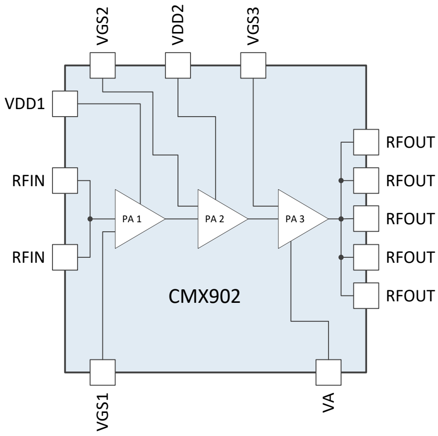
CMX902 Broadband Efficient RF Power Amplifier

Features

- **Wide operating frequency range**
  130MHz to 700MHz
- **Typical output power:**
  - 2.8W operating at 160MHz (4V)
  - 1.75W operating at 435MHz (3.3V)
- **High power gain 39dB**
- **High power added efficiency**
  greater than 60% at VHF
- **Single polarity supply voltage**
  2.5V to 6V
- **Small 28 pin WQFN package**

Applications

- **Marine AIS Class-B and Marine AIS-SART**
- **Wireless data communications:**
  FSK, FFSK/MSK, GFSK/GMSK, Multi-level FSK
- **Analogue FM handheld radio terminals**
- **Automatic meter reading (AMR)**
- **Wireless sensor networks**
  Mesh/Ad hoc systems
- **Remote control and sensing systems**
- **Commercial and consumer communications**



1 Brief Description

The CMX902 is a three stage high-gain and high efficiency RF power amplifier. The device is ideally suited for use in VHF and UHF frequency bands up to 700MHz.

The first and second stages of the amplifier operate in a class-A and class-AB mode respectively, and the third stage operates in a class-C mode for maximum efficiency.

External components are required to match the device input and output ports to 50 Ohms. The CMX902 is available in a small footprint 5mm x 5mm, low thermal resistance 28-pin WQFN package making it ideal for small form factor applications such as data modules as well as handheld radio terminals.

CONTENTS

1.1 History

Version	Changes	Date
2	Document front page rebranded as part of the CML SμRF product launch	22nd March 2021
1	First public release	2nd October 2017

This is Provisional Information; changes and additions may be made to this specification. Parameters marked TBD or left blank will be included in later issues.

2 Block Diagram

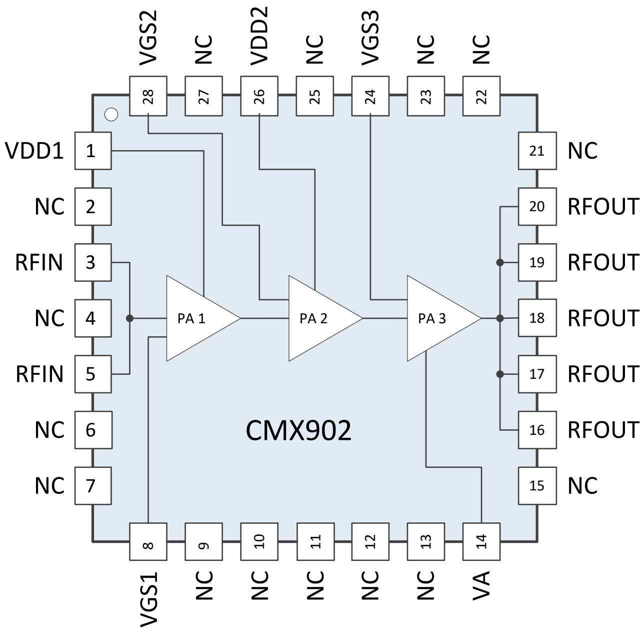


Figure 1 CMX902 Block Diagram

3 Performance Specification

3.1 Electrical Performance

3.1.1 Absolute Maximum Ratings

Exceeding these maximum ratings can result in damage to the device.

	Notes	Min.	Max.	Unit
Supply: V_{DD} - V_{SS}	1	-0.5	12.0	V
I_{DD} - I_{SS}	2		2.2	A
RF power at input pin	1		15	dBm
Output load VSWR			10:1	
RF Power per pin			30	dBm

Notes

1. Transient and not operational i.e. Vgs1, Vgs2 and Vgs3 set to 0V
2. Rating for peak or continuous operation

QT8 Package (28-pin WQFN)	Notes	Min.	Max.	Unit
Storage Temperature		-50	+125	°C

3.1.2 Operating Limits

Correct operation of the device outside these limits is not implied.

