### Front End GaAs IC 475 - 625 MHz

#### Features

- MoCA Compliant Front-End GaAs IC
- Linear Power Amplifier
- Integrated PA Bias Control
- PA Power Down Mode
- Transmit/Receive Switch
- Transmit Power Detector
- 0/3 dB Transmit Attenuator
- 0/15 dB Receive Attenuator
- 3.3 Volt Single Bias
- Integrated Digital Control Logic
- Compatible with EN2512 & EN2552
- Lead-free 3 mm 16-lead PQFN Package
- RoHS\* Compliant
- 50 Ω Characteristic Impedance

#### Description

The XZ1004-QT is an integrated front end GaAs IC for MoCA mid-band RF applications which is fully compatible with Entropic Communications chipset. It is housed in an industry standard 3 mm PQFN package and operates from a single 3.3 V bias. The chip includes a power amplifier, transmit/receive switch, power detector, switched attenuators, bias circuits and digital control circuitry. The transmit path includes a 3 dB switched attenuator and power for gain adjustment and linearity detector optimization. A switched attenuator in the receiver provides a 15 dB gain step. The integrated bias circuit stabilizes transmit amplifier performance over temperature and process variation with power down functionality and optional bias adjustment. The device typically delivers 20 dBm at P1dB and +34 dBm OIP3 across the operating temperature range. The digital inputs control all circuit operating modes and are compatible with Entropic's MoCA chipsets.

### **Ordering Information**<sup>1,2</sup>

| Part Number    | Package           |
|----------------|-------------------|
| XZ1004-QT-0G0T | Tape and Reel     |
| XZ1004-QT-EV1  | Sample Test Board |

1. Reference Application Note M513 for reel size information.

2. All sample boards include 5 loose parts.

\* Restrictions on Hazardous Substances, European Union Directive 2011/65/EU.

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#### Functional Block Diagram



### **Pin Configuration**

| Pin No. | Function | Pin No.    | Function            |
|---------|----------|------------|---------------------|
| 1       | RX_ATT   | 9          | VD1                 |
| 2       | TX_RX    | 10 L_OP    |                     |
| 3       | CAL      | CAL 11 I_C |                     |
| 4       | TX_IN    | 12         | DET_ATT             |
| 5       | TX_ATT   | 13         | VD3                 |
| 6       | PWR_DWN  | 14         | VDET                |
| 7       | 7 VD2    |            | RX_OUT              |
| 8       | BIAS_ADJ | 16         | RX_ADJ              |
|         |          | 17         | Paddle <sup>3</sup> |

3. The exposed pad centered on the package bottom must be connected to RF and DC ground.



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#### **Pin Description**

| Pin No. | Pin Name | Function  |
|---------|----------|---|
| 1       | RX_ATT   | Digital input. A logic high input voltage enables the 15 dB receive attenuator.   |
| 2       | TX_RX    | Digital input. A logic high voltage selects transmit mode, logic low selects receive mode.  |
| 3       | CAL      | Digital input. A logic high selects calibration mode (transmit amplifier output is diverted into the power detector). This pin overrides the TX_RX control input. |
| 4       | TX_IN    | Transmit RF input (50 Ω).   |
| 5       | TX_ATT   | Digital input. A logic low input voltage enables the 3 dB transmit attenuator.  |
| 6       | PWR_DWN  | Digital input. A logic low input voltage reduces the I <sub>D1</sub> current.   |
| 7       | VD2      | Bias supply.  |
| 8       | BIAS_ADJ | Bias adjustment of transmit amplifier using pull-up/down resistor (normally connected to $V_{DD}$ ).  |
| 9       | VD1      | Amplifier bias supply.  |
| 10      | L_OP     | External inductor connected to this pin sets the transmit return loss and linearity levels.   |
| 11      | I_0      | RF input in the receive mode and RF output in the transmit mode (50 $\Omega$ ).   |
| 12      | DET_ATT  | External RC network connected to this pin sets the power detector sensitivity.  |
| 13      | VD3      | Detector bias supply.   |
| 14      | VDET     | Power detector output voltage. Used during calibration mode to measure output power.  |
| 15      | RX_OUT   | Receive RF output (50 $\Omega$ ).   |
| 16      | RX_ADJ   | External RC network connected to this pin sets the receive attenuator gain step.  |



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#### **Evaluation Board Layout**



#### **Component Values**

| Component                   | Value  | Package |
|-----------------------------|--------|---------|
| R2, R4, R9                  | 3.3 Ω  | 0402    |
| R5                          | 100 Ω  | 0402    |
| R6                          | 0 Ω    | 0402    |
| R7                          | 2 kΩ   | 0402    |
| R8                          | 5.6 Ω  | 0402    |
| R10                         | 100 kΩ | 0603    |
| L1                          | 68 nH  | 0603    |
| L2                          | 8.2 nH | 0402    |
| C1 - C4, C6,<br>C7, C9, C13 | 100 pF | 0402    |
| C5, C12, C14                | 0.1 µF | 0402    |
| C8                          | 470 pF | 0402    |
| C11                         | 33 pF  | 0402    |

