This document is intended as a guide for 2-Point modulation set-up for the DE70322T AIS demonstration platform.

First, ensure that the AIS antenna port J6 is connected to a calibrated signal / FM modulation monitor (a spectrum analyser with FM demodulation capabilities is ideal) **via a suitable power attenuator.**

Set the measurement system for 162.025 MHz and enable the transmitter with the CMX7032 PLL programmed correctly for 162.025 MHz operation, unmodulated. This may require the Tx Mod level to be set to 0x 7070 (> 40 dB attenuation on both MOD1 and MOD2).

**Tx MOD levels**
Writing a 16 bit value to Tx MOD Levels sets the output signal levels at the MOD1 and MOD2 signal pins as follows:

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | MOD2 coarse (2dB) | | | MOD2 fine (0.2dB) | | | | 0 | MOD1 coarse (2dB) | | | MOD1 fine (0.2dB) | | | |

| b14 | b13 | b12 | MOD 2 Output Attenuation (coarse) |
|---|---|---|---|
| b6 | b5 | b4 | MOD 1 Output Attenuation (coarse) |
| 0 | 0 | 0 | 0dB |
| 0 | 0 | 1 | 2dB |
| 0 | 1 | 0 | 4dB |
| 0 | 1 | 1 | 6dB |
| 1 | 0 | 0 | 8dB |
| 1 | 0 | 1 | 10dB |
| 1 | 1 | 0 | 12dB |
| 1 | 1 | 1 | >40dB |

| b11 | b10 | b9 | b8 | MOD 2 Output Attenuation (fine) |
|---|---|---|---|---|
| b3 | b2 | b1 | b0 | MOD 1 Output Attenuation (fine) |
| 0 | 0 | 0 | 0 | 0dB |
| 0 | 0 | 0 | 1 | 0.2dB |
| 0 | 0 | 1 | 0 | 0.4dB |
| 0 | 0 | 1 | 1 | 0.6dB |
| 0 | 1 | 0 | 0 | 0.8dB |
| 0 | 1 | 0 | 1 | 1.0dB |
| 0 | 1 | 1 | 0 | 1.2dB |
| 0 | 1 | 1 | 1 | 1.4dB |
| 1 | 0 | 0 | 0 | 1.6dB |
| 1 | 0 | 0 | 1 | 1.8dB |

The default setting is 0dB for both MOD1 and MOD2 (0x 0000).
Note that MOD2 should be inverted so that the signals at TP5 and TP11 are in phase ('Tx 2-point or I/Q mode' = 0x 0004).

The tuning voltage for the PLL can be checked at TP17 and should be of the order of 2.4 V. Configure the AuxDAC2 output to 0x 8620 as a starting value for tuning the frequency reference.

Enable the RAMDAC high to bias the PA on. Note that the RAMDAC table can be set to a lower maximum level for continuous duty cycle test purposes (i.e. to give around +10 dBm output).

The output should show a continuous unmodulated carrier. Adjust the value of AuxDAC2 to obtain minimal frequency error. Note that the polarity of this is inverted (i.e. a larger value decreases the frequency).

Write 0x 0000 to the Tx Mod level control (this is 0dB for both Mod 1 and Mod 2) and enable transmission with a continuous repeated word 0x 00FF. The resultant modulation should look as follows:
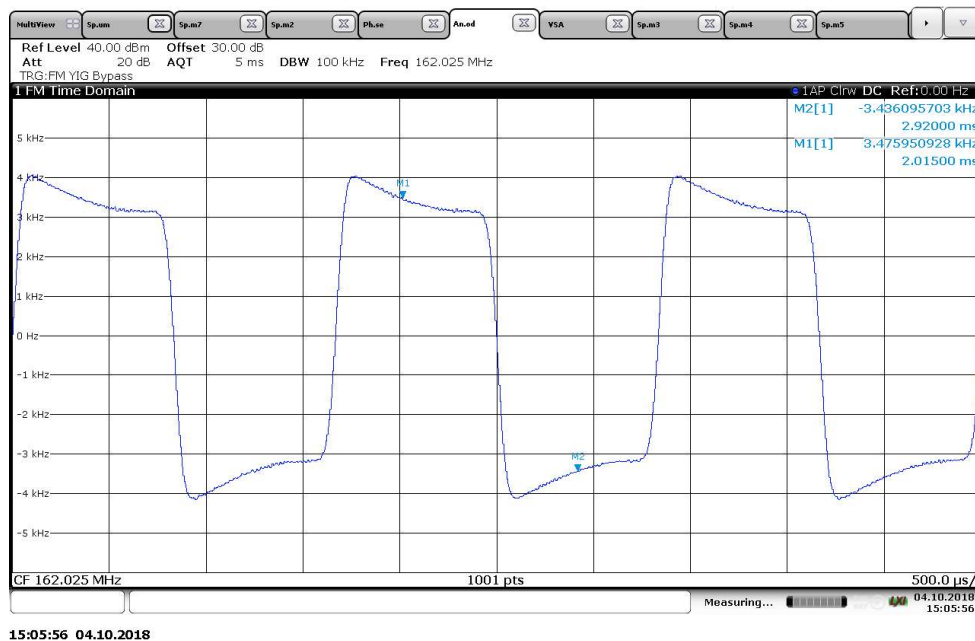


