CML Microcircuits

DE70322T/DE70322TC
Demonstration Kit
## User Manual

Features

- **AIS Class B AIS transceiver technology demonstrator**
- **Designed to meet IEC62287-1**
- **2 Watt Tx operation**
- **On-board ARM host microcontroller (DE70322T)**
- **On-board SCT7033 microcontroller (DE70322TC)**
- **C-BUS interface to host microcontroller**
- **On-board GNSS receiver**
- **Dual UART interface**
- **Small size: 122 x 57 mm**
- **Dual, independent GMSK receivers**
- **USB interface to PC**

Click here for:
- Latest Datasheet
- Product Data Resource
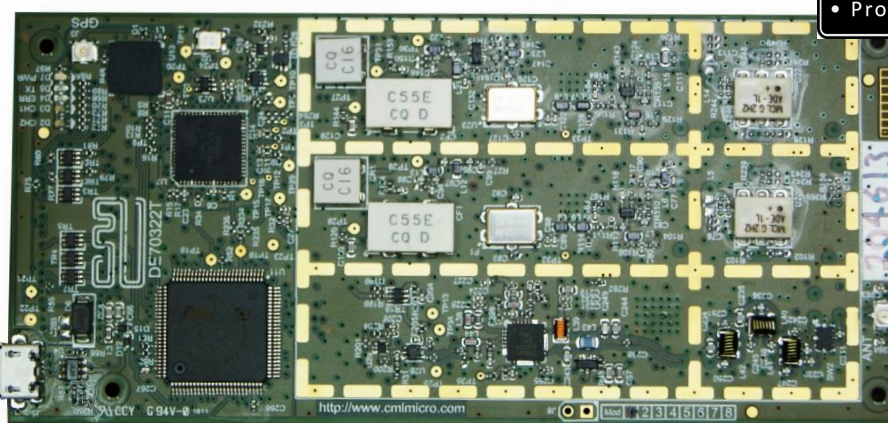
1   Brief Description

The DE70322T/DE70322TC is a complete AIS Class B CSTDMA (IEC 62287-1) technology demonstrator aimed at speeding manufacturers' design and development of AIS Class B transponders using the CMX7032 AIS Class B Baseband Processor with RF Synthesiser IC. The design is a flexible platform which allows users to configure and evaluate the CMX7032 with either 7032/7042FI-1.x or 7032/7042FI-3.x (for use with ExactEarth's exactTrax™protocol).

The DE70322T/DE70322TC implements a dual channel receiver / single transmitter on 161.975MHz (AIS channel 1) and 162.025MHz (AIS channel 2) with 25kHz channel spacing and 9600bps over-air data rate. The receivers are programmable across the entire marine band (156.000 to 162.050 MHz) while the transmitter is optimised for use in the upper marine band (160.000 to 162.050 MHz).

The unit is available in two variants:

- DE70322T uses an on-board ARM microcontroller (STM32F411VET6) which allows a USB-connected host to directly control the CMX7032 using the CML script processing language or to run an in-built Rx-only application. A JTAG header is also provided so that customers can implement their own code and/or implement a complete Class-B CSTDMA protocol stack. The microcontroller has sufficient memory and processing capability to run a suitable Class-B SOTDMA (IEC 62287-2) protocol stack, however the RF output of the pcb is limited to 2W.

- DE70322TC uses an SCT7033 microcontroller to implement a full Class-B CSTDMA protocol stack.

This document describes operation of the DE70322T. The SCT7033 Datasheet should be consulted for further details and operation of the DE70322TC.

The CMX7032 is configurable over the C-BUS interface once it has been loaded with the appropriate Function Image™. The on-board ARM microcontroller is included which can load a Function Image™ into the CMX7032 at power-up.

All necessary RF circuits, such as VCOs, a 2 watt PA (CMX902), harmonic filter, antenna switching, LNA and GNSS module are provided to facilitate easy evaluation and demonstration of the design as a Class B CSTDMA unit.
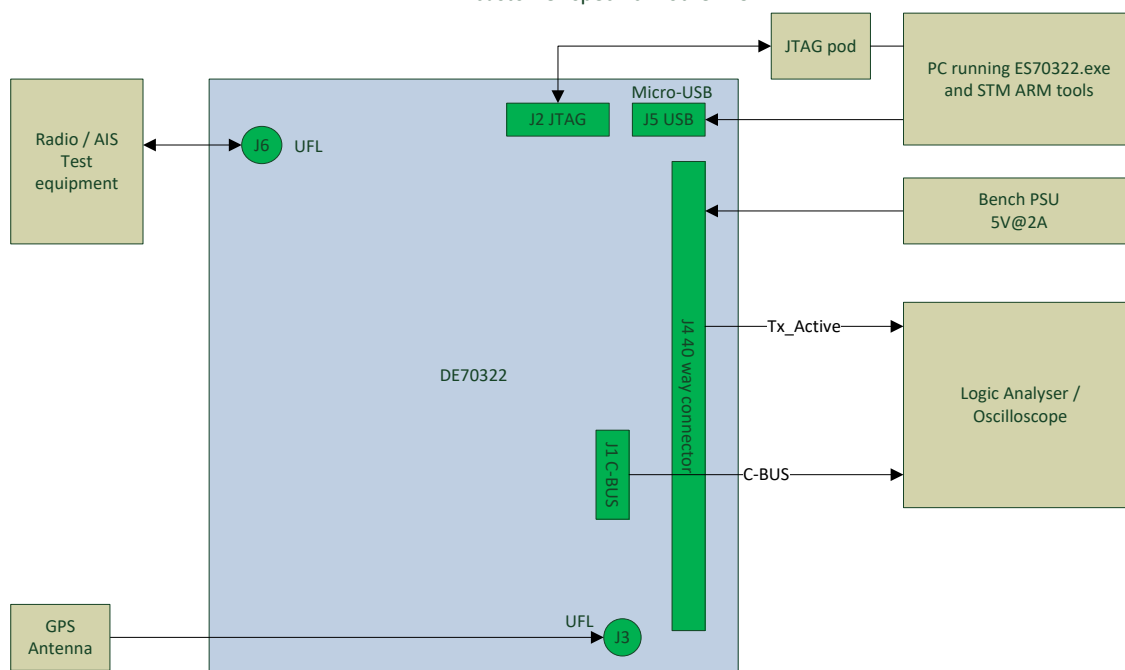
The DE70322T/DE70322TC design is production-engineered for low cost, with a minimum number of component types and values and using only low-cost, off-the-shelf components and addresses the component obsolescence issues with the DE70321. With the addition of suitable power supply and interface components, a complete Class-B AIS unit can be easily implemented. The UART signals are 3V3 logic levels which require external interfaces both for protection and signal conditioning. These are not provided on-board so as to leave the required interfaces as customer selectable options (NMEA-0183, NMEA-0183-HS, NMEA-2000, Bluetooth, IEC 61162-450, Ethernet etc.). The USB interface provided is suitable for direct connection to a host PC using the micro-USB connector. Note that NMEA-2000 / CANBUS is not supported on the STM32F411 microcontroller used on this pcb, however the STM32F413 does support this interface and is pin-compatible.

Status-indicating LEDs are provided on-board and also routed to the 40-way multi-way connector. A number of buffered open collector outputs and inputs to the ARM are also provided on the 40-way multi-way connector.

The TX_ACTIVE signal is provided to control an attached VHF-AIS antenna splitter if required, or as a test point used during testing to IEC 62287-1.
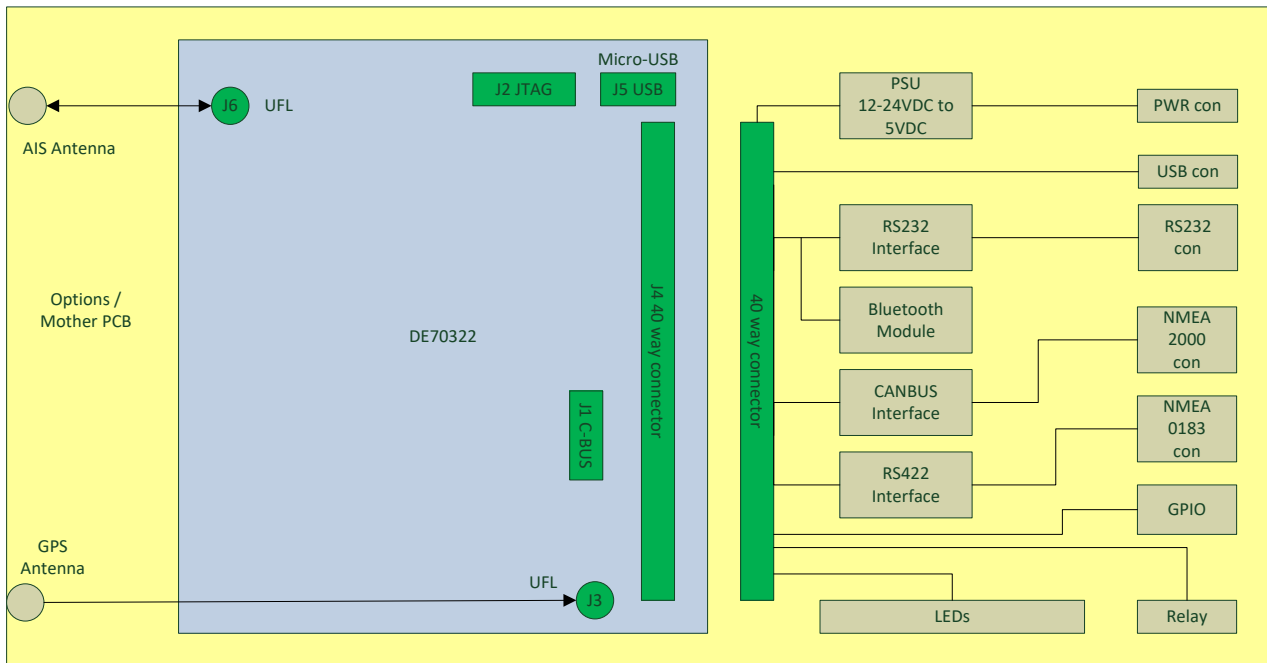
Typical implementation for
Class-B AIS in conjunction with
customer-specific Mother PCB

Typical bench / lab evaluation

Figure 1 Typical Configurations

CONTENTS

1.1　　History

Version	Changes	Date
A	Advance Draft	14.09.17
B	Updated	30.10.17
1	First public release	12.06.18
2	Correction to maximum input voltage. Correction to Evaluation Tests (8.3), Spurious response rejection. Updated DE70322(T) to remove brackets. Added reference to DE70322TC and SCT7033	12.06.18 03.10.19

This document is Advance status and will be subject to future modification. It should not be relied on for final product design.

