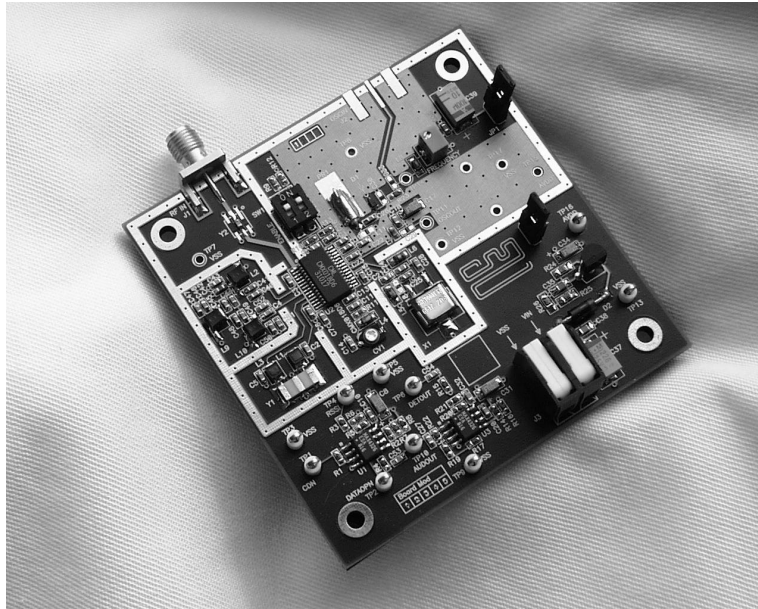


UM0181/1 July 1999

Advance Information

1.0 Features

- CMX018 Product Demonstration
- 860 - 935 MHz Operation
- Single 6 - 12 V Power Supply
- Audio Amplifier and Data Interface
- Simple and Easy to Use Controls
- Flexible VCO
- Optional Local Oscillator Input
- Footprint for Front End SAW Filter



1.1 Brief Description

The EV0181 Evaluation Kit comprises a single board containing the CMX018 UHF FM/FSK receiver, frequency potentiometer, VCO tank circuitry, IF filters, 79.3MHz overtone Colpitts crystal oscillator, tuned 10.7MHz quadrature tank circuit, miniature control switches and audio amplifier.

A multi-turn potentiometer allows the user to select an RF operating frequency between 860 - 935 MHz. The operating bandwidth and centre frequency can be optimised by modifying the VCO tank components.

The board is powered from a single 6 - 12 V dc power supply. Regulation circuitry sets the analog(AV_{DD}) supply for 3V operation. CMX018 supply current may be measured by removing the appropriate jumper.

A low profile 2-way DIL switch controls the device enable and gain select lines.

Links, test points and SMA connector provide access to various points in the circuit.

PCB footprints are provided to allow an external local oscillator to be connected to overcome settling time and frequency drift due to the frequency control potentiometer.

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Note: This product is in development: Changes and additions will be made to this specification. Items marked TBD or left blank will be included in later issues.

Information in this data sheet should not be relied upon for final product design.

