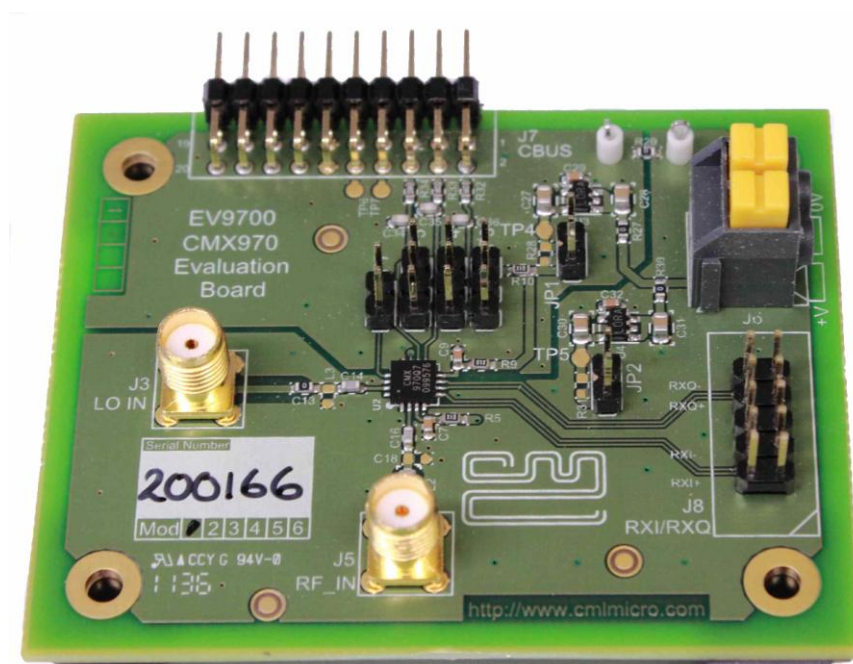


## Features

- CMX970 Quadrature IF Demodulator
- Frequency Range 20 – 300 MHz
- C-BUS Interface to Host Microcontroller
- Direct Control Mode (host-less operation)
- Easy Interfacing to PE0601-xxxx



## 1 Brief Description

The EV9700 is an Evaluation Kit designed for evaluating and demonstrating the capabilities of the CMX970 integrated circuit. All the circuits necessary to demonstrate the facilities provided by the IC, such as matching circuits, power supply regulators, etc are provided on the EV9700 board.

A C-BUS interface connector is provided for control of the EV9700 by a host microcontroller or CML PE0002 interface card. The CMX970 can also be used in a 'Direct Control' mode, where a host or PE0002 is not required.

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## 1.1 History

Version	Changes	Date
4	<ul style="list-style-type: none"> <li>Input frequency range now 300MHz</li> </ul>	13/8/12
3	<ul style="list-style-type: none"> <li>Correction from “ES9730” to “ES9700” and typographical errors</li> </ul>	12/04/2012
2	<ul style="list-style-type: none"> <li>Editorial Changes: e.g. ‘stand-alone’ mode to ‘Direct Control’ mode</li> </ul>	23/03/2012
1	<ul style="list-style-type: none"> <li>First Issue</li> </ul>	23/02/2012

CML recommends that you check for the latest product datasheet version from the Datasheets page of the CML website: [www.cmlmicro.com].

## 2 Block Diagram

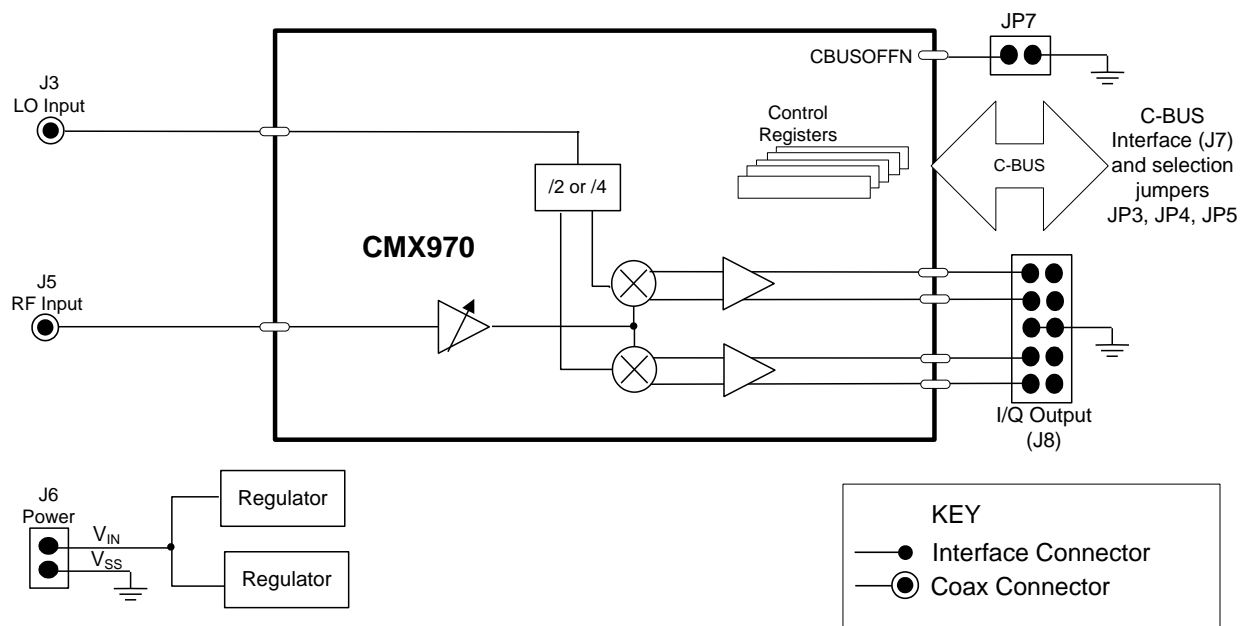


Figure 1 EV9700 Block Diagram

## 3 Preliminary Information

### 3.1 Laboratory Equipment

The following laboratory equipment is recommended for use when testing this evaluation kit:

- Power supply
- Two RF signal generators
- Oscilloscope

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

#### 3.1.1 Power Supply

The supply input voltage to the PCB is nominally 7.2V (3.6V to 7.6V acceptable). On-board regulators are provided to generate all voltage rails used on the PCB. The 7.2V supply should be rated at 100mA.

**NOTE:** Care should be exercised with the supplies as the circuitry is not protected for reverse polarity.

#### 3.1.2 Control Interface

To use the EV9700, the user will usually need a mechanism to send and receive data and commands via the C-BUS host microcontroller interface on the CMX970, which is brought out on connector J7. The CMX970 Datasheet and User Manual give details of the registers and commands. Alternatively, the CMX970 Direct Control mode can be used by fitting JP7, see section 7.1.3 for further details.

A PE0002 Interface Card can be used to control the EV9700. A user interface program specifically for the EV9700 is available from the CML website (see [www.cmlmicro.com](http://www.cmlmicro.com) for details).

## 3.2 Handling Precautions

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

#### 3.2.1 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.

#### 3.2.2 Contents - Unpacking

Please ensure that you have received all the items detailed on the separate information sheet (EK9700) and notify CML within seven 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 EV9700 Evaluation Kit. A more complete description of the kit and its use appears later in this document. The user should read the CMX970 datasheet before using this kit.

