Cellular Blocking Measurements to 12GHz

R. Hopper, S.J.Aitken, P. Aggarwal

Abstract

Cellular receivers are required to operate in the presence of unwanted interfering signals. This paper outlines a measurement system that enables the blocking performance of a receiver to be characterised. Careful design is required to mitigate the effects of the measurement system itself i.e. in-band phase noise and harmonics. The system meets the requirements for measuring against the GSM test specification 11.10[1] and the requirements specification 05.05[2], but is invaluable as it provides a significant amount of information about the receiver as a whole.

1. Introduction

The fundamental problem of a measurement system that can measure the blocking performance of a receiver from a few MHz to 12GHz is that the measurement system provides additional signals other than the interfering signal or blocker. These unwanted signals are the broad band noise, the harmonics and the phase noise of the blocking source.

For GSM/PCN applications the blocking range is split into two separate regions: the out-of-band blocking and the in-band blocking. The implementation in each case is required to be different. The out-of-band blocking system will be discussed first followed by the in-band.

2. Out-of-Band Blocking

To realise the out-of-band measurement system the frequency range was split into a number of regions. For GSM these were 10-600MHz, 600-1500MHz, 1500-3000MHz and 3.0-12.75GHz. For PCN these were 10-1200MHz, 1200-3000MHz and 3.0-12.75GHz. Low pass filters were used below the band with bandstop filters adjacent to the wanted receive band and highpass filters above the wanted receive band. These filter configurations were effective in removing the broadband noise while minimising the loss introduced at the blocker frequency.

What is the attenuation specification required?

This clearly depends upon the broad band noise from the signal generator used to provide the blocker. For the signal generator used in the measurement system the noise floor was consistently –135.6dBm/Hz at an output level of 10dBm. This level was chosen to reflect the worst case noise output and was largely independent of the frequency of the generator. This was measured using a receive bandpass filter + amplifier combination to filter out the 10dBm signal and provide sufficient amplification to get an accurate spectrum analyser reading. To reduce this level to below that of thermal a 50dB min attenuation of the filters was required.

The highpass and lowpass filters to accommodate the GSM and PCN/PCS bands were procured from filter suppliers. The bandstop filters were designed using HPEESOF and implemented on RT Duroid. The required tolerances to achieve the correct stopband were beyond the limits of the etch/patterning and so some manual trimming of the filters was necessary, particularly the PCN/PCS filters. The filters are shown in Figure 2.1 and Figure 2.2 with a more detailed picture of the PCS bandstop filter aswell Figure 2.3,2.4.

