



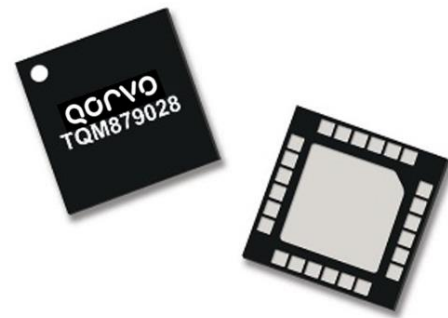
# TQM879028

## 0.6-4 GHz 1/2 W Digital Variable Gain Amplifier

### Product Overview

The TQM879028 is a digital variable gain amplifier (DVGA) featuring high linearity over the entire gain control range. This amplifier module integrates a gain block, a digital-step attenuator (DSA), and a high linearity ½ Watt amplifier into a compact 4 x 4 mm module. The internal 6-bit DSA provides a 31.5 dB gain control range in 0.5 dB steps, and is controlled with a serial peripheral interface (SPI™). The individual stages are accessible to external ports to allow for optimization of the last stage amplifier for use in any 3GPP telecom band and also allowing other functional blocks to be added in-between the stages.

The TQM879028 features variable gain from 0.5 dB to 32 dB at 2.14 GHz, +44 dBm output IP3, and +27.5 dBm P1dB while only consuming 230 mA current from a 5 V supply. The module is available in a compact 24-pin 4 x 4 mm leadless SMT package.

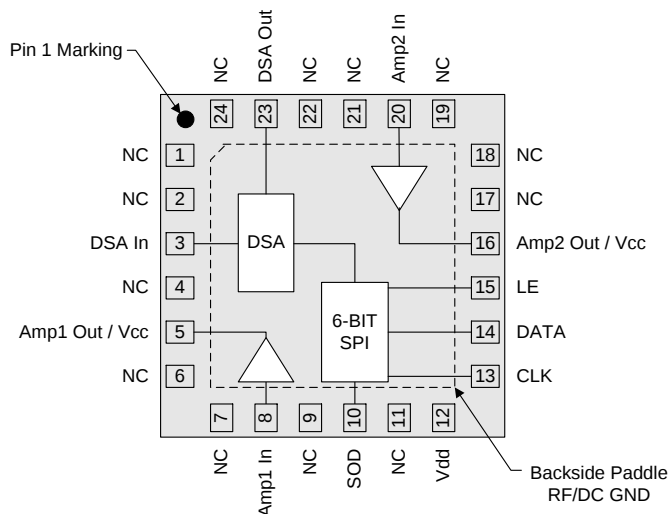


24 Pin 4x4 mm leadless SMT Package

### Key Features

- 600-4000 MHz
- 32 dB Maximum Gain at 2140 MHz
- 31.5 dB Gain Range in 0.5 dB Steps
- +44 dBm Output IP3
- +27.5 dBm Output P1dB
- 1.6 dB Noise Figure
- 3-wire SPI Control Programming
- Tunable for any 3GPP telecom band

### Functional Block Diagram



Top View

### Applications

- Wireless Infrastructure
- Small cell BTS
- Pre-5G / 5G Massive MIMO systems
- TDD-based architectures

### Ordering Information

| Part No.          | Description               |
|-------------------|---------------------------|
| TQM879028TR13     | 2500 pieces on a 13" reel |
| TQM879028-PCB2140 | 2140 MHz Evaluation Board |

## Absolute Maximum Ratings

| Parameter                         | Rating                  |
|-----------------------------------|-------------------------|
| Storage Temperature               | -65 to 150°C            |
| RF Input Power, CW, 50Ω, T=25°C   | +12 dBm                 |
| Supply Voltage (V <sub>DD</sub> ) | +5.5 V                  |
| Digital Input Voltage             | V <sub>DD</sub> + 0.5 V |

Operation of this device outside the parameter ranges given above may cause permanent damage.

## Recommended Operating Conditions

| Parameter                          | Min  | Typ | Max  | Units |
|------------------------------------|------|-----|------|-------|
| Supply Voltage (V <sub>DD</sub> )  | 4.75 | 5.0 | 5.25 | V     |
| T <sub>CASE</sub>                  | -40  |     | +105 | °C    |
| Tj for >10 <sup>6</sup> hours MTTF |      |     | +170 | °C    |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed over all recommended operating conditions.

## Electrical Specifications

Test conditions unless otherwise noted: V<sub>DD</sub> = +5V, Temp = +25°C, matched 2140 MHz reference circuit, max. gain setting

| Parameter                           | Conditions                                  | Min                              | Typ   | Max  | Units |
|-------------------------------------|---------------------------------------------|----------------------------------|-------|------|-------|
| Operational Frequency Range         |                                             | 600                              |       | 4000 | MHz   |
| Test Frequency                      |                                             |                                  | 2140  |      | MHz   |
| Gain                                |                                             | 29                               | 32    | 36   | dB    |
| Gain Control Range                  | 0.5 dB Step Size                            |                                  | 31.5  |      | dB    |
| Accuracy Error                      |                                             | ±(0.3+5% of Attenuation setting) |       |      | dB    |
| Input Return Loss                   |                                             |                                  | 20    |      | dB    |
| Output Return Loss                  |                                             |                                  | 14    |      | dB    |
| Output P1dB                         |                                             | +26.4                            | +27.5 |      | dBm   |
| Output IP3                          | P <sub>out</sub> = +11 dBm/tone, Δf = 1 MHz | +41                              | +44   |      | dBm   |
| Noise Figure                        |                                             |                                  | 1.5   |      | dB    |
| Total Supply Current                |                                             | 175                              | 230   | 255  | mA    |
| Amp 1 Current                       |                                             |                                  | 86    |      | mA    |
| Amp 2 Current                       |                                             |                                  | 142   |      | mA    |
| DSA Current                         |                                             |                                  | 2     |      | mA    |
| Thermal Resistance, θ <sub>jc</sub> | Junction to case                            |                                  |       | 26   | °C/W  |

## Serial Control Interface

The TQM879028 has a CMOS SPI™ input compatible serial interface. This serial control interface converts the serial data input stream to parallel output word. The input is 3-wire (CLK, LE and SID) SPI™ input compatible. At power up, the serial control interface resets the DSA to the minimum gain state. The 6-bit SID (Serial Input Data) word is loaded into the register on rising edge of the CLK, MSB first. When LE is high, CLK is internally disabled.

### Serial Control Timing Characteristics (Test conditions: $V_{DD} = +5\text{ V}$ , Temp.=25°C)

| Parameter                           | Condition                   | Min | Max | Units |
|-------------------------------------|-----------------------------|-----|-----|-------|
| Clock Frequency                     | 50% Duty Cycle              |     | 10  | MHz   |
| LE Setup Time, $t_{LE\text{SUP}}$   | after last CLK rising edge  | 10  |     | ns    |
| LE Pulse Width, $t_{LE\text{PW}}$   |                             | 30  |     | ns    |
| SID set-up time, $t_{SD\text{SUP}}$ | before CLK rising edge      | 10  |     | ns    |
| SID hold-time, $t_{SD\text{HLD}}$   | after CLK rising edge       | 10  |     | ns    |
| LE Pulse Spacing $t_{LE}$           | LE to LE pulse spacing      | 630 |     | ns    |
| Propagation Delay $t_{PLO}$         | LE to Parallel output valid |     | 30  | ns    |

### Serial Control DC Logic Characteristics (Test conditions: $V_{DD} = +5\text{ V}$ , Temp.=25°C)

| Parameter                           | Condition               | Min | Max      | Units         |
|-------------------------------------|-------------------------|-----|----------|---------------|
| Input Low State Voltage, $V_{IL}$   |                         | 0   | 0.8      | V             |
| Input High State Voltage, $V_{IH}$  |                         | 2.4 | $V_{DD}$ | V             |
| Output High State Voltage, $V_{OH}$ | On SOD pin              | 2.0 | $V_{DD}$ | V             |
| Output Low State Voltage, $V_{OL}$  | On SOD pin              | 0   | 0.8      | V             |
| Input Current, $I_{IH} / I_{IL}$    | On SID, LE and CLK pins | -10 | +10      | $\mu\text{A}$ |

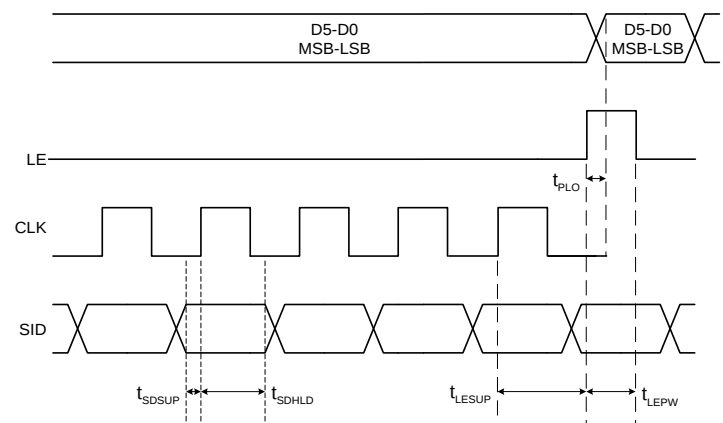
### SID Control Logic Truth Table

| 6-Bit Control Word |    |    |     |    |    | Gain Relative to Maximum Gain |
|--------------------|----|----|-----|----|----|-------------------------------|
| MSB                |    |    | LSB |    |    |                               |
| D5                 | D4 | D3 | D2  | D1 | D0 |                               |
| 1                  | 1  | 1  | 1   | 1  | 1  | Maximum Gain                  |
| 1                  | 1  | 1  | 1   | 1  | 0  | -0.5 dB                       |
| 1                  | 1  | 1  | 1   | 0  | 1  | -1 dB                         |
| 1                  | 1  | 1  | 0   | 1  | 1  | -2 dB                         |
| 1                  | 1  | 0  | 1   | 1  | 1  | -4 dB                         |
| 1                  | 0  | 1  | 1   | 1  | 1  | -8 dB                         |
| 0                  | 1  | 1  | 1   | 1  | 1  | -16 dB                        |
| 0                  | 0  | 0  | 0   | 0  | 0  | -31.5 dB                      |

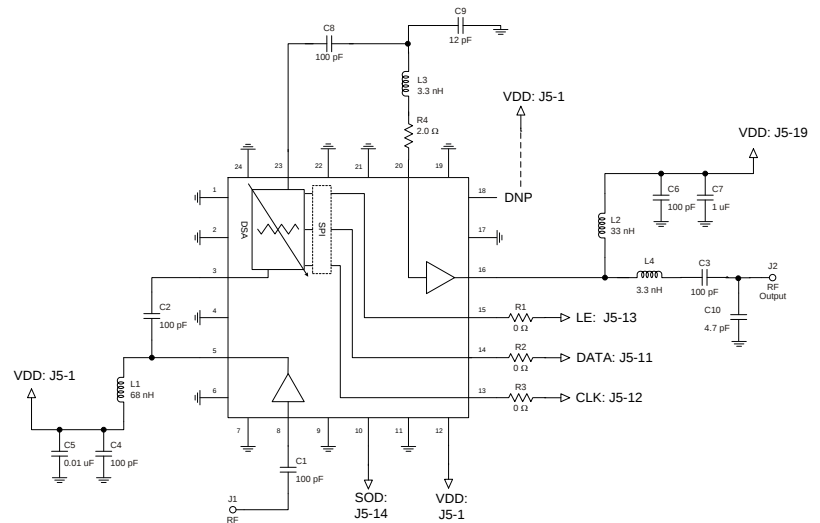
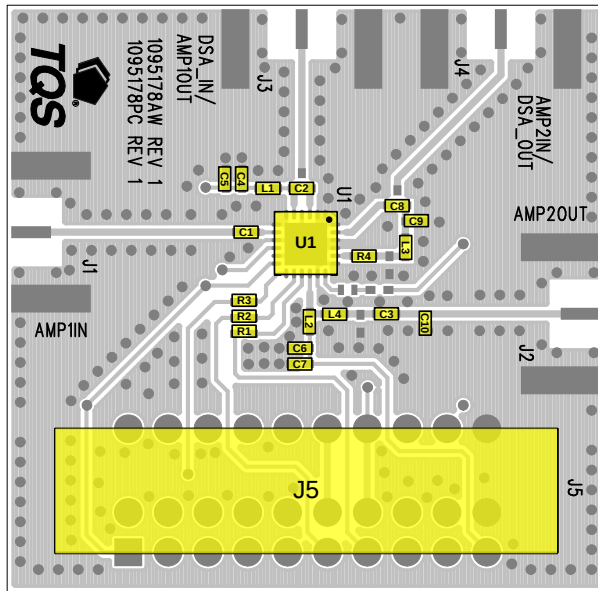
Any combination of the possible 64 states will provide a reduction in gain of approximately the sum of the bits selected.

