

# AFE7954 Quad RF Sampling 12 GSPS Digital-to-Analog Converter (DAC)

## 1 Features

- [Request full data sheet](#)
- Quad RF sampling 12-GSPS DACs
- Maximum RF signal bandwidth:
  - 4TX: 1200 MHz or
  - 2TX: 2400 MHz
- RF frequency range: 600 MHz - 12 GHz
- Digital step attenuators (DSA):
  - TX: 40 dB range, 0.125-dB steps
- Single or dual-band DUCs
- 16x NCOs per TX
- Optional Internal PLL/VCO for DAC or external clock at DAC sample rate
- SerDes data interface:
  - JESD204B and JESD204C compatible
  - 8 SerDes receivers up to 29.5 Gbps
  - Subclass 1 multi-device synchronization
- Package: 17-mm × 17-mm FCBGA, 0.8-mm pitch

## 2 Applications

- [Radar](#)
- [Seeker front end](#)
- [Defense radio](#)
- Tactical communications infrastructure
- [Wireless communications test](#)

## 3 Description

The AFE7954 is a high performance, wide bandwidth quad channel RF sampling DAC. With operation up to 12 GHz, this device enables direct RF sampling in the L, S, C and X-band frequency ranges without the need for additional frequency conversions stages. This improvement in density and flexibility enables high-channel-count, multi-mission systems.

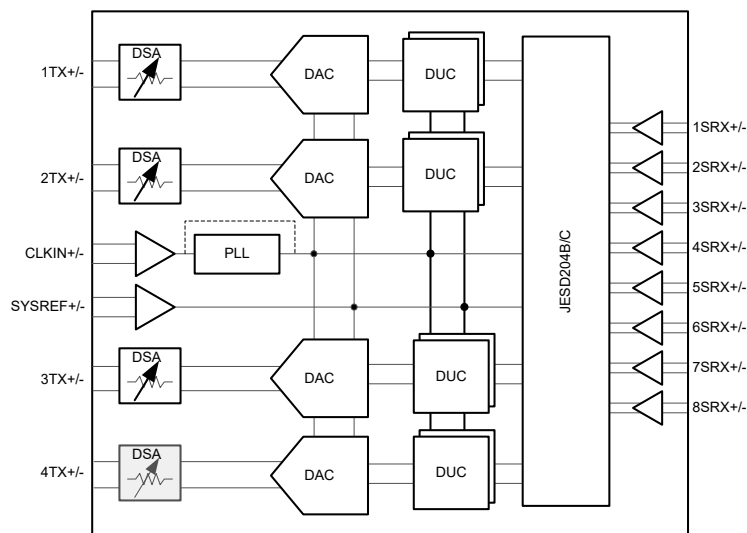
The signal paths support interpolation and digital up conversion options that deliver up to 1200 MHz of signal bandwidth for four DACs (TX) or 2400 MHz for two DACs. The output of the DUCs drives a 12-GSPS DAC (digital to analog converter) with a mixed mode output option to enhance 2nd Nyquist operation. The DAC output includes a variable gain amplifier (TX DSA) with 40-dB range and 1-dB analog and 0.125-dB digital steps.

### Package Information

| PART NUMBER | PACKAGE <sup>(1)</sup> | PACKAGE SIZE <sup>(2)</sup> |
|-------------|------------------------|-----------------------------|
| AFE7954     | FC-BGA                 | 17 mm × 17 mm               |

(1) For more information, see *Mechanical, Packaging, and Orderable Information*.

(2) The package size (length × width) is a nominal value and includes pins, where applicable.



**Functional Block Diagram**



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## 4 Description (continued)

Each receiver chain includes a 25-dB range DSA (Digital Step Attenuator), followed by a 3-GSPS ADC (analog-to-digital converter). Each receiver channel has an analog peak power detector and various digital power detectors to assist an external or internal autonomous automatic gain controller, and RF overload detectors for device reliability protection. Flexible decimation options provide optimization of data bandwidth up to 1200 MHz for four RX without FB paths or 600 MHz with two FB paths (1200 MHz BW each).

