Why are my detectors so slow?

The detector in an EMC analyser or receiver is the part of the system that actually measures the level of the signal after it has been extracted* from all the other frequency components.
We could simply connect the output from this detector the input of an ADC and plot the results on the screen. What would we see?
As the system scans across the required frequency range, we can expect the output to vary in response to the spectrum of the incoming signal. Obviously, we will need to restrict the rate of the scan such that the bandwidth of the ADC and other parts of the system can 'keep up'.
If we stop the scanning for a moment, so we are looking at just one frequency, the output would either be steady state (which would indicate a continuous input signal) or would vary with time (indicating a non-continuous input signal, ie one that included transients or bursts or was modulated).
In essence, the above describes how a 'normal' spectrum analyser operates.
EMC receivers (or analysers) are different.
A key issue is the handling of non-continuous signals.

**This extraction process is effectively a very narrowband filter which blocks all but the wanted frequency. A narrowband filter sounds simple enough, but those who work in this field know that it is actually quite a demanding task to create such a filter which has the required characteristics (bandwidth, shape, out-of-band attenuation etc,…). If you add the requirement to 'scan' such a filter across a wide frequency range, it becomes just plain impossible. So we use superhet techniques, as used in radio receivers to 'do' the scanning for us. This produces an output whose level equals the magnitude of the incoming signal at the selected frequency.*

Detectors
EMC standards specify the use of 3 (possibly soon 4!) different detectors. They all give different answers. They are Peak (Pk), Quasi-Peak (QP), Average (Ave) and, recently proposed, the RMS-average detector. The reason for this new detector is that it gives a better measure of the interference effect on digital communication services.

The diagrams 1, 2 and 3 show how the Pk, QP and Ave detectors work. Peak is quite self explanatory. There are effectively no time delays in the response, it simply indicates the highest signal level seen during the time the analyser dwells at a frequency. In effect, the detector produces its response virtually instantaneously so the Pk detector can be used for fast scanning. When the result has been acquired, the analyser moves to the next frequency and the detector is reset by discharging the capacitor. (The reset circuitry is not shown in the diagrams).
Again, the average detector is quite simple. It applies a linear average to the incoming signal.

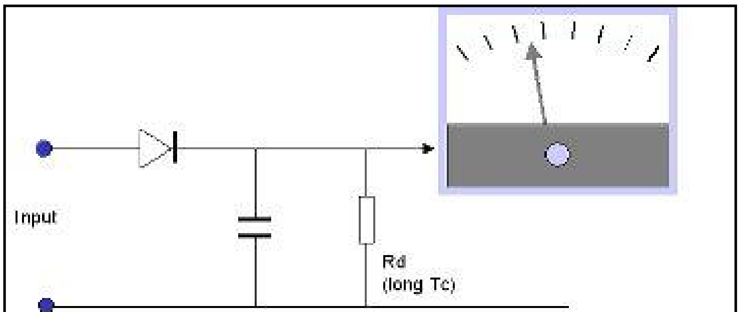


Fig 1: Peak detector

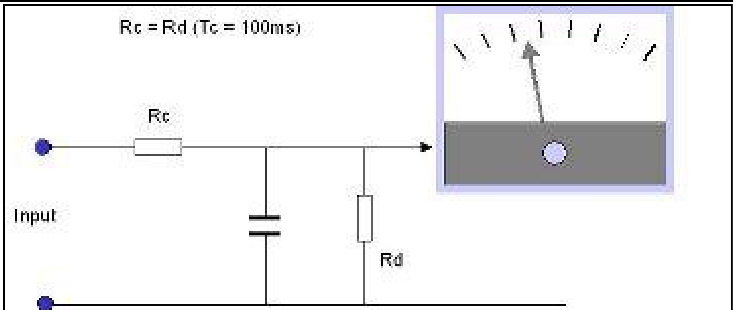
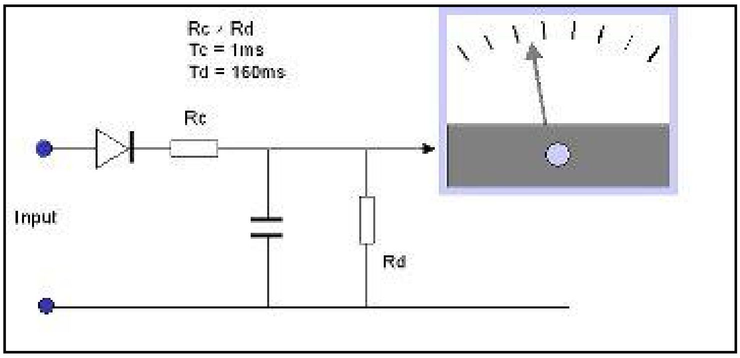