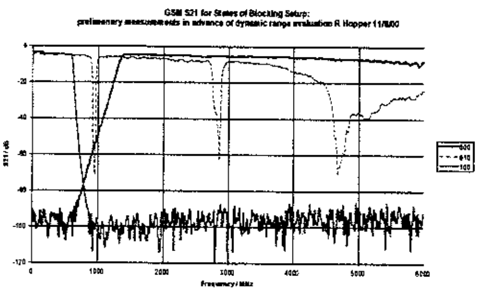

Figure 2.1 GSM Measurement Filters

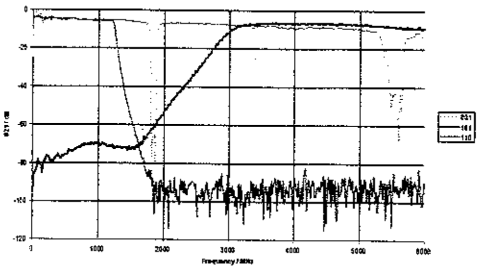

Figure 2.2 PCN Measurement Filters

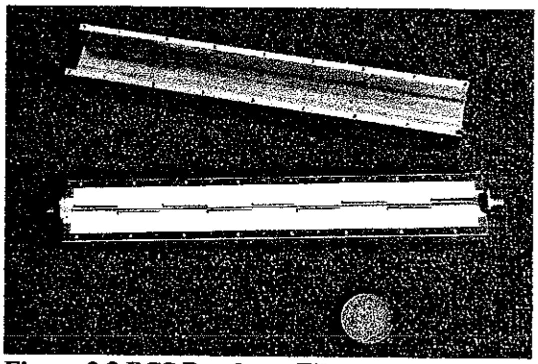

Figure 2.3 PCS Bandstop Filter

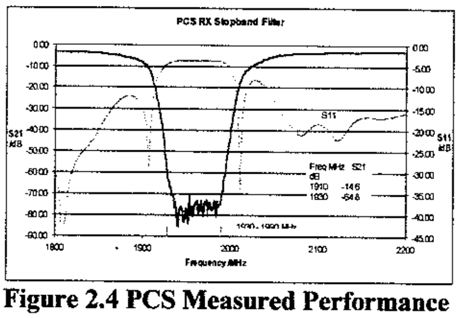

Figure 2.4 PCS Measured Performance

Don't harmonics of the source cause a problem for the low frequencies?

To determine whether there would be a problem from the harmonics of the blocking source the one to be used was characterised for harmonic performance from 50MHz to 500MHz. The results show a nearly consistent 40dB suppression of the 2nd and 3rd harmonics, Figure 2.5. These harmonics are not filtered before they are introduced to the receiver. In the case of a GSM system the following argument can be made. Let us assume that a receiver has a sensitivity to a 100MHz signal and we are introducing a 50MHz blocker at 0dBm then a –40dBm signal would be introduced at 100MHz. If the receiver produced a significant drop in SNR as a result of the 100MHz signal present then it is certain that when a 0dBm signal is introduced at 100MHz (as required by the test spec) then a significant SNR degradation would result. Thus the presence of harmonics from the blocking source would not result in spurious results as they would be picked up during the rest of the measurement. It is also of interest for GSM applications that the concession level which must be met by the receiver is –43dBm which is similar to the harmonic levels introduced from the blocking source.

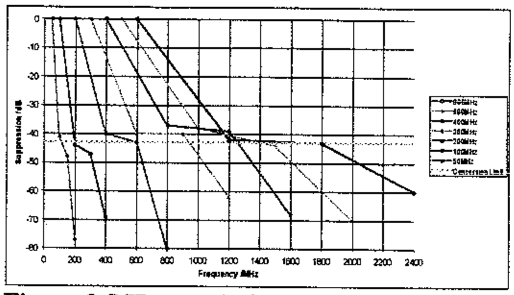

Figure 2.5 Harmonic Suppression of 8341B

The Out-of-Band Set-up.

The set-up for a GSM and PCN/PCS out-of-band blocking is based around the 6 filtering options for the source. The PCN and PCS bands can be accommodated using the same highpass and lowpass filters with replacement of the bandstop filter only being required. The configuration is flexible enough to enable blocking measurements to be made on other standards. Figure 2.6 shows the switched filter configuration with the blocking generator switched between the filter combinations under computer control. In each case a wanted signal is combined with the blocker signal before going to the receiver under test. The problem of intermodulation of signals in the sources, a common problem for intermodulation tests at high levels, is avoided here as the wanted signal is heavily padded off. This improves the absolute accuracy of the wanted signal as the generator is producing –50dBm rather than near the limit sensitivity value approx. –100dBm. A calibration routine is however used to improve the accuracy further.

The receiver is housed in a screened box with any control signals required provided through filtered connectors and the output signals buffered out, Figure 2.7. This is to avoid spurious being inadvertently being picked up by the receiver, the most likely spurious are those from existing basestations. It is useful to know what the local basestation frequencies are.

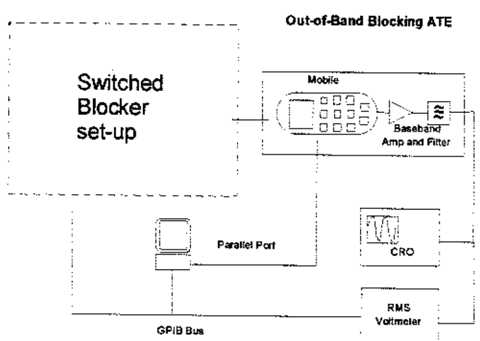

Figure 2.7 Out-of Band setup

How do we measure how good the receiver is?