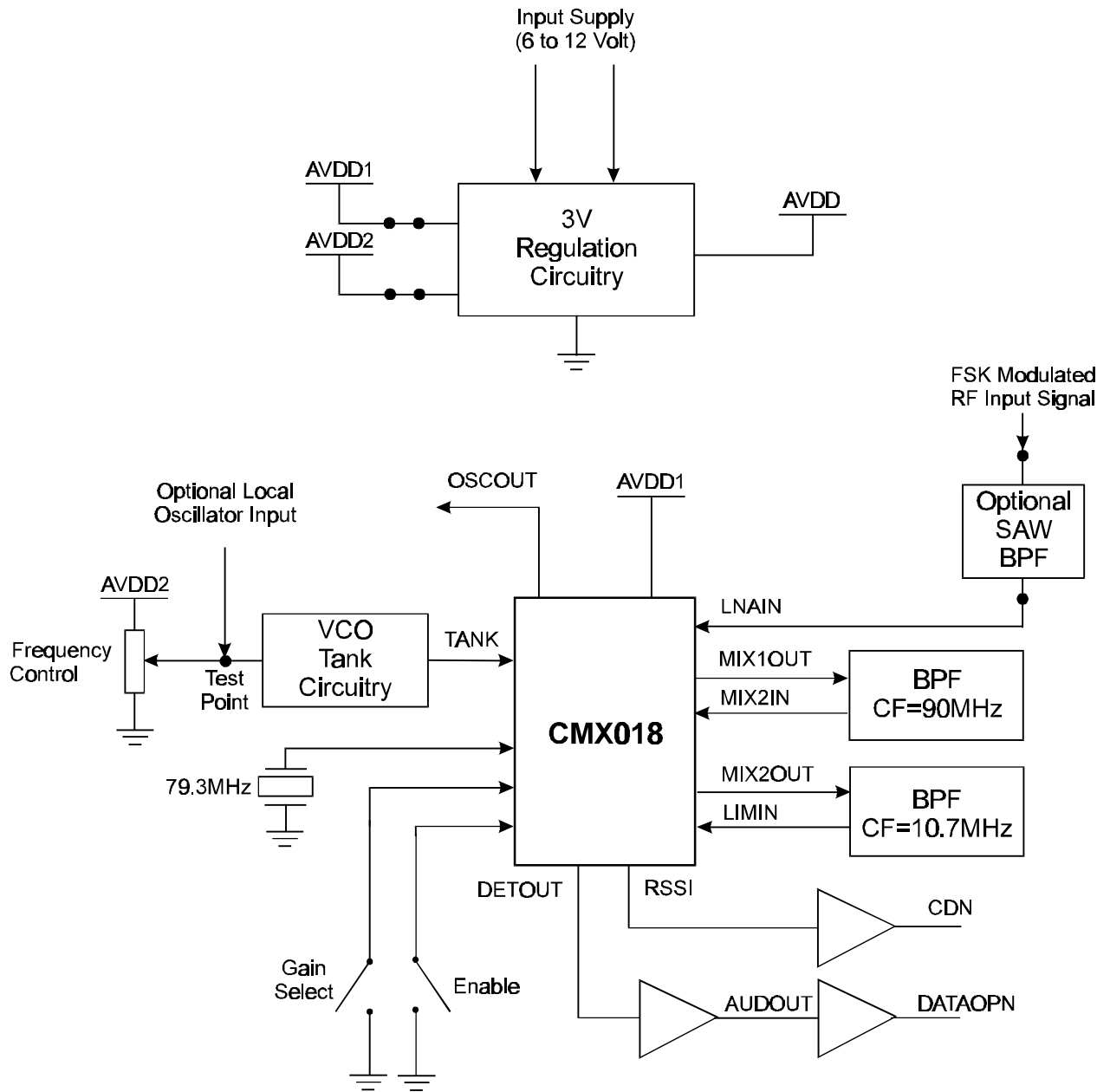


Figure 1 Block Diagram

1.2 Preliminary Information

1.2.1 Laboratory Equipment

The following laboratory equipment is needed to use this evaluation kit:

1.2.1.1 6-12V dc Power Supply

1.2.1.2 Radio Communications Test Set or similar

1.2.1.3 Oscilloscope or Audio Analyser

1.2.1.4 DVM or similar

1.2.2 Handling Precautions

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

1.2.2.1 Static Protection

This product uses low power CMOS circuits which 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.

1.2.2.2 Contents - Unpacking

Please ensure that you have received all of the items on the separate information sheet (EK0181) and notify CML within 7 working days if the delivery is incomplete.

1.2.3 Approvals

This Evaluation Kit is capable of producing radio frequency emissions. Users are advised to observe local statutory requirements which may apply to this product.

1.3 Quick Start

This section provides instructions for users who wish to experiment immediately with the evaluation kit. A fuller description of the kit and its use appears later in this document.

1.3.1 Setting-Up

The EV0181 comes pre-configured for an RF operating frequency of \approx 860MHz. The receiver is enabled and configured for low LNA gain.

Using suitable coaxial cable and adapters, connect RFIN, J1, to the 50 Ω input of a Radio Communications test set, or similar. Ensure this input level does not exceed the power levels specified in the target device data sheet.

Apply power to the input supply connector, J3, from a suitable 6-12V dc power supply.

Configure the Radio Communications test set to generate a 1kHz RF modulated input at 860MHz. Set the power level to -60dBm and modulation level to 100kHz.

RSSI and AUDOUT can be monitored at TP4 and TP10, respectively. Alternatively carrier detect and data can be monitored at CDN and DATAOPN, TP1 and TP2, respectively.

Using a DVM, monitor the dc voltage at RSSI. Set the RF operating frequency (860 - 935 MHz) by slowly adjusting the frequency potentiometer, RV1. Adjust RV1 until the dc level at RSSI is maximum. RV1 may need to be adjusted several times due to drift and settling time of the potentiometer.

The dc voltage measured at RSSI will be typically 0.7V (low gain mode) for an RF input level of -60dBm.

The recovered 1kHz tone measured at AUDOUT will be typically 0.5Vrms for a modulation level of 100kHz.

Operate switch SW1:1 to enable the receiver and switch SW1:2 to toggle between high and low LNA gain modes.