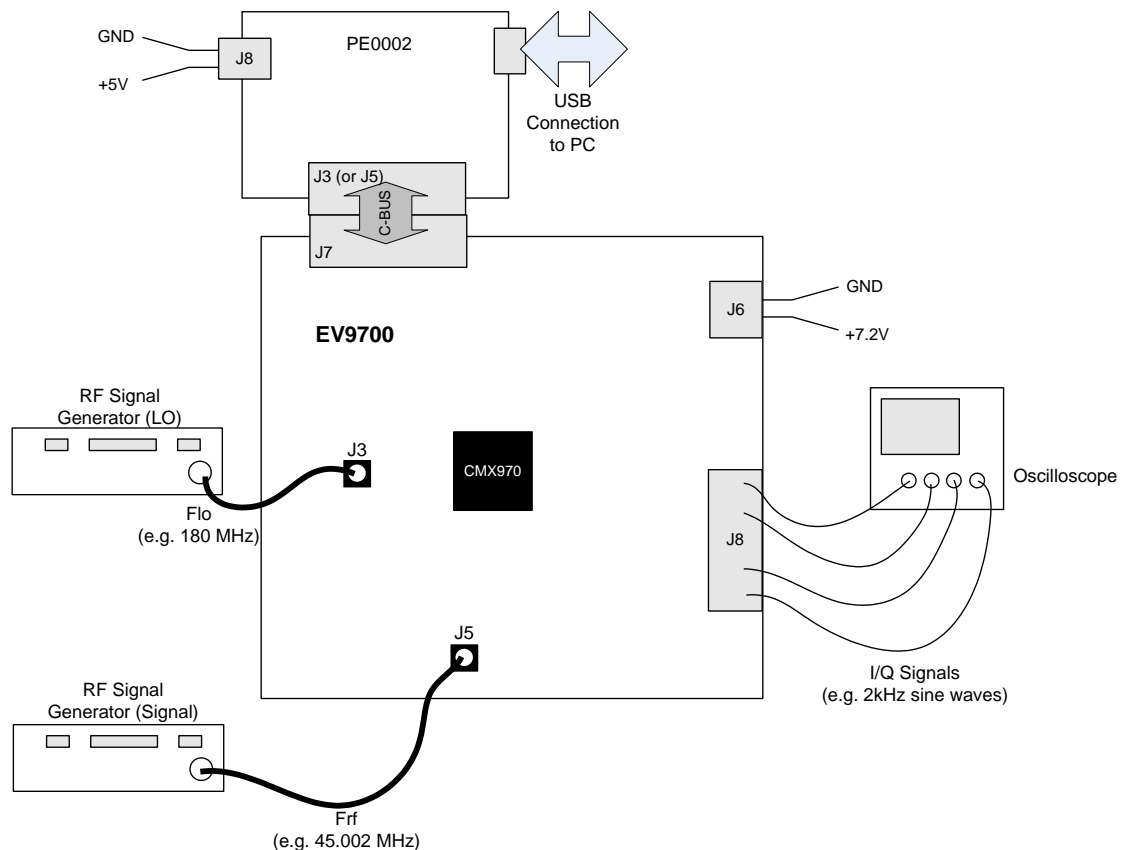
### 4.1 First – Initial Setup

#### 4.1.1 Make External Connections and Apply Power

An example of typical connections to the EV9700 is shown in Figure 2. Perform the following steps in sequence:

1. Connect test leads as shown in Figure 2, except the power to J6.
2. Connect a controller to C-BUS interface J7 (PE0002 can be used – see Figure 2. Note: J3 or J5 can be used on PE0002, but ensure that the correct C-BUS port is selected when programming data).
3. Install PE0002 hardware/software and apply power to PE0002 – see section 4.1.2.
4. Power should be applied to the main supply input J6 (7.2V nominal). The CMX970 device will be reset on power-up.

The board is now ready for operation.



**Figure 2 Typical Connections for EV9700**

#### 4.1.2 Hardware/Software Installation (for PE0002)

- Copy the file **ES9700xx.zip**, which is downloaded from the CML website following registration, to the hard drive of your host PC.
- Extract the files to the hard drive of your host PC.
  - Connect a 5V dc supply to the PE0002 Interface.
  - Connect a 7.2V dc supply to the EV9700.
  - Attach a USB cable from connector J2 of the PE0002 Interface Card to the PC USB port.
- Turn on the power supply to the PE0002. The PE0002 power-on indicator D6 will light
- Install the USB driver when requested. The driver is in the same folder where the **ES9700xx.zip** files were extracted to, in directory **.\Driver**. Follow instructions on the screen to install the USB driver. Click the 'Continue Anyway' button when the Message Box in Figure 3 is shown.



Figure 3 USB Driver Installation Message Box

## 4.2 Second – Configure

In this second step the EV9700 is configured for receive operation at 45MHz input frequency.

### 4.2.1 EV9700 Configuration

The following steps should be undertaken to configure the EV9700 to receive at 45MHz with an I/Q output. Set the applied signals and register values as shown in the following table.

**Note:** Setting the CMX970 registers requires the use of the PE00002 host connected as above. The CMX970 datasheet give details of the registers and commands.

Signal or Register	Setting	Note
LO_IN (J3)	180MHz @ -10dBm	This frequency is four times the RF input frequency.
RF_IN (J5)	45.002MHz	The input level here may be user defined: for example, an input signal of -60dBm at J5 the typical single-ended output level would be 250mV p-p at J8 pin 2. The output should be 2kHz sine and cosine waves on I and Q when the configuration in this table is completed.

Signal or Register	Setting	Note
General Reset register (\$1A)	To ensure the device and hardware are in known states issue the General Reset command	See lower right of GUI tab "C-BUS Control".
General Control register (\$1B)	The General Control register should be set to enable the following: <ul style="list-style-type: none"> <li>• Bias generator</li> <li>• Rx</li> </ul> Select LO/4 mode.	Write \$12 to register \$1B.
Control register (\$1C)	Set Rx Gain to maximum, output drive to low and phase correction circuit to off.	Write \$00 to register \$1C, this enables maximum gain, with low output drive capability and no phase correction. This gives the lowest power consumption mode.
Mode register (\$1D)	Enable I and Q outputs.	Write \$00 to register \$1D.
Offset register (\$1F)	The value written to this register will vary between devices, the default value (\$00) is a good starting point.	Check the dc levels on J8 (I and Q) to ensure that the dc offsets are less than 25mV; adjust the value written to \$1F as required.
Intermod Control register (\$2F)	For initial testing the default value (\$00) can be used so there is no need to write to this register.	The value written to this register can be adjusted to give the optimal intermod (IMD) performance, see CMX970 datasheet for further details.
RXI/Q (J8)	Differential Rx I/Q output.	The differential I and Q signals can be taken from J8.

### 4.3 Third – Operate

Following the configuration procedures given in sections 4.1 and 4.2, the EV9700 should be operating as a receiver at 45MHz. Various evaluation tests can now be performed.

## 5 Signal Lists

Input power supply connections are via the two-way snap socket J6. J3 and J5 are RF signals and use SMA 50 ohm sockets. J8 is a 10-pin header for differential I/Q outputs from the demodulator which can interface signals easily to a PE0601-xxxx evaluation kit.

Signal	Signal Type	PCB Connector
Ground	DC	J6 Pin 1
+Vin (7.2V nominal)	DC	J6 Pin 2
Quadrature Demodulator RF input	RF	J5
Local Oscillator RF input	RF	J3
Differential I/Q demodulator outputs	Baseband	J8
C-BUS interface (e.g. to PE0002)	Logic	J7

**Table 1 Signal List**

Connections to the host C-BUS interface J7 are shown in Table 2; all are 3.3V logic levels unless otherwise stated.