### Timing Diagram

CLK is internally disabled when LE is high



## TQM879028 600 – 650 MHz Reference Design



TQM879028 – 600 to 750 MHz

### Notes:

1. See Evaluation Board PCB Information section for material and stack-up.
2. All components are of 0402 size.
3. Distance from the right edge of L2 to the left edge of C10: 250 mils

## Bill of Material 600 – 650 MHz Reference Design

| Reference Des.         | Value   | Description                        | Manuf.    | Part Number    |
|------------------------|---------|------------------------------------|-----------|----------------|
| U1                     | n/a     | ½ W DVGA                           | Qorvo     | TQM879028      |
| C1, C2, C3, C4, C6, C8 | 100 pF  | CAP, 0402, 5%, 50V. NPO/COG        | various   |                |
| C5                     | 0.01 uF | CAP, 0402, 10%, 16V, X7R           | various   |                |
| C10                    | 4.7 pF  | CAP, 0402, +/- 0.1PF. 50V. NPO/COG | various   |                |
| C7                     | 1 uF    | CAP, 0402, 10%, 10V, X5R           | various   |                |
| C9                     | 12 pF   | CAP, 0402, +/- 2% 50V. NPO/COG     | various   |                |
| L1                     | 68 nH   | IND, 0402, 5%, ceramic core        | Coilcraft | 0402CS-68NXJL  |
| L2                     | 33 nH   | IND, 0402, 5%, ceramic core        | Coilcraft | 0402CS-33NXJL  |
| L3, L4                 | 3.3 nH  | IND, 0402, CHIP                    | Toko      | LL1005-FHL3N3S |
| R4                     | 2.0 Ω   | RES, 0402, +/- 1%, 1/10W           | various   |                |
| R1, R2, R3             | 0 Ω     | RES, 0402, CHIP                    | various   |                |

## Typical Performance 600 – 650 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD} = +5V$ , Temp =  $+25^{\circ}C$ , DSA at max. gain setting

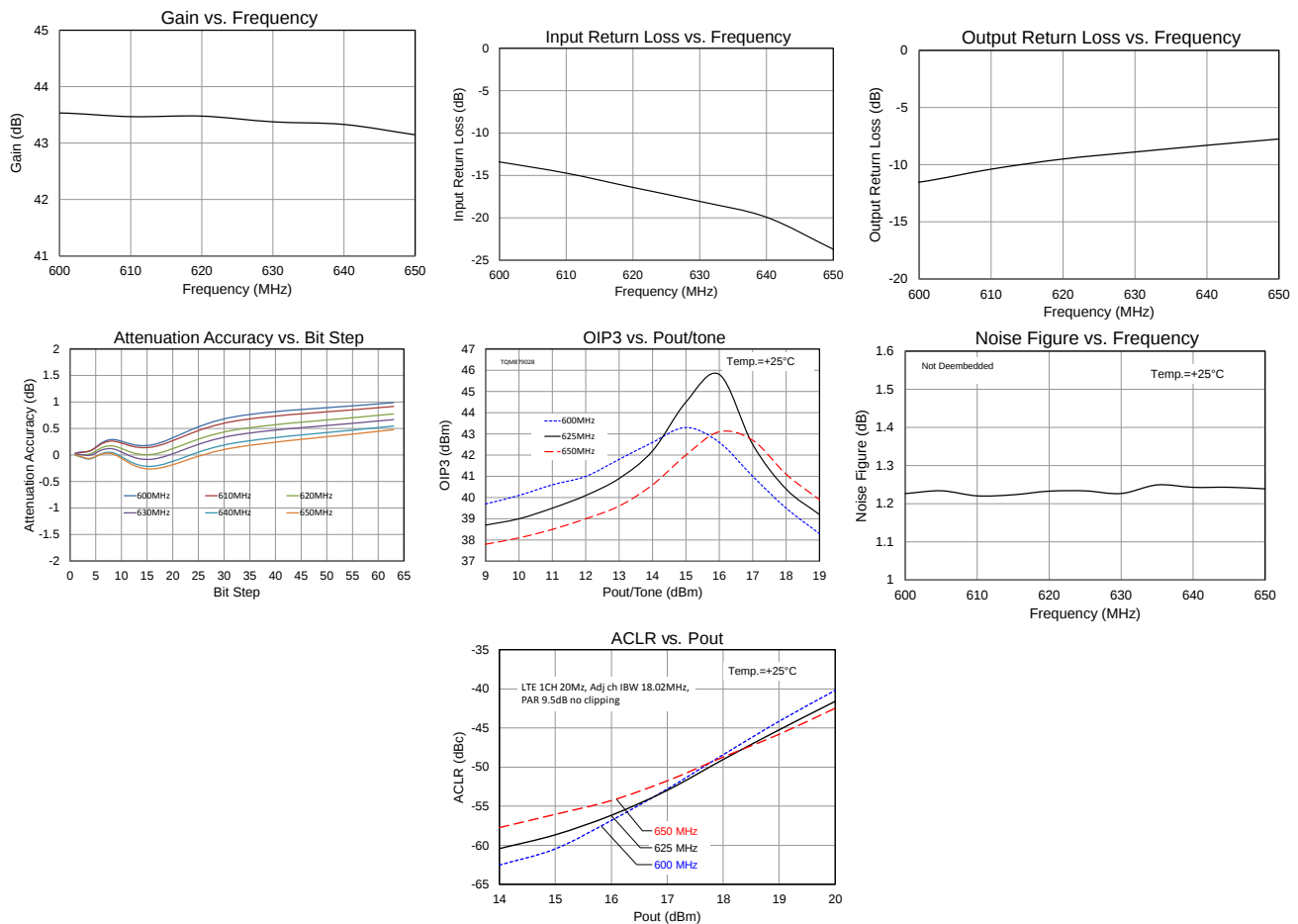
| Parameter                      | Conditions                              | Typical Values |       |       | Units |
|--------------------------------|-----------------------------------------|----------------|-------|-------|-------|
| Frequency                      |                                         | 600            | 625   | 650   | MHz   |
| Gain                           |                                         | 43.6           | 43.4  | 43.2  | dB    |
| Input Return Loss              |                                         | 13             | 17    | 20    | dB    |
| Output Return Loss             |                                         | 12             | 9     | 7     | dB    |
| Output P1dB                    |                                         | +26.6          | +27.1 | +27.4 | dBm   |
| Output IP3                     | Pout = +13 dBm/tone, $\Delta f = 1$ MHz | +41.8          | +41.0 | +39.5 | dBm   |
| LTE Chan. Power <sup>(1)</sup> | -50 dBc ACLR                            | +17.7          | +17.8 | +17.6 | dBm   |

Notes:

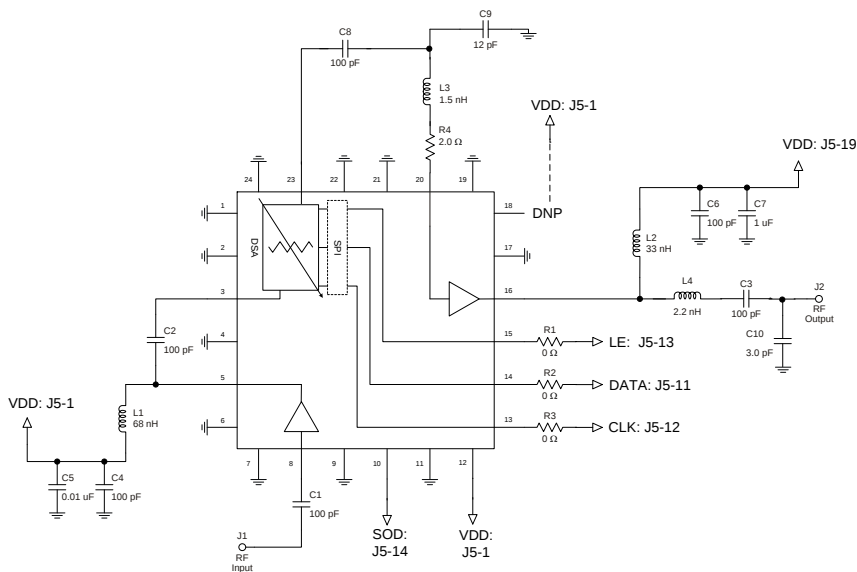
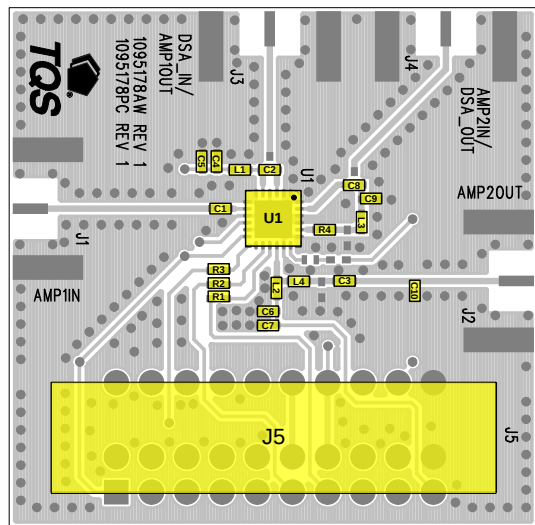
1. ACLR test set-up: 1 CH, 20 MHz BW, LTE E-TM1.1, 9.5 dB PAR at 0.01% Probability

## Performance Plots 600 – 650 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD} = +5V$ , Temp =  $+25^{\circ}C$ , DSA at max. gain setting



## TQM879028 700 – 800 MHz Reference Design



TQM879028 – 700 to 800 MHz

### Notes:

1. See Evaluation Board PCB Information section for PCB material and stack-up.
2. Components are 0402 unless specified otherwise
3. 0 Ohm resistors may be replaced with 50 Ohm traces in the target application layout.
4. Critical component placement:
  - a. Distance from the right edge of L2 to the left edge of C10: 470 mils