	Notes	Min.	Max.	Unit
Supply Voltage:				
$V_{DD} – V_{SS}$		2.5	6	V
$V_{GS} – V_{SS}$ (per stage)			2.5	V
Operating Air Temperature (T_{AMB})		-40	+85	°C
Maximum Allowable Junction Temperature			+125	°C
Maximum Continuous Power Dissipation (P_{DISS})	3, 4		1.8	W

Notes

3. Dependent on PCB layout arrangements and heatsinking, see section 5.2.2.
4. P_{DISS}= P_{DC}–P_{OUT} , where: P_{DC} = V_{DD} x I_{DD} and P_{OUT} = measured RF output power.

3.1.3 Operating Characteristics

For the following conditions unless otherwise specified: External components as recommended in Figure 12, V_{DD} = 4.0V

T_{AMB} = 25°C, V_{BIAS} = 3.3V

Specification	Min.	Typ.	Max.	Unit	Condition
RF Frequency Range	130	-	700	MHz	
Quiescent Current (from V_{DD})	-	-	1	µA	V_{BIAS} = V_{PARAMP} = 0V
Thermal Resistance R_{JC} (junction to central heatsink ground pad)	-	2.5	3	°C/W	

3.1.3.1 Operating Characteristics 160MHz

RF frequency = 160MHz, RF power input = -5dBm, V_{PARAMP} = 3.3V

Specification	Min.	Typ.	Max.	Unit	Condition
Maximum output power (Pmax160)	-	2.8	-	W	Pin = -5dBm
Power added efficiency	-	62.5	-	%	Pout = 2.8W, V_{DD} = 4V
Input power for Pmax160	-	-5	-	dBm	V_{DD} = 4V
Gain	- -	39.5 30	- -	dB dB	Pin = -5dBm Pin = -15dBm
Second harmonic	-	-23	-	dBc	Pmax 160
Third harmonic	-	-38	-	dBc	Pmax 160
Fourth harmonic	-	-54	-	dBc	Pmax 160
Other non-harmonic spurious	-	-	-75	dBc	Pmax 160
Input VSWR	-	See s_{11} data	-		See section 5.2.1
Stability, VSWR 5:1	Stable all phases, continuous operation, power output variation with load phase ±3 dB (typ.)				Variation from normal output power with 50Ω load.
Open circuit, Short circuit		No damage			Continuous operation for 30 seconds

3.1.3.2 Operating Characteristics 435MHz

RF frequency = 435MHz, RF power input = -5dBm, V_{PARAMP} = 3.3V

Specification	Min.	Typ.	Max.	Unit	Condition
Maximum output power (Pmax435)	-	2.4	-	W	V_{DD} = 4V
Output power	-	1.4	-	W	V_{DD} = 3V, 435MHz
Power added efficiency	-	54	-	%	Pout = 2.4W, V_{DD} = 4V
Input power for Pmax435	-	-10	-	dBm	V_{DD} = 4V
Gain	-	42.5	-	dB	
ACPR	-	-	-70	dBc	EN 300 086, 25kHz channel
Reverse Isolation	-	-60	-	dB	Pmax 435
Second harmonic	-	-30	-	dBc	Pmax 435
Third harmonic	-	-52	-	dBc	Pmax 435
Fourth harmonic	-	-46	-	dBc	Pmax 435
Other non-harmonic spurious	-	-	-75	dBc	Pmax 435
Input VSWR	-	See s_{11} data	-		See section 5.2.1
Stability, VSWR 5:1	Stable all phases, continuous operation, power output variation with load phase ±3dB (typ.)				
Open circuit, Short circuit		No damage			Continuous operation for 30 seconds

3.2 Typical Performance

3.2.1 Operation at 160MHz

Performance data measured using EV9021 PCB, circuit values as Table 2/Figure 12.

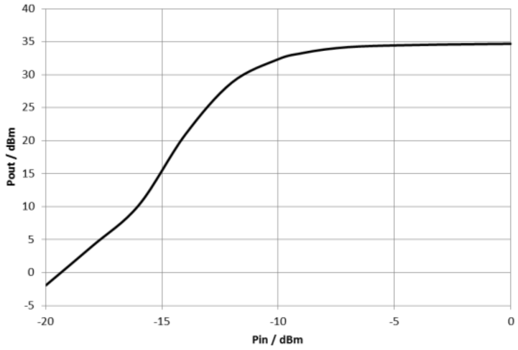


Figure 2 Input power to output power characteristic, V_{DD} = 4V

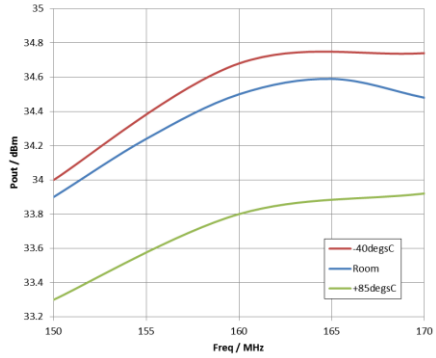


Figure 3 Variation of output power with frequency and temperature, V_{DD} = 4V, V_{PARAMP} = 3.3V, input level = -5dBm