CONNECTOR PINOUT for J7			
Connector Pin No.	Signal Name	Signal Type	Description
1	-	-	Spare pin. Leave unconnected.
2	CSN	I/P	C-BUS Chip Select.
3	-	-	Spare pin. Leave unconnected.
4	CDATA	I/P	C-BUS Data Input.
5	-	-	Spare pin. Leave unconnected.
6	SCLK	I/P	C-BUS Clock.
7	-	-	Spare pin. Leave unconnected.
8	RDATA	O/P	C-BUS Data Output (Test point only, not used by CMX970)
9	-	-	Spare pin. Leave unconnected.
10	IRQN	I/P	Interrupt request - if required. Not used, so remains unconnected on EV9700.
11	GNDD	Power	Connection to Digital Ground.
12	GNDD	Power	Connection to Digital Ground.
13	-	-	Spare pin. Leave unconnected.
14	-	-	Spare pin. Leave unconnected.
15	-	-	Spare pin. Leave unconnected.
16	-	-	Spare pin. Leave unconnected.
17	-	-	Spare pin. Leave unconnected.
18	-	-	Spare pin. Leave unconnected.
19	-	-	Spare pin. Leave unconnected.
20	-	-	Spare pin. Leave unconnected.

Table 2 C-BUS Interface

CONNECTOR PINOUT for J8			
J8 Pin No.	Signal Name	Signal Type	Description
2	RXI+	Baseband	Positive Rx I Output
4	RXI-	Baseband	Negative Rx I Output
8	RXQ+	Baseband	Positive Rx Q Output
10	RXQ-	Baseband	Negative Rx Q Output
1, 3, 7, 9	N/C	-	-
5, 6	GNDA	-	GNDA

Table 3 Quadrature Demodulator I/Q Output Connector

JUMPERS/LINKS			
Test Point Ref.	Positions	Default	Description
JP1	1-2	1-2	+3V3D
JP2	1-2	1-2	+3V3A
JP3	1-2/2-3	NF	pin 1 = +3V3D, pin 2 = GAIN (CSN), pin 3 = GNDD
JP4	1-2/2-3	NF	pin 1 = +3V3D, pin 2 = RESETN (S_DATA_IN), pin 3 = GNDD
JP5	1-2/2-3	NF	pin 1 = +3V3D, pin 2 = DIVSET (S_CLOCK), pin 3 = GNDD
JP7	1-2	NF	When fitted, CBUSOFFN pin is connected to GNDD and CMX970 is in Direct Control mode.
Note: JP3, JP4 and JP5 are to be used in Direct Control mode with JP7 fitted, see section 7.1.3.			

Table 4 Jumpers/Links

TEST LOOPS/POINTS		
Test Point Ref.	Typical Value	Description
TL3	0V	GNDA
TL4	0V	GNDD
TP4	3.3V	+3V3 regulator output (+3V3D - digital supplies)
TP5	3.3V	+3V3 regulator output (+3V3A - analogue supplies)
TP6	-	C-BUS connector: IRQN
TP7	-	C-BUS connector: REPLY DATA

Table 5 Test Loops and Points

**Notes:**

I/P	= Input	BI	= Bidirectional	N/C	= No connection
O/P	= Output	TL	= Test Loop	TP	= Test Point
GND	= Ground				

Note that the voltages are typical for their active state.

## 6 Circuit Schematics and Board Details

For clarity, circuit schematics are available as a separate high-resolution file available from the CML web site as part of the support files package. The layout on each side is shown in Figure 4, below. The PCB is a 4-layer design fabricated with FR4 material and is 1.6mm thick. Full Gerber and drill files are available on request.

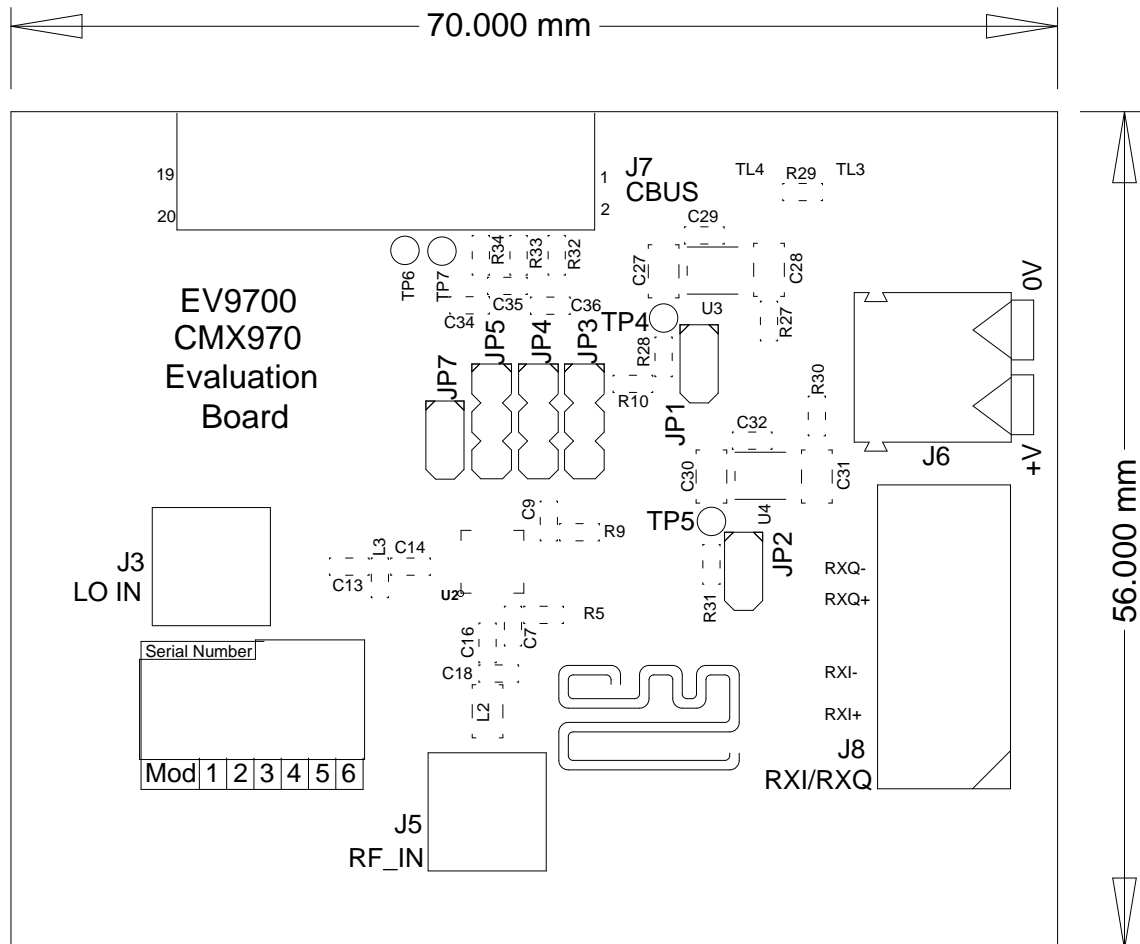
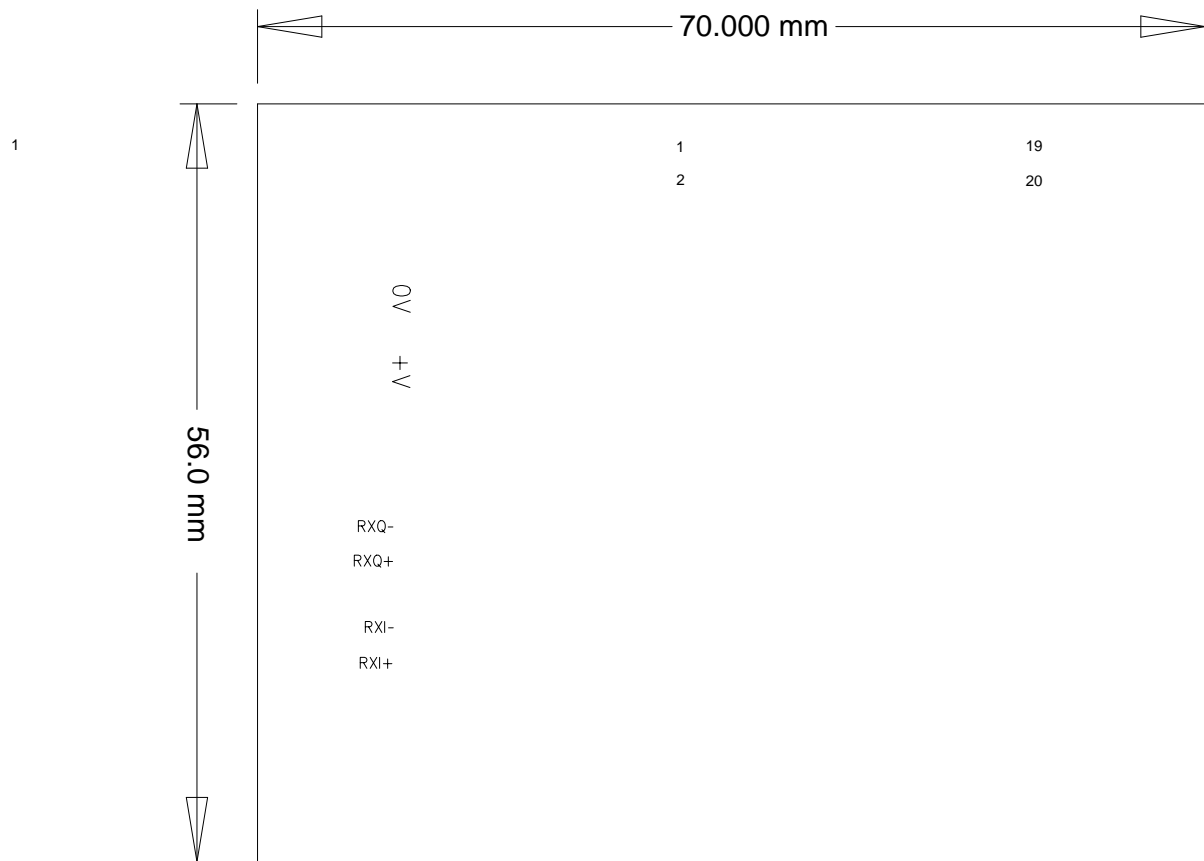