## 5 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| DATE      | REVISION | NOTES           |
|-----------|----------|-----------------|
| July 2023 | *        | Initial Release |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|                      |                                                                                                                                | MIN  | MAX              | UNIT |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------|------|------------------|------|
| Supply Voltage Range | DVDD0P9, VDDT0P9                                                                                                               | −0.3 | 1.2              | V    |
|                      | VDD1P2RX, VDD1P2TXCLK, VDD1P2TXENC, VDD1P2PLL, VDD1P2PLLCLKREF, VDD1P2FB, VDD1P2FBCML, VDD1P2RXCML                             | −0.3 | 1.4              | V    |
|                      | VDD1P8RX, VDD1P8RXCLK, VDD1P8TX, VDD1P8TXDAC, VDD1P8TXENC, VDD1P8PLL, VDD1P8PLLVC0, VDD1P8FB, VDD1P8FBCML, VDD1P8GPIO, VDDA1P8 | −0.5 | 2.1              | V    |
| Pin Voltage Range    | {1/2/3/4}TXOUT+/-                                                                                                              | −0.5 | VDDTX1P8+0.3     | V    |
|                      | REFCLK+/-, SYSREF+/-                                                                                                           | −0.3 | 1.4              | V    |
|                      | {1:8}SRX+/-                                                                                                                    | −0.3 | 1.4              | V    |
|                      | GPIO{B/C/D/E}x, SPICLK, SPISDIO, SPISDO, SPISEN, RESETZ, BISTB0, BISTB1                                                        | −0.5 | VDD1P8GPIO + 0.3 | V    |
|                      | IFORCE, VSENSE                                                                                                                 | −0.3 | VDDCLK1P8 + 0.3  | V    |
|                      | SRDAMUX1, SRDAMUX2                                                                                                             | −0.3 | VDDA1P8+0.3      | V    |
| Peak Input Current   | any input                                                                                                                      |      | 20               | mA   |
| T <sub>J</sub>       | Junction temperature                                                                                                           |      | 150              | °C   |
| T <sub>stg</sub>     | Storage temperature                                                                                                            | −65  | 150              | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Rating* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

### 6.2 ESD Ratings

|                    |                         |                                                                             | VALUE | UNIT |
|--------------------|-------------------------|-----------------------------------------------------------------------------|-------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins <sup>(1)</sup> | 1000  | V    |
|                    |                         | Charged device model (CDM), per ANSI/ESDA/JEDEC JS-002, all pins            | 150   |      |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

## 6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

|                                                                           |                                        | MIN  | NOM   | MAX                | UNIT |
|---------------------------------------------------------------------------|----------------------------------------|------|-------|--------------------|------|
| DVDD0P9, VDDT0P9                                                          | Supply voltage 0.9V                    | 0.9  | 0.925 | 0.95               | V    |
| VDD1P2{RX/TXCLK/TXENC/FB/PLL/<br>PLLCLKREF/FBCML/RXCML}                   | Supply voltage 1.2V                    | 1.15 | 1.2   | 1.25               | V    |
| VDD1P8{RX/RXCLK/TX/TXDAC/<br>TXENC/PLL/PLLVCO/FB/FBCLK/<br>GPIO}, VDDA1P8 | Supply voltage 1.8V                    | 1.75 | 1.8   | 1.85               | V    |
| T <sub>A</sub>                                                            | Ambient temperature                    | –40  |       | 85                 | °C   |
| T <sub>J</sub>                                                            | Operating Junction Temperature         |      |       | 110 <sup>(1)</sup> | °C   |
|                                                                           | Maximum Operating Junction Temperature | 125  |       |                    | °C   |

- (1) Prolonged use at or above this junction temperature can increase the device failure-in-time (FIT) rate. Refer to [SBAA403 application note](#) for additional details

## 6.4 Thermal Information AFE79xx

| THERMAL METRIC <sup>(1)</sup> |                                              | 17mmx17mm FC-BGA | UNIT |
|-------------------------------|----------------------------------------------|------------------|------|
|                               |                                              | 400 PINS         |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 16.2             | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 0.42             | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 4.85             | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 0.12             | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 4.6              | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 6.5 Transmitter Electrical Characteristics