2   Block Diagram
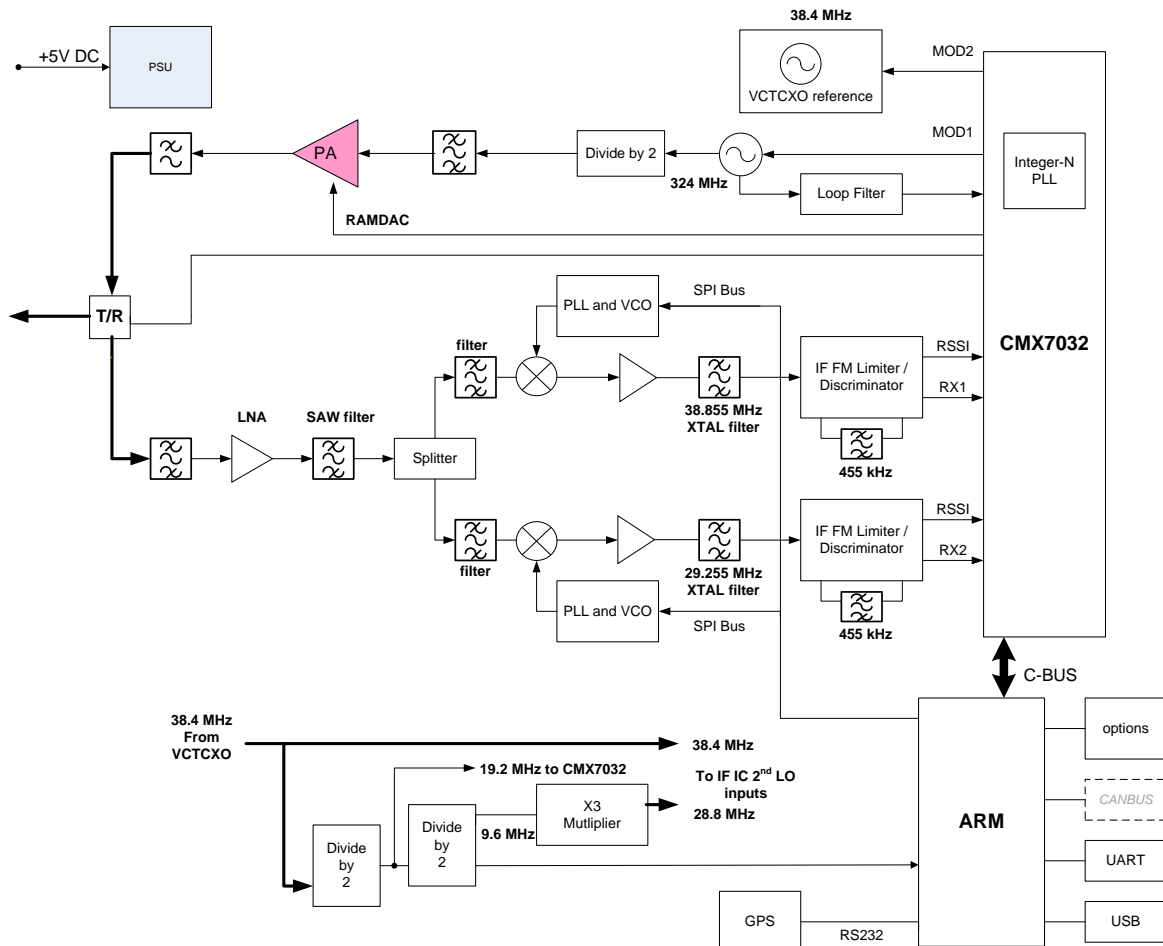

Figure 2 DE70322T – Tx/Rx Block Diagram

3   Preliminary Information

The DE70322T provides a platform for the evaluation and demonstration of the CMX7032 using either 7032/7042FI-1.x (Class B transceiver) or 7032/7042FI-3.x (Class B transceiver with exactTrax™). The Rx-only 7032/7042FI-2.x is not supported.

To use the DE70322T an on-board ARM microcontroller is provided which performs a similar function to the CML PE0003 Universal Interface Controller and implements the same script language interpreter needed to provide control and perform the higher levels of Class B protocol and user interface. This uses the USB interface to connect to a host PC.
Before use, the Function Image™ has to be loaded into the CMX7032. The CMX7032 is configured to load it directly over C-BUS from the on-board ARM under control of the host.

3.1   Laboratory Equipment

The following laboratory equipment is recommended for use when testing this Demonstration Kit:
*   Power Supply
*   Spectrum Analyser
*   RF Power Attenuator
*   RF Signal Generator
*   AIS Message Generator

For more detailed design or investigation work, additional RF test equipment may be required.

Power Supply
The supply input voltage to the PCB is nominally 5.0V (4.5V to 6.0V acceptable). On-board regulators are provided to generate all voltage rails used on the PCB. For Rx-only operation, the PCB can be powered from the USB connector only. For Tx operation, a 5.0V supply must be attached to J4. See Table 3 for details. The supply should be rated at 2A.

NOTE: Care should be exercised with the supplies as they are not protected for reverse polarity. Operation at 12V will exceed the power dissipation ratings of the internal regulators.

3.2 Handling Precautions

In common with other Demonstration Kits, this product is designed for use in office and laboratory environments. The following practices will help ensure its proper operation.

Static Protection

This product uses low-power CMOS circuits that can be damaged by electrostatic discharge. Partially-damaged circuits can function erroneously, leading to misleading results. Observe ESD precautions at all times when handling this product.

Contents - Unpacking

Please ensure that you have received all of the items detailed on the separate information sheet (EK70322T) and notify CML within 7 working days if the delivery is incomplete.

3.3 Approvals

This product is not approved to any EMC or other regulatory standard. Users are advised to observe local statutory requirements, which may apply to this product and the radio frequency signals that may emanate from it.

4   Quick Start

This section provides instructions for users who wish to experiment immediately with the DE70322T Demonstration Kits. A more complete description of these kits and their use appears later in this document. The user should read the appropriate CMX7032 Datasheet and User Manual (FI-1.x or FI-3.x) before using these kits.

For setup and operation of the DE70322TC refer to the SCT7033 Datasheet.

4.1   Setting-Up

Connect a PC using the USB interface to J5 (micro-USB connector). Install device drivers as required in a similar manner to the procedure for the CML PE0003 Universal Interface Card. If running on Windows 10, the drivers will install automatically without the prompt for driver signing.

Open the Windows Device Manager as shown in Figure 3.
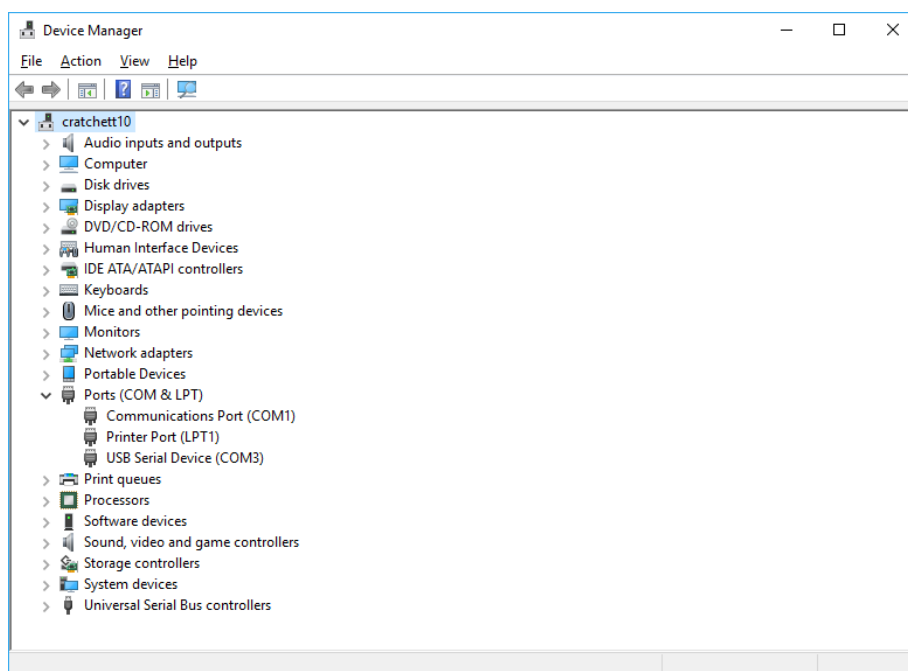
Figure 3 Windows Device Manager COM Port Allocation

Click on the Ports (COM & LPT) entry and note the COM port allocated to the DE70322T board. If using the DE70322T in Rx-only mode, then open the required COM port in a terminal emulator. The DE70322T will boot automatically. If using the DE70322T with the ES70322T GUI (available from the CML website) then start the GUI by clicking on the ES70322T icon. The COM Port Number dialogue shown in Figure 4 will be displayed. Select the allocated COM port and click OK.
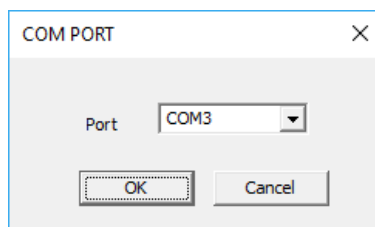
Figure 4 COM Port Number

Connect a 50Ω load to the PA output stage. The board is now ready for operation. An example of typical connections to the DE70322T is shown in Figure 5.

4.2   Adjustments

None required, the CMX70322T is delivered fully tested and ready for operation.