Figure 4a PCB Layout: top

**Figure 4b PCB Layout: bottom**

## 7 Detailed Description

The CMX970 datasheet (available from [www.cmlmicro.com](http://www.cmlmicro.com)) should be referred to for a detailed description of the CMX970 device.

The EV9700 functionality includes:

- Evaluation and demonstration of the CMX970 Quadrature IF/Rf Demodulator.
- Interface to CMX7163 or CMX7164 evaluation boards (PE0601-7163 / PE0601-7164, not included) to allow demonstration/test of QAM and 2-FSK / 4-FSK demodulation.
- An interface that allows the card to be connected to a host microcontroller, to allow real-time control. A PC user interface can be provided using a PE0002 and ES9700 software.

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

### 7.1 Hardware Description

#### 7.1.1 Power Supply

Two 3.3V regulated power supplies are generated on the PCB. U3 supplies the digital circuits and U4 the analogue circuits. Current drawn from each supply rail may be measured by connecting an ammeter across JP1 (digital) or JP2 (analogue), after removing the corresponding jumper.

#### 7.1.2 CMX970

The Evaluation Kit is configured to allow the CMX970 Quadrature IF/Rf Demodulator to operate over a broad range of input frequencies (20 to 300 MHz) i.e. no matching has been applied at the IFIN input (L2, C16 and C18). Matching can be applied to the IFIN input; this will increase the gain, improve the noise figure and degrade the IIP3.

The RxLO input (L3, C13, C14) can be used with an external source and there is no matching on this input so a broad range of LO frequencies can be applied.

The RXI/RXQ outputs can be accessed differentially for direct connection to a PE0601-xxxx kit, for example.

Power supply decoupling is provided by R5+C7 and R9+C9.

#### 7.1.3 CMX970 Direct Control Mode

Connecting JP7 puts the device into Direct Control mode (PE0002 is not used, CBUSOFFN = 0V) and the selectors JP3, JP4 and JP5 can then be used to select the various modes. The functions enabled by the jumpers are shown in Table 6; they can be selected by fitting a link between pins 2 and 1 (high logic condition) or pins 2 and 3 (low logic condition) of the appropriate jumper.

Jumper	Function
JP4	<b>RESETN</b> - when low, puts the device in low-power mode. Note that the pin does not have an internal pull-up resistor.
JP5	<b>DIVSET</b> - if low, sets LO divider to /2, if high sets LO divider to /4 (equivalent to bit 7 of the General Control Register, see CMX970 datasheet).
JP3	<b>GAIN</b> – if low, reduces the gain by 18dB; if high, sets gain to maximum.

**Table 6 CMX970 Direct Control Mode Jumper / Pin Functions**

## 7.2 PC Control Software Description

The EV9700 itself does not require any embedded firmware. However C-BUS control from an external microcontroller may be used. The CML product, PE0002, can be used with the EV9700 and PC software files (**ES9700xx.zip**). To use the software, connect the EV9700 as shown in Figure 2. First ensure the drivers supplied for the PE0002 are installed correctly. The executable must be in the same folder on the PC as the **EF0002xx.hex** file. Run the **ES9700xx.exe** and the main application window will open with a request for the Reset button to be pressed on the PE0002 board, see Figure 5. The window then displays a progress bar for the initialisation process. This software is common to a number of Evaluation Kits, so the appropriate kit must then be selected in a new dialog box, see Figure 6. Once the initialisation and kit selection process is complete, one of three tabs can be selected, as shown in Figure 7 to Figure 9.