Typical values at  $T_A = +25^\circ\text{C}$ , full temperature range is  $T_{A,\text{MIN}} = -40^\circ\text{C}$  to  $T_{J,\text{MAX}} = +110^\circ\text{C}$ ; TX Input Rate = 491.52MSPS below 6GHz and 1474.56MSPS above 6GHz,  $f_{\text{DAC}} = 11796.48\text{MSPS}$ ; PLL clock mode below 6GHz output frequency and External clock mode above 6GHz output frequency; interleave mode for 1<sup>st</sup> Nyquist, non-interleave mix mode for 2<sup>nd</sup> Nyquist, nominal power supplies; 1 tone at -1 dBFS; DSA Attenuation = 0dB; SerDes rate = 16.22Gbps, unless otherwise noted.

| PARAMETER                |                                                              | TEST CONDITIONS                                                                       | MIN  | TYP  | MAX   | UNIT |
|--------------------------|--------------------------------------------------------------|---------------------------------------------------------------------------------------|------|------|-------|------|
| DAC <sub>RES</sub>       | DAC resolution                                               |                                                                                       |      | 14   |       | bits |
| f <sub>RFout</sub>       | RF output frequency range                                    | f <sub>DAC</sub> = 12 GSPS, 1 <sup>st</sup> Nyquist                                   | 600  |      | 6000  | MHz  |
|                          |                                                              | f <sub>DAC</sub> = 12 GSPS, 2 <sup>nd</sup> Nyquist                                   | 6000 |      | 12000 |      |
|                          |                                                              | f <sub>DAC</sub> = 9 GSPS, 1 <sup>st</sup> Nyquist                                    | 600  |      | 4500  |      |
|                          |                                                              | f <sub>DAC</sub> = 9 GSPS, 2 <sup>nd</sup> Nyquist                                    | 4500 |      | 9000  |      |
|                          |                                                              | f <sub>DAC</sub> = 6 GSPS, 1 <sup>st</sup> Nyquist                                    | 600  |      | 3000  |      |
|                          |                                                              | f <sub>DAC</sub> = 6 GSPS, 2 <sup>nd</sup> Nyquist                                    | 3000 |      | 6000  |      |
| P <sub>max_FS</sub>      | Max Full Scale Output Power, max gain 1 tone, at device pins | f <sub>out</sub> = 850 MHz, f <sub>DAC</sub> = 5898.24 MSPS, -0.5dBFS                 |      | 4.2  |       | dBm  |
|                          |                                                              | f <sub>out</sub> = 1800 MHz, f <sub>DAC</sub> = 5898.24 MSPS, -0.5dBFS                |      | 4.6  |       | dBm  |
|                          |                                                              | f <sub>out</sub> = 2600 MHz, f <sub>DAC</sub> = 8847.36 MSPS, -0.5dBFS                |      | 4.0  |       | dBm  |
|                          |                                                              | f <sub>out</sub> = 3500 MHz, -0.5dBFS                                                 |      | 3.9  |       | dBm  |
|                          |                                                              | f <sub>out</sub> = 4900 MHz, -0.5dBFS                                                 |      | 3.1  |       | dBm  |
|                          |                                                              | f <sub>out</sub> = 3500 MHz, f <sub>DAC</sub> = 5898.24 MSPS, -0.5dBFS, straight mode |      | 1.0  |       | dBm  |