4.3   Operation

It is recommended that users familiarise themselves with the CMX7032 FI-1.x / FI-3.x Datasheet prior to attempting to use the DE70322T in Class B transceiver mode.

The following procedure is recommended:

1. Connect test leads as required (including the host PC to micro-USB interface J5).

2. If testing the transmitter, the RF output J6 should be connected to a suitable 50Ω load.

    THE USE OF AN EXTERNAL 50Ω LOAD IS ESSENTIAL TO PREVENT POSSIBLE DAMAGE TO THE PA STAGE.

    OPERATION OF THE DE70322T IN AIS CLASS B TRANSCEIVER MODE IS ONLY INTENDED TO BE UNDER LABORATORY CONDITIONS AND IS NOT TO BE USED FOR A LIVE AIS CLASS B APPLICATION. ENSURE THAT THE INTEGRITY OF THE LIVE AIS SYSTEM IS NOT COMPROMISED BY ANY RF EMISSIONS FROM THE DE70322T.

3. If testing the receiver, J6 should be connected to an RF signal generator modulated with a suitable AIS data source. A 30dB power attenuator can be used to protect the generator if required.

4. Power should be applied to the main supply (5V nominal).
    The CMX7032 device should be reset and programmed appropriately.

    To confirm operational status, the device's $AA and $A9 registers can be interrogated immediately after loading the FI. The value returned in $AA represents the device identification code (either $7032 or $7042) and the value returned in $A9 represents the version number of the FI loaded (e.g. $1023 for FI-1.0 version 2.3).

Following power-on, the on-board ARM will:

- Configure the ARM clocks for 96MHz operation
- Configure the ARM I/O pins appropriately
- Configure the Rx PLLs for AIS1 and AIS2 receive
- If the PLL LockDetect fails, the BIST LED will be lit
- Configure the USB port for use
- Start the ES70322 / PE0003 script handler and await instructions from the USB port
- If the DTR signal from the virtual COM port on the host PC is detected, then it will switch to autonomous Rx-only mode. In this mode the ARM will:
    - Load the CMX7032 with an FI Stored in ARM Flash
    - Configure the CMX7032 to look for AIS bursts on both channels
    - Report any received bursts via the USB port
    - Route GPS data to UART3 port
    - GPS data will also be routed to the USB connector.
    - The TX TIMEOUT LED will flash while the GPS is looking for a fix and lit constantly when a fix has been found.
    - If the '#' key is pressed on the terminal, the ARM will go into Test Mode. In Test Mode, GPS message processing is suspended, and each !AIVDM message is prefixed with an incrementing count and the elapsed time (in microseconds) since the last AIS message was received. Pressing '#' again will revert back to 'Normal Mode'.

LED Indicators

The function of the LED indicators is shown below for Rx-only mode. In normal operation, their function is defined by the user; however the following functionality is suggested in the table below. The drive signals (open collector) are also connected to the 40-way interface connector via separate resistors.

LED	Colour	Suggested Function
D2 - CH2_LED	Red	Indicates a transmission on channel A.
	Green	Indicates successful reception of a packet on channel A.
D3 - CH1_LED	Red	Indicates a transmission on channel B.
	Green	Indicates successful reception of a packet on channel B.
D4 - ERROR	Amber	This is lit if an error occurs.
D5 - TX_TOUT	Amber	This is lit if the transmitter times out or a CSTDMA Tx is deferred.
D7 - POWER	Green	This is lit if the 3.3V digital supply is active (not configurable).
LED	**Colour**	**Function in Rx-only mode**
D2 - CH2_LED	Green	On entry to rx-only mode: FI successfully loaded
	Red	FI Failed to load
	Green	Subsequently: pulse = message received on AIS channel A
D3 - CH1_LED	Green	pulse = message received on AIS channel B
D4 - ERROR	Amber	On = RF synth failed to lock ; off = RF synth locked
D5 - TX_TOUT	Green	Flashing = GPS looking for position fix ; On = GPS position fix found
D7 - POWER	Green	This is lit if the 3.3V digital supply is active (not configurable).

Table 1 LED Functions
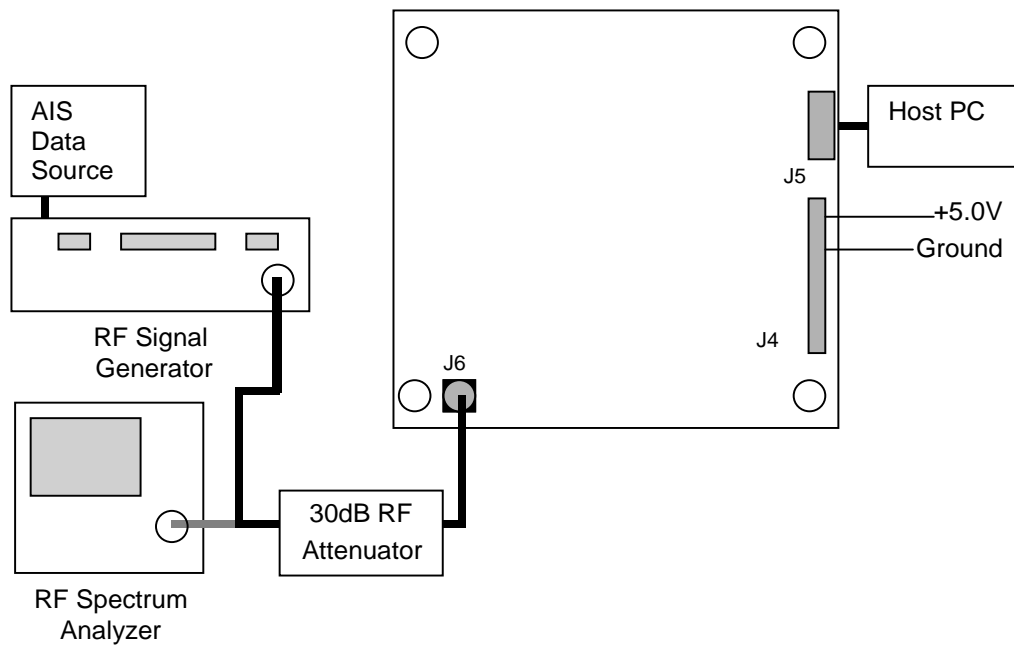
Figure 5 Typical Connections for DE70322T

To use the DE70322T the user will need to run the ES70322 software on a host PC to send and receive data and commands via the C-BUS, which can be monitored on J1. The CMX7032 Datasheet and User Manual give details of the registers and commands.

PE0003 scripts (which are compatible with the ES70322 software) for some of the typical command sequences are available from the technical portal of the CML website (see www.cmlmicro.com for details).

5 Signal Lists

Input power supply and I/O connections are via a 40 way connector, J4, as shown in Table 2. J3 and J6 are RF signals and use UFL 50 ohm sockets.

Connector	Function
J1	C-BUS monitor
J2	JTAG for ARM
J3	GPS (50 ohm UFL)
J4	40-way Power and I/O
J5	Micro-USB for host PC
J6	RF (50 ohm UFL)

Table 2 Signal List

Connector J4 is part number Harwin M50-3602042. A compatible mating part is Harwin M50-3102045. Connections to the 40-way Power and I/O connector are as shown in Table 3. All are 3.3V logic levels unless otherwise stated.

Pin	Signal Name	Type		Pin	Signal Name	Type	
1	CH_2_LED_RED	O	buffered	2	CH2_LED_GREEN	O	buffered
3	TX_TOUT_LED	O	buffered	4	ERROR_LED	O	buffered
5	CH1_LED_RED	O	buffered	6	CH1_LED_GREEN	O	buffered
7	CAN_CON	I	CanBus Connected	8	GND	P	
9	CANBUS_LO	I/O		10	CANBUS_HI	I/O	
11	TX_INHIBIT	I		12	GND	G	
13	Spare_2	I		14	Spare_1	I	
15	Spare_4	I		16	Spare_3	I	
17	UART3_RX	I	3V3	18	UART3_TX	O	3V3
19	AUX_IN_1	I	buffered	20	AUX_IN_2		buffered
21	AUX_OUT_3B	O	buffered	22	GNDD	G	
23	AUX_OUT_1B	O	buffered	24	AUX_OUT_2B	O	buffered
25	ALARM_OUTB	O	buffered	26	TX_ACTIVE	O	Antenna Splitter
27	UART1_RX	I	3V3	28	UART1_TX	O	3V3
29	USB_IODN	I/O	USB levels	30	GND	G	USB levels
31	USB_BUS+	P	USB levels	32	USB_IODP	I/O	USB levels
33	GND	G	Power Supply	34	GND	G	Power Supply
35	GND	G		36	GND	G	
37	+V	P		38	+V	P	
39	+V	P		40	+V	P	

Table 3 J4 Multi-way connector Table

TEST POINTS		Description
Test Point Ref.	Default Measurement	
TP1		Receiver A discriminator input to CMX7032 after inverting op-amp
TP2		Receiver B discriminator input to CMX7032 after inverting op-amp
TP5		MOD1 (CMX7032 modulation output to the VCO)
TP10		19.2MHz clock
TP11		MOD2 (CMX7032 modulation output to the VCTCXO)
TP12		CMX7032 Slot Clock input
TP13		+3.3V TX divider supply
TP15		CMX7032 Slot Clock output
TP16		ExactTrax TXVCO enable
TP17		TX PLL Tuning voltage
TP18		IRQ input from CMX7032 to ARM
TP19		Sync Output Test signal from ARM
TP20		SAFEBOOT_N test pin for GPS module
TP21		Digital ground
TP22		Analogue ground
TP23		+3.3V digital supply
TP24		+3.3V analogue supply
TP25		+3.3V TX VCO supply
TP26		+3.3V Receiver A supply
TP27		+3.3V Receiver B supply
TP28		Receiver A RSSI output
TP29		Receiver A discriminator output
TP30		Receiver B RSSI output
TP31		Receiver B discriminator output
TP32		Receiver A tuning voltage
TP33		Receiver B tuning voltage
TP34		TX VCO bias voltage
TP35		Power amplifier control voltage

Table 4 Test Points

Notes:
    I   =   Input
    O   =   Output   TP   =   Test Point
    I/O   =   Bidirectional
    Note that the voltages are typical for their active state (i.e. Tx or Rx operation enabled).