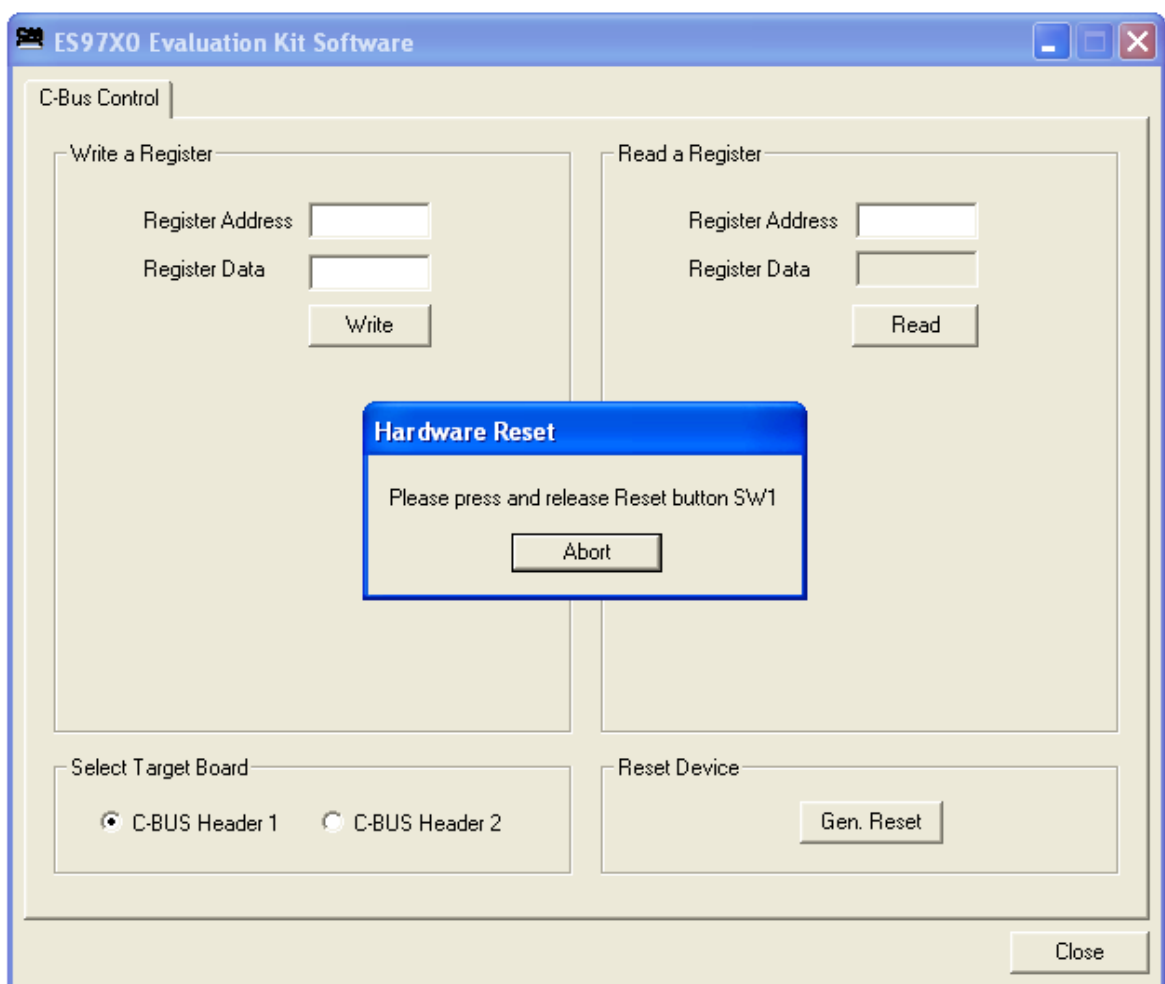
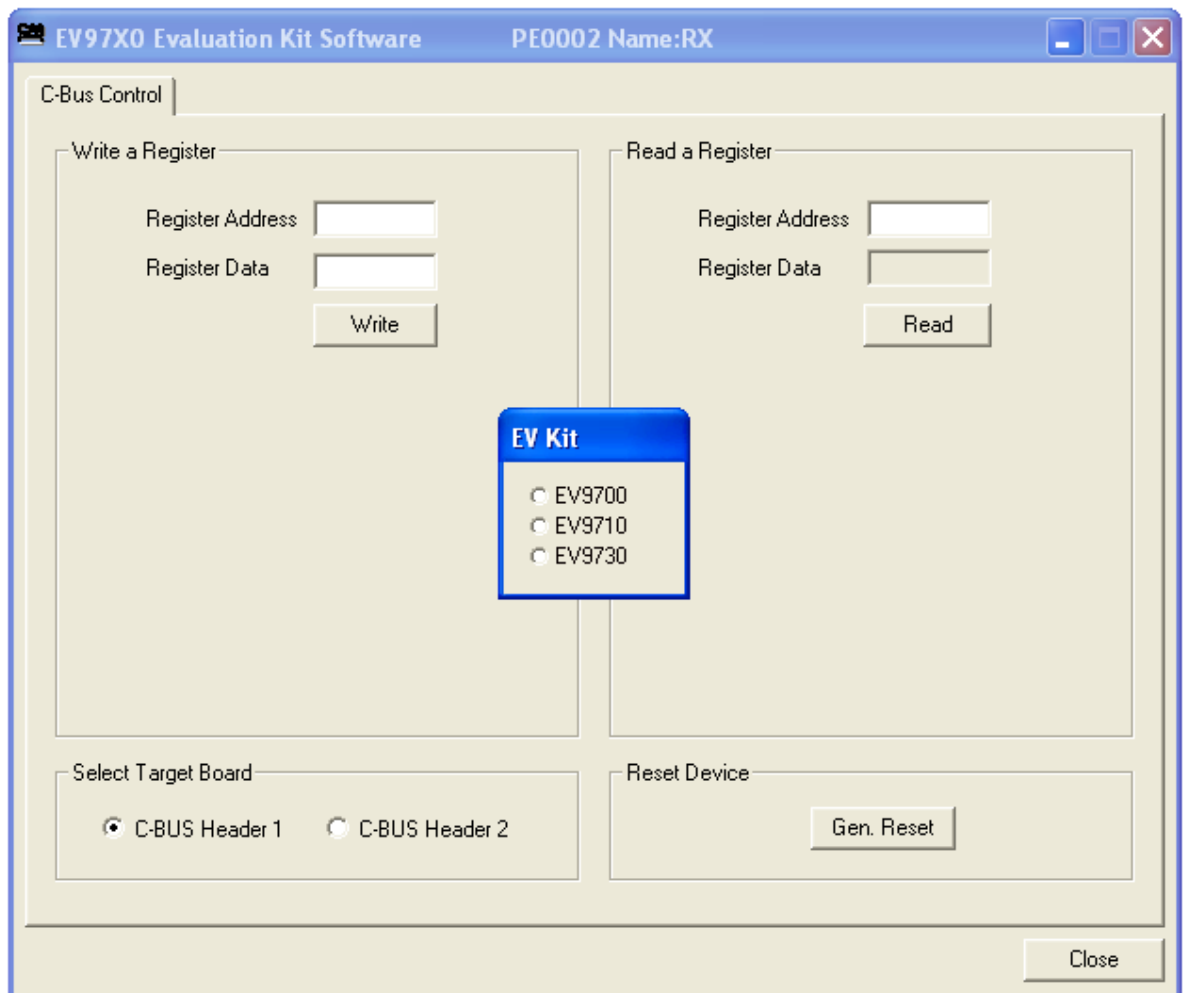