#### **Evaluation Board Schematic**



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#### **DC Specifications**

| Parameter                                  | Units | Min. | Тур. | Max. |
|--|-------|------|------|------|
| Supply Voltage (V <sub>DD</sub> )          | V     | 3.13 | 3.3  | 3.47 |
| Supply Current (I <sub>DD</sub> )          | mA    | —    | 200  | 265  |
| Supply Current (I <sub>D1</sub> )          | mA    | —    | 185  | —    |
| Supply Current (I <sub>D2</sub> )          | mA    | —    | 12   | —    |
| Supply Current (I <sub>D3</sub> )          | mA    | —    | 2.2  | —    |
| Supply Current (I <sub>bias_adj</sub> )    | mA    | —    | 2.5  | —    |
| Supply Current Power Shut Down State (IDD) | mA    | —    | 8    | —    |
| Logic Low (L)                              | V     | -0.5 | 0    | 0.2  |
| Logic High (H)                             | V     | 1.2  | 3.3  | 3.47 |
| Logic Low Current                          | mA    | -0.5 | —    | 1    |
| Logic High Current                         | mA    | -0.5 |      | 1    |

## Absolute Maximum Ratings<sup>4,5</sup>

| Parameter   | Absolute Max.             |  |  |
|---|---------------------------|--|--|
| Supply Voltage (V <sub>DD</sub> ) to Ground       | +7 V                      |  |  |
| $V_{\text{DD}}$ to any other $V_{\text{DD}}$      | +7 V                      |  |  |
| All other pins to ground                          | +6 V                      |  |  |
| Power Dissipation (Pdiss)                         | 1.0 W                     |  |  |
| Operating Temperature (Ta)                        | -40°C to +85°C            |  |  |
| Operating Humidity Range                          | 0% to 95% non-condensing  |  |  |
| Storage Temperature (Tstg)                        | -55°C to +150°C           |  |  |
| Storage Humidity Range                            | 0% to 100% non-condensing |  |  |
| Junction Temperature                              | 150°C                     |  |  |
| Thermal Resistance, Junction to Case <sup>6</sup> | 53°C/W                    |  |  |
| ESD (HBM)   | Class 0                   |  |  |
| ESD (HBM), I_O, TX_IN & RX_OUT                    | Class 1A                  |  |  |
| Lead Temperature (soldering)                      | Refer to App Note S2083   |  |  |
| RF Input Power @ pin 4 (TX_IN)                    | 10 dBm                    |  |  |
| RF Input Power @ pin 11 (I_O)                     | 20 dBm                    |  |  |

4. Exceeding any one or combination of these limits may cause permanent damage to this device.

5. MACOM does not recommend sustained operation above these survivability limits.

6. Thermal Resistance is calculated using XZ1004-QT-EV1 evaluation sample board.

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#### **Digital Control Specifications**

| Operating Mode                     | Control Inputs |       |        |        |         |  |
|------------------------------------|----------------|-------|--------|--------|---------|--|
|                                    | CAL            | TX_RX | TX_ATT | RX_ATT | PWR_DWN |  |
| TX Gain 1 (0 dB attenuation), GT1  | L              | Н     | Н      | L/H    | Н       |  |
| TX Gain 2 (3 dB attenuation), GT2  | L              | Н     | L      | L/H    | Н       |  |
| CAL                                | Н              | L/H   | L/H    | L/H    | н       |  |
| RX Gain 1 (0 dB attenuation), GR1  | L              | L     | L/H    | L      | н       |  |
| RX Gain 2 (15 dB attenuation), GR2 | L              | L     | L/H    | Н      | н       |  |
| Power Shut Down                    | L/H            | L/H   | L/H    | L/H    | L       |  |

#### Receive Specifications: Freq = 475 - 625 MHz, $T_A$ = -40°C to +85°C, $V_{DD}$ = 3.13 - 3.47 V, $Z_0$ = 50 $\Omega$

| Parameter                         | Test Conditions   | Units  | Min. | Тур.        | Max.         |
|-----------------------------------|---|--------|------|-------------|--------------|
| Receive Gain 1<br>(RX_ATT = L)    | —   | dB     | -1.2 | -0.8        | _            |
| Receive Gain 2<br>(RX_ATT = H)    | _   | dB     | -17  | -15.8       | -14.5        |
| Receive Gain Step Difference      | Gain 1, Gain 2  | dB     | 14.4 | 15          | 15.8         |
| Pass Band Ripple                  | Over Any 50 MHz   | dB     | —    | 0.5         | —            |
| Switch Time                       | 50% Control to 10/90% RF,<br>Gain 1 or 2 to Gain 2 or 1         | ns     | _    | _           | 100          |
| Noise Figure                      | Exclusive of Receive Added Noise<br>Gain 1<br>Gain 2            | dB     | _    | 1.0<br>16.7 | 1.44<br>17.9 |
| Receive Added Noise               | Noise Contribution from Amplifier<br>Output to RX_OUT In Gain 1 | dBm/Hz | _    | _           | -177         |
| Input Return Loss                 | —   | dB     | 11   | 15          |              |
| Output Return Loss                | _   | dB     | 11   | 15          | _            |
| Input Third Order Intercept Point | RX Power In = 0 dBm, 10 MHz spacing<br>Gain 1, Gain 2           | dBm    | 28   | 30          | _            |
| Input P1dB                        | Gain 1, Gain 2  | dBm    | 16   |             | —            |



