# **How to** use a Comparison Noise Emitter (CNE) to measure filter response

**Perhaps the best way for most of us to identify the characteristics of a filter is to use a network analyser, which allows the transmission ($S_{21}$ and $S_{12}$) and reflection ($S_{11}$ and $S_{22}$) coefficients to be measured accurately. However, for many EMC laboratories a network analyser may not be a standard piece of equipment and its cost is unlikely to be justified by simply carrying out cable or filter checks.**

A simple measurement of the frequency response (or the forward transmission coefficient, $S_{21}$) is usually sufficient to tell us whether or not the filter is behaving as expected. For this, a spectrum analyser with a tracking generator is a good solution, but again these are not common tools to have to hand. Using a "standard" spectrum analyser with a separate signal generator is painstakingly laborious, unless "spot" checks alone are carried out or an ATE process is used.

A quicker alternative is to use a wideband signal source such as the Comparison Noise Emitter (CNE), commonly used in EMC test laboratories as a reference source for a range of pre-test checks. This allows a rapid evaluation of the filter's performance to be made by substitution, using a standard spectrum analyser.

## Procedure

In addition to the Filter Under Test (FUT), a CNE, a spectrum analyser (ideally one with a "Trace A minus Trace B" or similar mathematical difference function) and an attenuator (10 dB or 20 dB) are needed.

Figure 1 shows a measurement being made of a 100 MHz lowpass filter. The purple trace in the background shows the direct output of the CNE III being used, with the yellow trace showing the filtered signal. At this stage the Trace A-Trace B difference function is not being used, but the filter characteristic is still clear.

To perform the test, connect the CNE, attenuator and analyser as shown in Figure 2. With the analyser set to cover the frequency range of concern, store the result in one of the trace memories (Trace B in this example) to record the baseline response of the CNE, attenuator and cable.

Insert the FUT between the attenuator and the analyser and repeat the measurement. With the analyser set to display the difference (A-B in this example), you can quickly see the forward transmission characteristic of the filter.