Figure 5 Reset Dialog Box

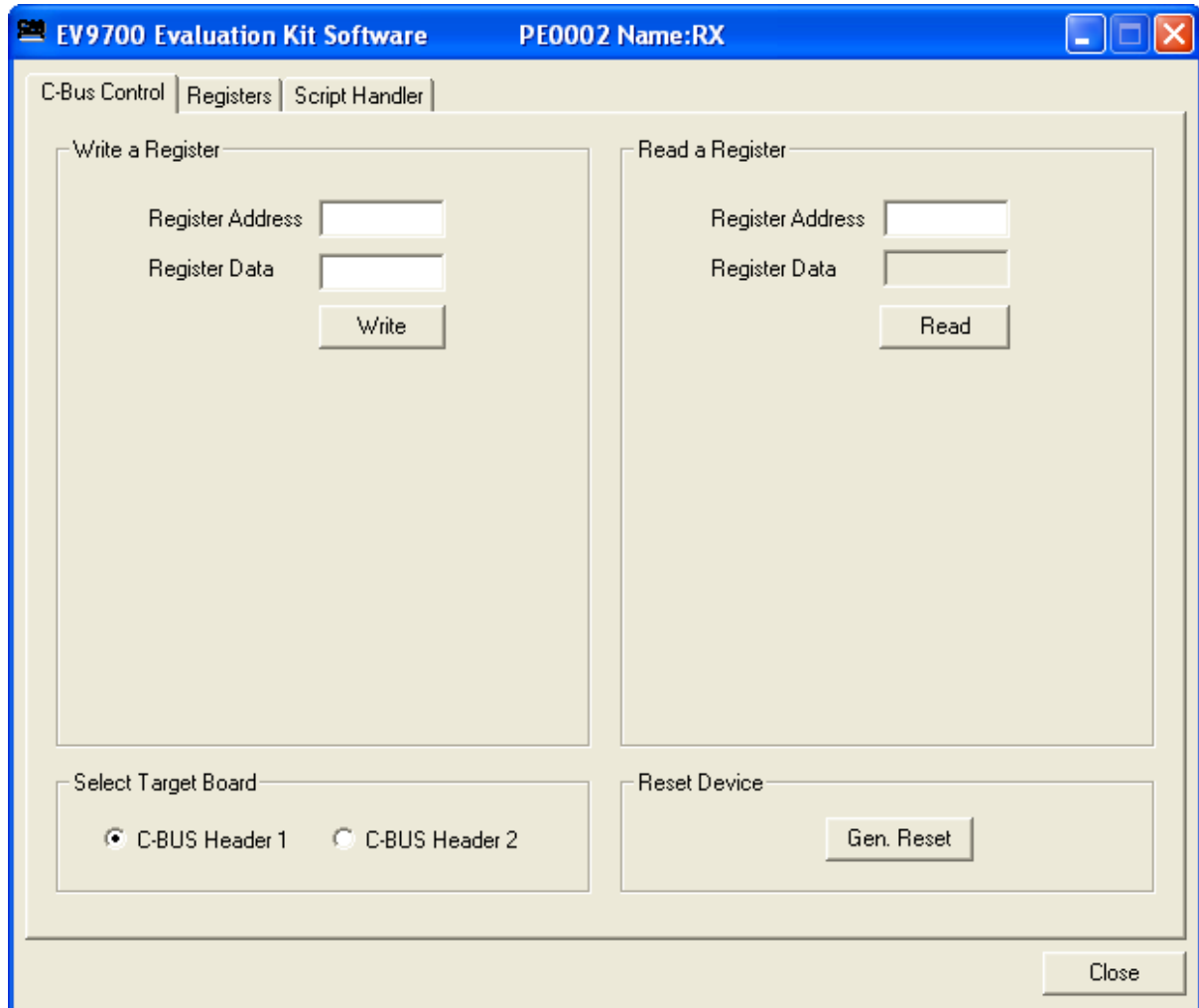


**Figure 6 Product Selection Dialog Box**

There are three tabs that represent a particular set of registers or a particular function of the CMX970. To select a tab simply click on the corresponding name in the row at the top of the program window. Setting or clearing the check box associated with a bit of a register will cause that bit to be set or cleared when the register is next written to. If the 'Auto Write' check box is set a register will be written whenever a check box, or list box associated with it, is modified. This removes the need to click the 'Write' button associated with that register. The program can be closed at any time by clicking the 'Close' button or by pressing 'Alt' and 'F4' keys simultaneously.

### 7.2.1 The C-BUS Control Tab

The C-BUS Control Tab allows the user to read from or write to any register or to issue a General Reset command, see Figure 7. The C-BUS header which is used can also be selected on this tab.



**Figure 7 The C-BUS Control Tab**

To perform a General Reset on the CMX970, either the Gen. Reset button can be clicked or a single write can be made to register \$1A. The following script (see section 7.2.3), which may be used with the **ES9700xx** software, is recommended.

```
;General Reset.pes
;This script will send a C-BUS General reset.
;Reset C-BUS (assigns register RESET a zero length parameter to get a single 8-bit write)
;format: register <device (1 or 2)> <C-BUS address> <# parameter bytes (0 to 2)>

RESET const $1A
        register 1 RESET 0
        copy 0 *RESET

;If using C-BUS port 2 then use the following lines
;    register 2 RESET 0
;    device 2
;    copy 0 *RESET
```

### 7.2.2 The Registers Tab

The Registers Tab gives the user access to all of the register controls on the CMX970, see Figure 8. Note that registers can be written to individually or as a whole mass register write ('Write All' in the bottom left hand corner of the window). If Auto Write is checked, the register is changed as soon as the user makes changes to this window.

In the case of the Offset and Intermod registers, slide bars have been used to allow easy control during evaluation.

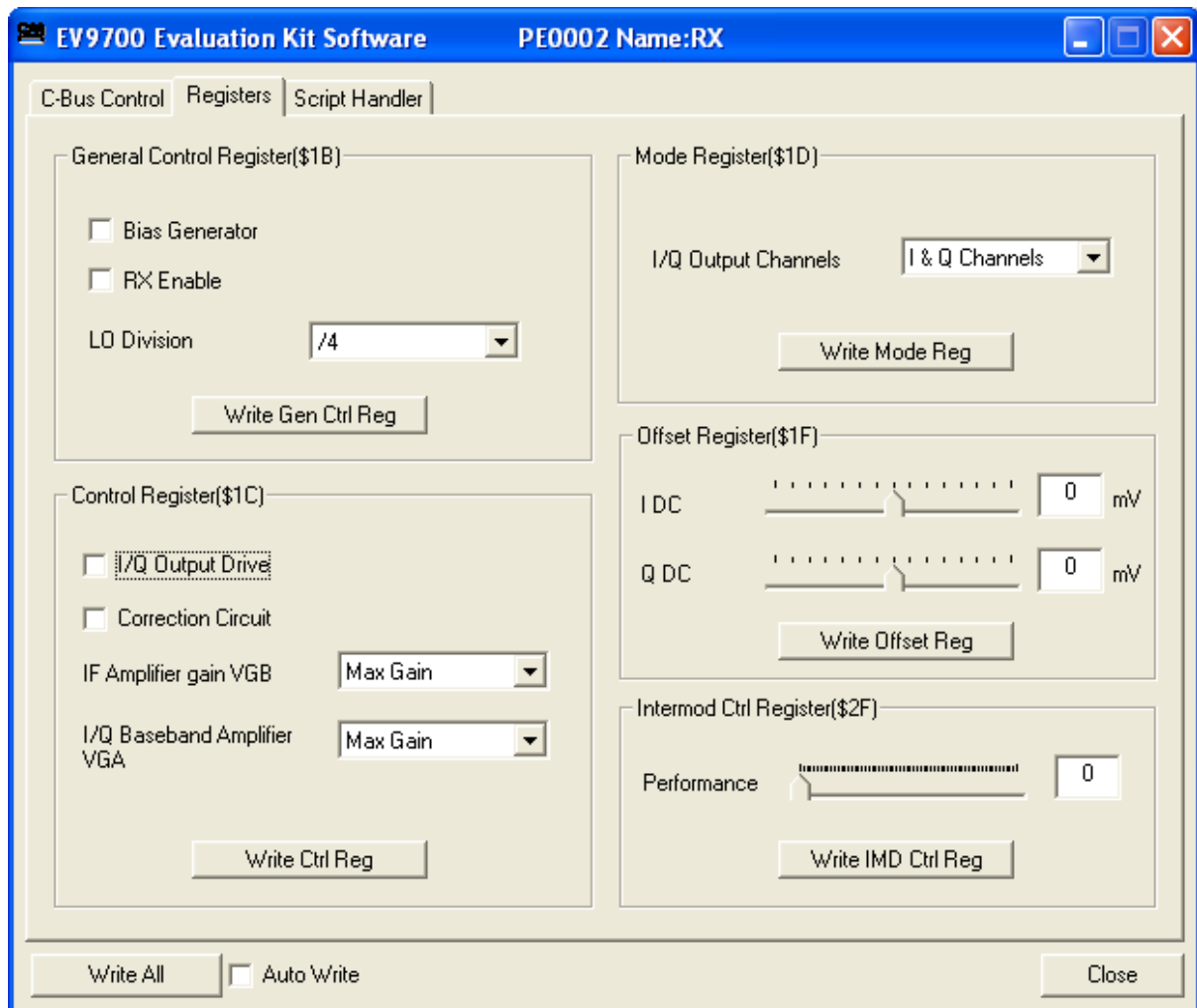
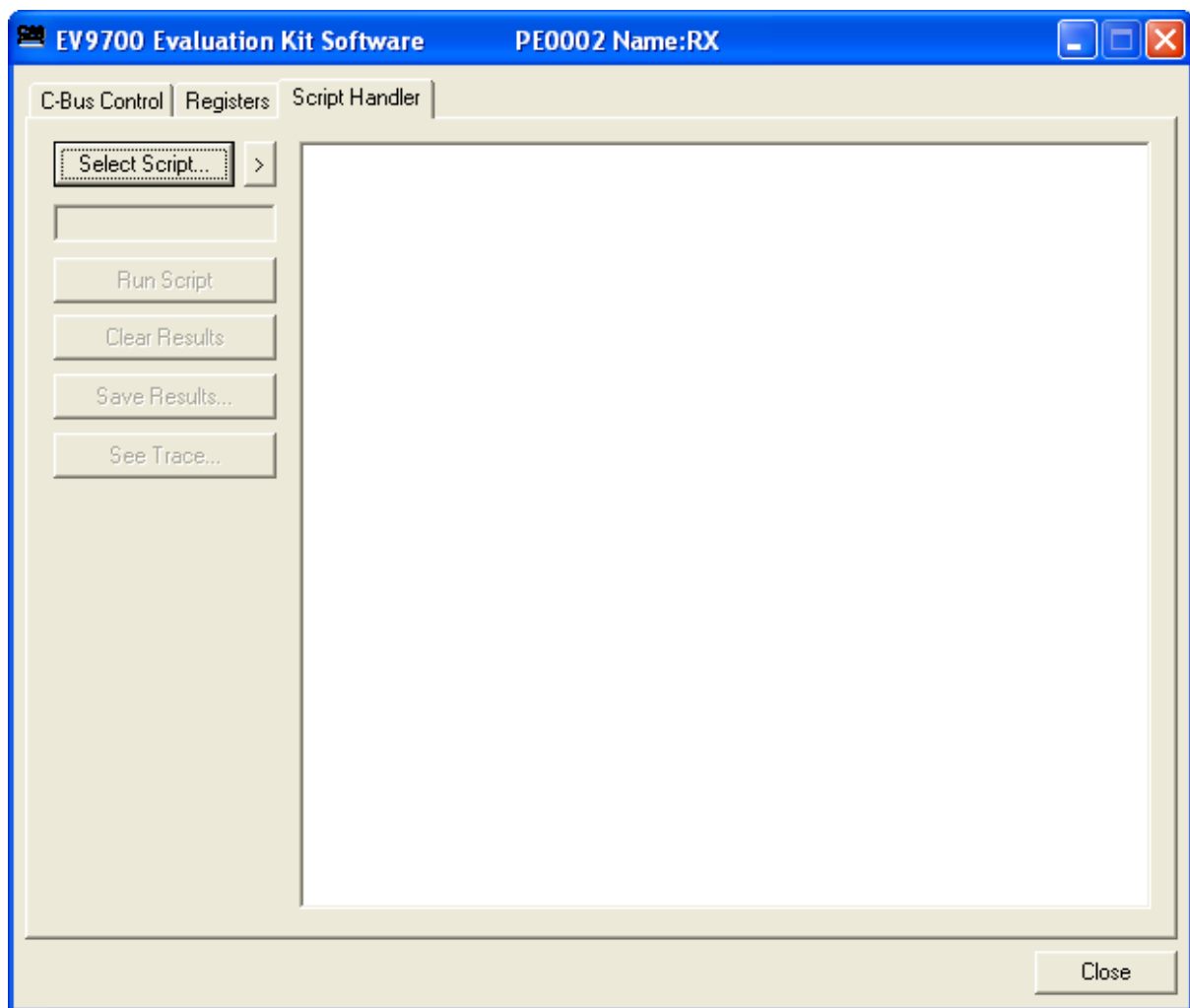