|                          |                                                              | f <sub>out</sub> = 4900 MHz, f <sub>DAC</sub> = 5898.24 MSPS, -0.5dBFS, straight mode |      | 0.1  |       | dBm  |
|                          |                                                              | f <sub>out</sub> = 4900 MHz, f <sub>DAC</sub> = 8847.36 MSPS, -0.5dBFS, straight mode |      | -0.7 |       | dBm  |
|                          |                                                              | f <sub>out</sub> = 8100 MHz, -0.1dBFS, mixed mode                                     |      | -2.8 |       | dBm  |
|                          |                                                              | f <sub>out</sub> = 9600 MHz, -0.1dBFS, mixed mode                                     |      | -4.3 |       | dBm  |
| R <sub>TERM</sub>        | Output termination resistor                                  | Default setting                                                                       |      | 50   |       | Ω    |
| ATT <sub>range</sub>     | DSA Attenuation range                                        |                                                                                       |      | 40   |       | dB   |
| ATT <sub>step</sub>      | DSA Analog Attenuation step                                  |                                                                                       |      | 1.0  |       | dB   |
|                          | DSA Attenuation step accuracy (DNL)                          | 0 < Atten < 40dB, before calibration                                                  |      | ±0.2 |       | dB   |
|                          | DSA Attenuation step accuracy (DNL)                          | 0 < Atten < 40dB, after calibration                                                   |      | ±0.1 |       | dB   |
| ATT <sub>phase-err</sub> | DSA Gain Steps Phase accuracy, any 8dB range                 | f <sub>out</sub> = 850MHz <sup>(2)</sup>                                              |      | ±1   |       | deg  |
|                          |                                                              | f <sub>out</sub> = 1800MHz <sup>(2)</sup>                                             |      | ±1   |       | deg  |
|                          |                                                              | f <sub>out</sub> = 2600MHz <sup>(2)</sup>                                             |      | ±1   |       | deg  |
|                          |                                                              | f <sub>out</sub> = 3500MHz <sup>(2)</sup>                                             |      | ±1   |       | deg  |
|                          |                                                              | f <sub>out</sub> = 4900MHz <sup>(2)</sup>                                             |      | ±1   |       | deg  |
|                          |                                                              | f <sub>out</sub> = 8100MHz <sup>(2)</sup>                                             |      | ±2   |       | deg  |
| G <sub>flat</sub>        | Gain flatness                                                | any 20MHz                                                                             |      | 0.1  |       | dB   |
|                          |                                                              | 600MHz BW, F <sub>out</sub> < 4.9G                                                    |      | 1.2  |       |      |