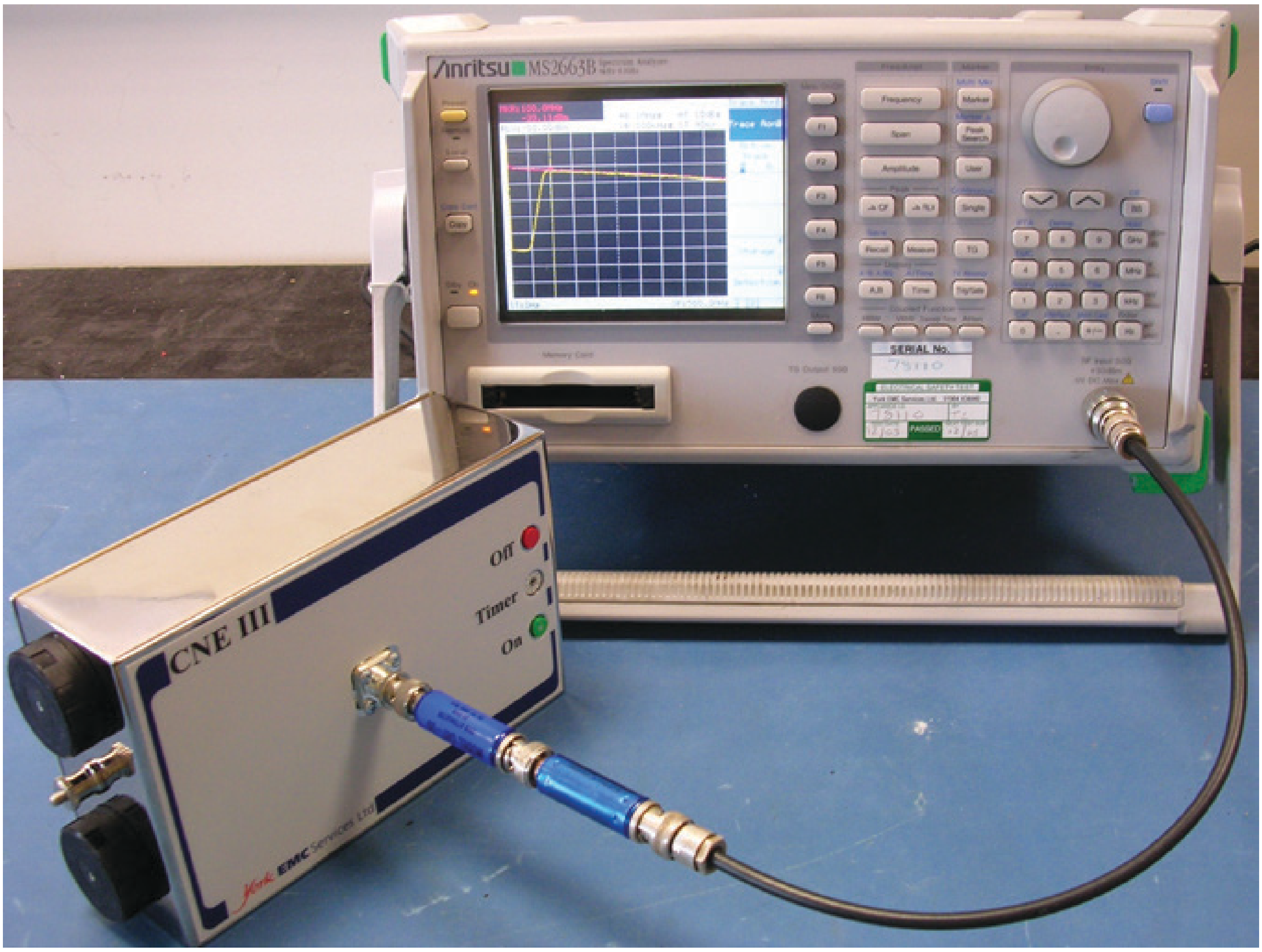


**Figure 1. Measurement of 100 MHz high-pass filter using a CNE III**

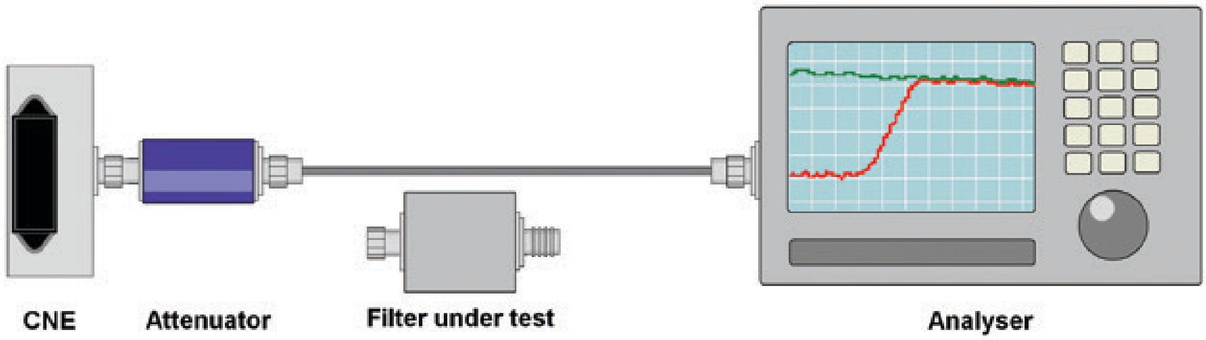


Figure 2. Filter test by substitution setup

If the spectrum analyser has no equivalent built-in difference function, then this can alternatively be carried out by exporting the data to a spreadsheet for manipulation.

This is straightforward enough, but there are a couple of points to note:

- Since the CNE signal is noise, averaging the measurement is recommended to produce a smoother, more usable trace. Use an averaging function (which most analysers have) over, say, 25 or more sweeps. Alternatively, turn the video bandwidth setting as low as it can go, although this latter approach can slow the measurement unacceptably.
- Why the external attenuator, when it reduces the dynamic range of the measurement? In the case of a non-absorptive FUT, signals in the stop-band are reflected back into the CNE. Most of this signal will be "lost" within the CNE, but some will be re-amplified and retransmitted to the FUT. The result is that there will be more signal appearing in the stop-band than there should be, giving a false impression of how good the filters rejection performance is. An external attenuator of 10 dB or 20 dB reduces this effect significantly (by improving the impedance matching and by effectively attenuating such reflected signals twice), so that although the dynamic range (the difference between the measured signal from the CNE and the analyser's noise-floor) is reduced, a greater stop-band rejection can be accurately measured. Since the stop-band "mis-match" exists on the output of the FUT as well, it's prudent to include attenuation in the analyser settings as well. The graphs in Figure 3 and Figure 4 show the difference in results taken using different levels of external attenuation when measuring a couple of standard, off-the-shelf commercial filters with a CNE III. **Note:** YRS and CNE VI generators have better output matching, so this effect is much less.
- Reflections are less of a factor for absorptive filters, which can be treated differently. Figure 5 shows the performance of a custom built bandpass filter, which was specifically designed to be absorptive in the stop-bands. This means that external attenuation is largely unnecessary and can be dispensed with to increase the dynamic measurement range. In each of the traces shown, the stop-band response displayed is dictated by the analyser noise-floor.
- Note that in all cases the reported frequency response of the filter is unchanged, with cut-off and cut-on frequencies accurately represented irrespective of those changes made to improve stop-band readings.