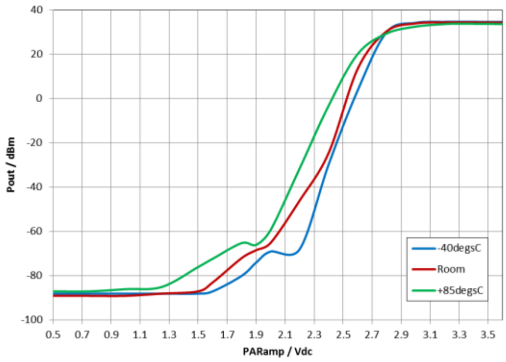


Figure 4 Output power vs. control voltage characteristics and variation with temperature, V_{DD} = 4V, input level = -5dBm

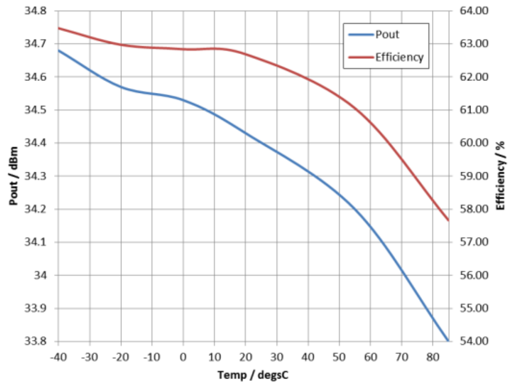


Figure 5 Output power and efficiency variation with temperature, V_{DD} = 4V, input level = -5dBm, V_{PARAMP} = 3.3V

3.2.2 Operation at 435MHz

Performance data measured using EV9021 PCB, circuit values as Table 2 / Figure 16.

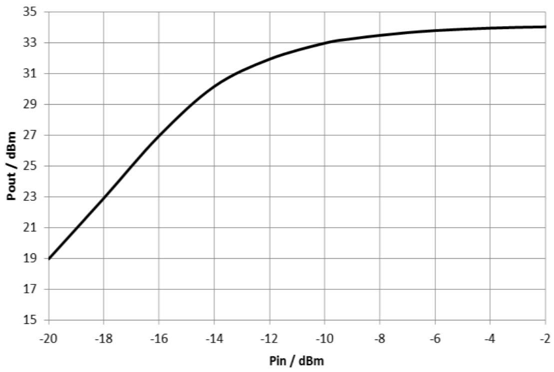


Figure 6 Input power to output power characteristic, V_{DD} = 4V at 435MHz

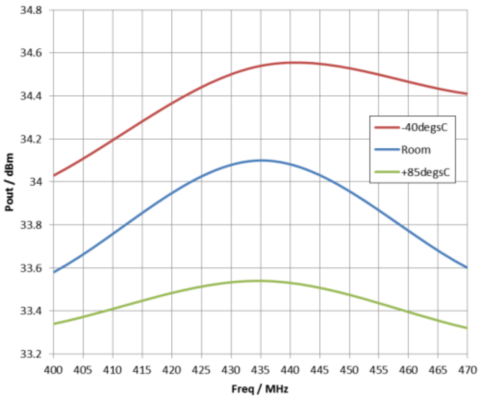


Figure 7 Variation in output power with frequency and temperature, V_{DD} = 4V, V_{PARAMP} = 3.3V, input level = -5dBm

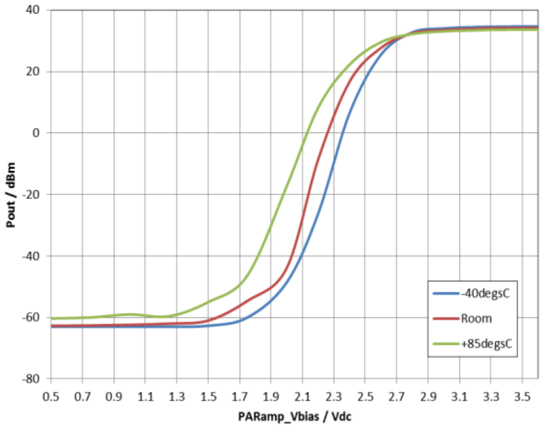


Figure 8 Output power vs. control voltage characteristics variation with temperature, V_{DD} = 4V, input level = -5dBm

