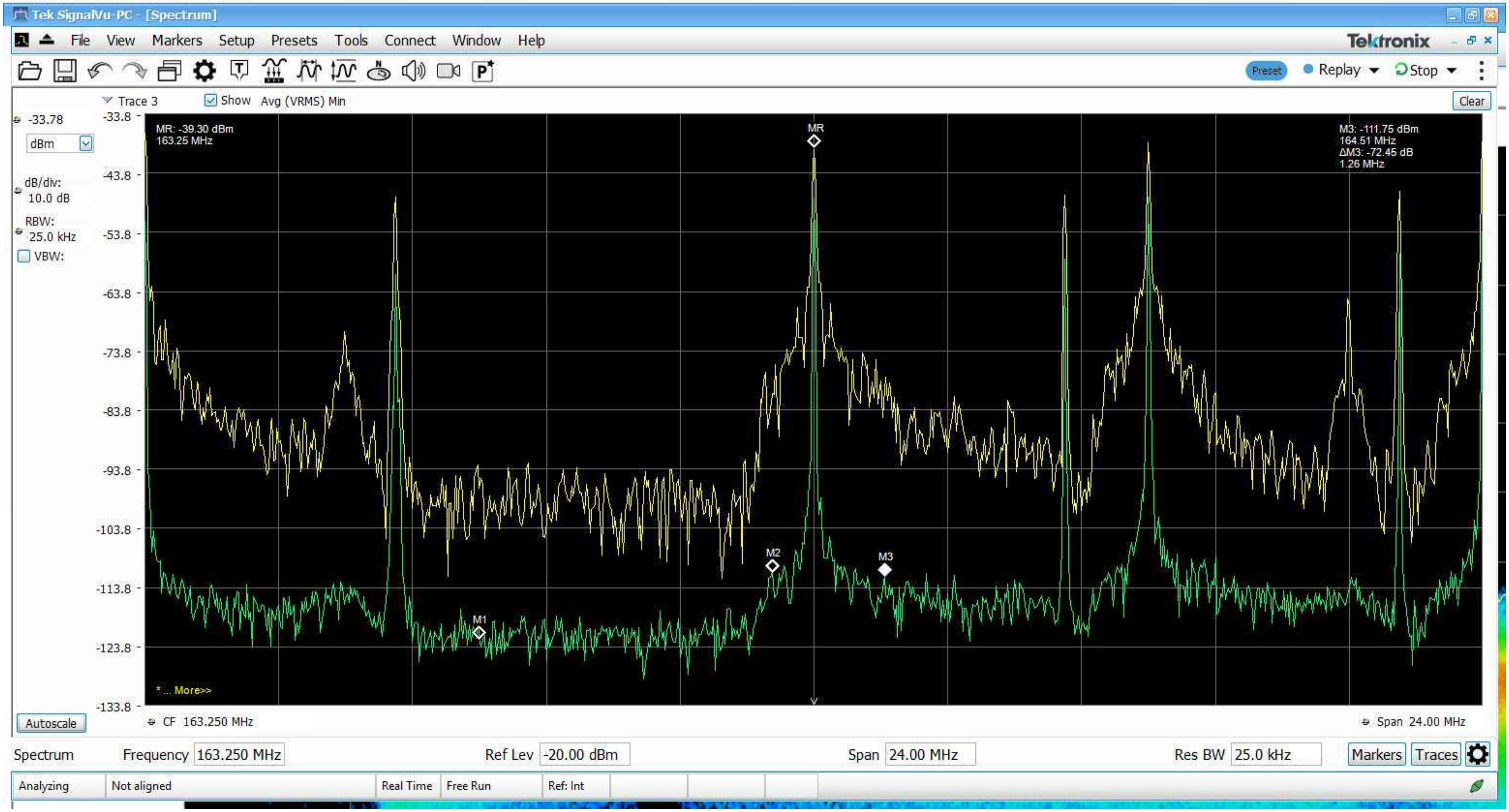
In-channel response was measured on Ch13 by injecting a standard multiburst video signal at the modulator video input port. This eliminates the need for VITS line selection since the test signal is present on all scan lines beginning with line 22, however it does create an interruption in program video during the test. This can be accomplished with stand alone modulators with a video test signal generator, and is also possible with newer IP-analog modulators where the desired test signal can be inserted on all scan lines rather than just a single line in the 'vertical interval'. The *Δ Spectrum* column above indicates the ICR of this modulator is .68 dB peak/valley or ± .35 dB. This measurement was made in my lab and not in an operational system. In summary, ICR can be measured quite accurately; however speed and the manual recording of results is an issue.