## 6.5 Transmitter Electrical Characteristics (continued)

Typical values at  $T_A = +25^\circ\text{C}$ , full temperature range is  $T_{A,\text{MIN}} = -40^\circ\text{C}$  to  $T_{A,\text{MAX}} = +110^\circ\text{C}$ ; TX Input Rate = 491.52MSPS below 6GHz and 1474.56MSPS above 6GHz,  $f_{\text{DAC}} = 11796.48\text{MSPS}$ ; PLL clock mode below 6GHz output frequency and External clock mode above 6GHz output frequency; interleave mode for 1<sup>st</sup> Nyquist, non-interleave mix mode for 2<sup>nd</sup> Nyquist, nominal power supplies; 1 tone at -1 dBFS; DSA Attenuation = 0dB; SerDes rate = 16.22Gbps, unless otherwise noted.

| PARAMETER                         |                                                                                    | TEST CONDITIONS                                                        | MIN | TYP   | MAX | UNIT |
|-----------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------|-----|-------|-----|------|
| IMD3                              | 3rd Order Intermodulation distortion, 2 tones at $f_{\text{IF}} \pm 10\text{ MHz}$ | $f_{\text{out}} = 850\text{MHz}$ , -7dBFS each tone                    |     | -66   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 1800\text{MHz}$ , -7dBFS each tone                   |     | -63   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 2600\text{MHz}$ , -7dBFS each tone                   |     | -62   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 3500\text{MHz}$ , -7dBFS each tone                   |     | -61   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 4900\text{MHz}$ , -7dBFS each tone                   |     | -57   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 8100\text{MHz}$ , -7dBFS each tone                   |     | -55   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 9600\text{MHz}$ , -7dBFS each tone                   |     | -52   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 850\text{MHz}$ , -13dBFS each tone                   |     | -74.4 |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 1800\text{MHz}$ , -13dBFS each tone                  |     | -71.1 |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 2600\text{MHz}$ , -13dBFS each tone                  |     | -73   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 3500\text{MHz}$ , -13dBFS each tone                  |     | -72   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 4900\text{MHz}$ , -13dBFS each tone                  |     | -67.8 |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 8100\text{MHz}$ , -13dBFS each tone                  |     | -64   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 9600\text{MHz}$ , -13dBFS each tone                  |     | -68   |     | dBc  |
| SFDR                              | Spurious Free Dynamic Range (within Nyquist zone)                                  | $f_{\text{out}} = 850\text{ MHz}$                                      |     | 50.8  |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 1800\text{ MHz}$                                     |     | 51.9  |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 2600\text{ MHz}$                                     |     | 42    |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 3500\text{ MHz}$                                     |     | 44    |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 4900\text{ MHz}$                                     |     | 46.1  |     | dBc  |
| $f_{\text{S}}/2 - f_{\text{OUT}}$ | Interleaving Image                                                                 | $f_{\text{DAC}} = 5898.24\text{MSPS}$ , interleave mode                |     | -51.9 |     | dBc  |
|                                   |                                                                                    | $f_{\text{DAC}} = 8847.36\text{ MSPS}$ , interleave mode               |     | -46.0 |     | dBc  |
|                                   |                                                                                    | $f_{\text{DAC}} = 11796.48\text{MSPS}$ , interleave mode               |     | -41   |     | dBc  |
| HD2                               | 2nd Harmonic Distortion (within Nyquist zone)                                      | $f_{\text{out}} = 850\text{ MHz}$                                      |     | -49   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 1800\text{ MHz}$                                     |     | -53   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 2600\text{ MHz}$                                     |     | -50   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 3500\text{ MHz}$                                     |     | -48   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 4900\text{ MHz}$                                     |     | -47   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 8100\text{ MHz}$                                     |     | -50   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 9600\text{ MHz}$                                     |     | -53   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 850\text{ MHz}$ , $A_{\text{OUT}} = -12\text{dBFS}$  |     | -60   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 1800\text{ MHz}$ , $A_{\text{OUT}} = -12\text{dBFS}$ |     | -64   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 2600\text{ MHz}$ , $A_{\text{OUT}} = -12\text{dBFS}$ |     | -45   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 3500\text{ MHz}$ , $A_{\text{OUT}} = -12\text{dBFS}$ |     | -57   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 4900\text{ MHz}$ , $A_{\text{OUT}} = -12\text{dBFS}$ |     | -58   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 8100\text{ MHz}$ , $A_{\text{OUT}} = -12\text{dBFS}$ |     | -60   |     | dBc  |
|                                   |                                                                                    | $f_{\text{out}} = 9600\text{ MHz}$ , $A_{\text{OUT}} = -12\text{dBFS}$ |     | -62   |     | dBc  |

## 6.5 Transmitter Electrical Characteristics (continued)

Typical values at  $T_A = +25^\circ\text{C}$ , full temperature range is  $T_{A,\text{MIN}} = -40^\circ\text{C}$  to  $T_{J,\text{MAX}} = +110^\circ\text{C}$ ; TX Input Rate = 491.52MSPS below 6GHz and 1474.56MSPS above 6GHz,  $f_{\text{DAC}} = 11796.48\text{MSPS}$ ; PLL clock mode below 6GHz output frequency and External clock mode above 6GHz output frequency; interleave mode for 1<sup>st</sup> Nyquist, non-interleave mix mode for 2<sup>nd</sup> Nyquist, nominal power supplies; 1 tone at -1 dBFS; DSA Attenuation = 0dB; SerDes rate = 16.22Gbps, unless otherwise noted.