1.3.2 Adjustments

To tune the 10.7MHz quadrature tank circuit slowly turn the capacitor trimmer, CV1.

A new RF operating frequency can be obtained by adjusting the trimmer potentiometer, RV1.

1.4 Signal Lists

CONNECTOR PINOUT				
Connector Ref.	Connector Pin No.	Signal Name	Signal Type	Description
J1	1	RFIN	I/P	CMX018 RF Input
J2	1	OSCIN	I/P	Optional Local Oscillator Input
J3	1	V_{IN}	Power	+ve power from external power supply
	2	V_{SS}	Power	0V power from external power supply

TEST POINTS		
Test Point Ref.	Default Measurement	Description
TP1	-	Carrier Detect output (CDN)
TP2	-	Data output (DATAOPN)
TP3	0V	V_{SS} connection
TP4	-	CMX018 RSSI output, pin 14.
TP5	0V	V_{SS} connection
TP6	-	CMX018 DETOUT output, pin 18.
TP7	0V	V_{SS} connection
TP8	0V	V_{SS} connection
TP9	0V	V_{SS} connection
TP10	-	Amplified DETOUT output (AUDOUT)
TP11	-	CMX018 Buffered Oscillator output, pin 21.
TP12	0V	V_{SS} connection
TP13	0V	V_{SS} connection
TP14	-	Frequency Control Voltage
TP15	3V	AV_{DD} connection
TP16	3V	AV_{DD} connection
TP17	0V	V_{SS} connection

JUMPERS			
Link Ref.	Positions	Default Position	Description
JP1	1-2	S/C	Disconnect to measure AV_{DD2} current
JP2	1-2	S/C	Disconnect to measure AV_{DD1} current

ADJUSTMENTS			
Adjustment Ref.	Adjustment	Adjustment Range	Description
CV1	Sensitivity	5pF - 30pF	10.7MHz Quadrature Tank Circuit Tuning
RV1	Frequency	0 - 3V	RF Operating Frequency Control

SWITCHES			
Switch Ref.	Positions	Default Position	Description
SW1:1	on/off	on	CMX018 Enable
SW1:2	on/off	on	CMX018 Gain Select