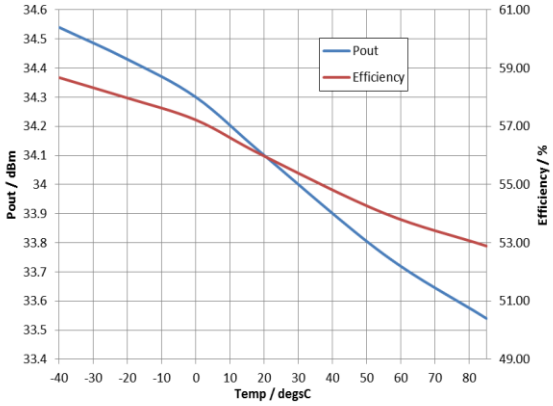


Figure 9 Output power and efficiency variation with temperature, V_{DD} = 4V, input level = -5dBm, V_{PARAMP} = 3.3V

4 Pin and Signal Definitions

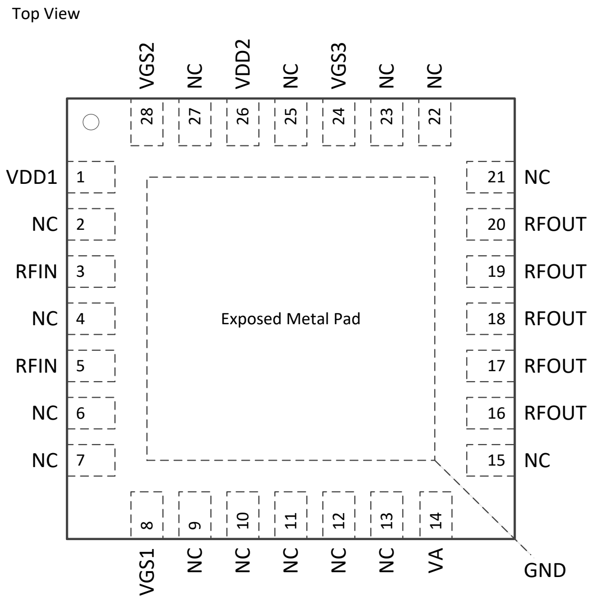


Figure 10 Pin Configuration

4.1 Pin List

Pin No.	Pin Name	Type	Description
1	VDD1	PWR	Power supply for the first stage
2	NC	NC	Connect to GND
3	RFIN	IP	Connect to pin 5
4	NC	NC	Connect to ground
5	RFIN	IP	RF signal input (off-chip DC blocking capacitor required)
6	NC	NC	Connect to GND
7	NC	NC	Connect to GND
8	VGS1	IP	Bias input for first stage
9	NC	NC	Connect to GND
10	NC	NC	Connect to GND
11	NC	NC	Connect to GND
12	NC	NC	Connect to GND
13	NC	NC	Connect to GND
14	VA	PWR	Connect to 3.3V
15	NC	NC	Connect to GND
16	RFOUT	OP	Power supply and RF output
17	RFOUT		
18	RFOUT		
19	RFOUT		
20	RFOUT		
21	NC	NC	Connect to GND
22	NC	NC	Connect to GND
23	NC	NC	Connect to GND
24	VGS3	IP	Bias input for output stage

Pin No.	Pin Name	Type	Description
25	NC	NC	Connect to GND
26	VDD2	PWR	Power supply for second stage
27	NC	NC	Connect to GND
28	VGS2	IP	Bias input for second stage
Exposed Metal Pad	GND	PWR	The central metal pad must be connected to ground.

Notes:

OP = Output PWR = Power Connection
IP = Input NC = No internal connection

4.2 Signal Definitions

Signal Name	Pins	Usage
V_{DD}	VDD	Power supply
V_{GS1}	VGS1	Bias input for the first amplifier stage
V_{GS2}	VGS2	Bias input for the second amplifier stage
V_{GS3}	VGS3	Bias input for the third amplifier stage
V_{PARAMP}	N/A	Combined control voltage with V_{GS1} V_{GS2} configured as Figure 12 (NB: see also section 8.1).
V_{BIAS}	N/A	Combined control voltage V_{GS3} and pin VA, configured as Figure 12.
V_{ss}	GND	Ground

5 Application Information

5.1 General Description

The CMX902 is a three-stage RF power amplifier producing high gain at full output power. An input power of up to -5dBm is required to achieve fully-saturated output power. The device requires only a single positive power supply. The primary ground connection is via a large central pad on the bottom of the package.