## Bill of Material 700 – 800 MHz Reference Design

| Reference Des.         | Value   | Description                             | Manuf.  | Part Number |
|------------------------|---------|-----------------------------------------|---------|-------------|
| n/a                    | n/a     | Printed Circuit Board                   | Qorvo   |             |
| U1                     | n/a     | TQM879028 Sample                        | Qorvo   | TQM879028   |
| L1                     | 68 nH   | Ind, 0402, 5%                           | various |             |
| L2                     | 33 nH   | Ind, 0402, 5%                           | various |             |
| L3                     | 1.5 nH  | Ind, 0402, 5%                           | various |             |
| L4                     | 2.2 nH  | Ind, 0402, 5%                           | various |             |
| R1, R2, R3             | 0 Ω     | RES, 0402, CHIP                         | various |             |
| R4                     | 2.0 Ω   | RES, 0402, 5%, 1/16W, CHIP              | various |             |
| C9                     | 12 pF   | CAP, 0402, 2%, 50V, NPO/COG             | various |             |
| C10                    | 3.0 pF  | CAP, 0402, +/-0.1, 50V, NPO/COG         | various |             |
| C1, C2, C3, C4, C6, C8 | 100 pF  | CAP, 0402, 5%, 50V, NPO/COG             | various |             |
| C5                     | 0.01 uF | CAP, 0402, 10%, 16V, X7R                | various |             |
| C7                     | 1 uF    | CAP, 0402, 10%, 10V, X5R                | various |             |
| J5                     | n/a     | Conn, Receptacle, 20POS., 100RT/A, DUAL | Tyco    | 5-532956-3  |

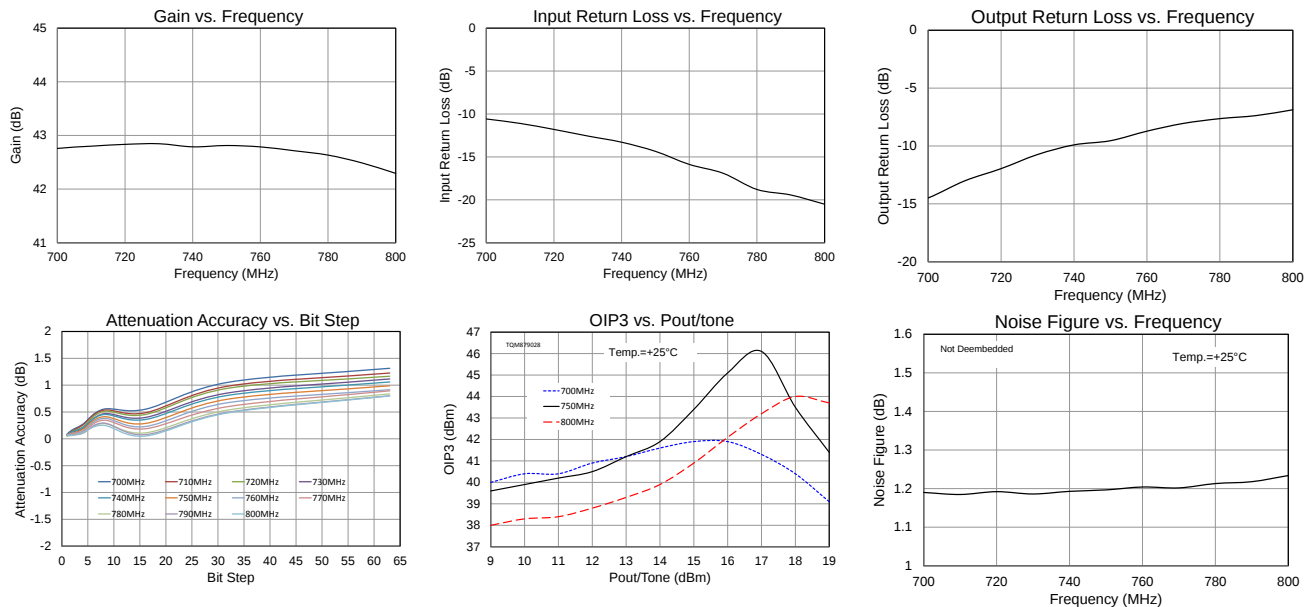
## Typical Performance 700 – 800 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp=+25°C, maximum gain state

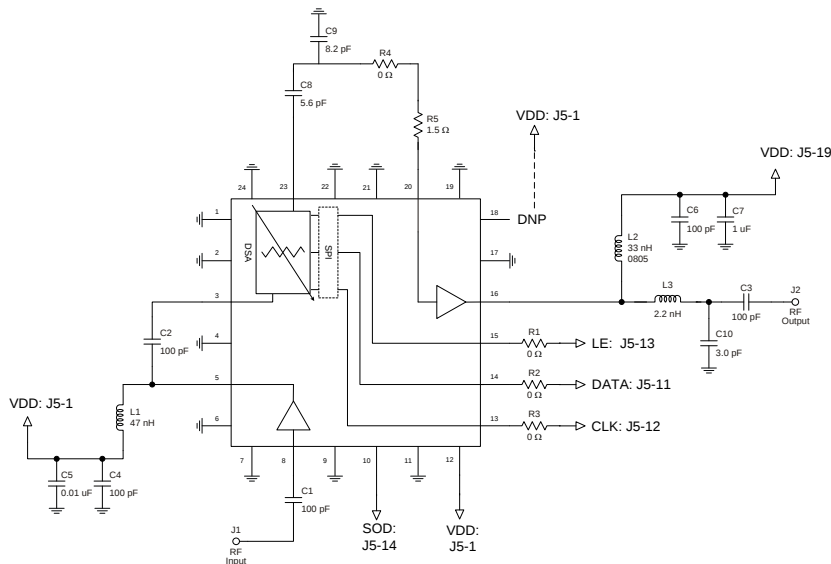
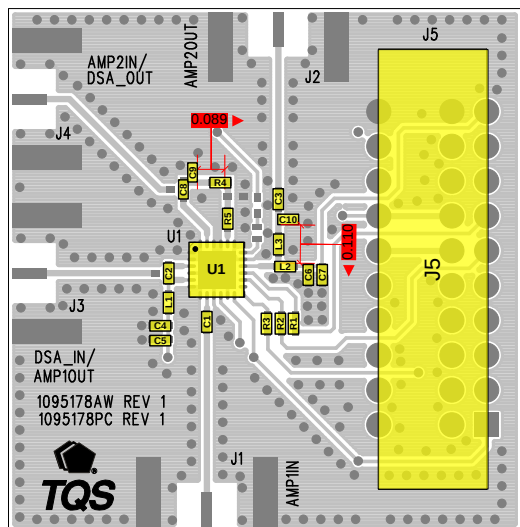
| Parameter            | Conditions                                 | Typical Value |       |       | Units |
|----------------------|--------------------------------------------|---------------|-------|-------|-------|
| Frequency            |                                            | 700           | 750   | 800   | MHz   |
| Gain                 |                                            | 42.8          | 42.7  | 42.3  | dB    |
| Gain Control Range   |                                            | 30.2          | 30.5  | 30.7  | dB    |
| Input Return Loss    |                                            | 11            | 14    | 20    | dB    |
| Output Return Loss   |                                            | 14            | 9     | 7     | dB    |
| Output P1dB          |                                            | +26.6         | +27.0 | +27.3 | dBm   |
| Output IP3           | $P_{out}= +13$ dBm/tone, $\Delta f= 1$ MHz | +41.2         | +41.2 | +39.3 | dBm   |
| Noise Figure         |                                            | 1.2           | 1.2   | 1.2   | dB    |
| Total Device Current |                                            | 230           |       |       | mA    |

## Performance Plots 700 – 800 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp=+25°C, maximum gain state



## TQM879028 869 – 960 MHz Reference Design



### Notes:

5. See Evaluation Board PCB Information section for PCB material and stack-up.
6. Components are 0402 unless specified otherwise
7. 0 Ohm resistors may be replaced with 50 Ohm traces in the target application layout.
8. Critical component placement:
  - b. Distance from the edge of L2 to the edge of C10: 110 mils
  - c. Distance from the edge of Tx line to the edge of C9: 130 mils

## Bill of Material 869 – 960 MHz Reference Design

| Reference Des.     | Value        | Description                             | Manuf.  | Part Number    |
|--------------------|--------------|-----------------------------------------|---------|----------------|
| N/A                | N/A          | Printed Circuit Board                   | Qorvo   | 1095178        |
| U1                 | N/A          | Variable Gain Amplifier                 | Qorvo   | TQM879028      |
| L1                 | 47 nH        | IND, 0402, 5%                           | various |                |
| L2                 | 33 nH        | IND, 0402, 5%                           | various |                |
| L3                 | 2.2 nH       | IND, 0402, 5%, 0.8 GHz                  | various |                |
| R1, R2, R3, R4     | 0 $\Omega$   | RES, 0402, CHIP                         | various |                |
| R5                 | 1.5 $\Omega$ | RES, 0402, 1%, 1/16W, CHIP              | various |                |
| C10                | 3.0 pF       | CAP, 0402, $\pm 0.1$ pF, 50V, U-Series  | AVX     | 04025U3R0BAT2A |
| C8                 | 5.6 pF       | CAP, 0402, $\pm 0.1$ pF, 50V, U-Series  | AVX     | 04025U5R6BAT2A |
| C9                 | 8.2 pF       | CAP, 0402, $\pm 0.1$ pF, 50V, U-Series  | AVX     | 04025U8R2BAT2A |
| C1, C2, C3, C4, C6 | 100 pF       | CAP, 0402, 5%, 50V, NPO/COG             | various |                |
| C5                 | 0.01 uF      | CAP, 0402, 10%, 16V, X7R                | various |                |
| C7                 | 1 uF         | CAP, 0402, 10%, 10V, X5R                | various |                |
| J5                 | n/a          | Conn, Receptacle, 20POS., 100RT/A, Dual | Tyco    | 5-532956-3     |