Notes: I/P = Input
 O/P = Output
 BI = Bidirectional

1.5 Circuit Schematics and Board Layouts

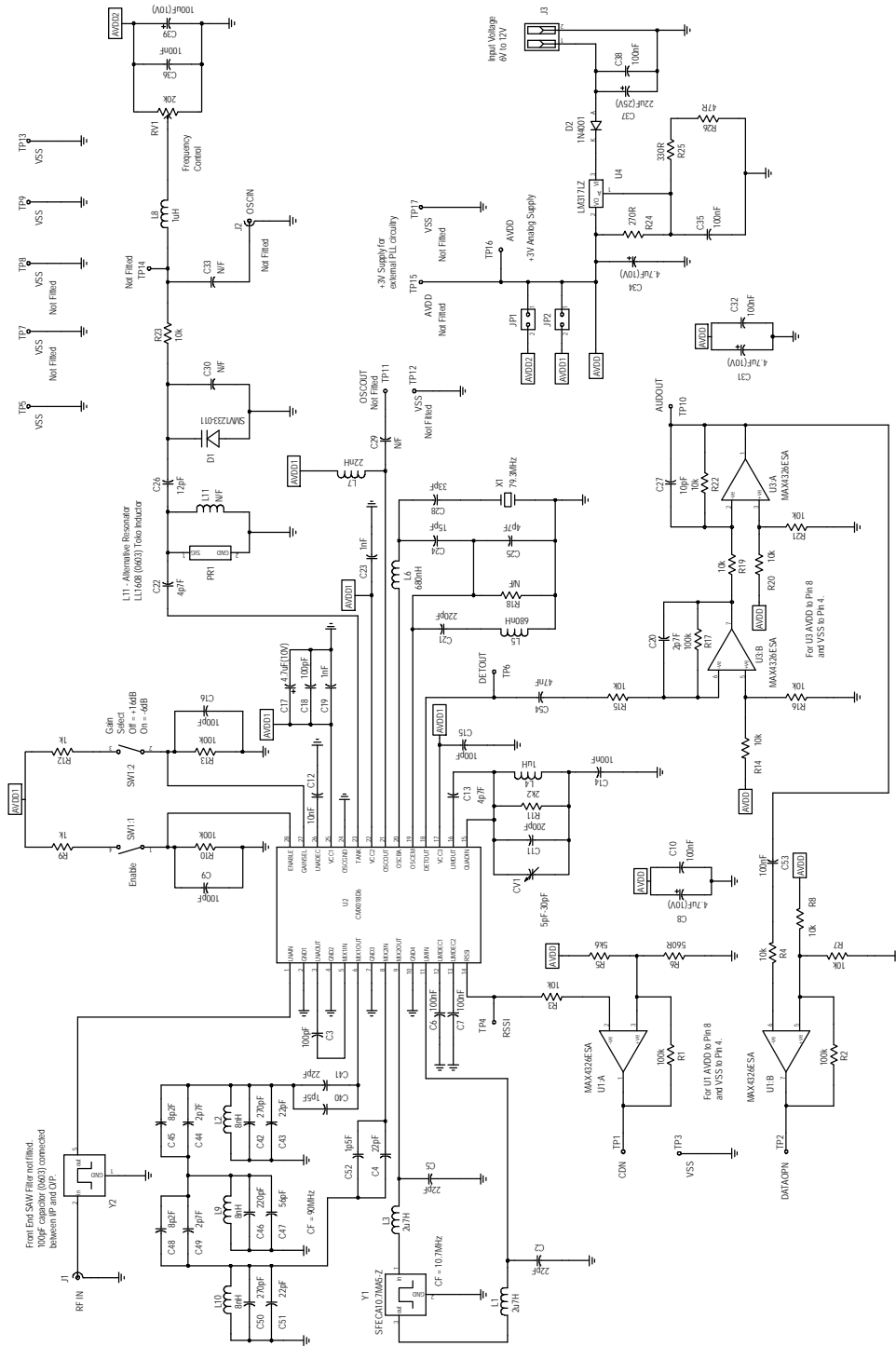
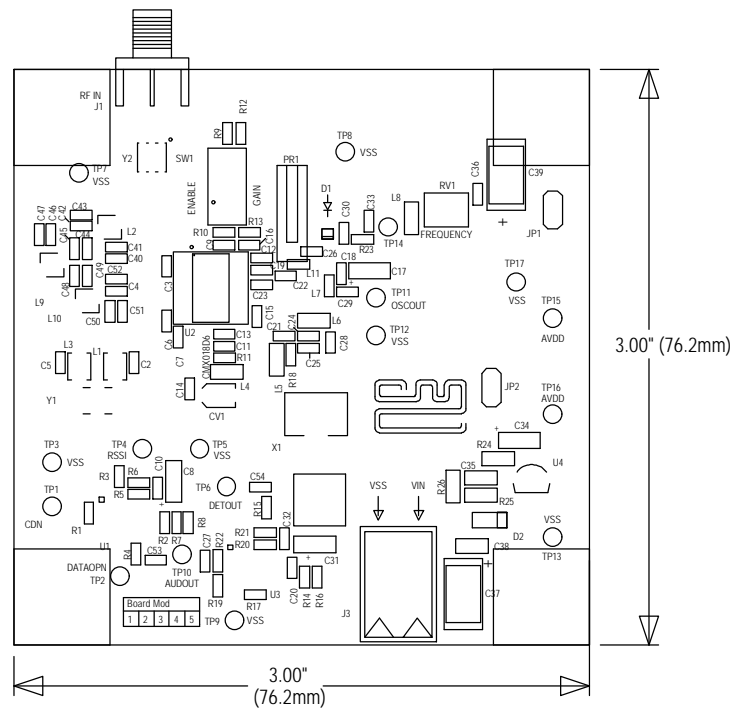