Fig 2: Average detector



The QP detector includes features of both the above. In particular, note how the time constant for the capacitor charging is short (1ms) compared with the discharge time constant (160ms). To understand why we need these alternative detectors, consider the fact that often, interference is subjective.

Detector purpose

For example, I have a table lamp which includes a phase angle controlled light dimmer stood next to my audio system. When the lamp is on, I can hear a 100Hz buzz superimposed on my audio output… drives me nuts!

I also have in the kitchen an electric cooker with an old temperature control system that switches power via a contactor which switches every 5 seconds or so when the oven is up to temperature. The transient created by the switching of this contactor is far greater than the transient caused by the phase angle switching of the lamp. If we use a peak detector, the oven controller would produce a result far higher than the lamp, and this is a problem, because it's the lamp that is actually the worse source when considering the subjective consequences of the interference. It may seem that the average detector would overcome this problem given the relatively fast repetition rate of the lamp transients. Unfortunately, the transients are so short (in both cases) that average detectors simply do not respond and the result for both sources is practically zero. Average detectors are in fact most useful when modulated signals are included in the interference input.

Quasi-peak detectors are simply a design that happens to produce the 'right' results, ie results that approximately correlate with the deleterious effect on broadcast reception and the subjective effect.

Actual waveforms

Fig 4 shows the response of a real detector. The dark red trace is the input, the blue trace is the peak detector and the green trace is the QP detector. The timebase has been set so that the measurement of one

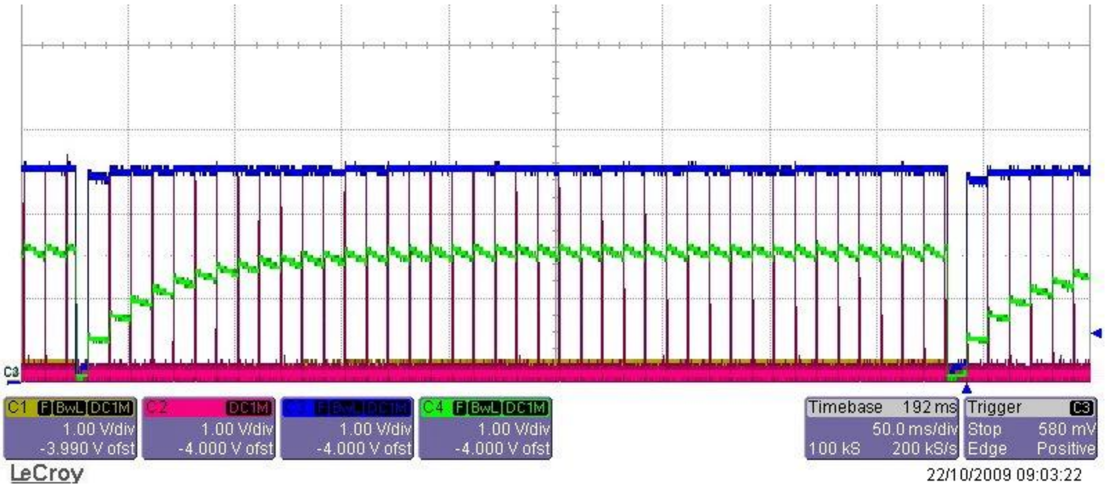


Fig 4. Oscilloscope view of detector output

frequency can be seen This is the dwell time and in this particular case it has been set to 400ms. All detectors are seen to be discharged at the beginning of each dwell time.