6   Script/GUI Mode

A Windows GUI can be used to control the DE70322T – either by manual register accesses or by running scripts.

Setting-Up

- Refer to Section 4.1 for driver installation.
- **Ensure that an external 50Ω attenuator or load is connected to the Antenna Socket (J6). Turning the PA on without a 50Ω load attached to the SMA connector (J6) is likely to result in damage to the unit.**
- Connect a dc supply to the DE70322T and set the voltage level to 5.0V.
- Attach a USB cable between connector J5 of the DE70322T and the USB port of the PC.
- Turn on the power supply.

The executable ES70322xx.EXE can now be run. There are five sheets within the tabbed dialog box structure. These are described in the following sections.

6.1   The C-BUS Control Tab

This tab provides basic C-BUS read, write and general reset functions. Each character entered into the Address and Data edit boxes is checked to ensure that it is a valid hexadecimal value. The radio buttons select an 8-bit or 16-bit read/write operation. The lengths of the entered values are limited to 2 characters (1 byte) for read or write register addresses and 2 or 4 characters (1 or 2 bytes) for the register write data. The General Reset button writes 01H to the CMX7032.
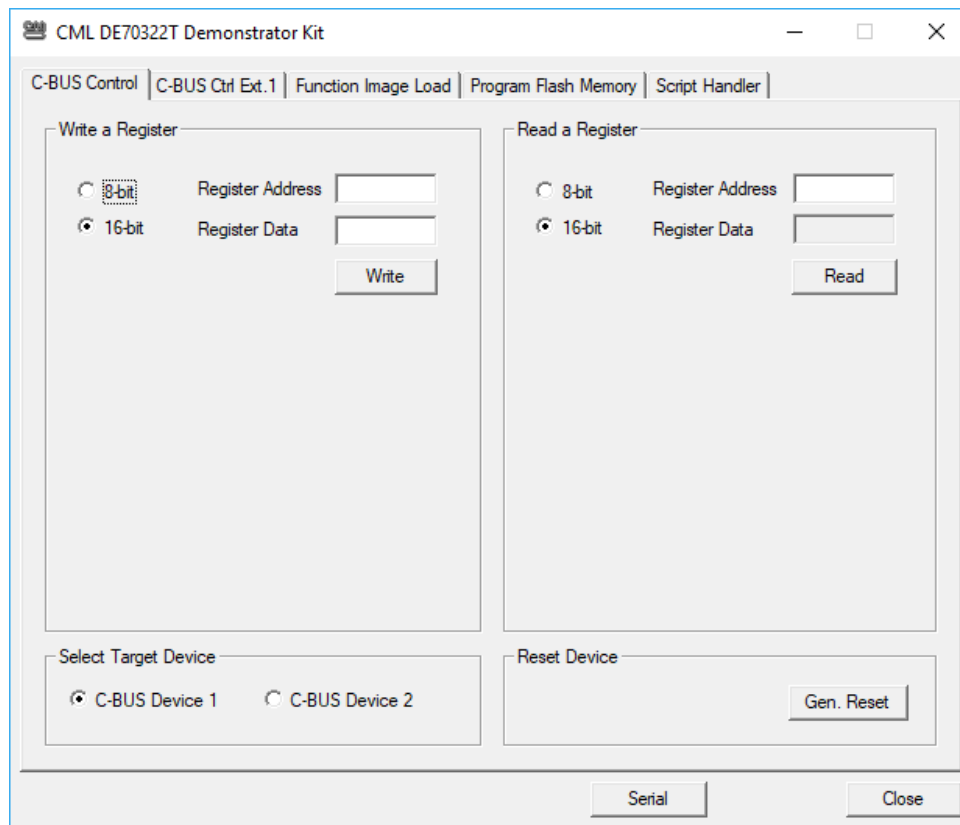
Figure 6 C-BUS Control Tab

6.2   The C-BUS Control Extended Tab (C-BUS Ctrl Ext. 1)

This tab provides multiple C-BUS read and write functions. Each row in the table represents a single action on a C-BUS register. Select the C-BUS register type from the drop down list. The Update button and the Data edit box will be configured according to the selection. Each character entered into the Address and Data edit boxes is checked to ensure that it is a valid hexadecimal value. The lengths of the entered values are limited to 2 characters (1 byte) for register addresses and 2 or 4 characters (1 or 2 bytes) for the register data. Click the Update button to read or write a single C-BUS register. For multiple C-BUS read or write operations, select the C-BUS registers using the Enable check boxes and click on the 'Wr all', 'Rd all' or 'Wr\Rd all' buttons. Click on the 'Wr all' button to write all the selected write type C-BUS registers. Click on the 'Rd all' button to read all the selected read type C-BUS registers. Click on the 'Wr\Rd all' button to read or write all of the selected C-BUS registers.

Figure 7 C-BUS Control Extended Tab

The C-BUS actions in the table are executed sequentially, starting at "1" (top left of the table). The 'Delay by instruction (ms)' box introduces a delay between the execution of each C-BUS action (default = no delay).

Click on the 'Clear all' button to reset the table. Click on the 'Clear data' button to reset the Data edit boxes.

The 'Lock' button may be used to disable the Description, Address and Type controls, preventing accidental changes. Click on the 'Lock' button again to re-enable these controls.

Use the 'Save Config…' button to save the current table. The Description, Address, Type, Data and Select columns are saved in the specified file. Use the 'Open Config…' button to load a previously saved table.

6.3   The Function Image™ Load Tab

This tab provides a utility for loading a CMX7032 Function Image™ from the host PC. Enter the name of the file containing the Function Image™, or navigate to the required file using the 'Browse' button. Enter the Activation Code, if required. The Activation code can be typed in, selected from the drop-down list or selected from a previously created list using the Activation Codes button. Select the target device and click the 'Load' button. The progress of the download from the host PC is shown visually on the progress bar and when the download has completed, a message box will be displayed indicating if the result of the download operation was successful or not.
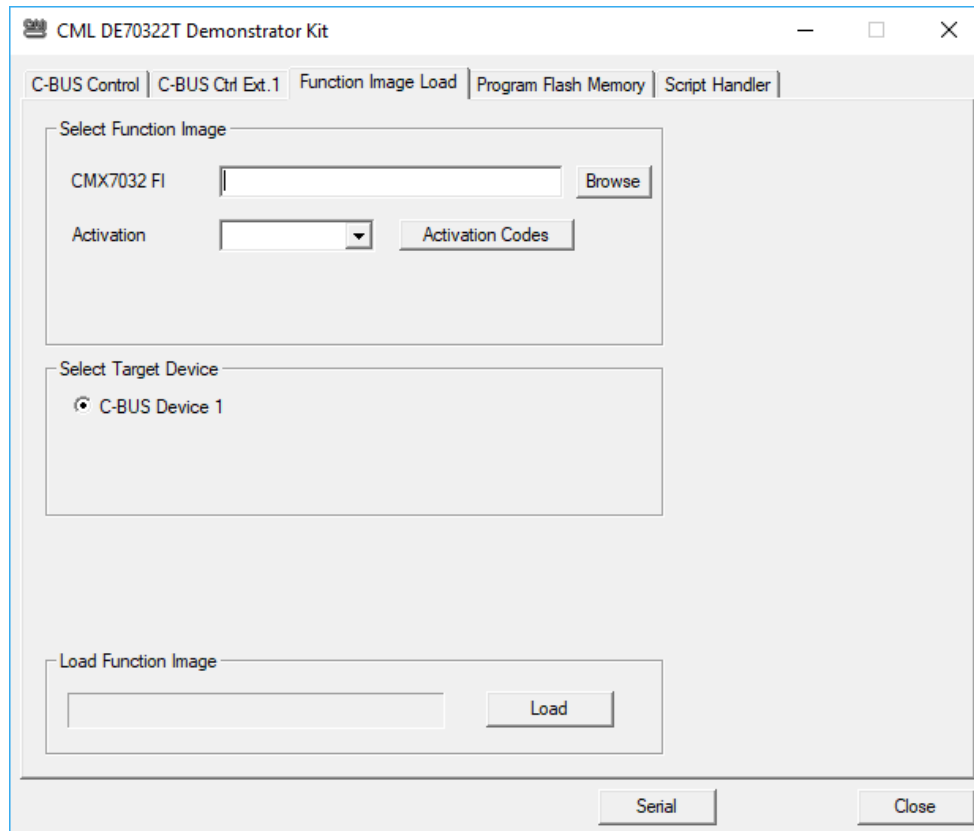