Carrier to Noise on Ch15



Carrier to Noise was measured on Ch15 in an operational system. The yellow trace is 'real time' and the blue trace is 'minimum hold'. Note that IF bandwidth was set at 10 Khz rather than the 25 Khz recommended in NCTA Recommended Practices, 2nd Edition. The noise floor (and video noise) was measured at +2 MHz above the visual carrier at -74.37 dB relative to visual carrier power level. Since the C/N measurement must be normalized to 4 MHz bandwidth, an adjustment factor of +26.02 dB is added. So, -74.4 dB plus 26.02 correction yields a C/N on Ch15 at 48.4 dB, which is nearly identical to a measurement taken with a different spectrum analyzer customized for cable television.

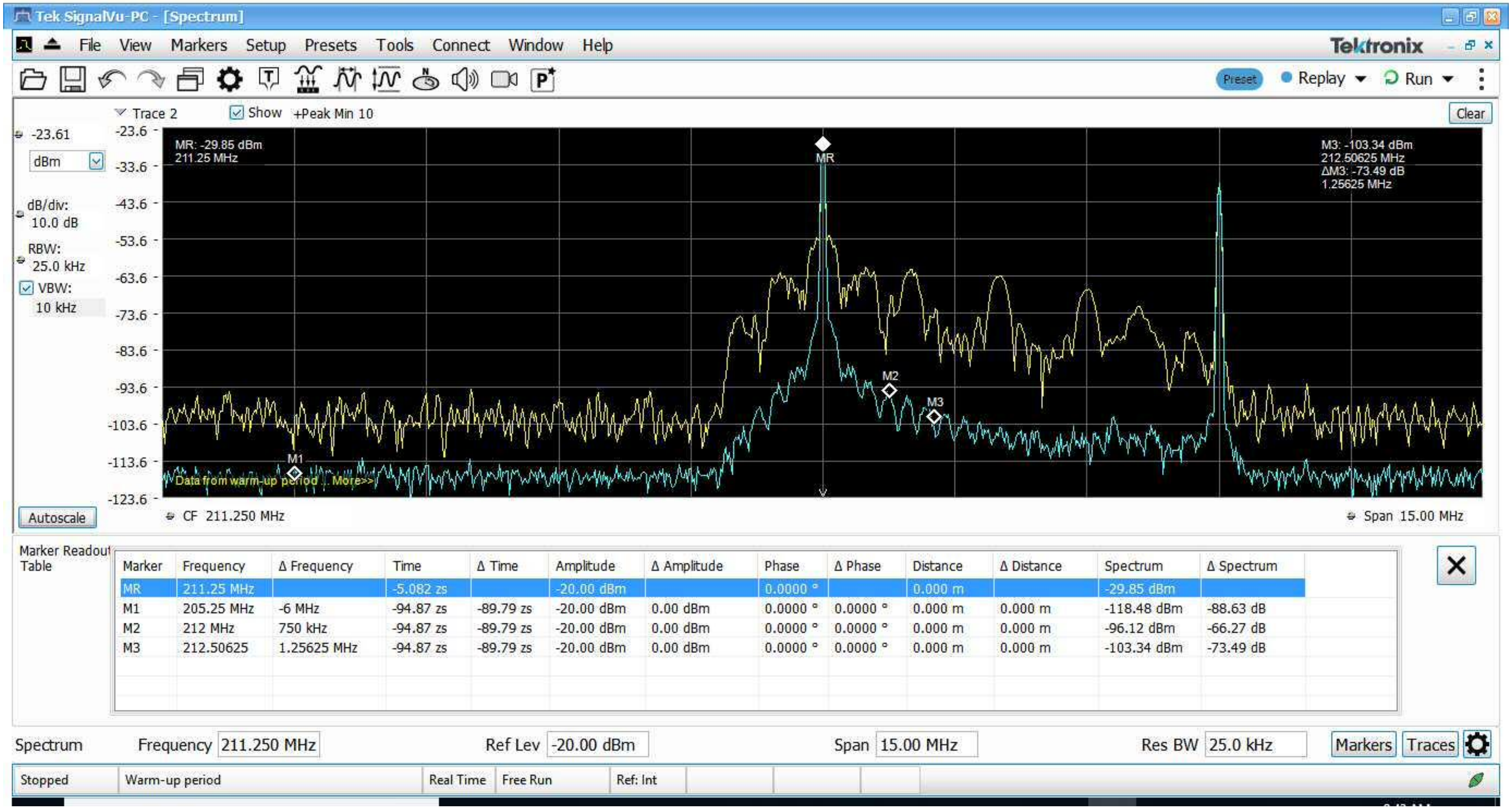
Discrete and composite beats (coherent disturbances) measured on Ch21/Ch20