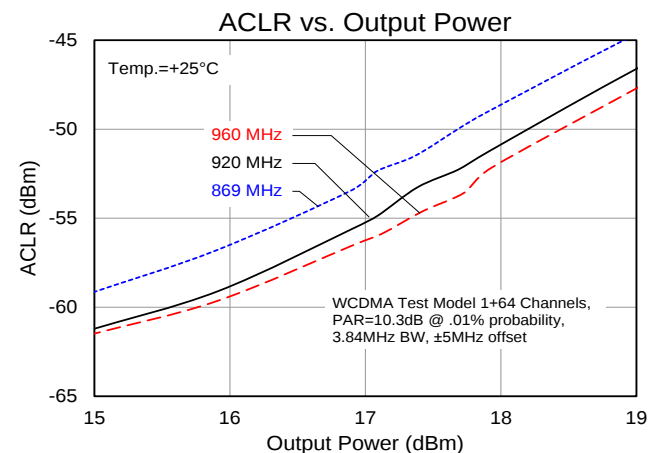
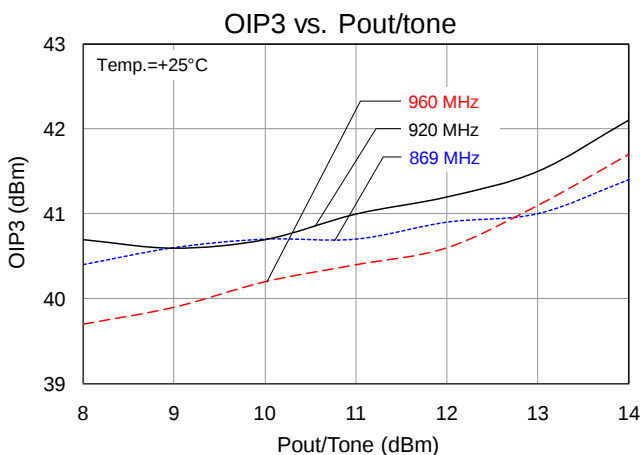
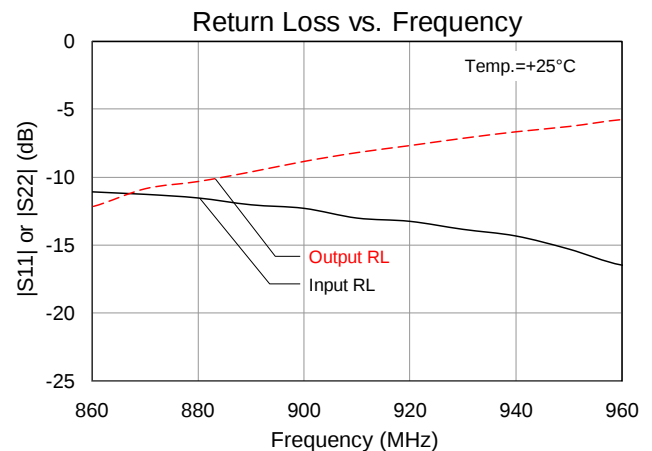
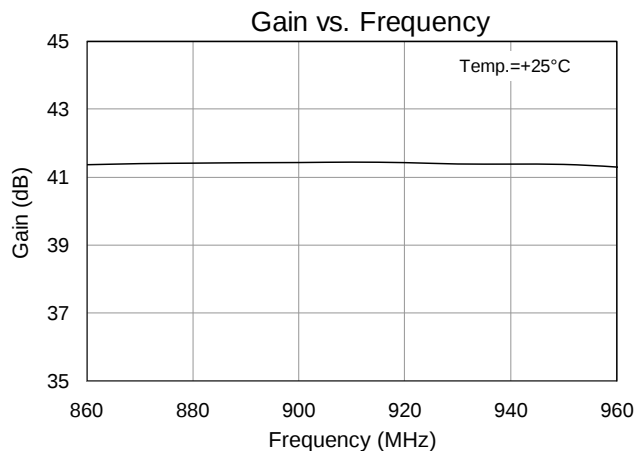
## Typical Performance 869 – 960 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp= $+25^{\circ}\text{C}$ , maximum gain state

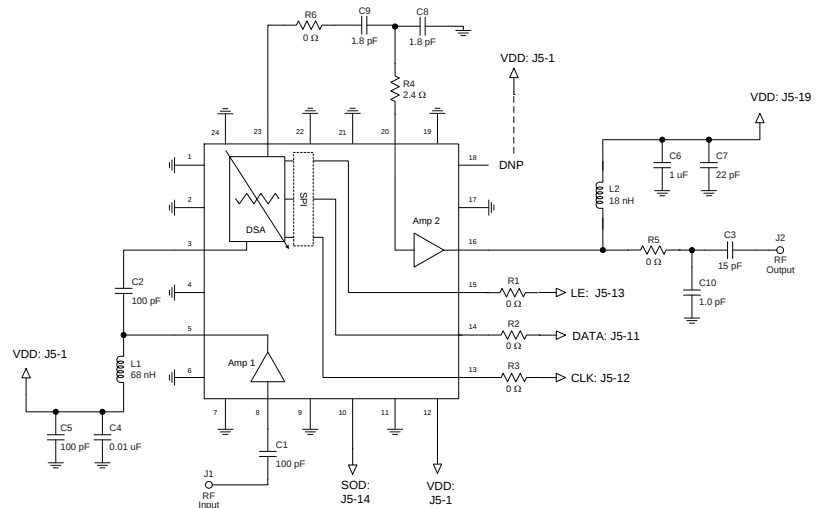
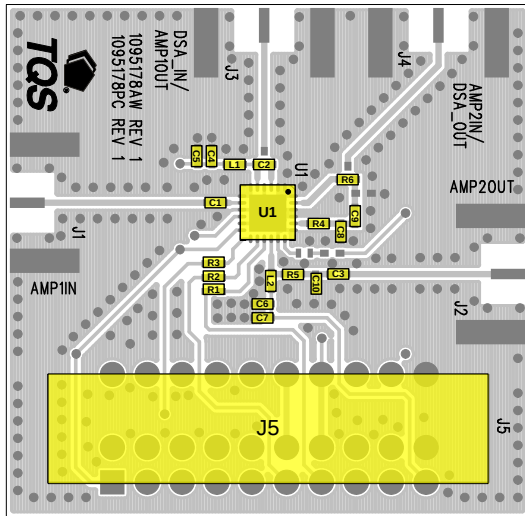
| Parameter          | Conditions                                   | Typical Value |       |       | Units |
|--------------------|----------------------------------------------|---------------|-------|-------|-------|
| Frequency          |                                              | 869           | 915   | 960   | MHz   |
| Gain               |                                              | 41.4          | 41.4  | 41.3  | dB    |
| Input Return Loss  |                                              | 11.2          | 13.1  | 16.2  | dB    |
| Output Return Loss |                                              | 10.8          | 7.9   | 5.8   | dB    |
| Output P1dB        |                                              | +26.8         | +27.3 | +27.6 | dBm   |
| Output IP3         | $P_{out} = +11$ dBm/tone, $\Delta f = 1$ MHz | +40.7         | +41.0 | +40.4 | dBm   |

## Performance Plots 869 – 960 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp= $+25^{\circ}\text{C}$ , maximum gain state



## TQM879028 1805 – 1880 MHz Reference Design



TQM879028 – 1805-1880 MHz

### Notes:

1. See Evaluation Board PCB Information section for PCB material and stack-up.
2. Components are 0402 unless specified otherwise
3. 0 Ohm resistors may be replaced with 50 Ohm traces in the target application layout.

## Bill of Material 1805 – 1880 MHz Reference Design

| Reference Des.     | Value        | Description                                 | Manuf.  | Part Number    |
|--------------------|--------------|---------------------------------------------|---------|----------------|
| n/a                | n/a          | Printed Circuit Board                       | Qorvo   | 1095178        |
| U1                 | n/a          | TQM879028 Sample                            | Qorvo   | TQM879028      |
| L1                 | 68 nH        | Ind, 0402, 5%                               | various |                |
| L2                 | 18 nH        | Ind, 0402, 5%                               | various |                |
| R1, R2, R3, R5, R6 | 0 $\Omega$   | RES, 0402, CHIP                             | various |                |
| R4                 | 2.4 $\Omega$ | RES, 0402, 5%, 1/16W, CHIP                  | various |                |
| C1, C2, C5         | 100 pF       | CAP, 0402, 5%, 50V, NPO/COG                 | various |                |
| C10                | 1.0 pF       | CAP, 0402, $\pm 0.1$ pF, 50V, NPO, U-Series | AVX     | 04025U1R0BAT2A |
| C3                 | 15 pF        | CAP, 0402, 5%, 50V, NPO/COG                 | various |                |
| C8, C9             | 1.8 pF       | CAP, 0402, $\pm 0.1$ pF, 50V, NPO, U-Series | AVX     | 04025U1R8BAT2A |
| C7                 | 22 pF        | CAP, 0402, 5%, 50V, NPO/COG                 | various |                |
| C4                 | 0.01 uF      | CAP, 0402, 10%, 16V, X7R                    | various |                |
| C6                 | 1 uF         | CAP, 0402, 10%, 10V, X5R                    | various |                |

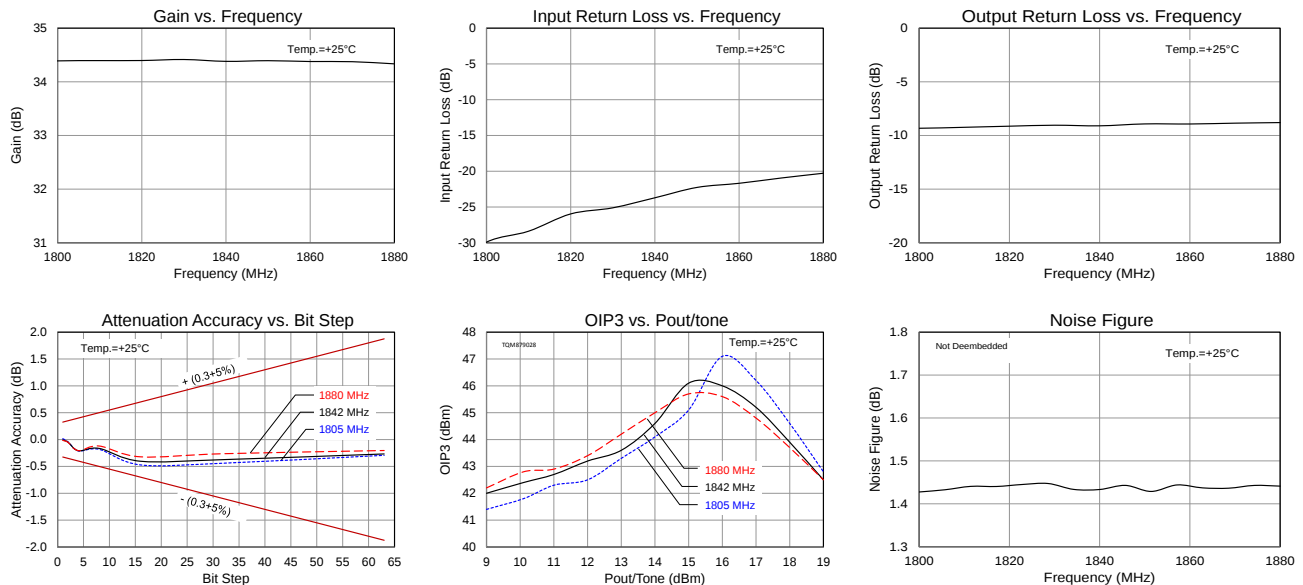
## Typical Performance 1805 – 1880 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp= $+25^{\circ}\text{C}$ , maximum gain state