Figure 8 Function Image™ Load Tab – via C-BUS

6.4 The Program Flash Memory Tab

This tab provides a way to program Function Images™ for the CMX7032 into Flash memory on the ARM processor. To load the function image enter or browse to the FI (.h file) using the 'FI Flash Area A' section, and click on the 'Load' button.
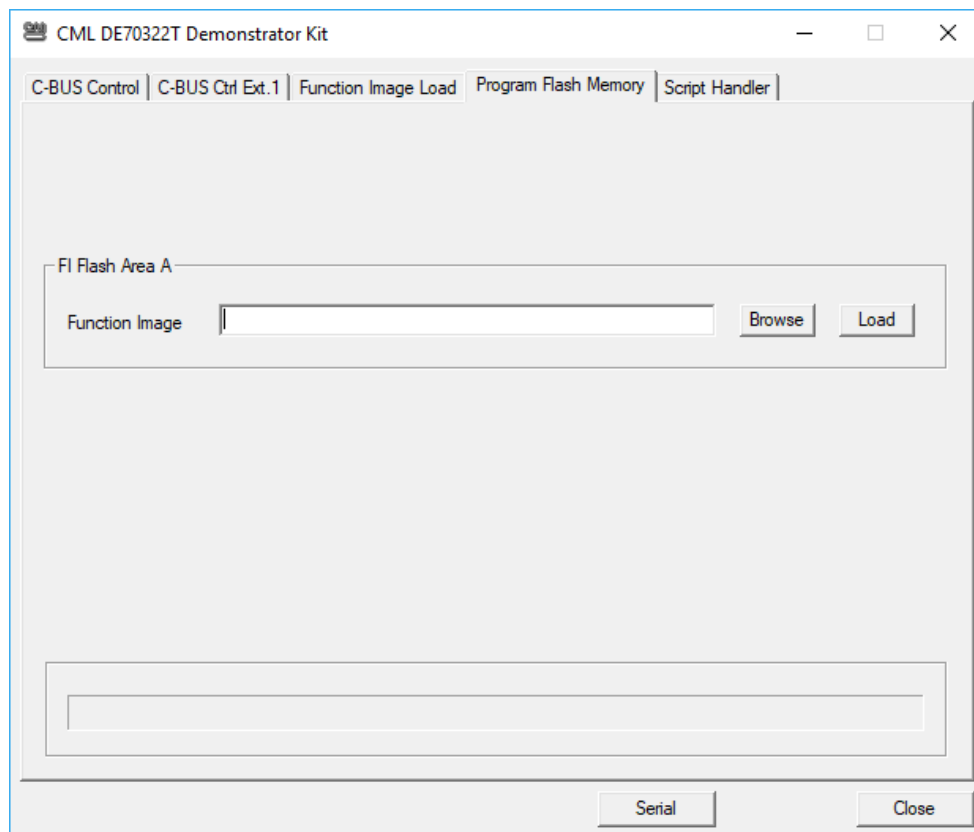

Figure 9 Program Flash Memory Tab

6.5 The Script Handler Tab

The Script Handler tab allows the execution of scripts. These are plain text files on the host PC which are compiled by the GUI, but executed on the ARM Microprocessor on the DE70322T. The script language is documented separately in the "Script Language Reference" document, which can be downloaded with the PE0003 support package from the CML website at www.cmlmicro.com.

The script language used by the DE70322T is identical to that used by the PE0003, except that the commands relating to 'static buffers' are not supported and the mapping of the 'port' commands to I/O pins is different, as shown in Section 6.6.

To select a script file, click on the 'Select Script' button. The Open File Dialog is displayed. Browse and select the script file. The folder that contains the script file will be the working folder of the script (i.e. all the files referenced in the script will be searched in this folder). Alternatively, select a script file from the recent files list. Click on the '>' button to display the list.

The results window displays the values returned by the script. These results can be saved to a text file or discarded by clicking on the 'Save Results' or 'Clear Results' buttons, respectively. When a script file is being executed, the 'Run Script' button will change to be the 'Abort' button, the rest of the tab will be disabled and the other tabs cannot be selected.
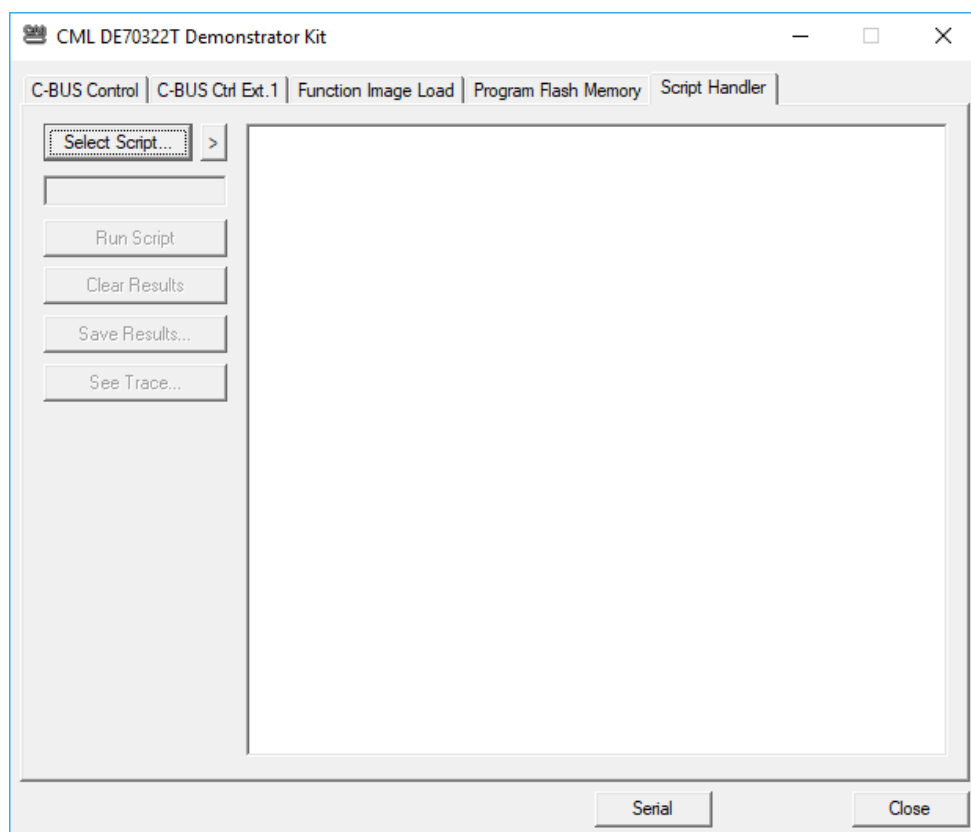

Figure 10 Script Handler Tab

After a script has finished running and when trace data is available, the 'See Trace…' button will be enabled. Click on the 'See Trace…' button to display the Trace dialog box. Note that the C-BUS transactions are only logged if the feature has been enabled in the script. See the "Script Language Reference" document for details.
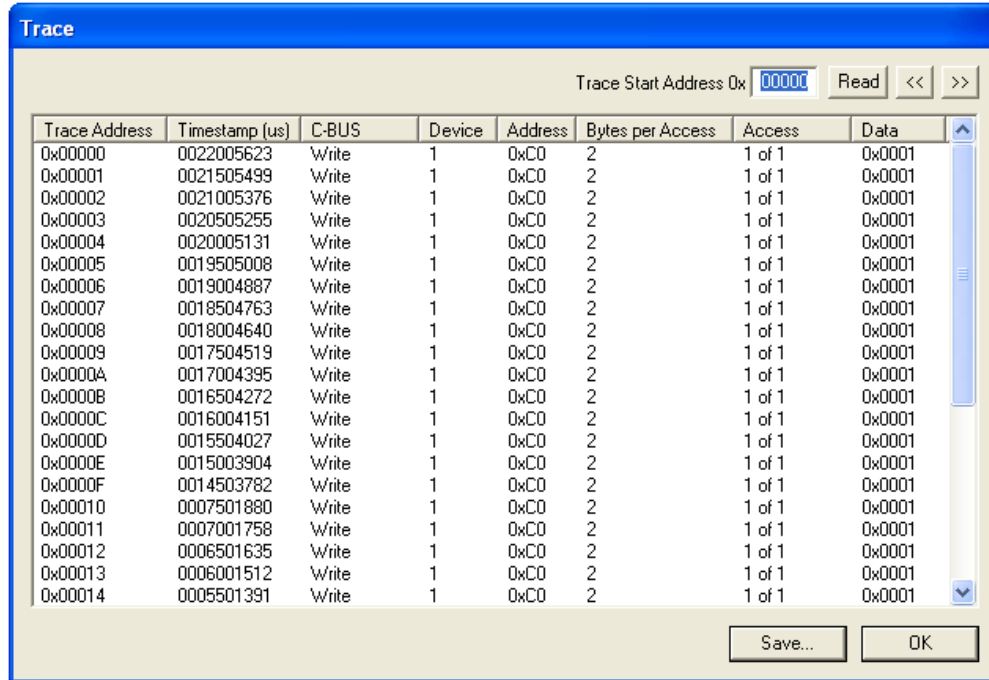
Figure 11 Trace Dialog Box

Click on the '>>' or '<<' buttons to upload and display the next or previous C-BUS transaction data block. Click on the 'Read' button to upload and display the C-BUS transaction data block starting at the address displayed in the Trace Start Address edit box. Use the 'Save…' button to save the trace data to a file.

6.6   Port Mapping

The I/O bits referred to by scripts as 'Port 1' and 'Port 2' are mapped to GPIO on the ARM microprocessor as follows:

Port 1 bits	ARM Reference	Hardware	I/O	Default
0	PD8	AUX_IN_1B	I	
1	PD9	AUX_IN_2B	I	
2	PD10	USB_CONnected	I	
3	PE7	CAN_CONnected	I	
4	PE11	SPARE 1	I/O	0
5	PE12	SPARE 2	I/O	0
6	PE13	SPARE 3	I/O	0
7	PE14	SPARE 4	I/O	0
8 to F	*Not used*	*Not used*	N/A	0

Table 5 Port 1 Mapping

Port 2 bits	ARM Reference	Hardware	I/O	Default
0	PE0	CH2_RED	O	0
1	PE1	TX_TIMEOUT	O	0
2	PE2	BIST_ERROR	O	0
3	PE3	CH2_GREEN	O	0
4	PE4	CH1_RED	O	0
5	PE5	CH1_GREEN	O	0
6	PB5	RX_ON	O	0
7	*PC13*	*SYNC_OUT_TEST*	N/A	0
8	PE8	PA_TEST_EN	O	0
9	PE9	TXVCOEN	O	0
A to F	*Not used*	*Not used*	N/A	0