Figure 8 The Registers Tab

### 7.2.3 The Script Handler Tab

The Script Handler Tab (shown in Figure 9) allows the execution of script files consisting of register write, read and delay commands. These are plain text files on the PC, which are compiled via the GUI but executed by the E2 Microprocessor on the PE0002 board. The script language is documented separately in the “Script Language Reference” document, which can be downloaded with the PE0002 support package from the CML website. Control of the EV9700 does not require the use of script files.



**Figure 9 The Script Handler Tab**

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.

After a script has finished running and when trace data is available, the 'See Trace...' button will be enabled. Up to 131072 C-BUS transactions can be logged in the PE0002 board. Click in 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.

## 7.3 Evaluation Tests

The EV9700 is intended to allow demonstration of the CMX970 integrated circuit. The following sections show some example tests (using LO/2 mode) along with typical results.

### 7.3.1 I/Q Signals

Apply a LO signal (J3) of 90MHz, -10dBm and a RF signal (J5) of 45.002MHz, -53dBm. Observing the results on an oscilloscope, the baseband I/Q outputs (J8) should look like the results in Figure 10. From this trace the peak to peak voltage of the RXQ- pin is 0.56V (RXQ = 1.12V differential) so the gain of the CMX970 can be calculated as 58dB.

From Figure 10, the 180 degree phase relationship between the RXn- and RXn+ signals can be observed and the 90 degree phase relationship between I and Q channels is also apparent.

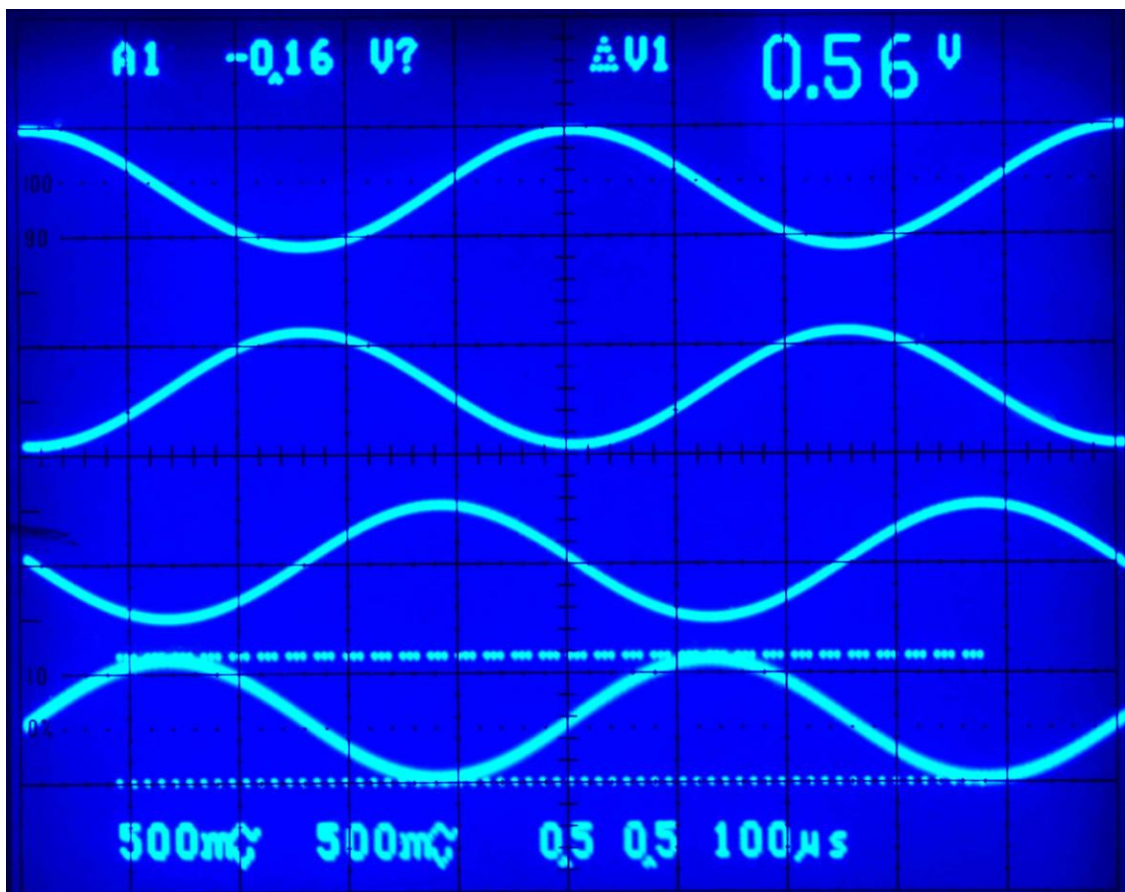


Figure 10 I/Q Output Signals

The signals, from bottom to top, are RXQ-, RXQ+, RXI-, RXI+

### 7.3.2 Noise figure

By applying a  $-100\text{dBm}$  signal to the EV9700 receiver input (J5) it is easy to evaluate the system noise figure by measuring the signal to noise on either I/Q output.