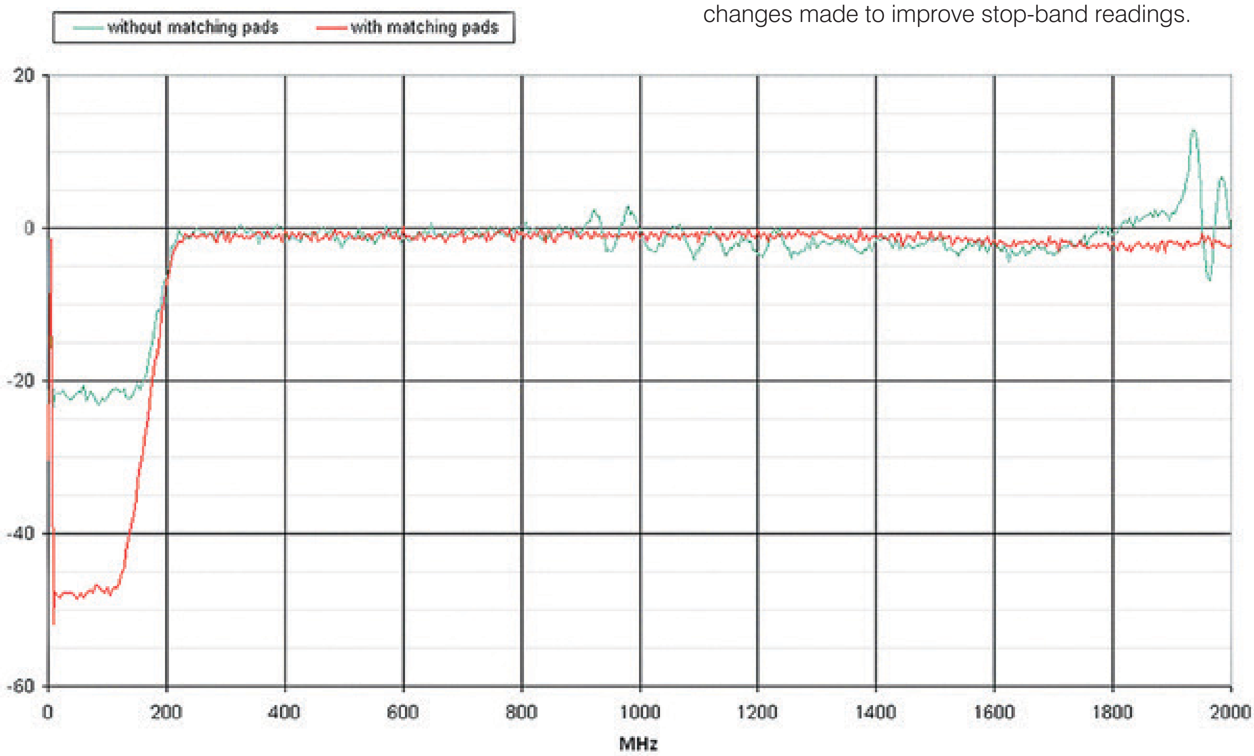


Figure 3. 250 MHz high-pass filter measurement

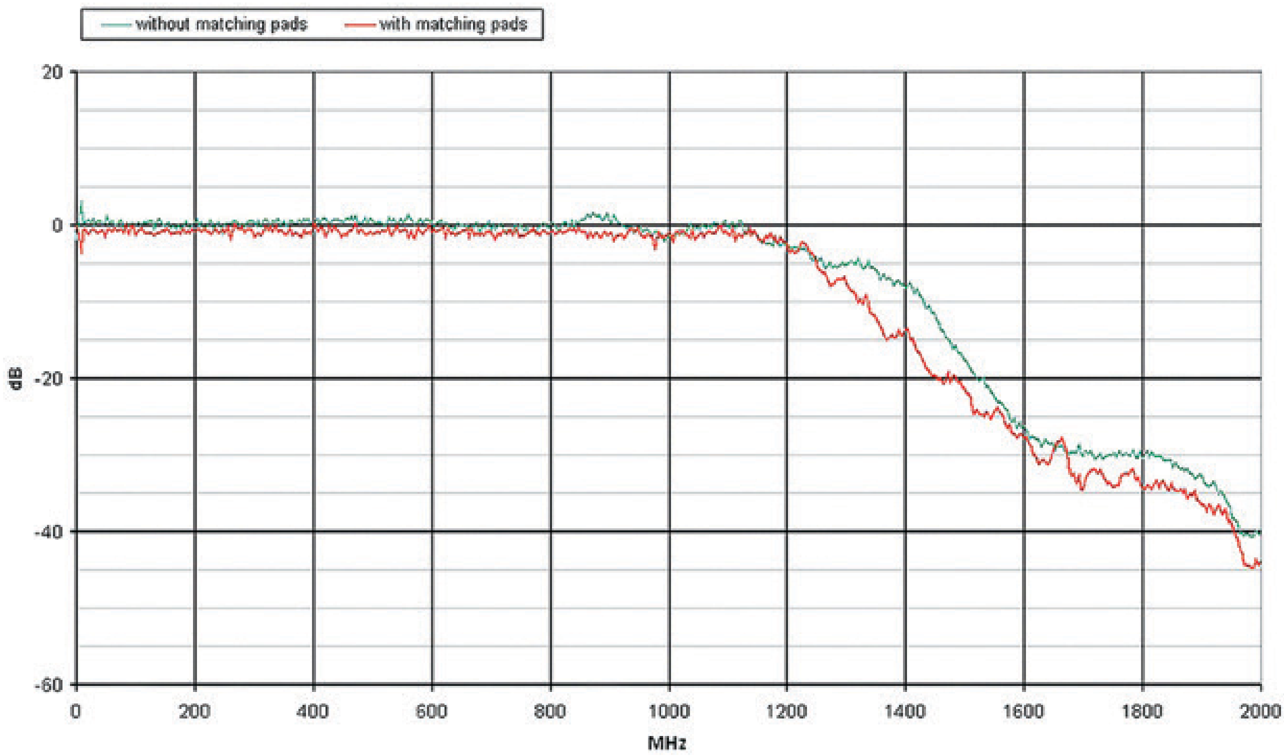


Figure 4. 1200 MHz low-pass filter measurement

