CML Microcircuits

COMMUNICATION SEMICONDUCTORS

Application Note
CMX7143
Modem Performance

Publication: AN/Wdata/7143/1 June 2008

1 Introduction

This document contains details of tests to compare the performance of low deviation GFSK with 4FSK for applications seeking to maximise data rate in a given channel. Both these modulations are available on the CMX7143 device[1]. For comparison purposes the chosen scenario is 9600bps in a 12.5kHz channel. The requirements of EN 300 113[2,3] are considered as part of the study.

1.1 References

[1] CMX7143 Datasheet (see www.cmlmicro.com)

[2] Electromagnetic compatibility and Radio spectrum Matters (ERM); Land mobile service; Radio equipment intended for the transmission of data (and/or speech) using constant or non-constant envelope modulation and having an antenna connector; Part 1 Technical Characteristics and Methods of Measurements, EN 300 113-1 , V1.6.1, 20th July 2007

[3] Electromagnetic compatibility and Radio spectrum Matters (ERM); Land mobile service; Radio equipment intended for the transmission of data (and/or speech) using constant or non-constant envelope modulation and having an antenna connector; Part 2 Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive, EN 300 113-2 , V1.4.1, 20th July 2007

1.2 Contents

2 Test Configuration

2.1.1 Modulation

The tests were conducted at 9600bits/s with 4FSK and GFSK modulation (4800symbols/s for 4FSK).

The GFSK deviation was 1.2kHz (half the deviation of GMSK). This modulation just fits in a 12.5kHz channel and is used for applications like the marine Automatic Identification System (AIS), see IEC 61993-2. The B_T used was 0.3.

The 4FSK is RRC filtered with an alpha of 0.2. Deviations of ±1.6kHz or ±1.9kHz for +3, –3 symbols, were used during the tests.

The GFSK operation used 7143FI-1.0.2.0.
The 4FSK operation used 7143FI-2.0.2.0.

Note: Measurements with earlier versions of the relevant CMX7143 Function Images™ are likely to give performance worse than that shown in this application note.

2.1.2 Hardware

The test system is shown in Figure 1 and details of the test receiver in Figure 2.