The first and second stages of the amplifier operate in class-A and class-AB mode, respectively. The final stage operates in Class-C mode. DC current will increase with RF input signal. The optimum load for maximum output power and efficiency is approximately 5Ω. An external matching network is required to match this impedance to a 50Ω load (see Figure 12). The RFIN pins are DC biased, thus a blocking capacitor is recommended between signal source and the input pins.

VDD1 and VDD2 provide DC power supply to the first and second stages, respectively. An RF tuning inductor is needed for each pin. Vgs1, Vgs2 and Vgs3 should be set to different bias voltages for maximum output power and efficiency; see Figure 12 and section 8.1 for further details.

5.2 Main Characteristics

5.2.1 Input Impedance

Typical CMX902 input impedance (S_{11}) is shown in Figure 11 as measured with EV9021 configured for 435MHz operation with a RC network of 470R and 1nF (but no other matching) at the input. The measured S_{11} response varies with inter-stage and output matching configuration. The configuration used for this measurement was the 435MHz circuit values from Figure 12 / Table 2.

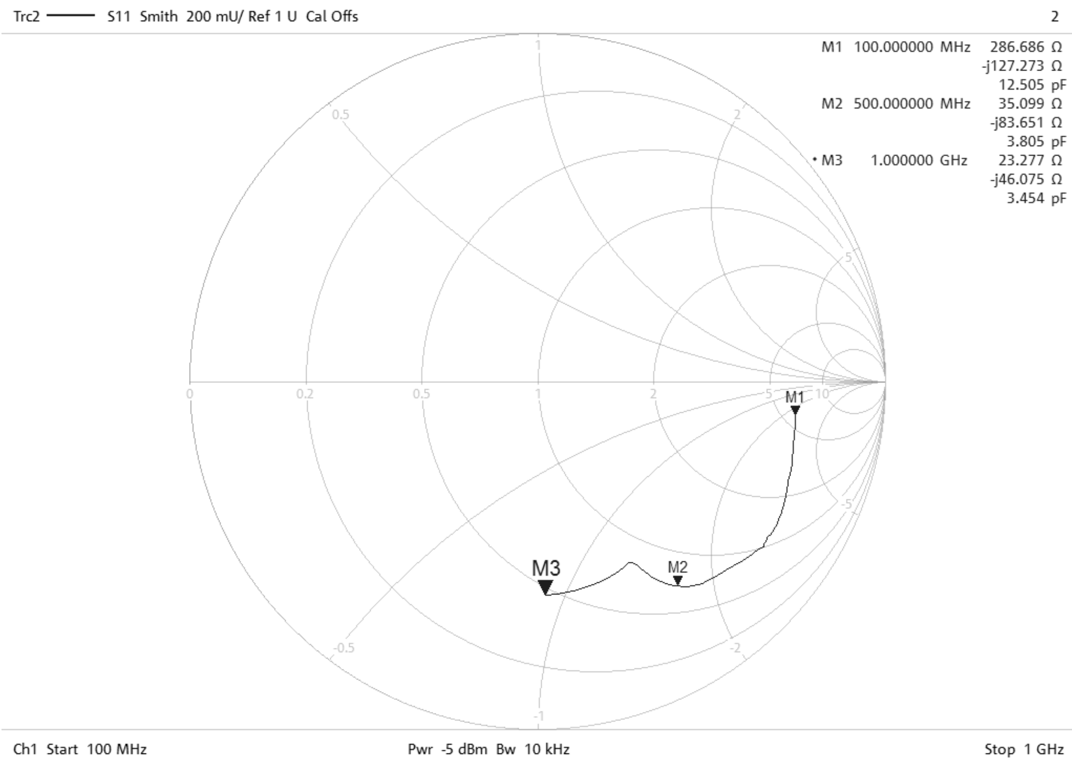


Figure 11 S_{11} response, V_{DD} = 4V, Vgs1 = 1.65V, Vgs2 = 1.35V and Vgs3 = 0.93V, Ids = 16mA