**Figure 1 – Modulation with a repeated '00FF' word - zero attenuation / maximum Mod 1 and Mod 2 levels.**

Note that the leading edge is higher deviation – this is from the VCO modulation driven by Mod 1. The reference modulation from Mod 2 is lower, limited by the VCTCXO.

By writing 0x 0010 to the Tx Mod values, the Mod 1 / VCO modulation is reduced by 2dB. The Mod 2 / reference modulation is then highest, as can be seen below.

**Figure 2 - Modulation with a repeated '00FF' word, Mod 2 = 0dB, Mod 1 = 2dB.**

Reduce the Mod 2 level, keeping Mod 1 fixed, until a good 'balanced' level square wave is produced. Note that the low nibbles of both the Mod 1 and Mod 2 values are limited to 0 to 9 in 0.2 dB steps.
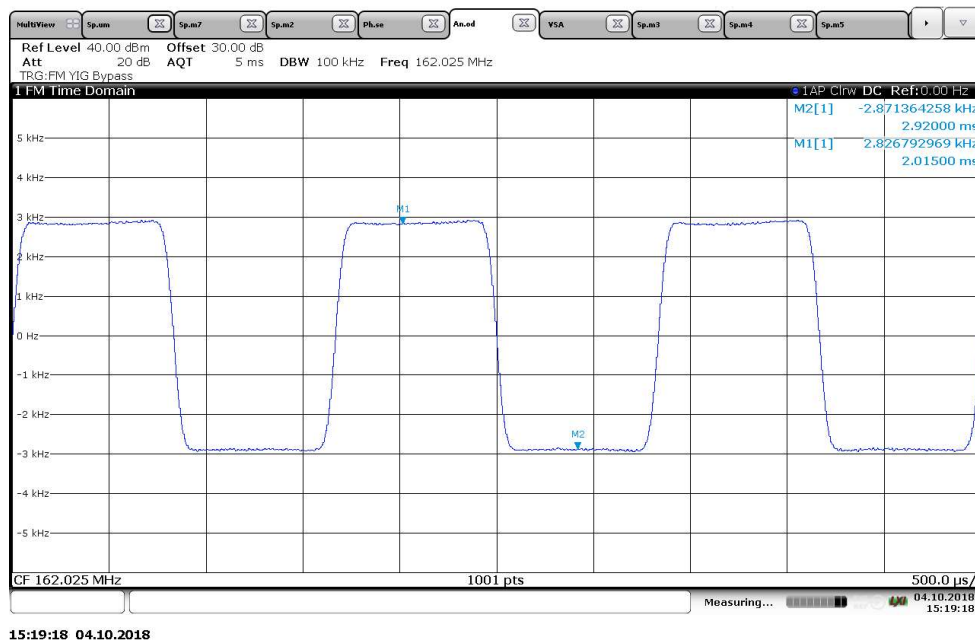