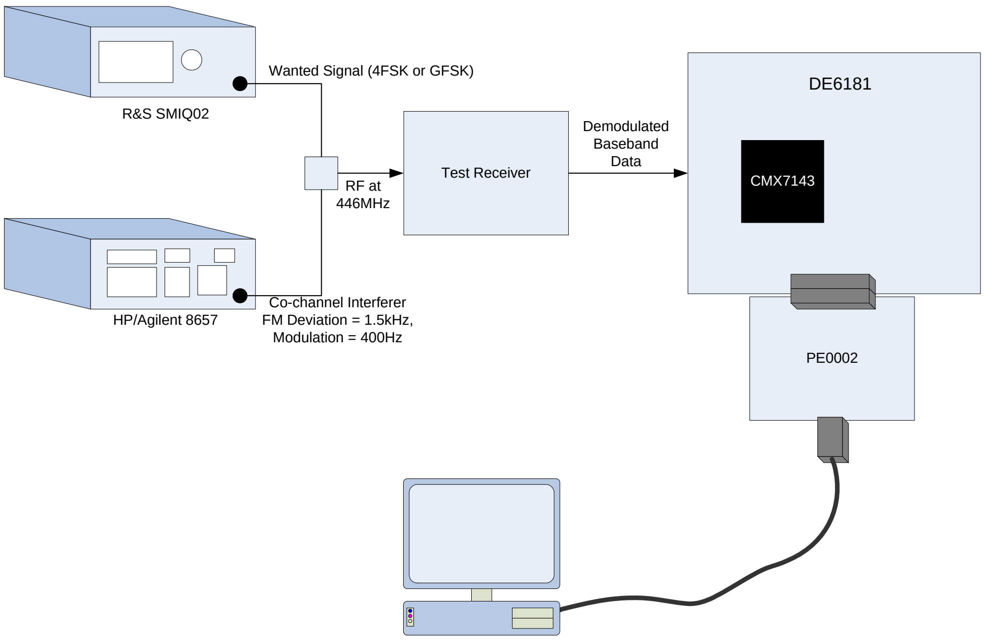

Figure 1 – Test system block diagram

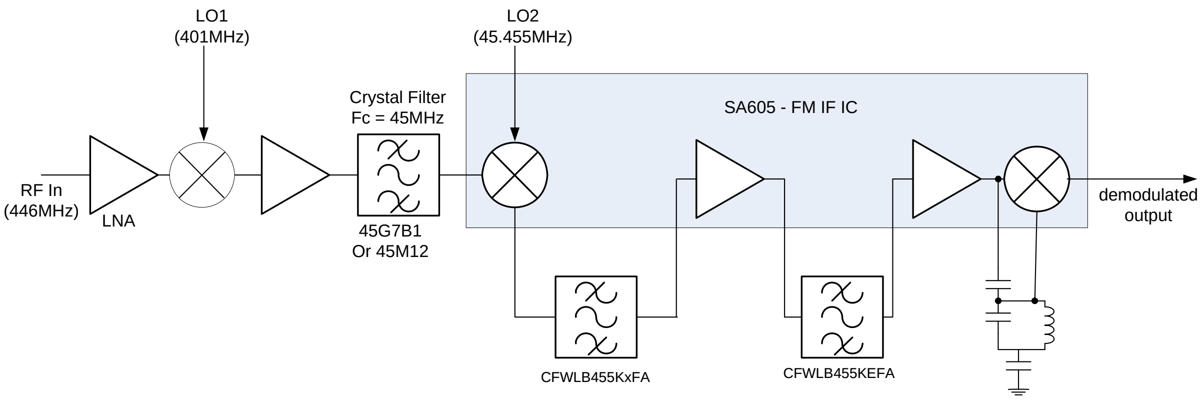

Figure 2 – Test receiver

The test receiver is representative of a typical application circuit as far as demodulator performance measurements are concerned. SAW RF filtering is provided before and after the LNA (not shown in the diagram). Channel filtering, in the form of crystal and ceramic filters, is representative of a practical solution. Local oscillator 1 is provided from a signal generator for flexibility however LO2 is generated from a crystal oscillator on the SA605 IC.

The SA605 IC is a well-known device that has been used for discriminator solutions for many years and although a number of more modern devices provide similar performance, the SA605 is a good reference solution. The main difference with the SA605 from some other devices is that two ceramic filters are required in the 455kHz IF chain. In our application only one filter is necessary for channel filtering requirements so the second filter is simply employed as a 'roofing filter' to ensure stability of the IF chain. The CFWLB455KEFA has a bandwidth of 15kHz (designed for 25kHz channels) and does not significantly affect the results measured.

The noise figure of the test receiver was measured as 9dB.

All test methods used in this document are based ETSI standard EN 300 113, ref [2,3]. The requirement for BER in receiver tests is 1%.

3 Measurements and Results

The measurements showed a number of interesting effects including how the RF hardware can impact the overall results.

3.1 Effect of Filter Bandwidths

Two filters in the test receiver (Figure 2) provide channel filtering, the crystal filter at 45MHz and the first ceramic filter at 455kHz, shown as CFWLB455KxFA. Both filters were found to have an influence on performance of the modem. This is shown in Figure 3 where results of co-channel are plotted for 45MHz filters with 7kHz (45G7) and 12kHz (45M12) pass-bands. Both devices are 4-pole crystal filters.

A similar effect was observed with the 455kHz filters. Initial tests were performed with CFWLB455KGFA filters which are designed for 12.5kHz voice channels. Performance was found to be significantly improved using filters designed for 25kHz channels (CFWLB455KEFA) however such a solution would clearly have poor adjacent channel rejection.

A satisfactory solution was found with the CFWLB455KFFA device, with this and the 45M12 crystal filter adjacent channel rejection comfortably met the 60dB required by EN 300 113, see Figure 4. (Note: The tests in Figure 4 used 4FSK with 1.6kHz deviation, performance is likely to be improved with 1.9kHz deviation)