Frequency (MHz)	S(1,1) Mag ∠Ang
100	0.746 ∠- 7.571°
150	0.755 ∠- 11.145°
200	0.762 ∠- 15.124°
250	0.774 ∠- 19.889°
300	0.788 ∠- 25.156°
350	0.802 ∠- 32.104°
400	0.784 ∠- 40.681°
450	0.759 ∠- 47.743°
500	0.712 ∠- 55.723°
550	0.637 ∠- 60.332°
600	0.596 ∠- 61.807°
650	0.581 ∠- 63.100°
700	0.586 ∠- 65.048°
750	0.594 ∠- 68.052°
800	0.600 ∠- 71.736°
850	0.605 ∠- 75.733°
900	0.609 ∠- 79.962°
950	0.612 ∠- 84.154°
1000	0.615 ∠- 87.993°

Table 1 S-parameter data (S_{11}), V_{DD} = 4V, Vgs1 = 1.65V, Vgs2 = 1.35V and Vgs3 = 0.93V, Ids = 16mA

5.2.2 Thermal Design

The large central pad on the bottom of the package should be electrically and thermally connected to the PCB ground plane, typically with 20 to 25 vias. A 0.2mm hole size is recommended and the vias must be from top layer to bottom layer. A typical solution is a via pattern based on an inner via diameter of 0.200mm (0.025mm plating of via walls), with 25 vias on a 0.670mm grid pattern; the vias do not need to be filled. The PCB layout should provide a thermal radiator appropriate for the intended operation/duty cycle in order to avoid an excessive junction temperature.

It should be noted that the peak power dissipation may exceed the maximum rated continuous power dissipation (P_{DISS}) when the transmitter is used for discontinuous transmission for example in TDMA transmission systems. In this case average power dissipation should not exceed P_{DISS}.