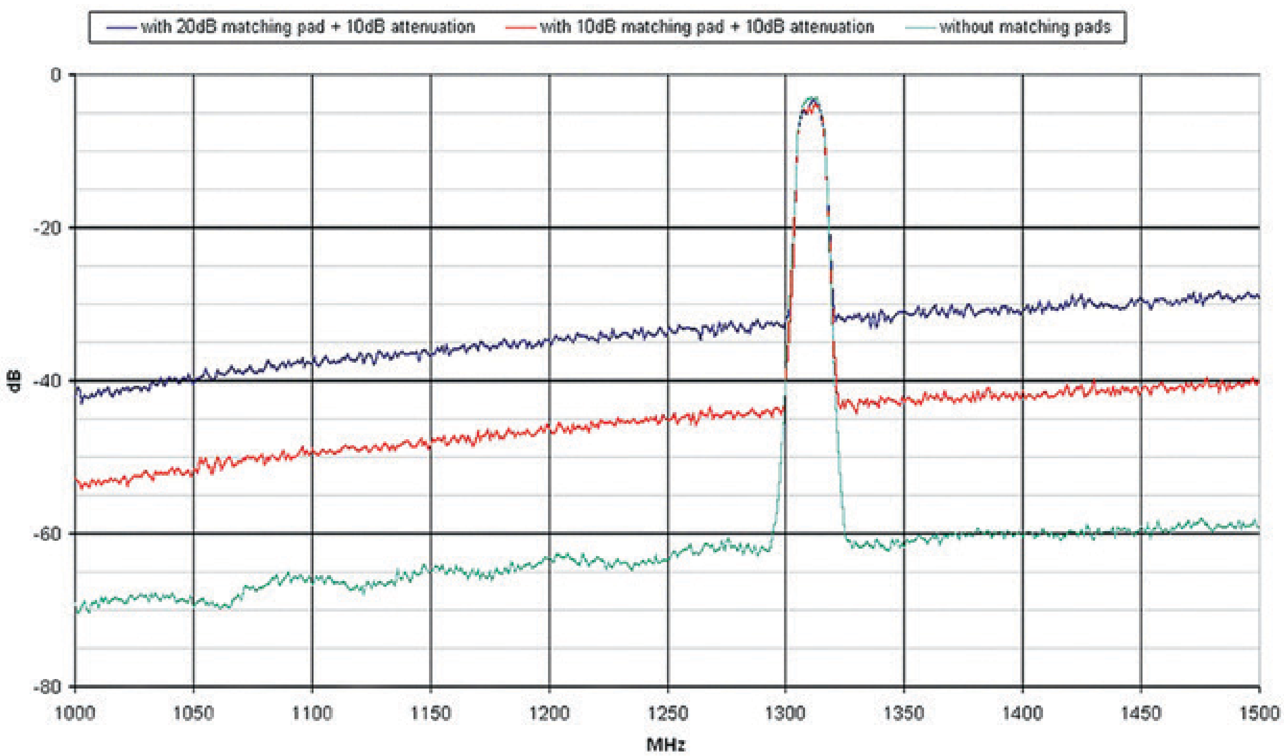


Figure 5. 1307 MHz band-pass filter measurement

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