To determine whether a receiver is able to meet the GSM specification 11.10 requires a Bit Error Rate measurement to be made. The measurement set-up is however more often used to provide an SNR. The SNR measurement can be made at an earlier stage of a receiver development and, more significantly, can be made significantly faster. If a BER measurement is required on every 200kHz to 12.75GHz that would take a few hundred hrs. The SNR is determined by measuring using an RMS voltmeter after the baseband signals are filtered using an appropriate baseband channel filter. The SNR is determined by measurements of the noise, the wanted signal and noise and then the wanted signal, the noise and the blocking signal. The final SNR, as determined by this method, is accurate only for +SNR values, any –ve required re-measuring at a backed-off blocker level. The measurement set-up uses an offset blocker at 20kHz from the channel spacing. This provides a more stringent test than is required by 11.10 as the cellular receivers are more able to cope with an on channel interferer than an offset one.

Where BER measurements are required the interface to the receiver is different from the SNR set-up.

Control Software: HPVEE

The automated control is provided by HPVEE Software. The choice was somewhat arbitrary between this and the Labview Software. The main pre-requisite was the ability to easily control the test kit used in the blocking set-up which include HP 8341B, HP8922M (for BER tests) and the HP RMS voltmeter.

3. In-Band Blocking

The in-band measurement set-up is simpler than the out-of-band set-up, Figure 3.1. Only a wanted signal source and a blocking source are required. The main issue in-band (and this is wider than the actual receive band for GSM applications) is that of the phase noise of the blocker. It is difficult in an automated set-up, where the blocker sweeps across the band, to provide sufficient rejection of the phase noise of the blocker such that any signal generator could be used.

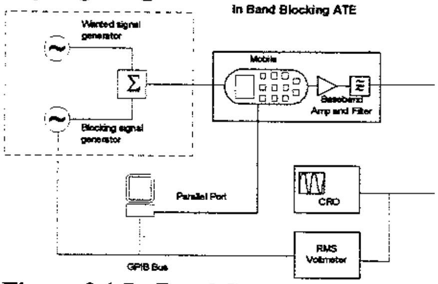

Figure 3.1 In-Band Set-up

How good does the blocking signal generator have to be?

For the in-band blocking measurement it is necessary to look closely at the specification required. The levels for GSM are given as –43dBm for offsets 600KHz-1.6MHz, -33dBm for offsets 1.6MHz-3.0MHz and –23dBm for offsets > 3MHz. If we assume that because we are measuring the receiver at 3dB above limit sensitivity then the blocking source can introduce an equivalent amount of phase noise in-band as there is thermal noise then we can get a baseline for determining the phase noise of the generator required. The phase noise required of the generator to achieve 10dB and 20dB better performance are then determined. Table 3.1.

	0dB margin	10dB margin	20dB margin
600kHz	112	122	132
1.6MHz	122	132	142
3MHz	132	142	152

Table 3.1 Required dBc/Hz of signal generator

To avoid the blocking generator affecting the result an R&S SMY02 is used. See Figure 3.2.

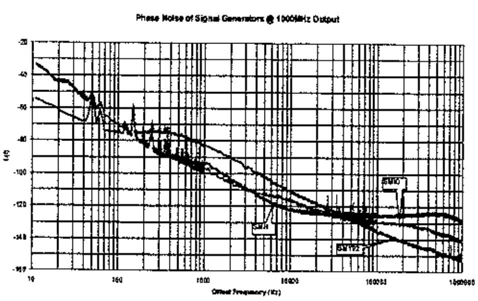

Figure 3.2 Phase Noise of some Generators

4. The results and what they can tell us

Careful design of the blocking measurement systems has enabled good quality information to be deduced about the receivers under development. The only area of the test where the limits of the test set-up still have an impact upon the results of the test are in the out-of-band blocking set-up for signals close to the in-band signals. In this case the rate of roll-off of the bandstop filter has resulted in insufficient rejection of the blocker broad band noise. Figure 4.1.