The red incoming signal is from the light dimmer and the 'spikes' at a repetition rate of 100Hz are clearly seen. Note how the QP detector is charged up by each spike due to its fast rise time, and between spikes, the slow discharge 'slope' can also be seen. From this image, it becomes obvious why EMC receivers (and analysers) are so slow when taking measurements with the QP detectors. Even with a 100Hz transient repetition rate, the detector takes some 200ms to achieve the 'correct' level. With slower repetition rates, the detector takes corresponding longer. CISPR16 specifies a 1 second dwell time for band B. Band B (150KHz – 30MHz) has an RBW of 9KHz and so the frequency step must be equal to or less than 9KHz. This means that there are at least (30,000-150)/9 results to be taken in this band. From this a scan time of 55 minutes can be deduced.

Figure 5 shows a similar situation, but this time the signal comprises the broadband 100Hz transients plus a narrowband component. When the analyser is at the frequency of this narrowband component the detector output has a mostly continuous nature. The figure shows this as the middle dwell period and the average detector (yellow trace) is clearly seen, rising to match the levels of the peak and QP detector levels.. Again note the time scale for the rise time. The QP detector shows a fast rise time (as

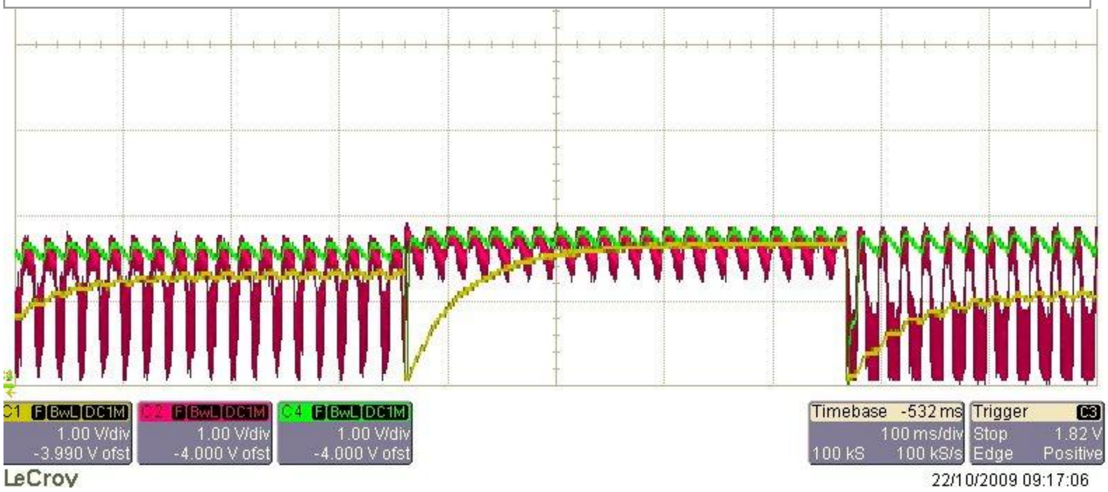


Fig 5: Detector response for steady state signal.

expected) and the average detector a relatively slow rise time. The measurements either side of this frequency peak show what happens as the continuous signal 'degenerates' towards the implusive 100Hz signal with consequent drop in the average result.

Scan time

The Laplace analysers actually sample the frequency every 0.6 x RBW and this is a fairly common practice, so the 55 minutes estimate (see above) becomes 92 minutes. Clearly it would be a great advantage if this process could be speeded up. We can 'adjust' the dwell time, reduce it from 1 second to (say) 100ms, at which time the results are within 10% of the final value for a 100Hz repetition rate. Obviously, if the repetition rate was slower than 100Hz, this error would increase, so reducing the dwell period is not recommended unless you know the characteristics of the signal. In order to speed up the test process however, standard practice at test labs and all those experienced in the art of EMC is to initially scan with the Pk detector. Because the Pk detector will always produce the highest result (compared with the QP and Ave detectors) it will be obvious that if this Pk result was below the limits, then the EUT is compliant. In this case no further testing is required.