**Figure 3 - Repeated '00FF' word adjusted for best square wave shape, in this example 0x 0710 (Mod 2 = 1.4dB, Mod 1 = 2dB).**
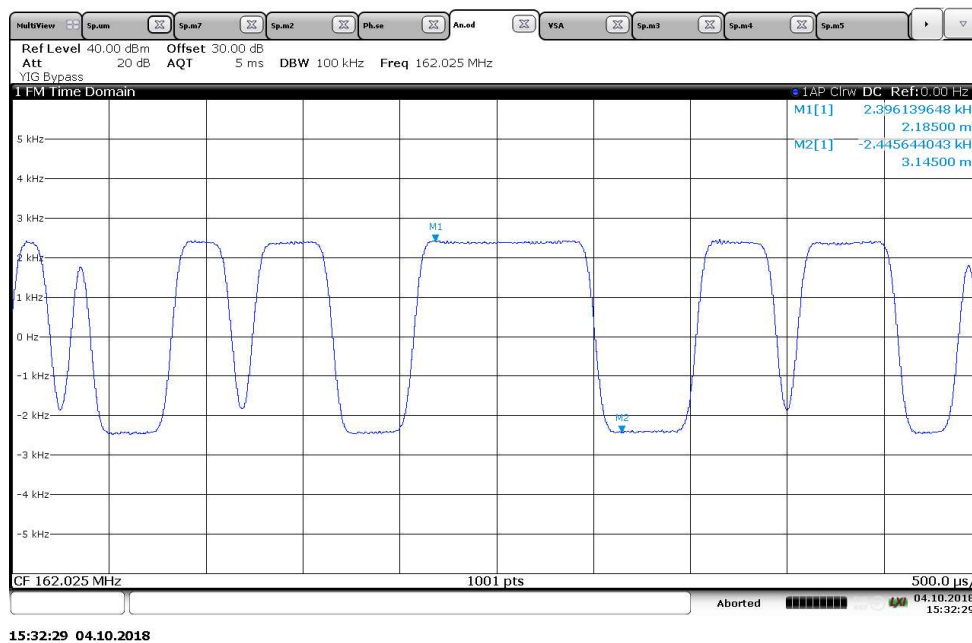
Next, reduce BOTH the Mod 2 and Mod 1 levels in roughly equal steps until a +/-2.4 kHz deviation clean square wave is produced. A typical value is around 0x 2320.
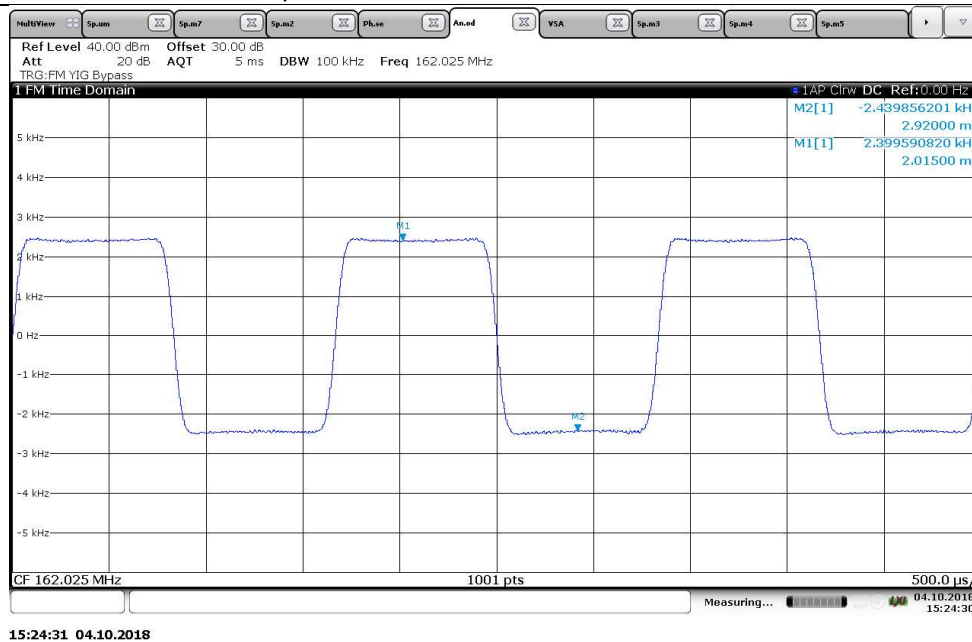
**Figure 4 - Repeated '00FF' word adjusted for +/- 2.4 kHz deviation, in this example 0x 1517.**

Finally, switch to transmitting the internally generated PRBS sequence and observe the demodulated GMSK waveform.



**Figure 5 - Demodulated GMSK waveform showing balanced modulation.**

Re-check the centre frequency and adjust the AuxDAC2 value if required. A typical value is around 552 decimal (0x 8628 written to $A7).

This completes the modulation and frequency adjustment for the DE70322T.  The final AuxDAC2 and Tx Mod levels used should be recorded or ideally stored within the units ARM FLASH memory.