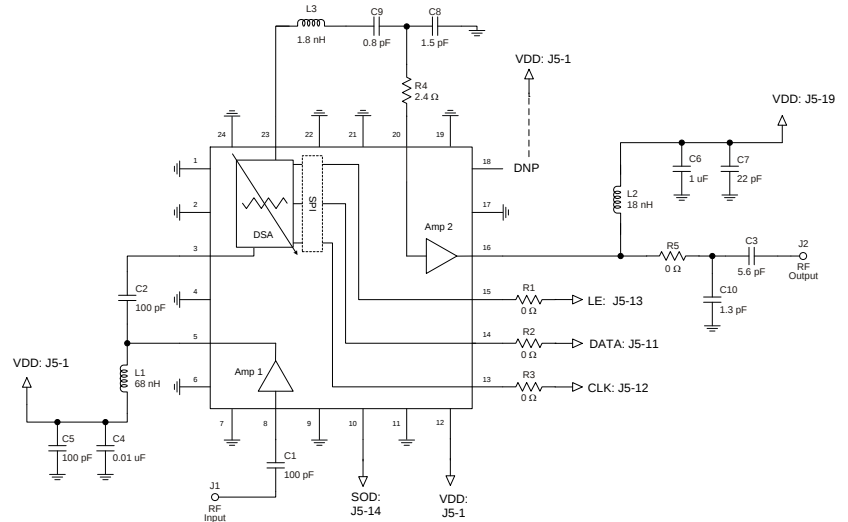
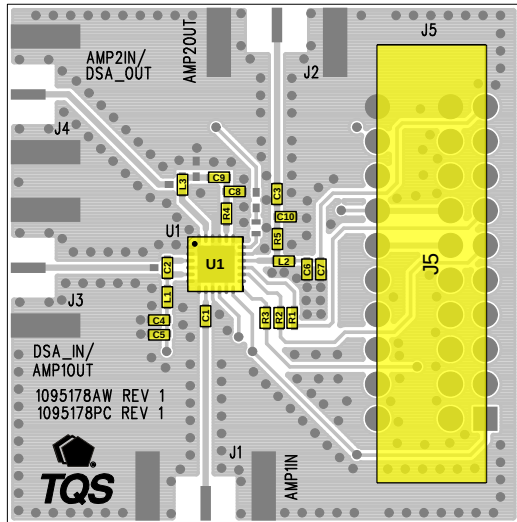
| Parameter            | Conditions                                             | Typical Value |       |       | Units |
|----------------------|--------------------------------------------------------|---------------|-------|-------|-------|
| Frequency            |                                                        | 1805          | 1842  | 1880  | MHz   |
| Gain                 |                                                        | 34.3          | 34.3  | 34.3  | dB    |
| Gain Control Range   |                                                        | 32.2          | 32.1  | 32.0  | dB    |
| Input Return Loss    |                                                        | 20            | 20    | 20    | dB    |
| Output Return Loss   |                                                        | 9             | 9     | 9     | dB    |
| Output P1dB          |                                                        | +27.6         | +27.6 | +27.6 | dBm   |
| Output IP3           | $P_{out}=+11\text{dBm}/\text{tone}$ , $\Delta f=1$ MHz | +42.3         | +42.8 | +42.9 | dBm   |
| Noise Figure         |                                                        | 1.4           | 1.4   | 1.4   | dB    |
| Total Device Current |                                                        | 230           |       |       | mA    |

## Performance Plots 1805 – 1880 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp= $+25^{\circ}\text{C}$ , maximum gain state



## TQM879028-PCB2140 Evaluation Board



### Notes:

1. See Evaluation Board PCB Information section for PCB material and stack-up.
2. Components are 0402 unless specified otherwise
3. 0 Ohm resistors may be replaced with 50 Ohm traces in the target application layout.

## Bill of Material – TQM879028-PCB2140

| Reference Des. | Value        | Description                             | Manuf.  | Part Number    |
|----------------|--------------|-----------------------------------------|---------|----------------|
| N/A            | N/A          | Printed Circuit Board                   | Qorvo   | 1095178        |
| U1             | N/A          | Variable Gain Amplifier                 | Qorvo   | TQM879028      |
| L1             | 68 nH        | Inductor, 0402                          | various |                |
| L2             | 18 nH        | Inductor, 0402                          | various |                |
| L3             | 1.8 nH       | Inductor, 0402                          | various |                |
| R1, R2, R3, R5 | 0 $\Omega$   | Resistor, 0402                          | various |                |
| R4             | 2.4 $\Omega$ | Resistor, 0402                          | various |                |
| C1,C2,C5       | 100 pF       | Capacitor, 0402                         | various |                |
| C3             | 5.6 pF       | Capacitor, 0402                         | various |                |
| C9             | 0.8 pF       | CAP, 0402, $\pm 0.1$ pF, 50V, U-Series  | AVX     | 04025U0R8BAT2A |
| C10            | 1.3 pF       | CAP, 0402, $\pm 0.1$ pF, 50V, U-Series  | AVX     | 04025U1R3BAT2A |
| C8             | 1.5 pF       | CAP, 0402, $\pm 0.1$ pF, 50V, U-Series  | AVX     | 04025U1R5BAT2A |
| C7             | 22 pF        | Capacitor, 0402                         | various |                |
| C4             | 0.01 $\mu$ F | Capacitor, 0402                         | various |                |
| C6             | 1 $\mu$ F    | Capacitor, 0402                         | various |                |
| J5             | n/a          | Conn, Receptacle, 20POS., 100RT/A, Dual | Tyco    | 5-532956-3     |

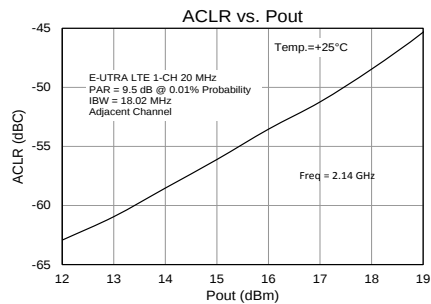
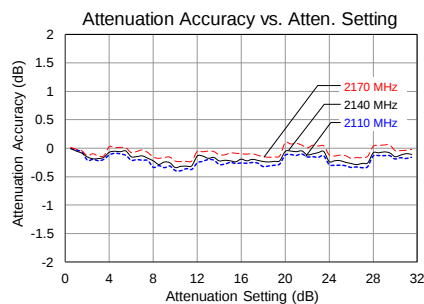
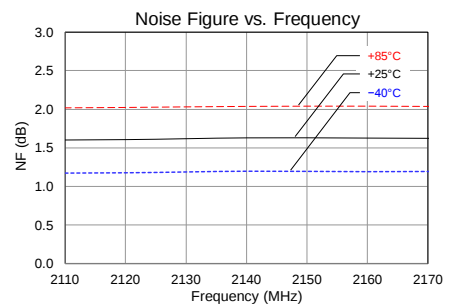
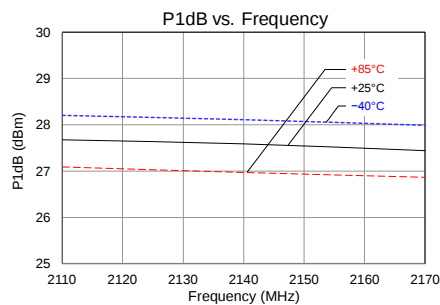
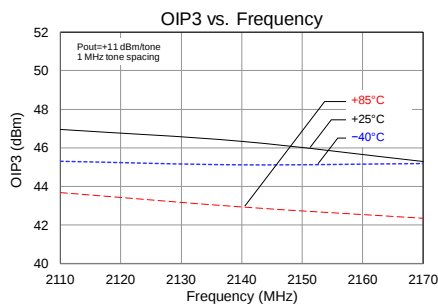
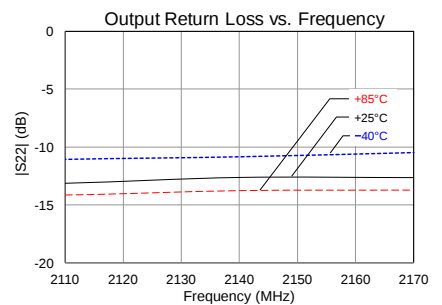
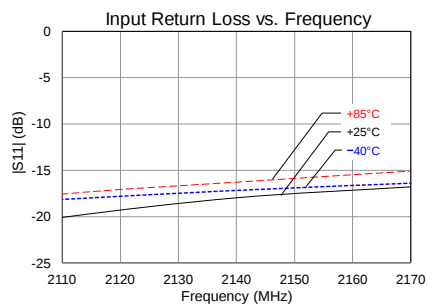
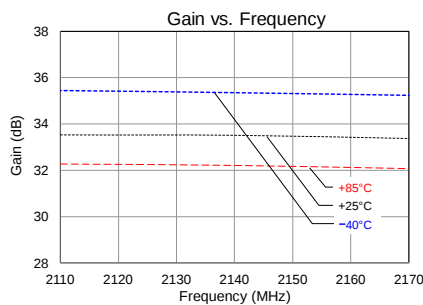
## Typical Performance – TQM879028-PCB2140

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp=+25°C, maximum gain state

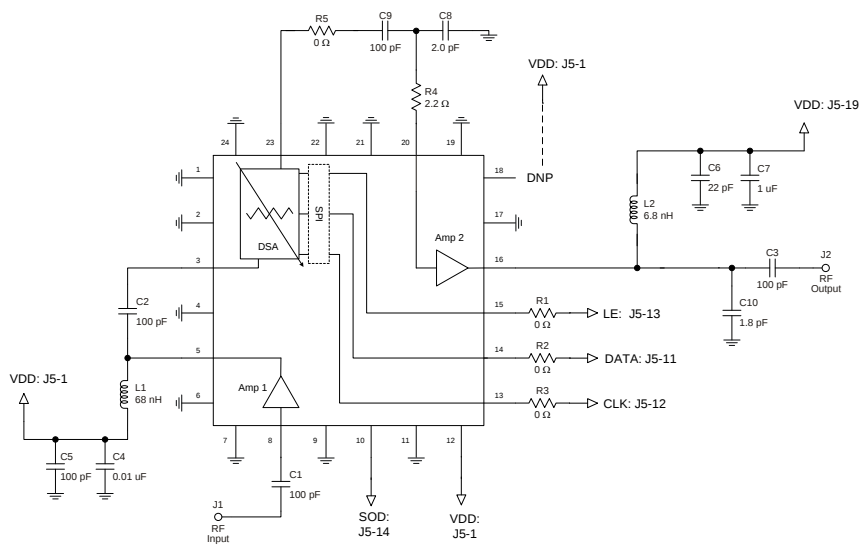
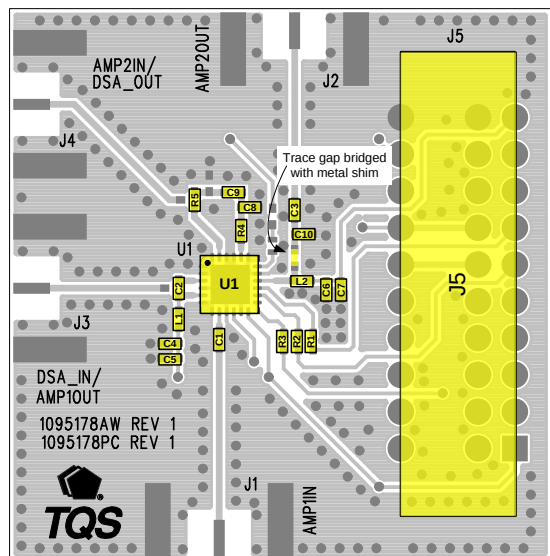
| Parameter          | Conditions                                   | Typical Value |       |       | Units |
|--------------------|----------------------------------------------|---------------|-------|-------|-------|
| Frequency          |                                              | 2110          | 2140  | 2170  | MHz   |
| Gain               |                                              | 32            | 32    | 32    | dB    |
| Input Return Loss  |                                              | 20.1          | 18.0  | 16.8  | dB    |
| Output Return Loss |                                              | 13.1          | 12.6  | 12.6  | dB    |
| Output P1dB        |                                              | +27.7         | +27.6 | +27.4 | dBm   |
| Output IP3         | $P_{out} = +11$ dBm/tone, $\Delta f = 1$ MHz | +45           | +44   | +43   | dBm   |
| Noise figure       |                                              | 1.6           | 1.6   | 1.6   | dB    |

## Performance Plots – TQM879028-PCB2140

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp=+25 °C, maximum gain state



## TQM879028 1800 – 2200 MHz Reference Design



### Notes:

- Notes:
- See Evaluation Board PCB Information section for PCB material and stack-up.
- Components are 0402 unless specified otherwise
- 0 Ohm resistors may be replaced with 50 Ohm traces in the target application layout.