Table 6 Port 2 Mapping

7   Circuit Schematics and Board Details

For clarity, circuit schematics are available as separate high-resolution files. The layout on each side is shown below. A bill of materials is also available from the CML website. The PCB is an 8-layer design fabricated with FR4 material and is 1.6mm thick. Full Gerber and Drill files are available on request. The DE70322T has been designed for low-cost production.
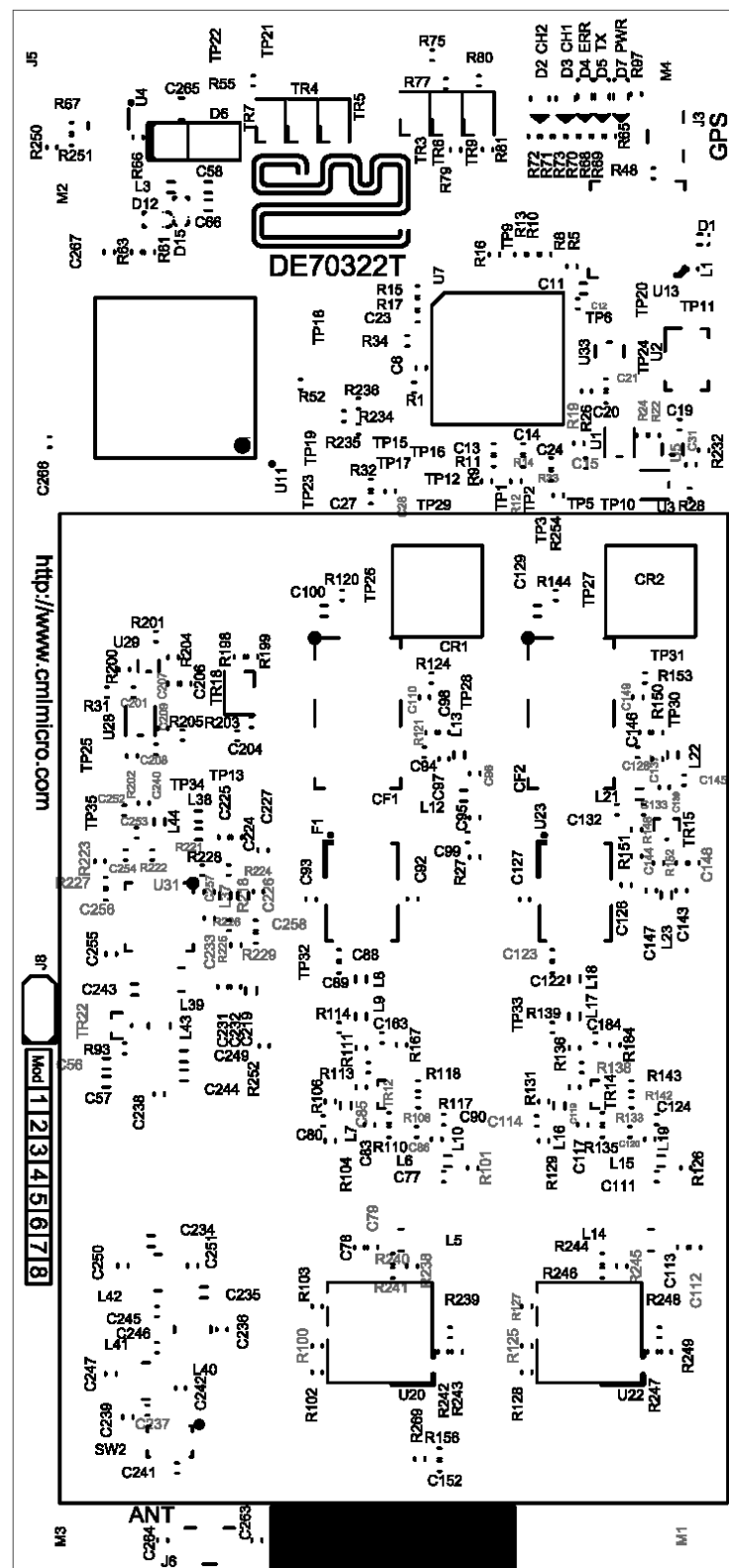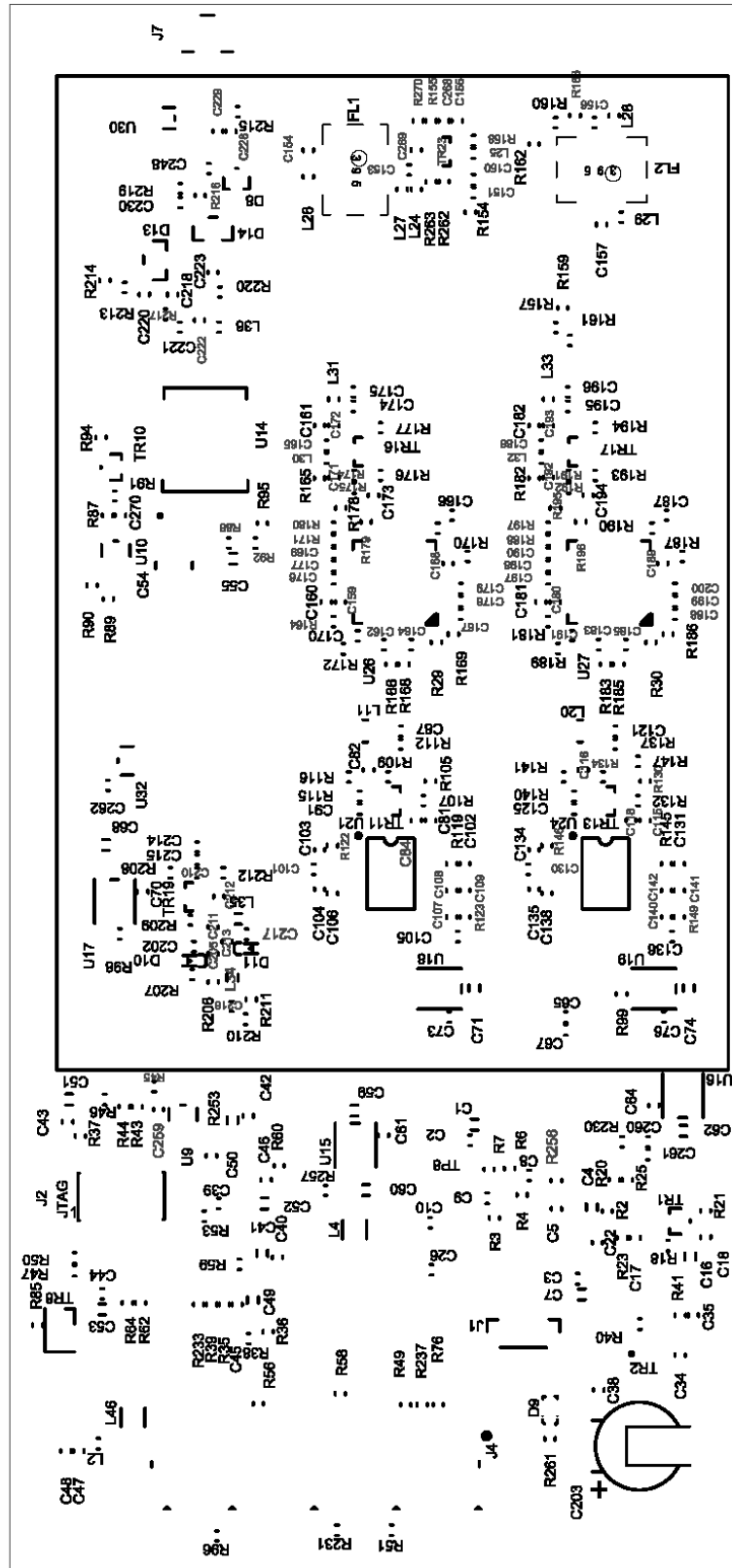

Figure 12 PCB Layout: top

Figure 13 PCB Layout: bottom

8   Detailed Description

The CMX7032 Datasheet and User Manual (available from www.cmlmicro.com) should be referred to for a detailed description of the CMX7032. There are separate datasheets and user manuals for each Function Image^{TM} (FI-1.x and FI-3.x).

The DE70322T functionality includes:
- Demonstration of the CMX7032 RF synthesiser functionality at ≈320MHz in Tx mode.
- Demonstration of full dual channel AIS receiver performance.
- An interface that allows the card to be connected to a host PC, to allow real-time control.
- Demonstration of AIS transmitter performance.
- On-board GNSS receiver.
- Implementation of customer software in on-board ARM microcontroller

In summary, the DE70322T provides the core for the user to create a complete AIS class B CSTDMA transponder solution.

If further design support is required, please contact your regional CML office or an approved CML distributor.

8.1   Hardware Description

Front End LNA
The receiver LNA is implemented with a BFR193W (U25) giving high gain and low noise figure.

SAW Image Filters
Filters FL1 (before the LNA) and FL2 (after the LNA) are marine band SAW filters (Golledge MA06510) and provide image and other spurious response rejection. FL1 is followed by a two-way resistive splitter to the independent receivers.

Mixers
After provision for attenuation and matching, each receiver uses a Mini-Circuits double balanced diode ring mixer to mix from marine band to IF. These are followed by amplifiers to overcome the mixer and splitter losses.

IF Crystal Filters
The IF filters (F1 and F2) are 4-pole crystal filters (Golledge MP03973 and MP05825 respectively) with a pass band of approximately +/-7.5kHz. Correct matching of the filters is necessary to achieving optimum performance.

Receiver 1st Local Oscillators
The 1st LOs of the receivers are generated in the LMX2571 fractional-N PLL devices (one for each receiver). These devices include in-built VCOs.

Rx Band / MHz	Rx IF / MHz	LO Range / MHz
156.025-162.025	RXA 38.855	117.170-123.270
156.025-162.025	RXB 29.255	126.770-132.770

Table 7 Local Oscillator Frequencies

By default the PLL's are tuned to AIS1 and AIS2 channels using the data in the table below:

Register		Hex Data	
R60		A000	
R58		8C00	
R53		7806	
R47		0000	
R42		0210	
R41		0803	
R40		031C	
R39		11FB	
R35		1805	
R34		1000	
R33		0000	
R32		0000	
R31		0000	
R30		0000	
R29		0000	
R28		0000	
R27		0000	
R26		0000	
R25		0000	

	RXA		RXB
R24		0010	
R23		0000	
R22		0000	
R21		0000	
R20		0000	
R19		0000	
R18		0000	
R17		0000	
R16		0000	
R15		0000	
R14		0000	
R13		0000	
R12		0000	
R11		0000	
R10		0000	
R9		0000	
R8		001F	
R7		0084	
R6		8D63	
R5		0101	
	RXA		RXB
R4	3017		3015
R3	1200		1200
R2	2559		C6C0
R1	7A06		7A2D
R0	0C03		0C03

Table 8 PLL Data Registers

Reference Oscillator

A 38.4MHz VCTCXO is provided on the PCB. Note that for transmit operation, both the VCO and the reference need to be modulated.