Figure 2 Evaluation Board - Circuit Schematic



Note: Board material is FR4

Figure 3 Evaluation Board Layout - Assembly

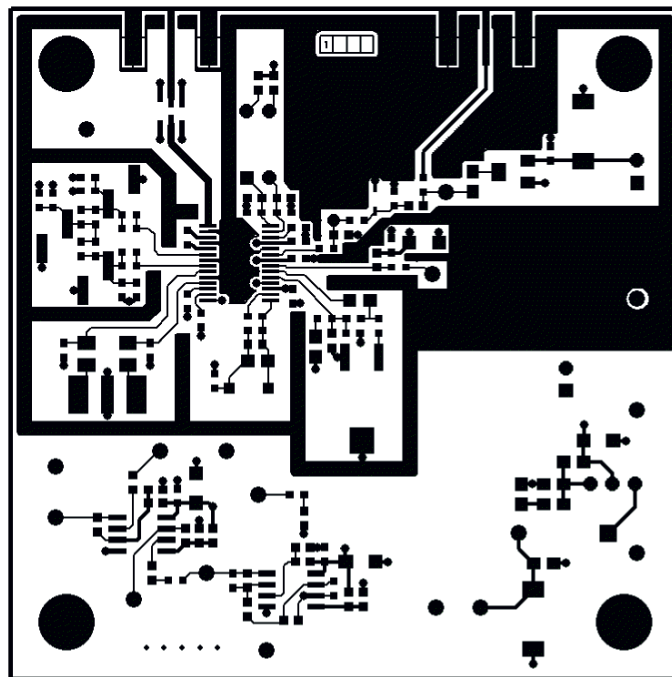


Figure 4 Evaluation Board Layout - Top Copper

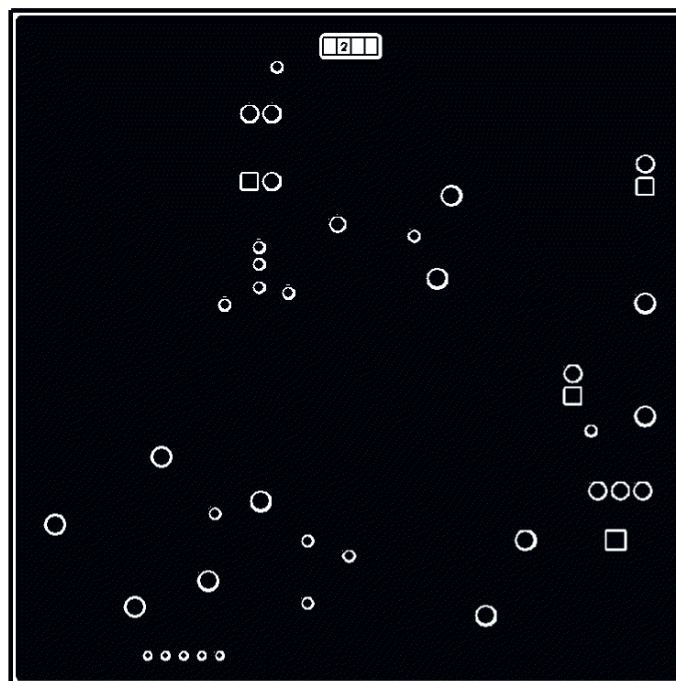


Figure 5 Evaluation Board Layout - Layer Two Copper

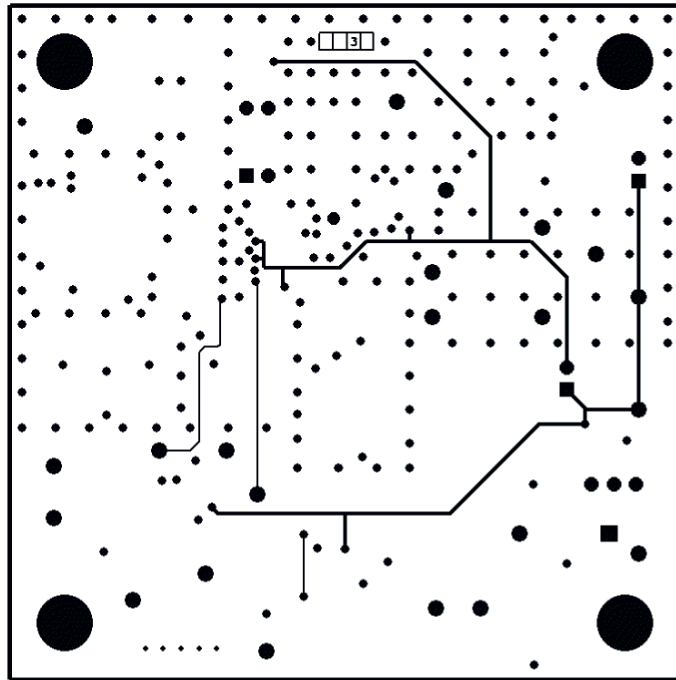


Figure 6 Evaluation Board Layout - Layer Three Copper

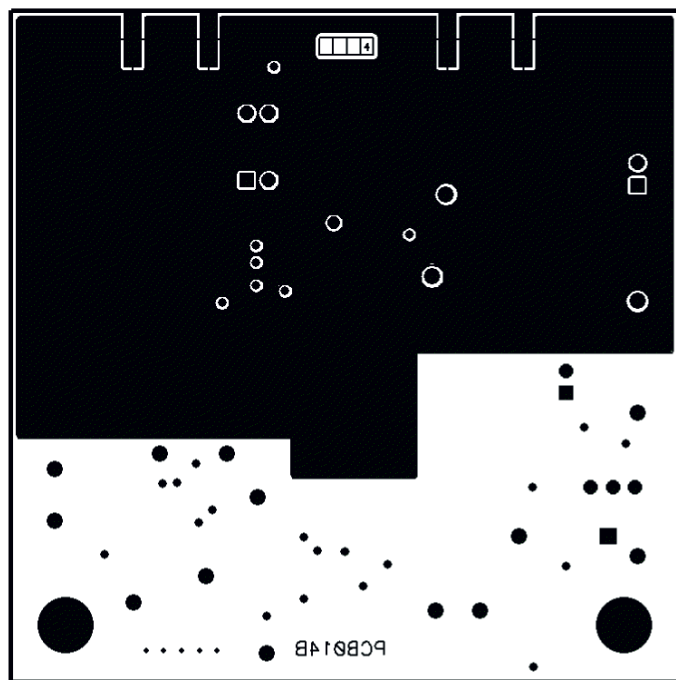


Figure 7 Evaluation Board Layout - Bottom Copper

1.6 Detailed Description

The EV0181 Evaluation Kit comprises a single board containing the CMX018 UHF FM/FSK receiver, frequency control potentiometer, VCO tank circuitry, IF filters, 79.3MHz overtone Colpitts crystal oscillator, tuned 10.7MHz quadrature tank circuit, miniature control switches and audio amplifier.

A multi-turn potentiometer allows the user to select an RF operating frequency between 860-935MHz. The operating bandwidth and centre frequency can be optimised by modifying the VCO tank components.

The board is powered from a single 6-12V dc power supply. Regulation circuitry sets the analog (AV_{DD}) supply for 3V operation. CMX018 supply current may be measured by removing the appropriate jumper.

A low profile 2-way DIL switch controls the device enable and gain select lines.

Links, test points and SMA connector provide access to various points in the circuit.

This open-loop configuration is not recommended for the majority of customer applications. A closed-loop PLL design is required to improve controllability and overcome stability and drift problems.

External PLL circuitry could be connected to test points TP11 (OSCOUT) and TP14. This configuration also requires the capacitor C29 to be fitted and inductor L8 removed.

Alternatively PCB footprints are provided to allow the user drive the VCO externally from a stable source to overcome frequency drift due to the frequency control potentiometer, RV1.

1.6.1 Hardware Description

1.6.1.1 Operating Voltage

The supply regulation circuitry contains a single regulator and associated components to provide the analog supply (AV_{DD}). The operating voltage is set to 3.0V.

The supply feed is split three ways to reduce interference and to enable the user to separately measure various device/circuitry currents.

The supply regulation can be bypassed and external supplies applied, via jumpers JP1 - JP2.

1.6.1.2 Current Measurement

Supply currents for the evaluation device and other board circuitry can be measured by removing the appropriate jumper and replacing it with a multimeter.

1.6.1.3 RF Input and LNA