## Bill of Material – 1800 – 2200 MHz Reference Design

| Reference Des.     | Value        | Description                             | Manuf.  | Part Number |
|--------------------|--------------|-----------------------------------------|---------|-------------|
| N/A                | N/A          | Printed Circuit Board                   | Qorvo   | 1095178     |
| U1                 | N/A          | Variable Gain Amplifier                 | Qorvo   | TQM879028   |
| L1                 | 68 nH        | Inductor, 0402                          | various |             |
| L2                 | 6.8 nH       | Inductor, 0402                          | various |             |
| R1, R2, R3, R5     | 0 $\Omega$   | Resistor, 0402                          | various |             |
| R4                 | 2.2 $\Omega$ | Resistor, 0402                          | various |             |
| C1, C2, C3, C5, C9 | 100 pF       | Capacitor, 0402                         | various |             |
| C10                | 1.8 pF       | Capacitor, 0402                         | various |             |
| C8                 | 2.0 pF       | Capacitor, 0402                         | various |             |
| C6                 | 22 pF        | Capacitor, 0402                         | various |             |
| C4                 | 0.01 $\mu$ F | Capacitor, 0402                         | various |             |
| C7                 | 1 $\mu$ F    | Capacitor, 0402                         | various |             |
| J5                 | n/a          | Conn, Receptacle, 20POS., 100RT/A, Dual | Tyco    | 5-532956-3  |

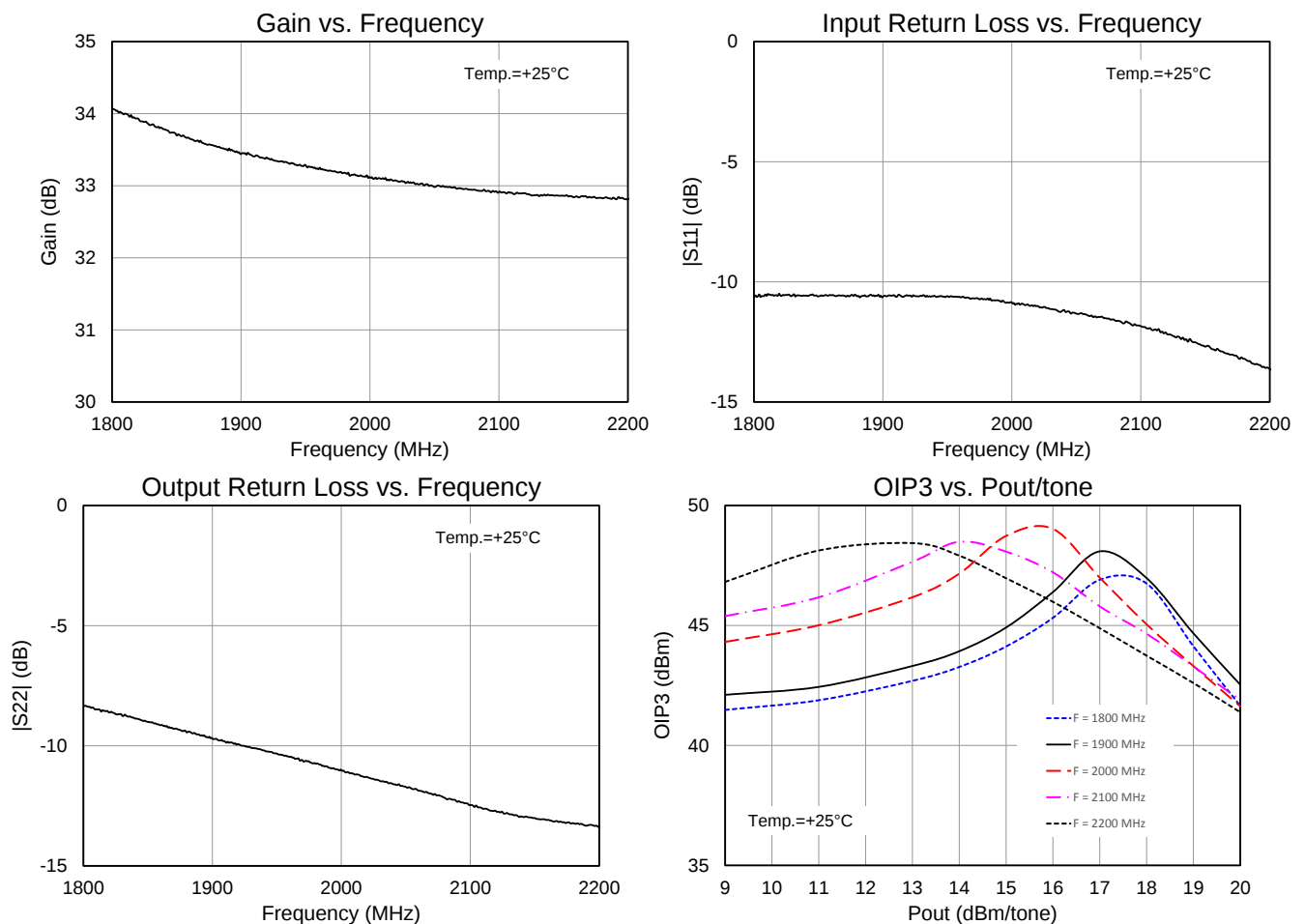
## Typical Performance 1800 – 2200 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp= $+25^{\circ}\text{C}$ , maximum gain state

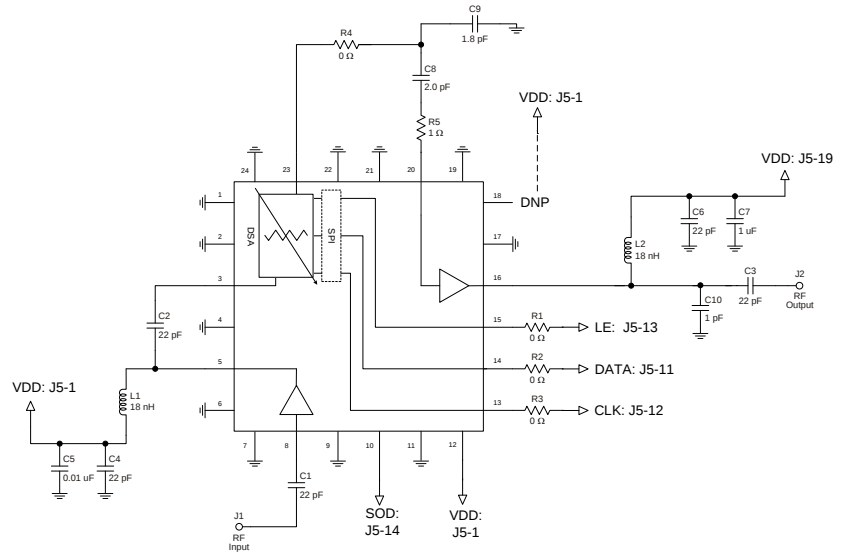
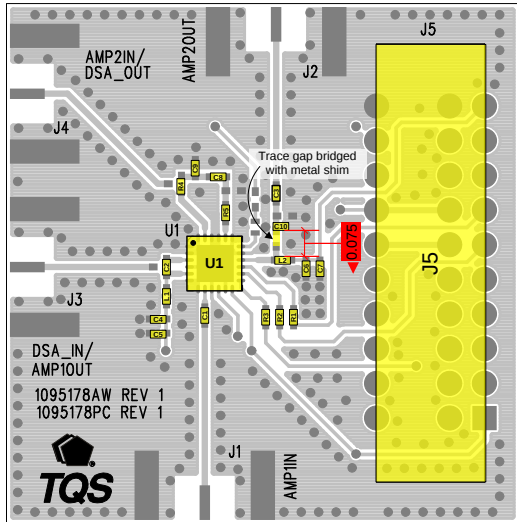
| Parameter          | Conditions                                   | Typical Value |       |       | Units |
|--------------------|----------------------------------------------|---------------|-------|-------|-------|
| Frequency          |                                              | 1800          | 2000  | 2200  | MHz   |
| Gain               |                                              | 34.1          | 33.1  | 32.8  | dB    |
| Input Return Loss  |                                              | 10.6          | 10.9  | 13.6  | dB    |
| Output Return Loss |                                              | 8.4           | 11.0  | 13.4  | dB    |
| Output P1dB        |                                              | +27.7         | +27.7 | +27.7 | dBm   |
| Output IP3         | $P_{out} = +12$ dBm/tone, $\Delta f = 1$ MHz | +42.7         | +46.2 | +48.4 | dBm   |

## Performance Plots 1800 – 2200 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp= $+25^{\circ}\text{C}$ , maximum gain state



## TQM879028 2500 – 2700 MHz Reference Design



### Notes:

- Notes:
- See Evaluation Board PCB Information section for PCB material and stack-up.
- Components are 0402 unless specified otherwise
- 0 Ohm resistors may be replaced with 50 Ohm traces in the target application layout.
- Critical component placement: Distance from the edge of L2 to the edge of C10: 75 mils (9.2 °at 2600 MHz)

## Bill of Material 2500 – 2700 MHz Reference Design

| Reference Des.     | Value      | Description                                 | Manuf.  | Part Number    |
|--------------------|------------|---------------------------------------------|---------|----------------|
| N/A                | N/A        | Printed Circuit Board                       | Qorvo   | 1095178        |
| U1                 | N/A        | Variable Gain Amplifier                     | Qorvo   | TQM879028      |
| L1, L2             | 18 nH      | Ind, 0402, 5%                               | various |                |
| R1, R2, R3, R4     | 0 $\Omega$ | RES, 0402, CHIP                             | various |                |
| R5                 | 1 $\Omega$ | RES, 0402, 5%, 1/16W, CHIP                  | various |                |
| C10                | 1 pF       | CAP, 0402, $\pm 0.1$ pF, 50V, NPO, U-Series | AVX     | 04025U1R0BAT2A |
| C9                 | 1.8 pF     | CAP, 0402, $\pm 0.1$ pF, 50V, NPO, U-Series | AVX     | 04025U1R8BAT2A |
| C8                 | 2 pF       | CAP, 0402, $\pm 0.1$ pF, 50V, NPO, U-Series | AVX     | 04025U2R0BAT2A |
| C1, C2, C3, C4, C6 | 22 pF      | CAP, 0402, 5%, 50V, NPO/COG                 | various |                |
| C5                 | 0.01 uF    | CAP, 0402, 10%, 16V, X7R                    | various |                |
| C7                 | 1 uF       | CAP, 0402, 10%, 10V, X5R                    | various |                |
| J5                 | n/a        | Conn, Receptacle, 20POS., 100RT/A, DUAL     | Tyco    | 5-532956-3     |