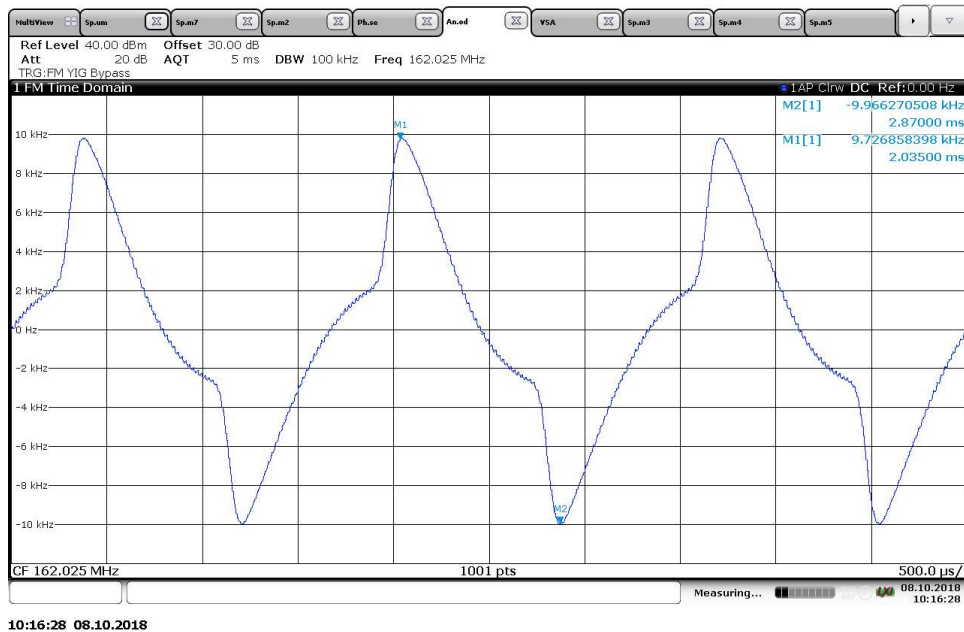*J Flowers, CML Systems 10 October 2018*

*Ancillary Information*

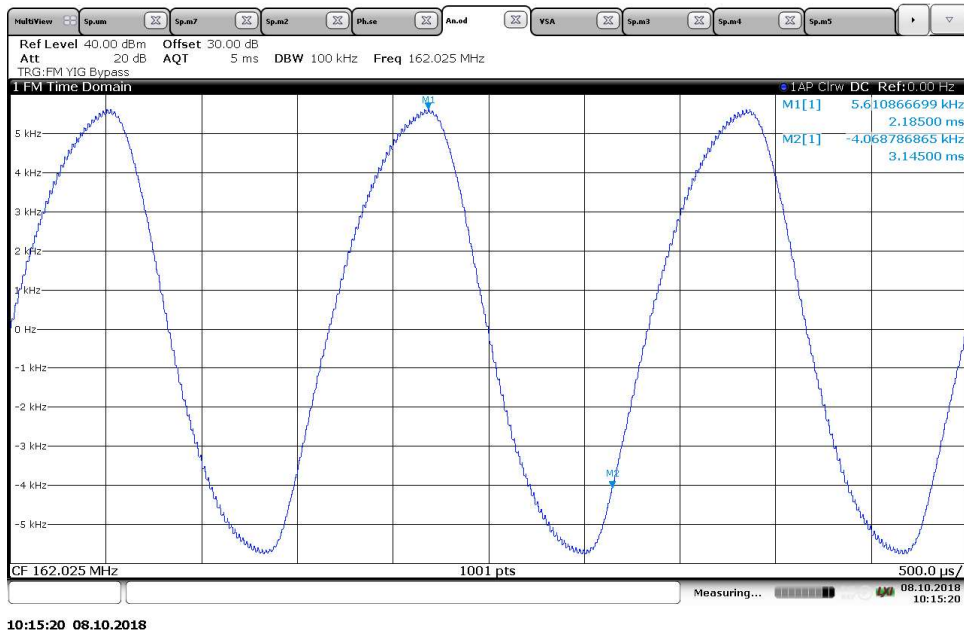Figure 6 – Mod setting 0x 7000 = Mod2 OFF, Mod 1 maximum. Note +/- 10 kHz peaks.



Figure 7 – Mod setting 0x 0070 = Mod2 maximum, Mod 1 OFF.

## $C8 – Command register

| DAC tasks | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 | 001 to 100 | DACwrite | Write N data words from C-BUS to DAC(s) | |

The format of the data for the DAC task ($A7) is:

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| on | 0 | 0 | 0 | DAC select | | DAC data (unsigned) | | | | | | | | | |

The value in b8-10 of the Data Task indicates the number of DAC's that will be updated.

Therefore, to update AuxDAC2, write;
$A7 = 0x 8628 = Data write, b15 = on, DAC2 ('01'), value 0x 228 = 552 decimal, then
$C8 = 0x 0900 = Write 1 data word from C-BUS ($A7) to DAC.

### Tx Mod Levels
The Function Image allows tx mod levels to be changed whilst in Tx mode by writing the levels to $A7, then setting $C1:b15. Note that this bit will cause a single write to the mod level register, for multiple writes, it must be cycled through 0 and back to 1 again.

Therefore, to update the Tx Mod Levels, write:
$C1 = 0x 0000, then
$A7 = <MOD2, MOD1 >, then
$C1 = 0x 8000.

Note that if b14-0 of $C1 are in use, then these values should be preserved whenever b15 is changed.