The 38.4MHz signal provides the 2nd LO signal for receiver A. It is also divided by 2 to give 19.2MHz, which is then divided by two, then multiplied by 3 and filtered to provide a 28.8MHz 2nd LO signal for receiver B. The 19.2MHz signal also provides the XTAL clock input to the CMX7032 and the ARM microcontroller.

2nd IF / Demodulation

The IF signals from the crystal filters are matched to the input of the NJM2591V FM/IF demodulation IC (U21 for receiver A, U24 for receiver B). This IC and surrounding circuitry provide a number of functions:

- A mixer from the 1st IF to 455kHz (the 2nd IF)
- Further channel filtering using inexpensive ceramic filters (e.g. AEL LTC455EW)
- A limiter/discriminator demodulator using a ceramic resonator (e.g. AEL D455K000S003)
- RSSI outputs that can be monitored by CMX7032 AUX ADCs.

Transmitter

The transmitter provides at least +33dBm over the range 156.000 to 162.025MHz. The transmit VCO (TR19) operates at twice the wanted frequency. This is locked using PLL1 on the CMX7032, which provides a 3.3V charge pump output. Modulation is applied using diode D10. The VCO output is buffered by U29, then divided by two using U28. This then drives the CMX902 power amplifier module U31.

The CMX7032 RAMDAC output is connected to the PA control line via an op-amp buffer (U32).

A high current linear regulator U14 provides the supply to the PA. This can be shut down using the circuitry of TR10/22, which provides a Tx time-out function. The time-out function can be over-ridden for test and set-up by setting the PA_TEST_EN signal high – this feature should be used with care so as to not exceed the temperature limits of the PA device.

Tx/Rx Switch

Tx/Rx RF switching is provided by a Mini-Circuits VSW2-33-10W+ switch, avoiding the need for high current PIN diodes. The switch is activated to route RF1 (Tx path) to the antenna via the TxEN signal from the CMX7032. An additional pair of anti-parallel diodes (D8) protect the SAW filter FL1 input from extremely strong signals (e.g. a nearby VHF DSC / voice transceiver). This branch of the switch then goes to the receiver LNA.

Harmonic filter

L40, L41 and associated components form a low loss low pass filter with traps centred at the 2nd and 3rd Tx harmonics.

RF Detector

A discrete, lumped element directional coupler is formed around L36 and L42, prior to the harmonic filter. The forward and reverse outputs from these are detected (D13, D14 and associated circuitry) and the outputs can be monitored using AUX ADC1 and 2. This is for antenna fault detection rather than for accurate VSWR measurement.

GNSS Receiver

This is provided by a UBLOX EVA-M8 module (U13). A suitable active antenna should be connected to J3. The EVA-M8 has a variety of antenna fault detection features. The device is available in different variants to cover GPS, GLONASS, Beidou, Galileo operation. By default the GPS/GLONASS version is fitted. Connection to the ARM is via UART2. The device can be power-saved either under software control or by using the EXTINT signal. Battery backup is provided, so the device will initiate a "warm start" at every power-on following the initial operation.

Power-on in initialisation state:

UART:	9600,8,n,1
TimePulse:	on, aligned to UTC
AntennaSense:	on (ANT_OK and ANT_OFF active)
EXTINT0:	off
GPS mode:	GPS and GLONASS
NMEA mode:	4.0
Reference:	WGS84

The uBlox M8 should report the following at power-on:

```
09:06:40    $GNTXT,01,01,02,u-blox AG - www.u-blox.com*4E
09:06:40    $GNTXT,01,01,02,HW UBX-M8030 00080000*60
09:06:40    $GNTXT,01,01,02,ROM CORE 3.01 (107888)*2B
09:06:40    $GNTXT,01,01,02,FWVER=SPG 3.01*46
09:06:40    $GNTXT,01,01,02,PROTVER=18.00*11
09:06:40    $GNTXT,01,01,02,GPS;GLO;GAL;BDS*77
09:06:40    $GNTXT,01,01,02,SBAS;IMES;QZSS*49
09:06:40    $GNTXT,01,01,02,GNSS OTP=GPS;GLO*37
09:06:40    $GNTXT,01,01,02,LLC=FFFFFFFF-FFFFFFFF-FFFFFFFF-FFFFFFFF-FFCFFFFF*28
09:06:40    $GNTXT,01,01,02,ANTSUPERV=AC SD PDoS SR*3E
09:06:40    $GNTXT,01,01,02,ANTSTATUS=DONTKNOW*2D
09:06:40    $GNTXT,01,01,02,PF=3FF*4B
```

Time pulse at 1Hz aligned to UTC. The data on the serial bus to accompany this pulse (time, date etc) will <u>follow</u> the pulse after the position fix has been calculated. Note that the correction data to convert GPS time to UTC is only transmitted every 12 ½ minutes, so the host should verify that the pulse supplied to the CMX7032 is aligned correctly to the even second periodically, and especially after a possible leap-second change on Jan 1st or June 30th each year.

UBX-CFG-TP5 data:

Byte offset	Value (hex)	Name	
0	00	tpIdx	Timepulse
1	00	version	
2	00 00	reserved	
4	00 00	Cable delay	
6	00 00	RF group delay	
8	00 00 00 01	freq	1 Hz
12	00 00 00 01	freq when locked	1 Hz
16	00 00 03 E8	Pulse length	1 ms
20	00 00 03 E8	Pulse length when locked	1 ms
24	00 00 00 00	User delay	
28	00 00 00 7E	configuration	On, lockGps, lockOther,isFreq
			isLength, alignToW, polarity, gridUTC

EXTINT configured for Power control, high = GNSS on, low = GNSS off

UBX-CFG-PM2

Byte offset	Value (hex)	Name	
0	02	version	
1	00	reserved	
2	00	reserved	
3	00	reserved	
4	00 00 00 60	flags	Enable EXTINT high = on
8	00 00 00 00		
12	00 00 00 00		
16	00 00 00 00		
20	00 00 00 00		
22	00 00		
24	00 00 00 00		
	00 00 00 00		
	00 00 00 00		
	00 00 00 00		
	00 00 00 00		
	00 00		
44	00 00 00 00		

See "u-blox8-M8_ReceiverDescrProtSpec_(UBX-13003221)_Public.pdf"for further configuration options.

Host Controller

This is a STM32F411 ARM micro-controller (U11) which can load and control the CMX7032 Function-Image, interface to the GNSS receiver and provide other interface and control functions. The manufacturer's datasheets and application notes should be studied for full details. The following I/O facilities are provided:

- C-BUS to control the CMX7032
- SPI-Bus with two chip selects to control the LMX2571 PLL/VCOs
- UART to control the uBlox EVA-M8M GNSS device
- Two UARTs for Presentation Interface or MKD or Pilot Plug or Sensors
- USB Interface
- GPIO for switches and indicators

The STM32F411 does not support CANBUS / NMEA2000 operation, but can be replaced by the STM32F413 device which is pin-compatible if this feature is required.

The host controller implements an Rx-only AIS receiver if the DTR signal is detected on power-on. This configures the device for Rx operation on AIS1 and AIS2 and feeds any decoded AIS message over the USB and UART1 interfaces as they are received. Additionally, it will also output the $GNRMC and $GNGSA sentences at one second intervals.

8.2   Application Information

The DE70322T is a technology demonstrator and has been designed to meet the requirements for AIS class B (IEC 62287-1). However the DE70322T itself is a demonstration PCB and has not been approved to any product standards. The user is advised to use caution whilst transmitting, so as to ensure that the integrity of the live AIS system is not compromised and to comply with the local regulatory requirements.

Refer to the SCT7033 Datasheet for additional information relating to the DE70322TC only.

Interfacing to an external Antenna Splitter (to combine a VHF FM Marine radio onto the same antenna as the AIS unit) is facilitated by the provision of the TX_ACTIVE signal on the 40-way multi-connector.

Operation as a Class B SOTDMA (IEC 62287-2) device is supported except for the RF PA output power requirement of 5W. Operation as a Class A (IEC 61993-2) device is partially supported but the following differences should be observed:
- A third Rx channel dedicated to DSC receive is required
- LNA / mixers will require modification to support the increased Intermodulation requirement
- The PA will need to be replaced with a 12.5W capable device
- Additional sensor and PI interfaces required

Operation as a Class 1, 2 or 3 AtoN (IEC 62320-2) should be feasible using this module, subject to the PA requirement. Operation as an AIS-SART (IEC 61097-14) should be feasible, though the Rx capability becomes redundant in this mode. Operation as a Base / Shore Station (IEC 62320-1) is subject to same restrictions as noted for Class A.

Where allowed by local regulations, transmission on ASM1 and ASM2 using 9600 bps GMSK is possible by re-programming the Tx PLL's to the appropriate frequencies.

Operation in Rx-Only mode does not have an applicable IEC standard, though the RED requirements will need to be considered for use in EU / CEPT countries.

8.3 Evaluation Tests

The DE70322T is intended to allow demonstration of CMX7032 RF synthesiser and baseband modem performance. The following is a list of tests from the IEC AIS standards (see below) along with the typical DE70322T performance. Performance standards:

- IEC62287-1   AIS Class B
- IEC61193-2   AIS Class A

Frequency Error
Compliant, based on the selected 38.4 MHz VCTCXO.