I forgot to activate the marker table (in this first waveform) to view the actual values for CSO and CTB; however one can use the 10 dB horizontal scale lines to easily determine that CSO is close to -70 dB and CTB is around -80 dB! This measurement was taken in an operational system where Ch20 is not used. Therefore, I placed makers at -6 MHz relative to the Ch21 visual carrier for my CTB measurement and at -.75 MHz and +1.25 MHz relative to the visual carrier for two of the three possible CSO beat locations.

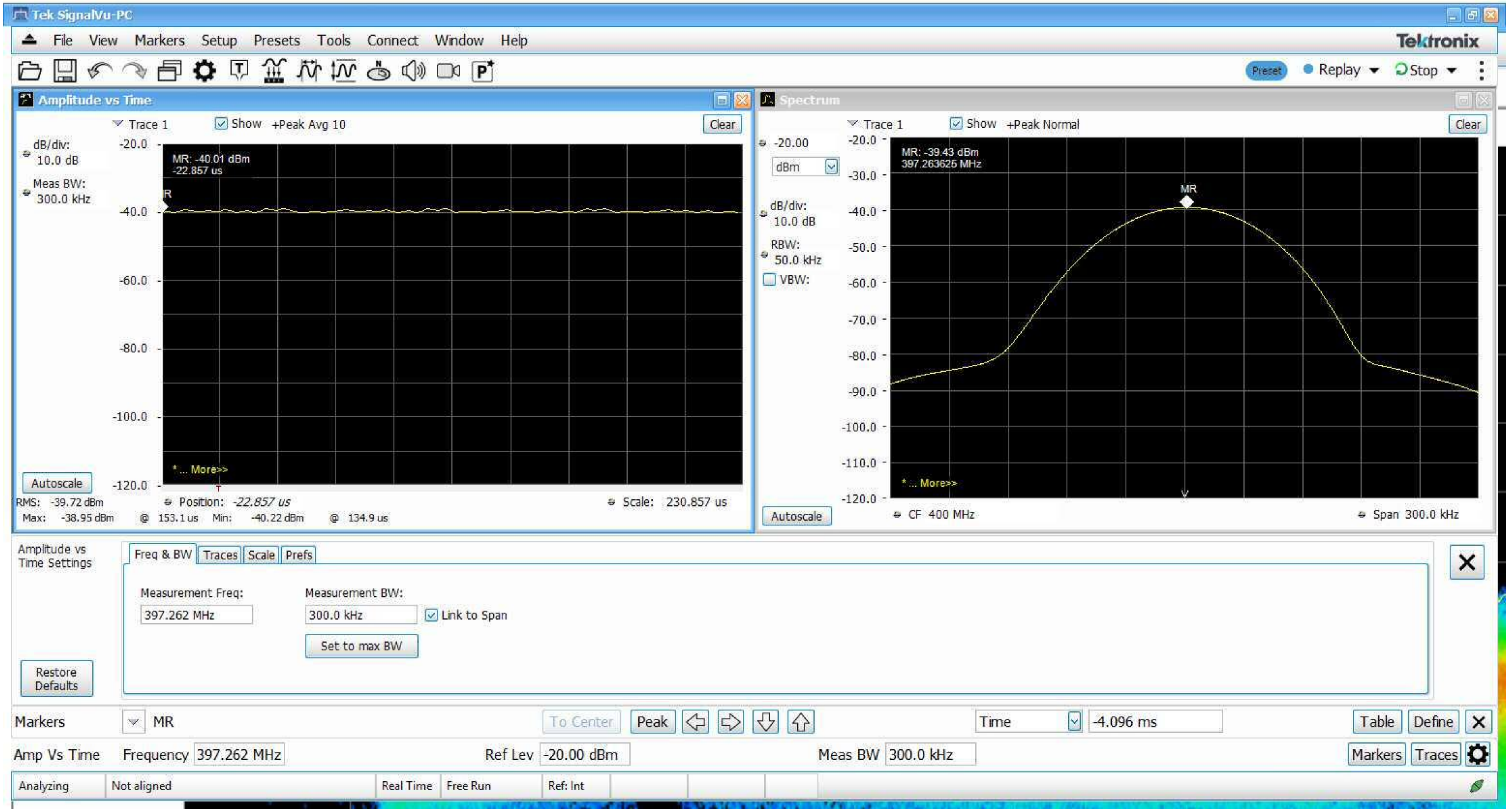
The next waveform is also for CSO/CTB, but was taken in my lab with the marker table on screen for illustration purposes.