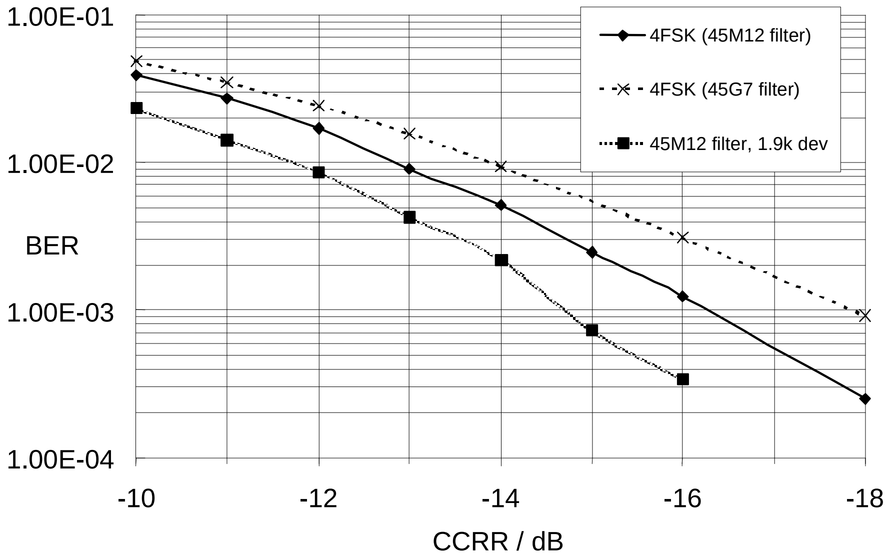

Figure 3 – Co-channel performance of 4FSK modulation with alternative analogue filters and deviations.

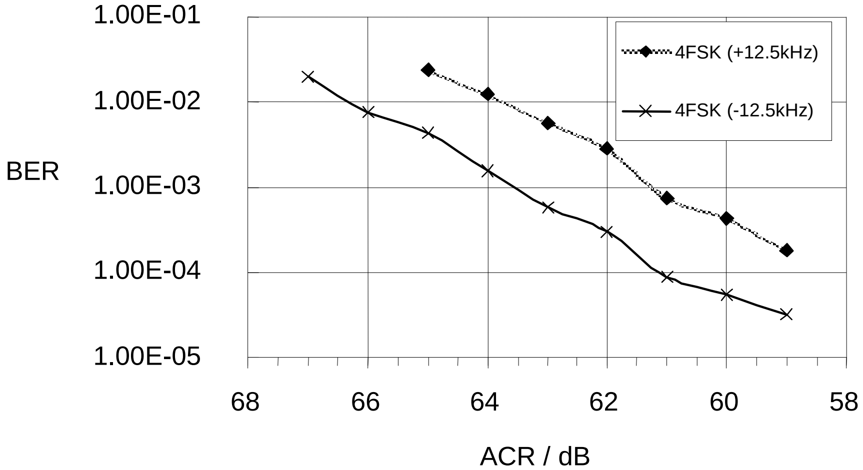

Figure 4 – Receiver Adjacent Channel Rejection (ACR) with 45M12 and CFWLB455KFFA filters

Another issue demonstrated by Figure 3 is the effect of deviation. Initially a deviation of ±1.6kHz for 4FSK +3 or –3 symbols was selected. This was used in the two of the curves in Figure 3, however it was found that this deviation could be increased while still meeting the EN 300 113 adjacent channel power requirements. A deviation of 1.9kHz was found to provide ACP of circa 63dB, adequate margin on the 60dB requirement. With this deviation improved performance was measured, as shown in the final curve on Figure 3.

3.2 GFSK vs 4FSK

Having assessed the variations due to the hardware and the modulation types it is now possible to compare the performance of GFSK and 4FSK for the selected scenario. The co-channel performance measured with an analogue FM interferer as specified in EN 300 113, ref [2], is shown in Figure 5. At the test limit of 1% BER the 4FSK modulation has about 1.5dB advantage over the GFSK and the 4FSK meets the 12dB requirement of EN 300 113 while the GFSK does not. The GFSK does meet the requirements of marine AIS (IEC61993-2) of 17dB at 20% PER which is equivalent to BER of 0.1%.