For example, apply a LO signal (J3) of  $90\text{MHz}$ ,  $-10\text{dBm}$  and a RF signal (J5) of  $45.002\text{MHz}$ ,  $-100\text{dBm}$ . With these conditions the output I/Q signal is evaluated (Figure 11) and the noise figure can be calculated as follows (including I/Q measurement correction factor of  $3\text{ dB}$ ):

$$\begin{aligned}\text{Noise figure} &= \text{SNR dB} - (-174 \text{ dBm/Hz} - (-100 \text{ dBm})) - 3\text{dB} \\ &= -60.5 + 74 - 3 \\ &= 10.5\text{dB}\end{aligned}$$

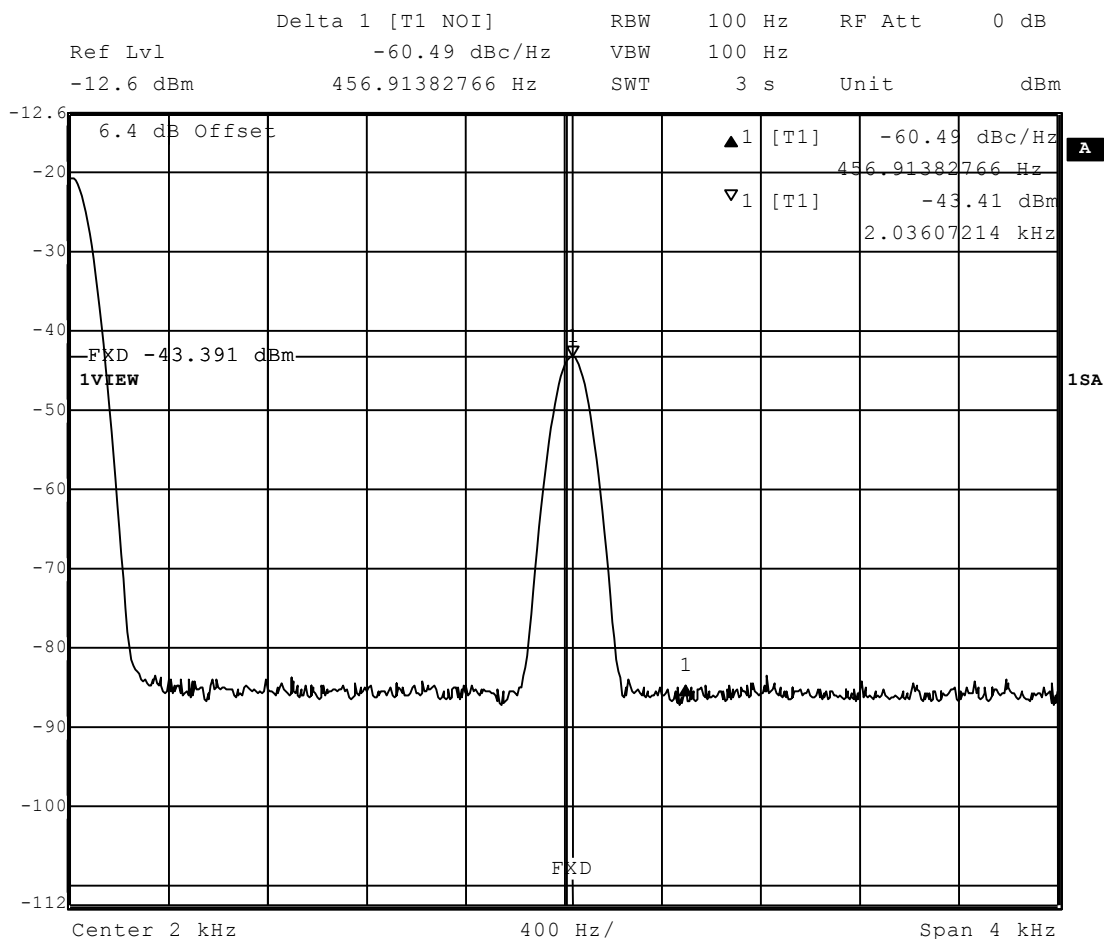


Figure 11 I/Q Signal to Noise Measurement

## 7.4 Troubleshooting

The CMX970 is a complex RF system. If incorrectly programmed or modified, results will be at variance from datasheet performance. Please study the CMX970 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.

### 7.4.1 General

Error Observed	Possible Cause	Remedy
ES9700xx.exe software fails to run correctly and reports an error during start up.	Faulty USB port or cable.	Check USB cable to your PC.
	PE0002 or EV9700 is not powered up during start up.	Power up PE0002 (5.0V) and EV9700 (7.2V).
	Incorrect software for PE0002.	Contact: <a href="mailto:techsupport@cmlmicro.com">techsupport@cmlmicro.com</a>
Programming data to EV9700 does not appear to work.	The data is being programmed to the wrong C-BUS port on PE0002.	Check whether EV9700 is connected to PE0002 Port 1 (J5) or Port 2 (J3) and ensure that the correct window is used for programming data. (See PE0002 user manual for further information).

Table 7 Possible General Errors

### 7.4.2 Quadrature IF Demodulator Operation

Error Observed	Possible Cause	Remedy
No output from the demodulator.	The demodulator and/or the bias has not been enabled. C-BUS Rx enable (\$1B, b1). C-BUS Bias enable (\$1B, b4).	Set C-BUS Rx enable (\$1B, b1='1') and set C-BUS Bias enable (\$1B, b4='1').
	No LO signal applied.	Check LO signal is present at sufficient drive level.
	The wrong Rx divider ratio has been selected (\$1B, b7)	Check CMX970 datasheet for details on register \$1B to ensure correct divider ratio selected.

Table 8 Possible Quadrature IF Demodulator Errors

## 8 Performance Specification

### 8.1 Electrical Performance

#### 8.1.1 Absolute Maximum Ratings

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

	<b>Min.</b>	<b>Max.</b>	<b>Units</b>
Supply Voltage ( $V_{IN} - V_{SS}$ )	0.0	8.4	V
Current into or out of $V_{IN}$ and $V_{SS}$ pins	0	+200	mA
Current into or out of any other connector pin	-20	+20	mA

#### 8.1.2 Operating Limits

Correct operation of the EV9700 Evaluation Kit outside these limits is not implied.

	<b>Notes</b>	<b>Min.</b>	<b>Max.</b>	<b>Units</b>
Supply Voltage ( $V_{IN} - V_{SS}$ )		3.6	7.6	V

### 8.1.3 Operating Characteristics

For the following conditions unless otherwise specified:  $V_{IN} - V_{SS} = 7.2V$ ,  $T_{AMB} = +25^{\circ}C$ .

	Notes	Min.	Typ.	Max.	Units
<b>DC Parameters</b>					
$I_{IN}$ (CMX970 powersaved)	1	–	0.1	–	mA
$I_{IN}$ (CMX970 Enabled)	1	–	16	–	mA
<b>AC Parameters</b>					
<b>RF Input</b>					
Frequency Range		20	–	300	MHz
<b>IQ Output</b>					
Differential Output Voltage	2	–	500	–	mVp-p
DC Level		–	1.6	–	V
<b>45MHz Operation</b>					
Gain	3	56	58	60	dB
Noise Figure		–	10	–	dB
Input Third Order Intercept Point	4	–	-15	–	dBm
<b>C-BUS Interface</b>					
See CMX970 datasheet					

**Notes:**

1. Total PCB current consumption.
2. 45MHz input at -60dBm at J5.
3. Gain is measured from an unmatched IFIN to differential voltage measured at output of I or Q channels, Intermod Control Register = \$00.
4. OUTDRV bit = '1'.

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