The RF SMA input connector, RFIN, J1, is connected to the LNAIN pin of the CMX018 via a 100pF ac coupling capacitor. This capacitor can be removed and replaced by a low loss front end bandpass SAW filter, whose frequency response is application specific.

The six pad SAW filter footprint employed in the EV0181 layout is compatible with a large range of SAW filter devices available from various manufacturers.

Typical SAW filters which may be of interest are the wide band B4637 (902 - 928 MHz), B4682 (869 - 894 MHz) and equivalent narrow band devices, manufactured by Siemens Matsushita Components. These SAW filters have typically 2dB insertion loss and I/O matching impedance of 50Ω.

The LNA switched gain function which is used to increase the dynamic range of the receiver, is controlled by gain select switch SW1:2. In the 'off' position the LNA will be in high gain mode, and low gain selected when in the 'on' position (default).

High gain mode is used where maximum sensitivity is required for low level input signals. Where high level signals are present at the receiver input, which causes difficulties due to inter-modulation, the gain of the LNA can be reduced by typically 22dB, from approximately +16dB to -6dB.

The output of the LNA is fed to the first on-chip mixer (MIXIN, pin 5) via an ac coupling capacitor, C3. With a good front end band pass SAW filter no further filtering should be required at the LNA output. However, customer requirements may mean an additional SAW filter is necessary at this point, for further spurious rejection.

Please refer to the CMX018 device data sheet for specifications on LNA input levels (LNAIN, pin 1).

1.6.1.4 VCO Tank Circuitry

The local oscillator circuitry is formed by two capacitors, C22 and C26, a coaxial resonator, PR1, and varactor diode, D1, which is driven by the frequency control potentiometer, RV1. The dc voltage derived from the potentiometer, RV1, can be measured at TP14. Alternatively the inductor, L8, can be removed and dc control voltage applied to the VCO tank circuitry via TP14.

The user may also drive the VCO externally from a stable source to overcome frequency drift due to the frequency control potentiometer, RV1. This setup is recommended if the user wishes to perform detailed measurements with the EV0181 evaluation board. The capacitor, C33, should be fitted (100pF), R23 replaced with a 0Ω resistor and inductor, L8, removed before applying an external local oscillator signal via OSCIN, J2 (not fitted). The external local oscillator signal connected to OSCIN should be at a typical input level of -10dBm.