| PARAMETER        |                                                  | TEST CONDITIONS                                                     | MIN | TYP  | MAX | UNIT |
|------------------|--------------------------------------------------|---------------------------------------------------------------------|-----|------|-----|------|
| HD3              | 3rd Harmonic Distortion (within Nyquist zone)    | $f_{\text{out}} = 850\text{ MHz}$                                   |     | -62  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 1800\text{ MHz}$                                  |     | -55  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 2600\text{ MHz}$                                  |     | -57  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 3500\text{ MHz}$                                  |     | -60  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 4900\text{ MHz}$                                  |     | -54  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 8100\text{ MHz}$                                  |     | -54  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 9600\text{ MHz}$                                  |     | -56  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 850\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$  |     | -80  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 1800\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$ |     | -79  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 2600\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$ |     | -77  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 3500\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$ |     | -77  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 4900\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$ |     | -78  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 8100\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$ |     | -82  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 9600\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$ |     | -80  |     | dBc  |
| HDn, n >= 4      | Harmonic Distortion n >= 4 (within Nyquist zone) | $f_{\text{out}} = 850\text{ MHz}$                                   |     | -81  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 1800\text{ MHz}$                                  |     | -88  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 2600\text{ MHz}$                                  |     | -86  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 3500\text{ MHz}$                                  |     | -79  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 4900\text{ MHz}$                                  |     | -86  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 8100\text{ MHz}$                                  |     | -87  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 9600\text{ MHz}$                                  |     | -85  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 850\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$  |     | -93  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 1800\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$ |     | -98  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 2600\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$ |     | -84  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 3500\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$ |     | -87  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 4900\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$ |     | -87  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 8100\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$ |     | -87  |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 9600\text{ MHz}, A_{\text{OUT}} = -12\text{dBFS}$ |     | -87  |     | dBc  |
| SFDR +/- 250 MHz | Spurious Free Dynamic Range within +/- 250 MHz   | $f_{\text{out}} = 850\text{ MHz}$                                   |     | 68.5 |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 1800\text{ MHz}$                                  |     | 79.4 |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 2600\text{ MHz}$                                  |     | 77   |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 3500\text{ MHz}$                                  |     | 75   |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 4900\text{ MHz}$                                  |     | 76   |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 8100\text{ MHz}$                                  |     | 61   |     | dBc  |
|                  |                                                  | $f_{\text{out}} = 9600\text{ MHz}$                                  |     | 64   |     | dBc  |
| $f_s/4$          | Fixed Spur                                       | $f_{\text{DAC}} = 5898.24\text{MSPS}$                               |     | -64  |     | dBFS |
|                  |                                                  | $f_{\text{DAC}} = 8847.36\text{MSPS}$                               |     | -75  |     | dBFS |
|                  |                                                  | $f_{\text{DAC}} = 11796.48\text{MSPS}$                              |     | -67  |     | dBFS |
| $f_s/2$          | Fixed Spur                                       | $f_{\text{DAC}} = 5898.24\text{MSPS}$                               |     | -49  |     | dBFS |
|                  |                                                  | $f_{\text{DAC}} = 8847.36\text{MSPS}$                               |     | -48  |     | dBFS |
|                  |                                                  | $f_{\text{DAC}} = 11796.48\text{MSPS}$                              |     | -48  |     | dBFS |

## 6.5 Transmitter Electrical Characteristics (continued)

Typical values at  $T_A = +25^\circ\text{C}$ , full temperature range is  $T_{A,\text{MIN}} = -40^\circ\text{C}$  to  $T_{J,\text{MAX}} = +110^\circ\text{C}$ ; TX Input Rate = 491.52MSPS below 6GHz and 1474.56MSPS above 6GHz,  $f_{\text{DAC}} = 11796.48\text{MSPS}$ ; PLL clock mode below 6GHz output frequency and External clock mode above 6GHz output frequency; interleave mode for 1<sup>st</sup> Nyquist, non-interleave mix mode for 2<sup>nd</sup> Nyquist, nominal power supplies; 1 tone at -1 dBFS; DSA Attenuation = 0dB; SerDes rate = 16.22Gbps, unless otherwise noted.