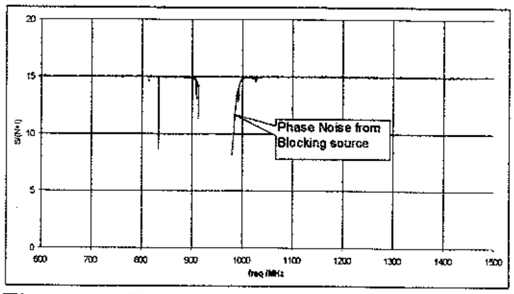

Figure 4.1 Example 600-1500MHz Response

The GSM specifications require that only a limited number of exceptions are allowable for 0dBm out-of-band blockers and these have to be met with a blocker at –43dBm. It is common to have exceptions at significant LO and IF products i.e. the image. Where the receiver SNR demonstrates degradation these frequencies are re-measured using the BER test.

The following sections provide an insight into the information that a blocking measurement can provide:

SNR: If the blocking signal does not degrade the SNR performance then what is measured is the SNR at 3dB above limit sensitivity.

Compression: Where there is a gradual change in the SNR as the blocker moves into the receive band in the in-band region then this indicates compression. Figure 4.2.

Close in Phase Noise of the Local Oscillator: The close in SNR variation out to 3MHz in the in-band region characterises the phase noise of the local oscillator of the receiver as the blocker mixes this phase noise into the IF bandwidth, Figure 4.2

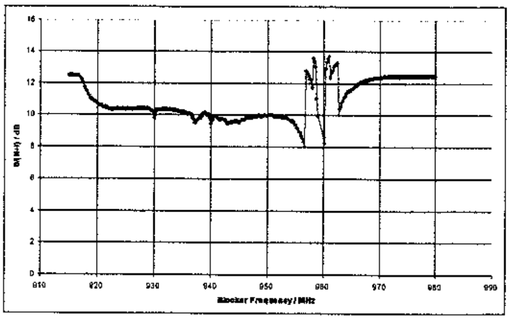

Figure 4.2 Example In-Band response

Sideband Performance: If the local oscillator of the receiver has poor sideband performance or poor 13MHz rejection (in the case of GSM) then the blocking signals at the same offsets will result in SNR degradation.

Receive Mixer Balance: If the receive mixer displays poor balance then the 2n×LO spurious will be more significant.

Front End Protection: Where there is insufficient filtering in the front end then unwanted products will produce blocking responses.

Some Example plots are provided to demonstrate a good blocking response with a limited number of exceptions required.