6 General Application Schematic

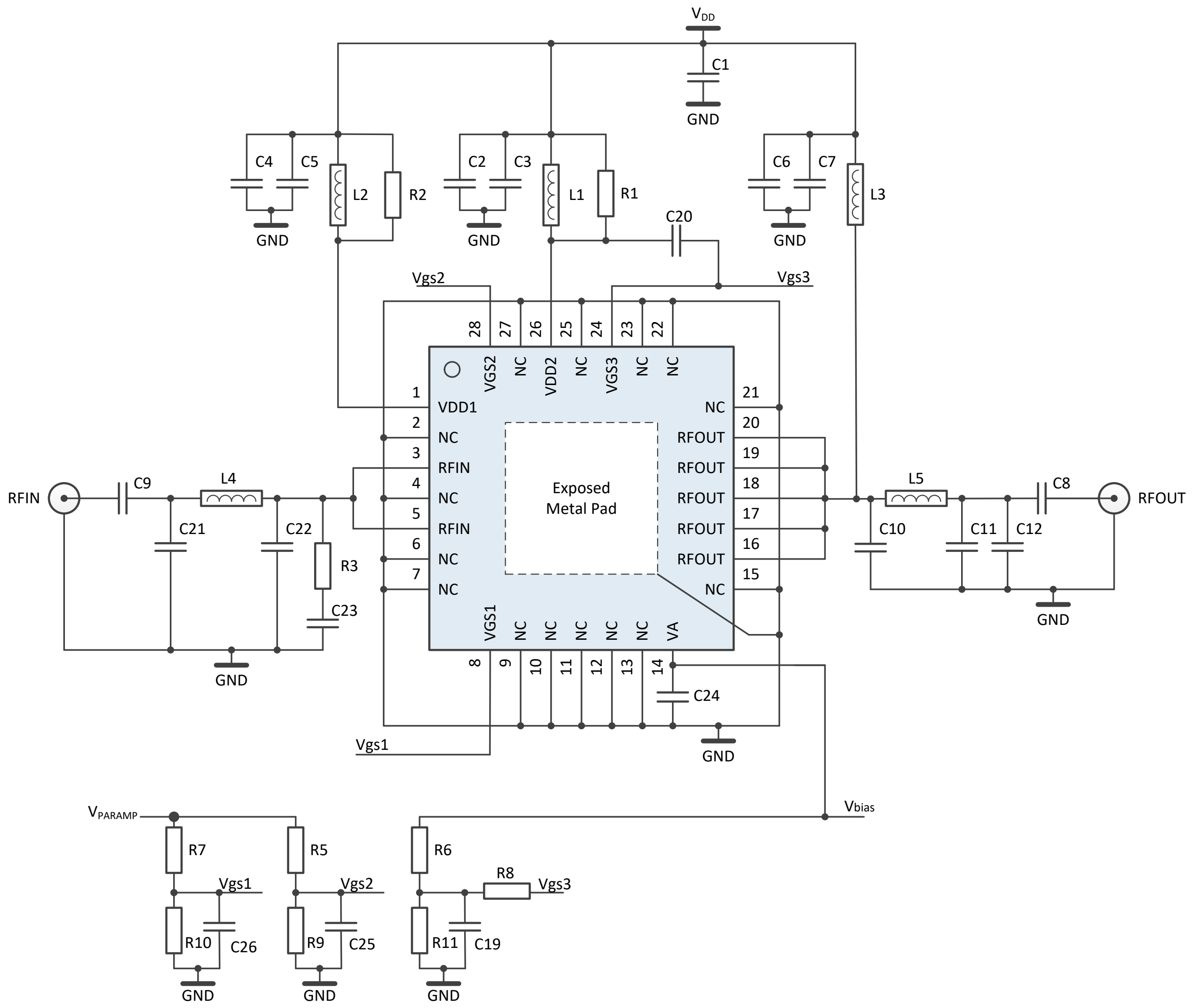


Figure 12 CMX902 Recommended External Components

Frequency (MHz)	L1 (0603CS) (nH)	L2 (0603CS) (nH)	L3 (nH)	L4 (0630CS) (nH)	L5 (nH)	C21 (pF)	C22 (pF)	C10 (pF)	C11 (pF)	C12 (pF)	R1 (Ω)	R2 (Ω)
160	56	56	19	150	12	-	3.3	12	56	5.6	200	200
435	27	27	16	43	3.6	2.2	-	4.7	10	8.2	-	-

Table 2a Recommended External Components (variations with frequency)

R1	200Ω	C1	4.7µF	C19	100pF
R2	200Ω	C2	Note 1	C20	N/F
R3	680Ω (Note 2)	C3	1uF	C21	Table 2a
R5	68kΩ	C4	Note 1	C22	Table 2a
R6	100kΩ	C5	1uF	C23	1nF
R7	68kΩ	C6	Note 1	C24	Note 1
R8	51R	C7	1uF	C25	10nF
R9	47kΩ	C8	Note 1	C26	10nF
R10	68kΩ	C9	Note 1		
R11	39kΩ	C10	Table 2a		
		C11	Table 2a		
		C12	Table 2a		

Notes:

1. 470pF
2. 470Ω recommended at 450MHz
3. All inductors are Coilcraft (www.coilcraft.com)
4. For 435MHz operation with V_{DD} = 2.7 V to 3.3V see recommended value changes in section 8.2.

Table 2b Recommended External Components (common values)

7 PCB Layout

Careful layout of the PCB is essential for best performance. Recommended layout may be taken from evaluation kit EV9021.

8 Application Notes

8.1 Output Power Control

The output power of the CMX902 can be controlled by varying V_{PARAMP} from 0V to 3.3V. This in turn adjusts V_{GS1} and V_{GS2}. It is recommended to connect V_{GS3}, along with VA (pin 14), to 3.3V dc. This gives a satisfactory power control characteristic for TDMA systems like DMR (ETSI standards EN 300 113 and TS 102 361).

8.1.1 TDMA Operation

Careful assessment of device stability is advised during power ramping when operating into non-50Ω loads.

8.2 Operation at 2.7V to 3.3V over 400 to 470 MHz

With reference to Figure 12 and Table 2, the following component changes are recommended for operation at V_{DD} = 3V:

C21 = 4.7pF, C11 = 18pF and C12 = DNF.

Figure 13 shows typical output power levels at +2.7V, +3V and +3.3V over the 400 to 470 MHz operating band.