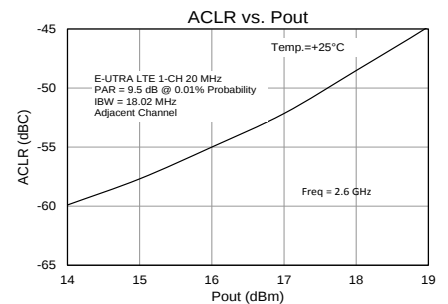
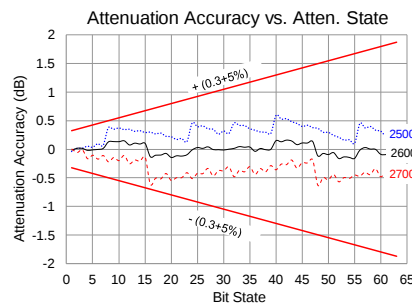
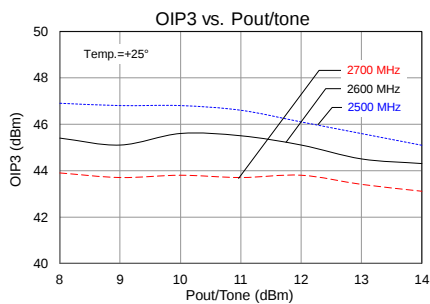
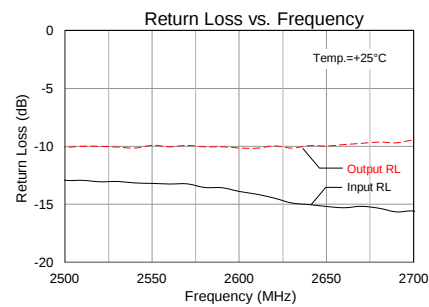
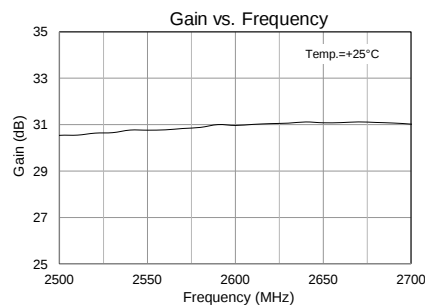
## Typical Performance 2500 – 2700 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp=+25 °C, maximum gain state

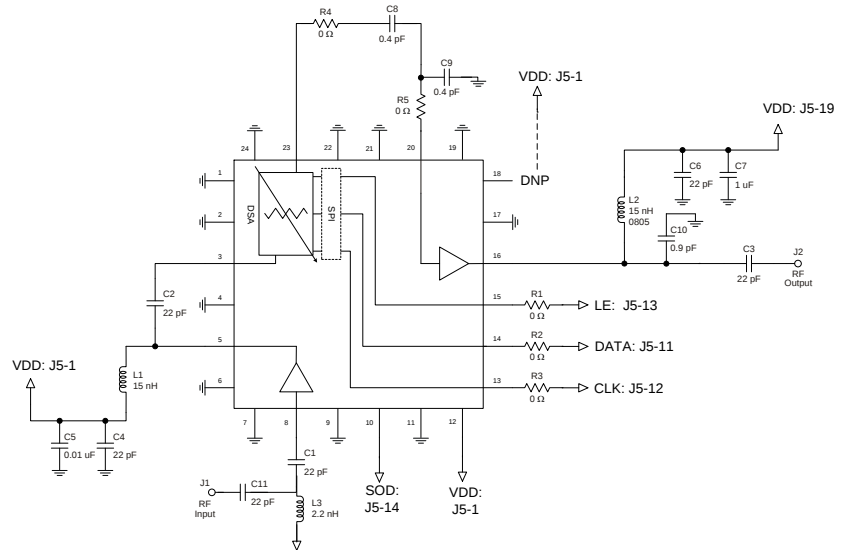
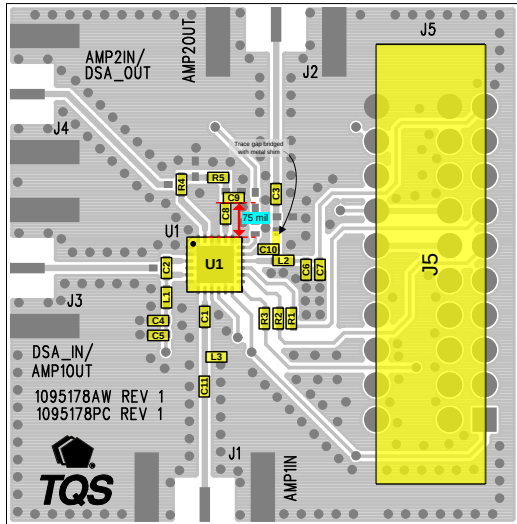
| Parameter          | Conditions                              | Typical Value |       |       | Units |
|--------------------|-----------------------------------------|---------------|-------|-------|-------|
| Frequency          |                                         | 2500          | 2600  | 2700  | MHz   |
| Gain               |                                         | 30.5          | 30.9  | 31.0  | dB    |
| Input Return Loss  |                                         | 12.9          | 13.8  | 15.7  | dB    |
| Output Return Loss |                                         | 10.2          | 10.3  | 9.7   | dB    |
| Output P1dB        |                                         | +27.9         | +27.8 | +27.5 | dBm   |
| Output IP3         | Pout = +11 dBm/tone, $\Delta f = 1$ MHz | +46.5         | +45.5 | +44   | dBm   |

## Performance Plots 2500 – 2700 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp=+25 °C, maximum gain state



## TQM879028 3400 – 3600 MHz Reference Design



### Notes:

1. See Evaluation Board PCB Information section for PCB material and stack-up.
2. Components are 0402 unless specified otherwise
3. 0 Ohm resistors may be replaced with 50 Ohm traces in the target application layout.
4. Critical component placement:
  - a. Distance between U1 to L3 (right edge): 145 mils
  - b. Distance between U1 to C11 (right edge): 205 mils

## Bill of Material 3400 – 3600 MHz Reference Design

| Reference Des.          | Value        | Description                                 | Manuf.  | Part Number    |
|-------------------------|--------------|---------------------------------------------|---------|----------------|
| N/A                     | N/A          | Printed Circuit Board                       | Qorvo   | 1095178        |
| U1                      | N/A          | Variable Gain Amplifier                     | Qorvo   | TQM879028      |
| L1, L2                  | 15 nH        | Ind, 0402, 5%                               | various |                |
| R1, R2, R3, R4, R5      | 0 $\Omega$   | RES, 0402, CHIP                             | various |                |
| L3                      | 2.2 nH       | Ind, 0402, 5%, CHIP                         | various |                |
| C10                     | 0.9 pF       | CAP, 0402, $\pm 0.1$ pF, 50V, NPO, U-Series | AVX     | 04025U0R9BAT2A |
| C8, C9                  | 0.4 pF       | CAP, 0402, $\pm 0.1$ pF, 50V, NPO, U-Series | AVX     | 04025U0R4BAT2A |
| C1, C2, C3, C4, C6, C11 | 22 pF        | CAP, 0402, 5%, 50V, NPO/COG                 | various |                |
| C5                      | 0.01 $\mu$ F | CAP, 0402, 10%, 16V, X7R                    | various |                |
| C7                      | 1 $\mu$ F    | CAP, 0402, 10%, 10V, X5R                    | various |                |
| J5                      | n/a          | Conn, Receptacle, 20POS., 100RT/A, Dual     | Tyco    | 5-532956-3     |

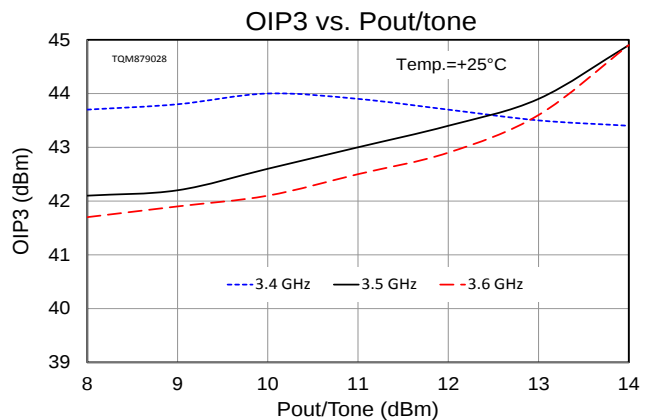
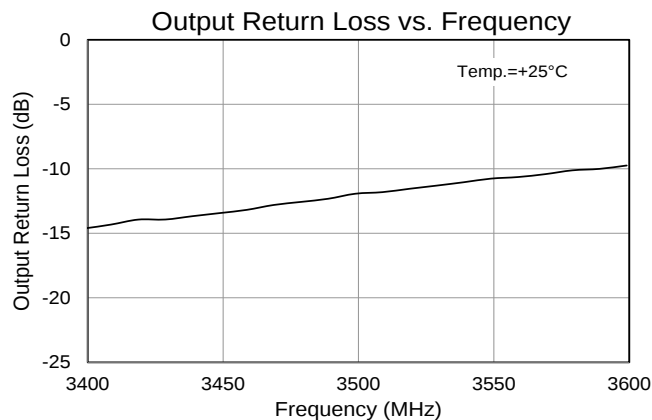
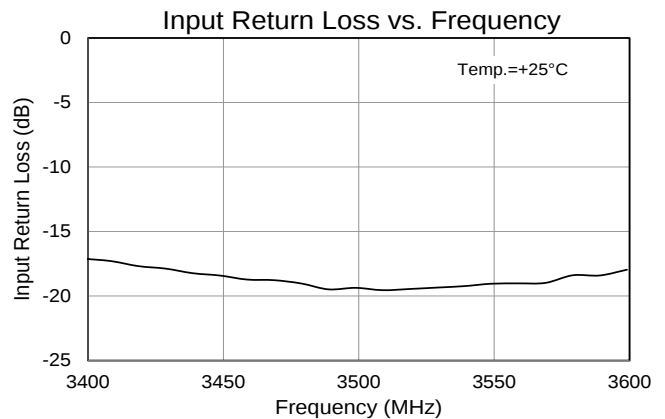
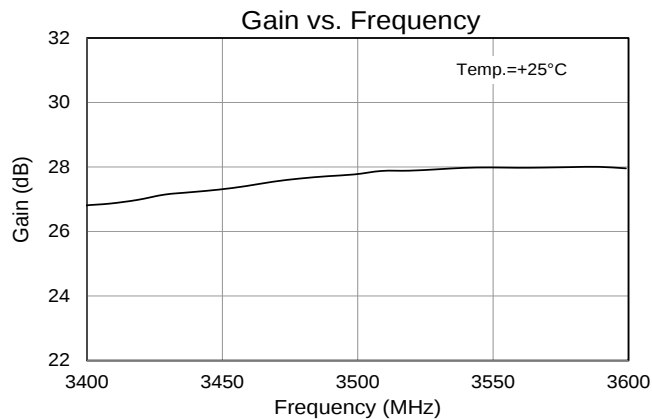
## Typical Performance 3400 – 3600 MHz Reference Design

Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp.=+25°C, maximum gain state

| Parameter          | Conditions                           | Typical Value |       |       | Units |
|--------------------|--------------------------------------|---------------|-------|-------|-------|
| Frequency          |                                      | 3400          | 3500  | 3600  | MHz   |
| Gain               |                                      | 26.9          | 27.9  | 28.0  | dB    |
| Input Return Loss  |                                      | 16            | 19    | 17    | dB    |
| Output Return Loss |                                      | 14            | 12    | 10    | dB    |
| Output P1dB        |                                      | +26.3         | +26.7 | +26.6 | dBm   |
| Output IP3         | Pout= +11 dBm/tone, $\Delta f=1$ MHz | +42.5         | +43   | +44   | dBm   |

## Performance Plots 3400 – 3600 MHz Reference Design

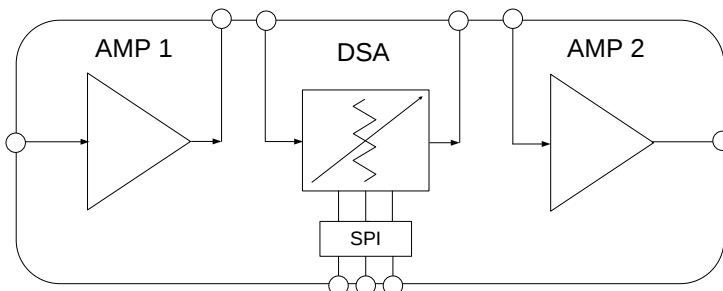
Test conditions unless otherwise noted:  $V_{DD}=+5$  V,  $I_{DD}=230$  mA (typ.), Temp.=+25°C, maximum gain state



## Detailed Device Description

The TQM879028 is a digital variable gain amplifier (DVGA) featuring high linearity over the entire gain control range. The amplifier module features the integration of a 50  $\Omega$  internally matched high linearity low noise amplifier gain block, a digital step attenuator (DSA), along with a high linearity  $\frac{1}{2}$ W amplifier as shown in the functional diagram below. The DVGA has an operational frequency range from 0.7 – 4.0 GHz. The three stages are individually accessible via package I/O contacts. This permits full flexibility to insert other components or filters between the stages.