The IF filters and second IF crystal have been designed so the local oscillator frequency must be set 90MHz higher than the RF input signal, for the receiver to work correctly.

For evaluation purposes space is provided for the user to fit an LL1608 Toko inductor at L11. This inductor is an alternative to the coaxial resonator, PR1. The inductor will have a typical value of 3.3nH for these operating frequencies. Capacitors C22 and C26 may need to be modified with this alternative resonator.

Customers concerned about the manufacture of a coaxial resonator, PR1, may wish to consider the use of a PCB track resonator. Refer to an RF/Microwave designer's guide to obtain more information on microstrip design.

1.6.1.5 First IF Stage

The voltage controlled local oscillator, obtained from the tank resonator circuitry, down-converts the RF input signal, such that the first IF is typically centred at 90MHz.

The first IF is filtered using a 3-pole Chebyshev LC narrow bandpass filter (capacitively coupled). The filter has a 3dB pass bandwidth of approximately 3.5MHz and insertion loss of approximately 10dB.

The 'Mini Spring Air Core' Coilcraft inductors (A03T-2) used in the filter have a tolerance of 2%. Multiple capacitor footprints have been employed in the filter layout to achieve optimum performance using preferred component values.

The filter has been designed to have the same I/O matching impedance as the CMX018 I/O pins, MIX1OUT and MIX2IN, which have an impedance of 100Ω.

If the user wishes to modify the IF frequencies or filter bandwidth, refer to an RF designer's guide for information on RF filter design.

1.6.1.6 Second IF Stage

A 79.3MHz overtone colpitts crystal oscillator circuit is used to down-convert the first IF, such that the second IF is centred at 10.7MHz.

This oscillator stage contains a Euroquartz low profile 79.3MHz crystal in a UM-5 package and has a temperature stability of ± 20 ppm. This AT third overtone mode crystal has been designed to operate with a load capacitance of 20pF.

The second IF is filtered using a standard Murata 10.7MHz ceramic chip filter, Y1. The filter has a 3dB pass bandwidth of 280 ± 50 kHz and 20dB attenuation bandwidth of 650kHz maximum. The maximum insertion loss specified for this filter is 6dB.

The I/O matching impedance of the filter is 330Ω, therefore, a simple narrow band LC matching network has been designed around the filter for matching to the CMX018 I/O pins, MIX2OUT and LIMIN, which have an impedance of 430Ω.

Refer to an RF designer's guide to obtain information on matching networks and overtone colpitts crystal oscillators.

If the user wishes to modify the IF frequencies a different crystal frequency is required.

1.6.1.7 RSSI and Demodulated Output

In low gain mode an RF signal level of -100dBm at RFIN, J1, will produce an RSSI voltage at TP4 of typically 0.2V. The RSSI voltage will increase with increasing RF input level at a rate of approximately 20mV/dB up to a typical voltage of 0.7V (low gain mode) at an RF input level of -60dBm.

An operational amplifier U1:A is configured as a comparator to provide a carrier detect output, CDN, at TP1. This output will go to a logic '0' when the RSSI voltage level is greater than typically 300mV. The threshold level can be adjusted by modifying the potential divider resistors R5 and R6.

A 10.7MHz quadrature tank circuit (CV1, C11, C13, C14, L4 and R11) is used to finally extract the baseband signal. The trimmer capacitor CV1 is used to tune the circuit whilst R11 determines the Q and thus the amplitude and distortion of the demodulated output.

The CMX018 detector output pin (DETOUT pin 18) can be monitored via TP6. This output is first amplified using an operational amplifier U3. The amplified output can be monitored at AUDOUT, TP10. The level measured at AUDOUT will be typically 0.5Vrms for a 1kHz RF modulated input with a modulation level of 100kHz.

The second amplifier (B) in the U1 package is also configured as a comparator to provide a digital output of the signal at AUDOUT. The threshold level is set to half supply using the potential divider resistors R7 and R8.

Note, the audio amplifier and data output stage is not a 'total' solution. It is designed to show that data can be recovered and should give reasonable BER for RF input levels >-90dBm (high gain mode). This output circuitry may need to be modified or bypassed depending on the user's application. Reception of large continuous streams of 1's or 0's will not be possible unless the ac coupling capacitors, C53 and C54, are bypassed.

1.6.2 Adjustments and Controls

1.6.2.1 Frequency Control

The trimmer potentiometer, RV1, controls the local oscillator frequency. The control voltage derived (0-3V) from this potentiometer allows the RF operating frequency to be set between 860 - 935 MHz (90MHz below local oscillator).