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## **Transmit Specifications:**

## Freq = 475 - 625 MHz, $T_A$ = -40°C to +85°C, $V_{DD}$ = 3.13 - 3.47 V, $Z_0$ = 50 $\Omega$

| Parameter   | Test Conditions   | Units | Min.                 | Тур.                 | Max.         |
|---|---|-------|----------------------|----------------------|--------------|
| Transmit Gain 1<br>(TX_ATT = H)                           | -40°C to +85°C, 475 MHz<br>-40°C to +85°C, 625 MHz  | dB    | 16.5<br>15.5         | 18.5<br>17.5         | 20.5<br>19.5 |
| Transmit Gain 2<br>(TX_ATT = L)                           | -40°C to +85°C, 475 MHz<br>-40°C to +85°C, 625 MHz  | dB    | 13.5<br>12.5         | 15.5<br>14.5         | 17.5<br>16.5 |
| Transmit Gain Step Difference                             | Gain 1, Gain 2  | dB    | 2.5                  | 3.0                  | 3.5          |
| Pass Band Ripple  | Over Any 50 MHz   | dB    | —                    | 0.5                  | —            |
| Input Return Loss   |   | dB    | 9                    | 11                   | —            |
| Output Return Loss  | _   | dB    | 11                   | 15                   | _            |
| Output Third Order Intercept Point                        | TX Power Out =+ 7 dBm, 10 MHz spacing<br>-40°C<br>+25°C<br>+85°C  | dBm   | 30.7<br>30.0<br>29.0 | 42.5<br>38.5<br>34.5 | _            |
| Output P1dB   | -40°C<br>+25°C<br>+85°C   | dBm   | 19.2<br>18.5<br>17.0 | 22.0<br>21.5<br>20.5 | _            |
| PA Output to RX Output Isolation                          | TX Mode (TX_RX=H; CAL=L; RX_ATT=L)<br>Calibration Mode (CAL=H)  | dB    | 24<br>30             |                      | 38<br>40     |
| PA Output to I_O Isolation                                | Calibration Mode (CAL=H)  | dB    | 22                   | —                    | _            |
| Power Detector Min Output Voltage<br>(No TX Output Power) | Detector Output Load 100 kΩ<br>-40°C<br>+25°C<br>+85°C  | mV    | 405<br>425<br>445    | _                    | _            |
| Power Detector CW Output Voltage                          | Detector Output Load 100 kΩ<br>TX Power Out = +3.3 dBm<br>TX Power Out = +7.0 dBm                               | mV    | 600<br>734           | 675<br>814           | 750<br>894   |
| Power Detector Delta Voltage                              | Detector Output Load 100 kΩ<br>TX Power Out = +3.3 dBm, +25°C & 3.3 V<br>TX Power Out = +7.0 dBm, +25°C & 3.3 V | mV    | 241<br>369           | 256<br>392           | 271<br>416   |
| Power Detector Video Bandwidth                            |   | MHz   | _                    | 50                   | _            |
| Power Detector Switch Time                                | Detector Output Load 100 kΩ<br>50% Control to 10/90% RF   | ns    |                      |                      | 150          |
| Noise Figure  | Gain 1<br>Gain 2  | dB    | _                    | _                    | 6<br>9       |
| Spurious (2nd Harmonics)                                  | TX Power Out = +7 dBm   | dBm   |                      | -38                  | -30          |
| Spurious (All Others)                                     | TX Power Out = +7 dBm   | dBm   |                      | -60                  | -50          |

<sup>6</sup> 

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## **Typical Performance Curves Receive Path (RX)**



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0.45

0.50

0.55

Frequency (GHz)

0.60

0.65

0.50

0.55

Frequency (GHz)

0.60

0.45



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0.65

0.65

0.65

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### Typical Performance Curves Transmit Path (TX)



Input Return Loss







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#### Gain - Step Difference



#### **Output Return Loss**



#### Voltage Detector @ 625 MHz



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### Typical Performance Curves Transmit Path (TX)





P1dB\_TX1







P1dB\_TX2







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#### **Typical Performance Curves**

#### Isolation PA to IO in Cal Mode



#### Isolation PA to RX in Cal Mode



Isolation PA to RX in TX Mode



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#### **Handling Procedures**

Please observe the following precautions to avoid damage:

#### **Static Sensitivity**

Gallium Arsenide Integrated Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.





<sup>&</sup>lt;sup>†</sup> Reference Application Note S2083 for lead-free solder reflow recommendations and PCB footprint information. Meets JEDEC moisture sensitivity level 1 requirements. Plating is 100% matte tin over copper.

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