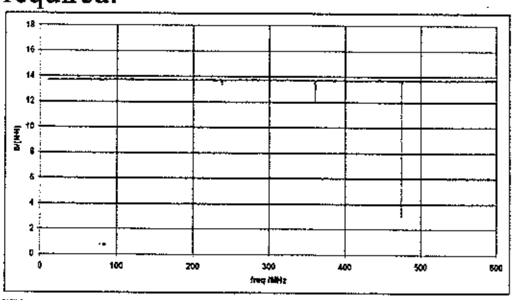

Figure 4.3 Example 10-600MHz Response

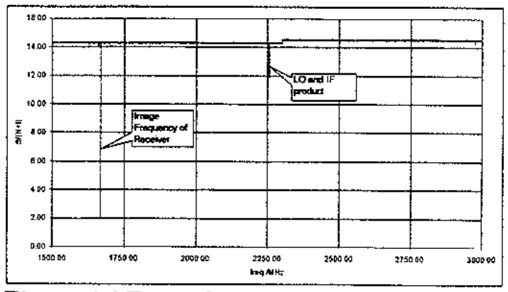

Figure 4.4 Example 1.5-3.0 GHz Response

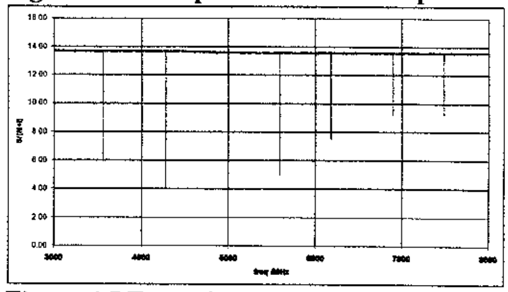

Figure 4.5 Example 3.0-8.0 GHz Response

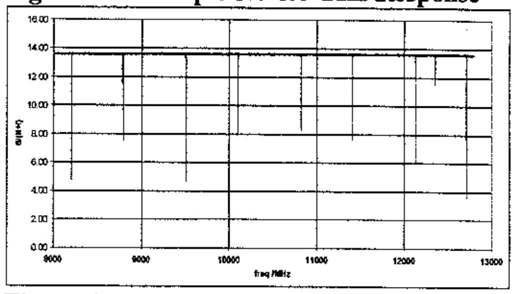

Figure 4.6 Example 8.0-13.0 GHz Response

5. Conclusion

An automated blocking measurement system has been demonstrated. The system enables testing of cellular receivers against GSM, PCN and PCS specifications but can be easily adapted for other cellular receivers i.e. US TDMA, CDMA.

6. Acknowledgements

The authors wish to thank Siemens ICM CD MP for sponsoring the development of this automated measurement system.

7. References

1 Digital Cellular Telecommunications System Mobile Station Conformance Specification: GSM 11.10.

2 Digital Cellular Telecommunications System Radio Transmission and Reception: GSM 05.05.

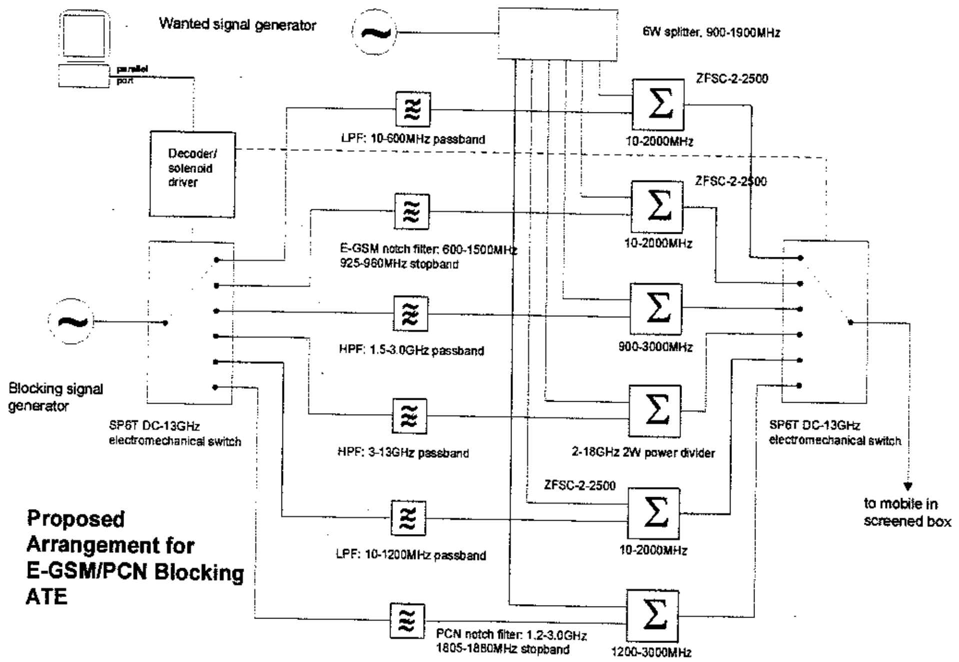

Figure 2.6 Switched Filter configuration for Out-of-band blocking signal