### Functional Schematic Diagram



#### AMP1

AMP1 is a high linearity low noise amplifier. The amplifier has high gain across a broad range of frequencies while also providing very low noise. It is internally matched and only requires an external RF choke and blocking/bypass capacitors for operation from a single +5V supply. The internal active bias circuit also enables stable operation over bias and temperature variations. At 1.9 GHz, the amplifier typically provides 19.8 dB gain, +36 dBm OIP3, and 1.3 dB Noise Figure while only drawing 85 mA of current.

#### DSA (Digital Step Attenuator)

The DSA is a high linearity, low insertion loss, 6-bit, 31.5 dB Digital Step Attenuator (DSA) operating over the 700 - 4000 MHz frequency range. The digital step attenuator uses a single positive 5V supply and has a serial peripheral interface (SPI™) for changing attenuation states. This product maintains high attenuation accuracy over frequency and temperature. No external matching components are needed for the DSA.

#### AMP2

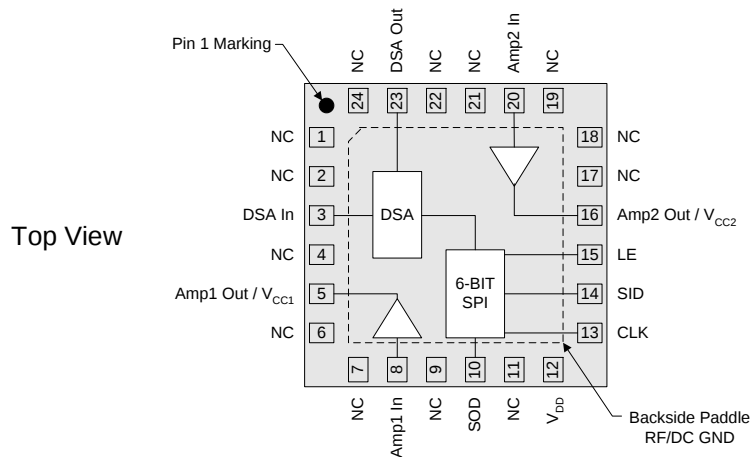
AMP2 is a high-linearity driver amplifier that delivers high performance past 4GHz. With external tuning it can achieve over +44 dBm OIP3 with +27 dBm P1dB while only consuming 143 mA of quiescent current.

## Chain Analysis Table

This table provides the typical performance of individual stages in the module as well as overall module performance. Frequency = 2140 MHz.

| Parameter | AMP1 | DSA  | AMP2  | Overall Module | Units |
|-----------|------|------|-------|----------------|-------|
| Gain      | 19.8 | -1.6 | 14.4  | 32.6           | dB    |
| NF        | 1.5  | 1.6  | 3.9   | 1.6            | dB    |
| OIP3      | +36  | +55  | +44   | +44            | dBm   |
| P1dB      | +20  | +30  | +27.6 | +27.6          | dBm   |
| Icc       | 85   | 2    | 143   | 230            | mA    |

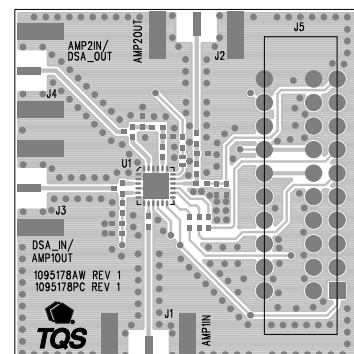
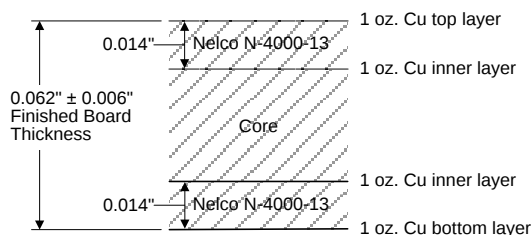
## Pin Configuration and Description



| Pin No.                                      | Label                            | Description                                                                                                                                |
|----------------------------------------------|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| 1, 2, 4, 6, 7, 9, 11, 17, 18, 19, 21, 22, 24 | NC (No Connect)                  | No electrical connection. Land pads should be provided for PCB mounting integrity.                                                         |
| 3                                            | DSA In                           | DSA Input                                                                                                                                  |
| 5                                            | Amp1 Out / V <sub>CC1</sub>      | RF output / DC supply (Amp1). Matched to 50 Ohms. Bias feed and DC blocking                                                                |
| 8                                            | Amp1 In                          | RF input (Amp1). Matched to 50 Ohms. DC blocking capacitor required.                                                                       |
| 10                                           | SOD                              | Serial Output Data                                                                                                                         |
| 12                                           | V <sub>DD</sub>                  | DC Supply                                                                                                                                  |
| 13                                           | CLK                              | Serial Clock                                                                                                                               |
| 14                                           | SID                              | Serial Input Data                                                                                                                          |
| 15                                           | LE                               | Latch Enable                                                                                                                               |
| 16                                           | Amp2 Out / V <sub>CC2</sub> Amp2 | RF output / DC supply (Amp2). Band-specific matching circuit, bias feed and DC blocking capacitor required.                                |
| 20                                           | Amp2 In                          | RF input (Amp2). Band-specific matching circuit required.                                                                                  |
| 23                                           | DSA Out                          | DSA Output                                                                                                                                 |
| Backside Paddle                              | RF/DC GND                        | RF/DC ground. Use recommended via pattern to minimize inductance and thermal resistance. See PCB Mounting Pattern for suggested footprint. |

## Evaluation Board PCB Information

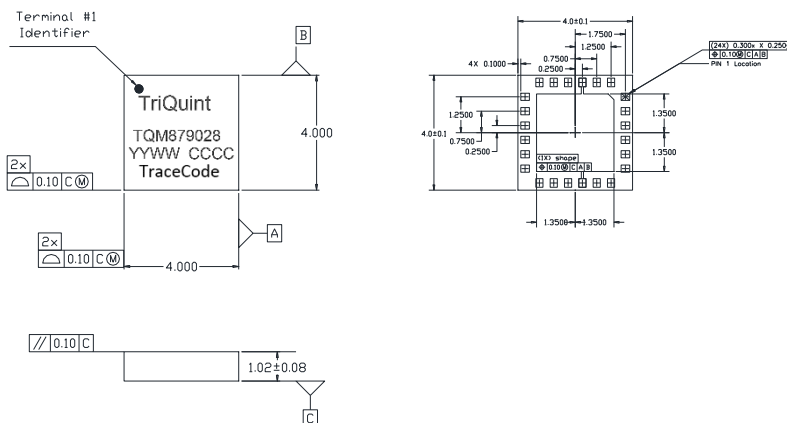
### Qorvo PCB 1095178 Material and Stack-up



### Mechanical Information

#### Package Marking and Dimensions

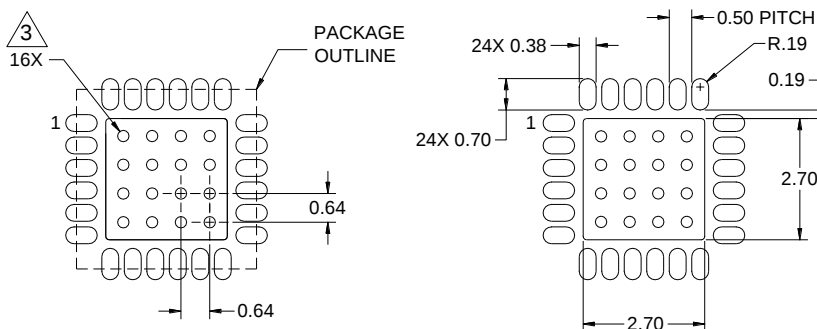
Marking: Part number – TQM879028  
 Year/week/country code - YYWW CCCC  
 Trace Code – Up to 6 characters



#### Notes:

1. All dimensions are in millimeters. Angles are in degrees.
2. Dimension and tolerance formats conform to ASME Y14.4M-1994.
3. The terminal #1 identifier and terminal numbering conform to JESD 95-1 SPP-012.

### PCB Mounting Pattern



COMPONENT SIDE

#### Notes:

1. All dimensions are in millimeters. Angles are in degrees.
2. Use 1 oz. copper minimum for top and bottom layer metal.
3. Vias are required under the backside paddle of this device for proper RF/DC grounding and thermal dissipation.
4. Do not remove or minimize via hole structure in the PCB. Thermal and RF grounding is critical.
5. We recommend a 0.35mm (#80/.0135") dia. bit for drilling via holes and a final plated thru diameter of 0.25 mm (0.10").
6. Ensure good package backside paddle solder attach for reliable operation and best electrical performance.
7. There is no effect to the RF performance if Pads 9 and 22 are removed from the land pattern.

## Handling Precautions

| Parameter                        | Rating   | Standard                 |
|----------------------------------|----------|--------------------------|
| ESD – Human Body Model (HBM)     | Level 1A | ESDA / JEDEC JS-001-2012 |
| ESD – Charged Device Model (CDM) | Level C3 | JEDEC JESD22-C101F       |
| MSL – Moisture Sensitivity Level | Level 3  | IPC/JEDEC J-STD-020      |



Caution!  
ESD-Sensitive Device

## Solderability

Compatible with both lead-free (260°C max. reflow temp.) and tin/lead (245°C max. reflow temp.) soldering processes. Solder profiles available upon request.

Contact plating: Electrolytic plated Au over Ni

## RoHS Compliance

This part is compliant with EU 2002/95/EC RoHS directive (Restrictions on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment). This product also has the following attributes:

- Product uses RoHS Exemption 7c-I to meet RoHS Compliance requirements
- Halogen Free (Chlorine, Bromine)
- Antimony Free
- TBBP-A (C<sub>15</sub>H<sub>12</sub>Br<sub>4</sub>O<sub>2</sub>) Free
- PFOS Free
- SVHC Free

## Contact Information

For the latest specifications, additional product information, worldwide sales and distribution locations:

**Web:** [www.qorvo.com](http://www.qorvo.com)

**Tel:** 1-844-890-8163

**Email:** [customer.support@qorvo.com](mailto:customer.support@qorvo.com)

For technical questions and application information:

**Email:** [appsupport@qorvo.com](mailto:appsupport@qorvo.com)

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