Discrete and composite beats (coherent disturbances) measured on Ch13/Ch12



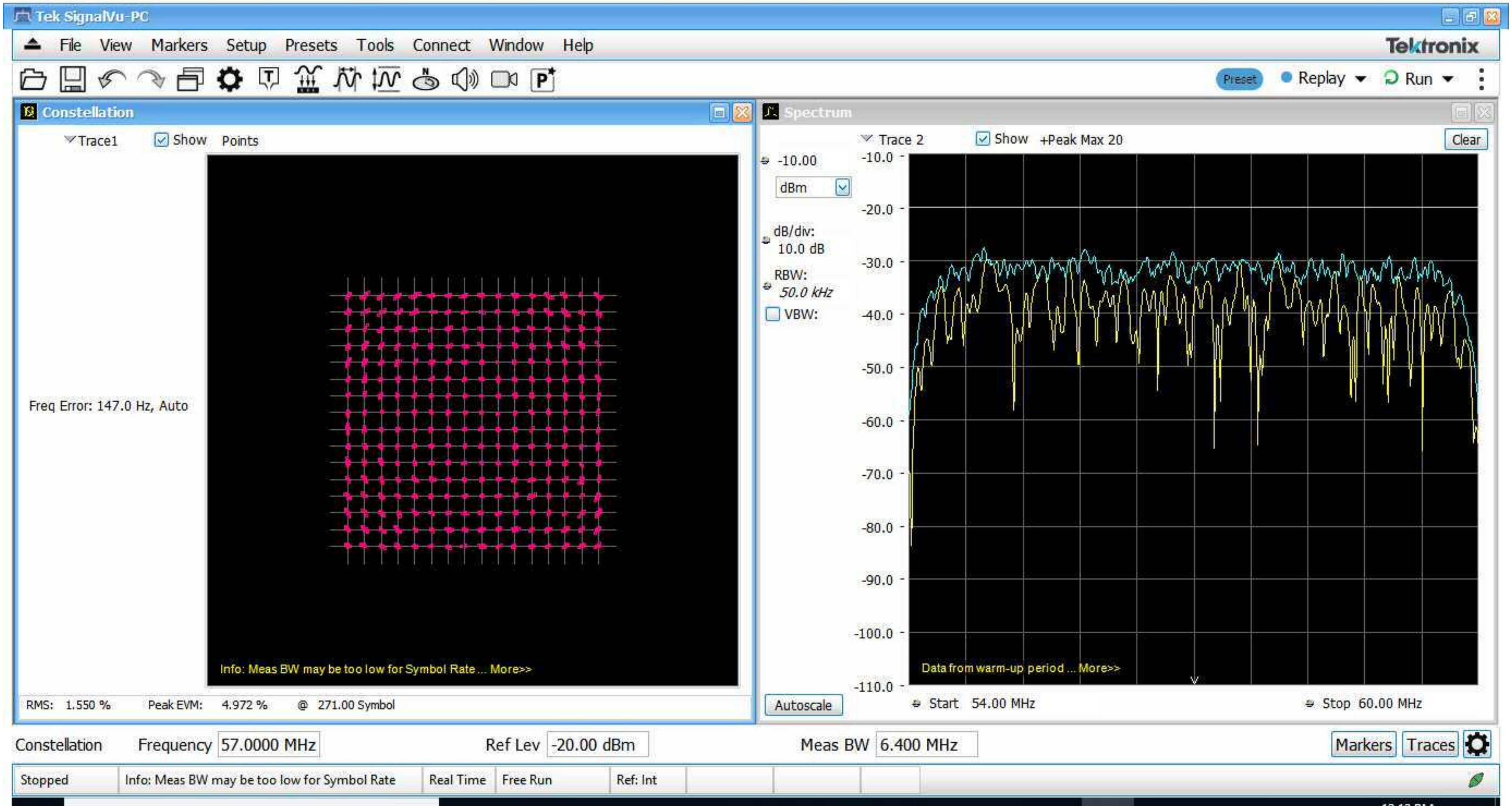
This is similar to the previous measurement except that I now have the marker table on-screen. Values for CSO are not as good (as the previsious measurement) because I'm using a multiburst signal on the modulator input, and the repetitive nature of the video content makes for higher average video signal-noise content. However, even with the test pattern in use worst case CSO at +.75 MHz is -66.3 dB and -73.49 dB at +1.25 MHz. CTB (at Ch12) is -88.6 dB. Of course one would expect very low values with this method since my measurement was made in the lab, and composite distortions should therefore not be present.

Low frequency interference on Ch53



Accurate LFI measurements can be made with the RTA-VSA, however it's time consuming as the measurement is in dB and must then be converted to %. The left screen window measures 'amplitude of the visual carrier versus time'. A careful adjustment of the measurement parameters yields .29 dB maximum variation, or just over 1%. Again, this agrees closely with measurements conducted with a separate analyzer designed specifically for FCC related measurements. Accuracy is fine, but speed of measurement is an issue.

QAM Analysis on Ch02 (in my lab)



I'm including this final screen shot to demonstrate that QAM (amplitude and phase) measurements are possible with a RTA with a general purpose VSA option enabled. The EVM and RMS% values shown in the left window are high because I did not have time to properly set all testing parameters such as input filter type, QAM carrier response, plus a handful of others that must be set properly in order to conduct accurate measurements on a 64 or 256-QAM J.83 Annex B carrier. While it does illustrate that QAM measurements can be made with a general purpose real-time analyzer with vector signal analysis, again the time to measure each carrier could prove to be prohibitive for general testing. But, if nothing else were available, it would be adequate for the testing of most QAM parameters.