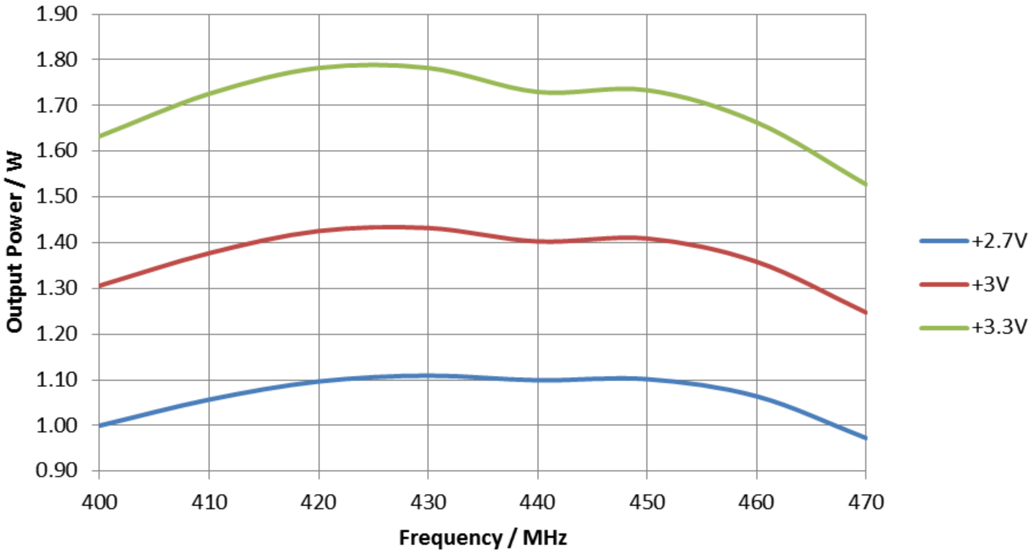
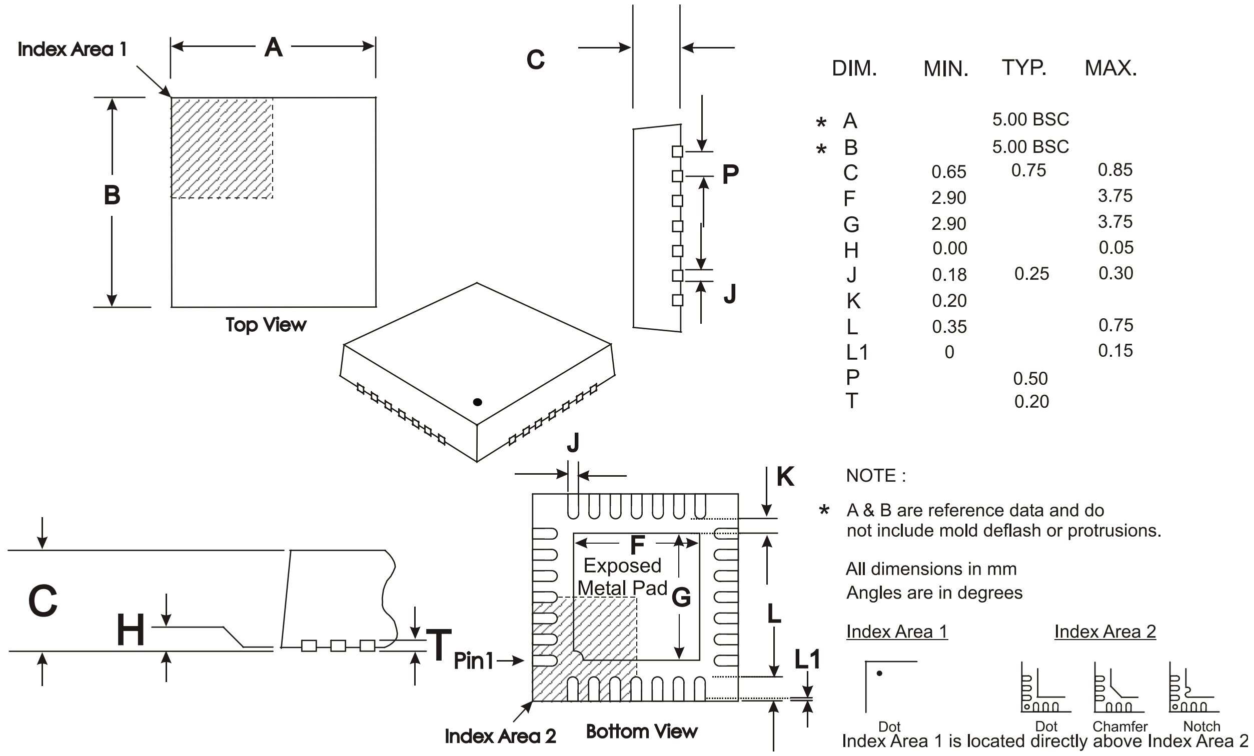


Figure 13 Typical Output Power at Lower Supply Voltages

9 Packaging



DIM.	MIN.	TYP.	MAX.
* A		5.00 BSC	
* B		5.00 BSC	
C	0.65	0.75	0.85
F	2.90		3.75
G	2.90		3.75
H	0.00		0.05
J	0.18	0.25	0.30
K	0.20		
L	0.35		0.75
L1	0		0.15
P		0.50	
T		0.20	

Depending on the method of lead termination at the edge of the package, pull back (L1) may be present.
L minus L1 to be equal to, or greater than 0.3mm
The underside of the package has an exposed metal pad which should ideally be soldered to the pcb to enhance the thermal conductivity and mechanical strength of the package fixing. Where advised, an electrical connection to this metal pad may also be required

Figure 14 QT8 Mechanical Outline of 28-pin WQFN (QT8)

9.1 Ordering

Order as Part No. CMX902QT8

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