Using a DVM, monitor the dc voltage at RSSI. Set the RF operating frequency (860 - 935 MHz) by slowly adjusting the frequency potentiometer, RV1. Adjust RV1 until the dc level at RSSI is maximum. RV1 may need to be adjusted several times due to drift and settling time of the potentiometer.

The frequency control potentiometer draws a typical current of 150 μ A from the AV_{DD2} supply.

1.6.2.2 10.7MHz Quadrature Tank Tuning

The trimmer capacitor, CV1, allows the user to tune the 10.7MHz quadrature tank circuit.

1.6.2.3 Enable and Gain Select

The evaluation device enable and gain select lines are controlled by switch SW1.

Switch SW1:1 allows the user to configure the CMX018 for zero-power. With SW1:1 in the 'on' position the device is enabled (default), and when SW1:1 is in the 'off' position the device is in zero-power mode.

The LNA switched gain function which is used to increase the dynamic range of the receiver, is controlled by gain select switch SW1:2. In the 'off' position the LNA will be in high gain mode, and low gain selected when in the 'on' position (default).

1.6.2.4 VCO Tank Circuitry

The coaxial resonator consists of a length of RG405 semi-rigid cable. For operating frequencies between 950 - 1025 MHz (i.e RF input 860 - 935 MHz) the outer shield should be cut to approximately 0.256" (6.5mm). One end of the inner wire should be soldered to the outer whilst the other end should be soldered to the tank PCB pad. The resonator should be laid down and outer soldered to PCB ground plane. The overall length of the resonator should be approximately 0.343" (8.7mm).

Reducing the length of the coaxial resonator, PR1, will increase the resonant frequency and vice versa. Increasing C22 and C26 will reduce resonant frequency.

The capacitance ratio of C26 to varactor diode, D1, will determine the achievable operating band for the 0 - 3V control voltage. Therefore to reduce the bandwidth, reduce C26 and/or insert a small picofarad capacitor, C30. The introduction of C30 will also reduce the resonant frequency.

1.6.3 PCB Design

The EV0181 PCB is a 4-layer design, with an overall thickness of 0.062" (1.57mm), including top and bottom layer copper. The top layer comprises the regulation circuitry connections, RF signal tracks and ground plane. The second layer is purely a ground plane for the supply. Layer three contains the analog power supply tracks, AV_{DD} which feed all the board's sub-circuits. The bottom layer contains another ground plane for additional screening.

CMX018 ground pins are connected directly to the top layer ground plane as close to the package as possible. The power supply pins are bypassed to ground directly at the package using decoupling capacitors with direct returns to ground.

Using microstrip techniques the RFIN track on the 4-layer PCB has been designed to provide a line impedance of 50 Ω . This design technique is based on the track width and separation distance between track and ground plane for a given dielectric constant of the PCB material. The layout assumes the board material is FR4 with a ground plane on the second layer, separated from the top layer by 0.016" (0.41mm). Therefore, for a dielectric constant between 4-5 and track width of 0.032" (0.81mm), an approximate 50 Ω line impedance is obtained.

Refer to an RF/Microwave designer's guide to obtain more information on microstrip line impedance design.

1.7 Performance Specification

1.7.1 Electrical Performance

1.7.1.1 Absolute Maximum Ratings

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

	Notes	Min.	Max.	Units
Supply ($V_{IN} - V_{SS}$)		-0.3	40.0	V
Current into or out of V_{IN} and V_{SS} pins		0	150	mA
Storage Temperature		-10	+70	°C
Operating Temperature		+10	+35	°C
Input Power to J1, RFIN			0	dBm

1.7.1.2 Operating Limits

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

	Notes	Min.	Max.	Units
Supply ($V_{IN} - V_{SS}$)		6V	12V	V
Supply ($AV_{DD} - V_{SS}$)		2.7V	3.3V	V
Operating Temperature		+10	+35	°C

1.7.1.3 Operating Characteristics

For the following conditions unless otherwise specified:

$AV_{DD} = 3.0V$, $T_{amb} = +25^{\circ}C$

RFIN = 860MHz, 50Ω source impedance.

	Notes	Typ.	Units
DC Parameters			
I_{DD} (evaluation board - CMX018 enabled in high gain mode)	1	60	mA
I_{DD} (evaluation board - CMX018 disabled)	2	10	mA

Notes:

- SW1:1 on and SW1:2 off.
- SW1:1 off.

Refer to current CML CMX018 data sheet for further information.

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**Oval Park - LANGFORD
MALDON - ESSEX
CM9 6WG - ENGLAND**

**Telephone: +44 (0)1621 875500
Telefax: +44 (0)1621 875600
e-mail: sales@cmlmicro.co.uk
<http://www.cmlmicro.co.uk>**