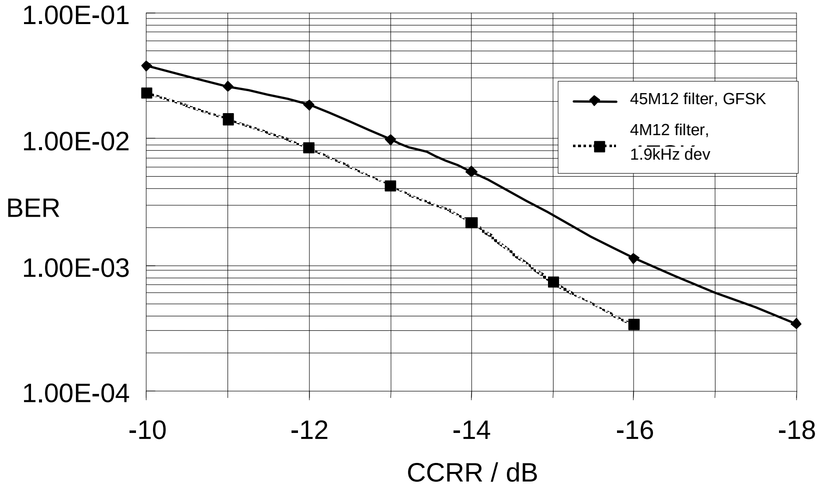

Figure 5 – Comparison of 4FSK and GFSK co-channel performance

Measuring receiver sensitivity 4FSK has a bigger advantage (circa 5dB) over the GFSK, as shown in Figure 6. The difference is due to the different characteristics of the interference in the CCRR test and the noise in the sensitivity test. It is worth emphasising that to generate these graphs exactly the same hardware was used, just the Function Image™ changed and the appropriate modulation selected on the signal generator.

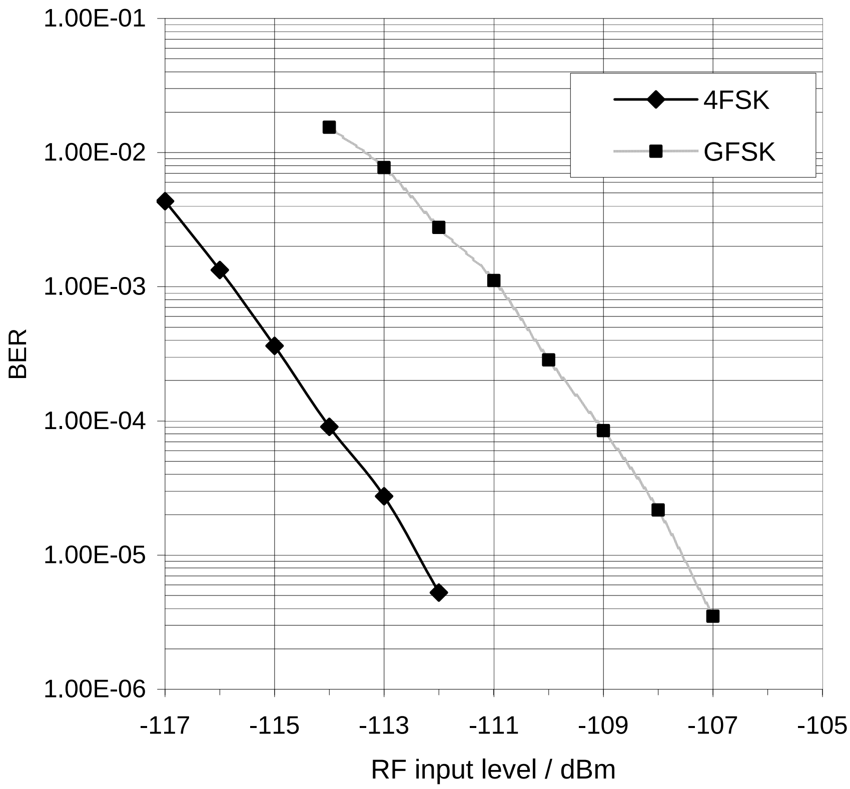

Figure 6 – Comparison of 4FSK (1.9kHz deviation) and GFSK sensitivity

4 Glossary of Terms

ACP	Adjacent Channel Power (of the transmitter)
ACR	Adjacent Channel Rejection (of the receiver)
BER	Bit Error Rate
GFSK	Gaussian Frequency Shift Keying
GMSK	Gaussian Minimum Shift Keying
IF	Intermediate Frequency
PER	Packet Error Rate
RRC	Root Raised Cosine
CCRR	Co-Channel Rejection Ratio
4FSK	Four-Level Frequency Shift Keying

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