Only if the Pk detector exceeds a limit will measurement with the other detectors be necessary.

In many cases, the limits are exceeded only at certain discrete frequencies. Some analysers are fitted with markers which can be 'dropped' onto these problem frequencies and which will then display the Pk, QP and Ave levels at these points. These will enable fast and accurate monitoring of these problem frequencies, virtually in real time, enabling troubleshooting and modifications to be observed immediately.

Fig 6 shows a screenshot taken from a Laplace EMC analyser with the Pk detector plot displayed and a tabular list of the measurements at the marked frequencies. These are currently showing the QP values.

Fig 6. Marker display

For convenience, an alternative view is the bargraph plot, shown here (Fig 7) which shows immediately how the results compare with the limits. The centre line is normalised to the limit level and results are plotted +/-20dB, with the uncertainty margin clearly shown. The buttons on the RHS allow the different detectors to be selected and displayed. Difference plots can also be shown.

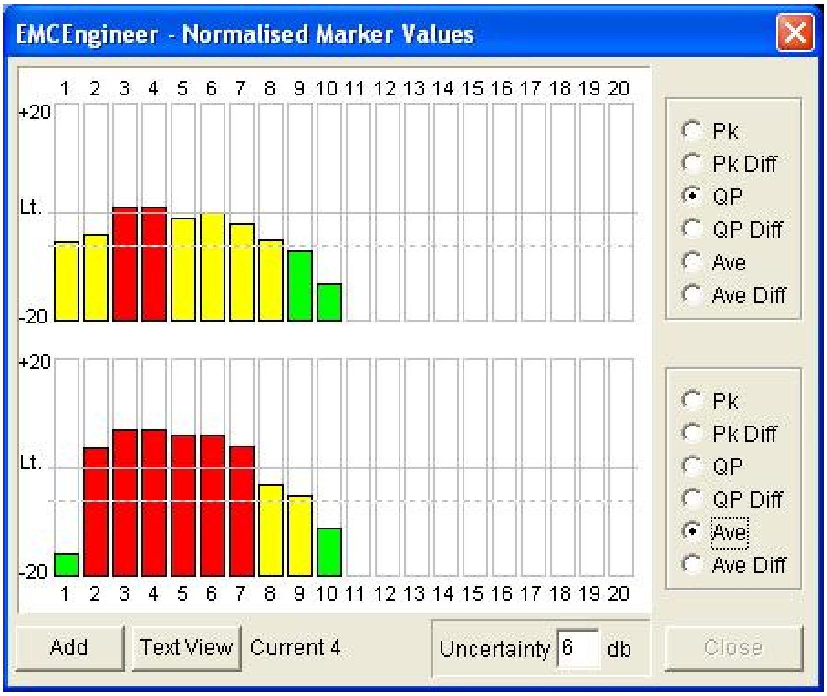


Fig 7. bargraph presentation

There are proposals to allow the use of the RMS-Average detector as an alternative to the QP and Ave detectors with just the one limit level (which would be 4dB above the current Ave level, hence 6dB below the QP level). Where only the QP limit is applied to a band, the QP limit would be retained. The advantages are that only one detector is used for the entire frequency range (9KHz – 18GHz) and that this detector has a faster response time than the QP or Ave detectors.

Conclusion

True EMC measurements do require the use of specialised detectors, and these involve significant time constants which result in slow scan rates. Faster scanning leads to increased likelihood of error and would be non-compliant. However, techniques do exist which can provide significantly faster results without loss of accuracy, and which can provide key measurements in real time displayed in a form which allows easy interpretation of compliance status.

Author: David Mawdsley

Laplace Instruments Ltd

Distributed by:
Reliant EMC LLC
3311 Lewis Ave
Signal Hill CA 90755
408-916-5750
www.reliantemc.com