Tx Adjacent Channel Power (ACP)
The transmitter comfortably meets the stringent −70 dBc mask for continuous transmission defined for AIS Class A (see Figure 14). Note that the Class B standard is relaxed to −60 dBc but is for slotted transmission, so includes switching transients. To evaluate the Class B mask, real-time control by a host microcontroller is recommended.
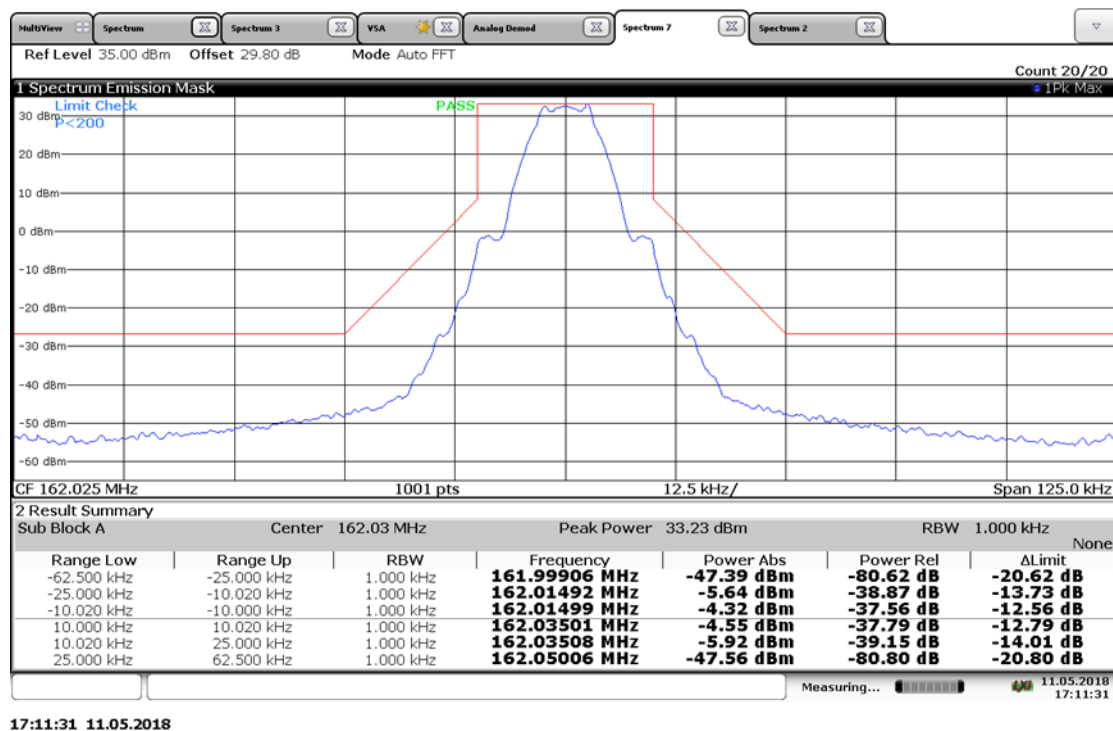

Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
−62.500 kHz	−25.000 kHz	1.000 kHz	161.99906 MHz	−47.39 dBm	−80.62 dB	−20.62 dB
−25.000 kHz	−10.020 kHz	1.000 kHz	162.01492 MHz	−5.64 dBm	−38.87 dB	−13.73 dB
−10.020 kHz	−10.000 kHz	1.000 kHz	162.01499 MHz	−4.32 dBm	−37.56 dB	−12.56 dB
10.000 kHz	10.020 kHz	1.000 kHz	162.03501 MHz	−4.55 dBm	−37.79 dB	−12.79 dB
10.020 kHz	25.000 kHz	1.000 kHz	162.03508 MHz	−5.92 dBm	−39.15 dB	−14.01 dB
25.000 kHz	62.500 kHz	1.000 kHz	162.05006 MHz	−47.56 dBm	−80.80 dB	−20.80 dB

17:11:31 11.05.2018

Figure 14 Continuous PRBS Modulated Tx Spectral Mask at the PA Output
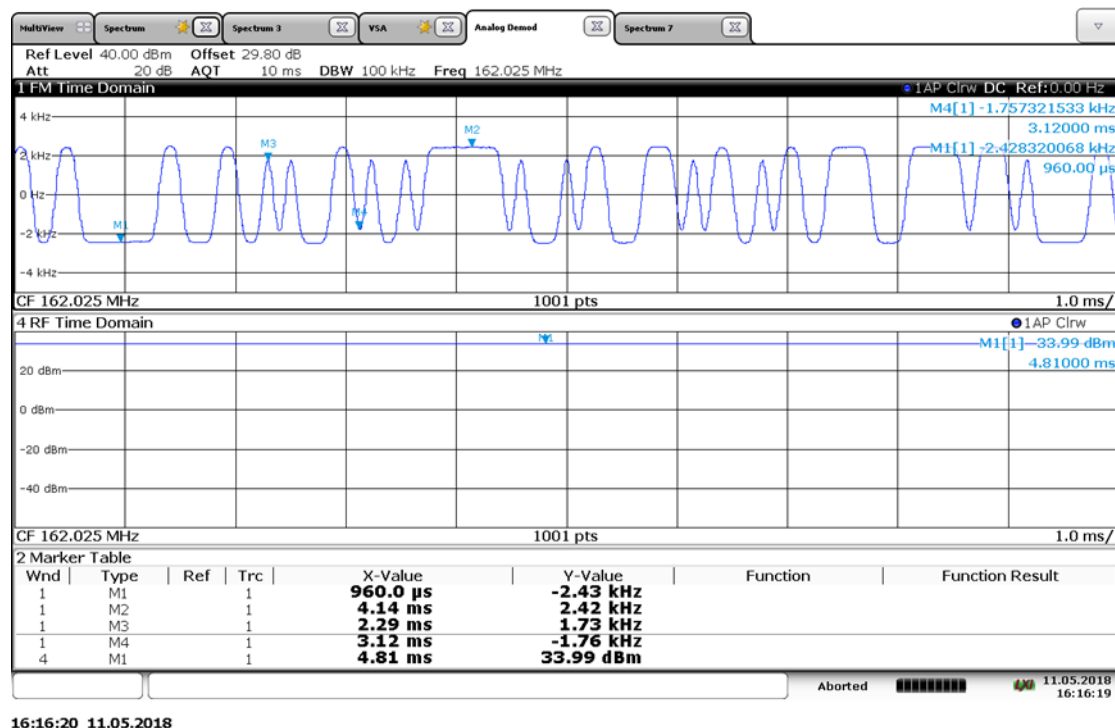
(+33 dBm, 162.025MHz)

Figure 15 Tx Modulation

Spurious Emissions
DE70322T meets the Tx spurious emissions requirements by at least 5dB.

Maximum Usable Sensitivity
Typically –112dBm for less than 20% Packet Error Rate (PER).

Errors at High Input Levels
Both receivers are error free at the test limits of –7 and –77dBm.

Co-channel Rejection
With an interferer on the same frequency this is typically –9 dB for less than 20% PER.

Adjacent Channel Rejection (ACR)
ACR performance is limited by local oscillator phase noise rather than filter rejection but is typically 76 dB for less than 20% PER

Spurious Response Rejection
Front-end SAW filters are provided on the DE70322T to limit out-of-band responses. In particular, screening is required between the input and output of the crystal filter to reduce the 2nd image response. This is achieved by the matching networks being on opposite sides of the PCB. All spurious rejections are typically 80 dB or better.

Intermodulation Response Rejection
The DE70322T meets the Class B requirement of 65dB for less than 20% PER.

Blocking or Desensitisation
Blocking performance is excellent and is virtually error free at the test limits.

8.4   Troubleshooting

The DE70322T is a complex RF and Baseband system. If incorrectly programmed or modified, results will be at variance from datasheet performance. Please study the CMX7032 datasheet, this manual and the associated schematics and layout drawings carefully when troubleshooting.

This section provides suggestions to help users resolve application issues they might encounter.

Receiver Operation

Error Observed	Possible Cause	Remedy
DE70322T fails to operate	FI not loaded	Reset by cycling power. Check Activation codes and Checksums.
Rx synthesiser not locked	Incorrect configuration components	Check that the separate Rx PLL synthesiser programming data is correct.

Transmitter Operation

Error Observed	Possible Cause	Remedy
Tx synthesiser not locked	Incorrect configuration components	Check that power to the TXVCO is enabled (+3V3_VCO).
Poor Tx modulation spectrum	Modulation levels incorrect	Use the Transmit Repeated Word modem command with data $00FF whilst observing the demodulated GMSK waveform. Adjust the mod levels to both the VCTCXO and VCO to give the most evenly balanced square wave using the Tx Mod Levels CONFIG task. Note that these levels may need to be different across the frequency band and from unit to unit.

# 9		Performance Specification

## 9.1		Electrical Performance

Absolute Maximum Ratings

Exceeding these maximum ratings can result in damage to the Demonstration Kit.

	Min.	Max.	Units
Supply Voltage (V_{IN} - V_{SS})	0.0	6.0	V
Current into or out of V_{IN} and V_{SS} pins	0	+2.0	A
Current into or out of any other connector pin	-20	+20	mA

Operating Limits

Correct operation of the DE70322T Demonstration Kit outside these limits is not implied.

	Notes	Min.	Typ	Max.	Units
Supply Voltage (V_{IN} - V_{SS})		4.5	5.0	6.0	V

Operating Characteristics

For the following conditions unless otherwise specified:

VCTCXO Frequency = 38.4MHz, Bit Rate = 9.6kbps,
V_{IN} - V_{SS} = 5 V, Tamb = +25°C.

	Notes	Min.	Typ.	Max.	Units
DC Parameters (Excluding PA Supply)					
I_{DD} (CMX7032 powersaved)	1	–	25	–	mA
I_{DD} (Tx)	1	–	TBD	–	mA
I_{DD} (Rx, LNA enabled)	1	–	TBD	–	mA
AC Parameters					
Tx Output					
Tx Output Impedance		–	50	–	Ω
Tx Output Power		–	33	–	dBm
Rx Input					
Rx Input Impedance		–	50	–	Ω
Rx Sensitivity	2	–	-112	–	dBm
Maximum Input Level - without damage		–	–	0	dBm
VCTCXO					
Reference Clock Frequency		–	38.4	–	MHz
Reference Clock Level	3	1	–	–	Vp-p

µC Interface
See CMX7032 Datasheet

Notes: 1.   PCB current consumption, not current consumption of the CMX7032
2.   20% Packet Error Rate (PER)
3.   Typically clipped sine wave

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