| PARAMETER              |                                                                           | TEST CONDITIONS                              | MIN | TYP   | MAX | UNIT |
|------------------------|---------------------------------------------------------------------------|----------------------------------------------|-----|-------|-----|------|
| 3*f <sub>S</sub> /4    | Fixed Spur                                                                | 2nd Nyquist, f <sub>DAC</sub> = 5898.24MSPS  |     | -76   |     | dBFS |
|                        |                                                                           | 2nd Nyquist, f <sub>DAC</sub> = 8847.36MSPS  |     | -89   |     | dBFS |
|                        |                                                                           | 2nd Nyquist, f <sub>DAC</sub> = 11796.48MSPS |     | -63   |     | dBFS |
| ACPR <sub>1xcarr</sub> | ACPR - 1 carrier, LTE 20MHz E-TM1.1 carrier f <sub>out</sub> = 0.85 GHz   | Atten=0dB, Pout=-13dBFS                      |     | -68.5 |     | dBc  |
|                        |                                                                           | Atten=20dB, Pout=-13dBFS                     |     | -67.2 |     | dBc  |
|                        |                                                                           | Atten=28dB, Pout=-13dBFS                     |     | -64.5 |     | dBc  |
|                        |                                                                           | Atten=39dB, Pout=-13dBFS                     |     | -53.9 |     | dBc  |
| ACPR <sub>1xcarr</sub> | ACPR - 1 carrier, LTE 20MHz E-TM1.1 carrier f <sub>out</sub> = 1.8425 GHz | Atten=0dB, Pout=-13dBFS                      |     | -70.7 |     | dBc  |
|                        |                                                                           | Atten=20dB, Pout=-13dBFS                     |     | -68.3 |     | dBc  |
|                        |                                                                           | Atten=28dB, Pout=-13dBFS                     |     | -62.9 |     | dBc  |
|                        |                                                                           | Atten=39dB, Pout=-13dBFS                     |     | -52.0 |     | dBc  |
| ACPR <sub>1xcarr</sub> | ACPR - 1 carrier, LTE 20MHz E-TM1.1 carrier f <sub>out</sub> = 2.6 GHz    | Atten=0dB, Pout=-13dBFS                      |     | -71   |     | dBc  |
|                        |                                                                           | Atten=20dB, Pout=-13dBFS                     |     | -68   |     | dBc  |
|                        |                                                                           | Atten=28dB, Pout=-13dBFS                     |     | -62   |     | dBc  |
|                        |                                                                           | Atten=39dB, Pout=-13dBFS                     |     | -51.3 |     | dBc  |
| ACPR <sub>1xcarr</sub> | ACPR - 1 carrier, LTE 20MHz E-TM1.1 carrier f <sub>out</sub> = 3.5 GHz    | Atten=0dB, Pout=-13dBFS                      |     | -70   |     | dBc  |
|                        |                                                                           | Atten=20dB, Pout=-13dBFS                     |     | -67   |     | dBc  |
|                        |                                                                           | Atten=28dB, Pout=-13dBFS                     |     | -60   |     | dBc  |
|                        |                                                                           | Atten=39dB, Pout=-13dBFS                     |     | -49.8 |     | dBc  |
| ACPR <sub>1xcarr</sub> | ACPR - 1 carrier, LTE 20MHz E-TM1.1 carrier f <sub>out</sub> = 4.9 GHz    | Atten=0dB, Pout=-13dBFS                      |     | -68.8 |     | dBc  |
|                        |                                                                           | Atten=20dB, Pout=-13dBFS                     |     | -65.9 |     | dBc  |
|                        |                                                                           | Atten=28dB, Pout=-13dBFS                     |     | -60.6 |     | dBc  |
|                        |                                                                           | Atten=39dB, Pout=-13dBFS                     |     | -49.5 |     | dBc  |
| ACPR <sub>1xcarr</sub> | ACPR - 1 carrier, NR 100MHz E-TM1.1 carrier f <sub>out</sub> = 2.6 GHz    | Atten=0dB, Pout=-13dBFS                      |     | -65   |     | dBc  |
|                        |                                                                           | Atten=20dB, Pout=-13dBFS                     |     | -62   |     | dBc  |
|                        |                                                                           | Atten=20dB, Pout=-13dBFS                     |     | -55   |     | dBc  |
|                        |                                                                           | Atten=39dB, Pout=-13dBFS                     |     | -44.3 |     | dBc  |
| ACPR <sub>1xcarr</sub> | ACPR - 1 carrier, NR 100MHz E-TM1.1 carrier f <sub>out</sub> = 3.5 GHz    | Atten=0dB, Pout=-13dBFS                      |     | -64   |     | dBc  |
|                        |                                                                           | Atten=20dB, Pout=-13dBFS                     |     | -59   |     | dBc  |
|                        |                                                                           | Atten=28dB, Pout=-13dBFS                     |     | -52   |     | dBc  |
|                        |                                                                           | Atten=39dB, Pout=-13dBFS                     |     | -41.1 |     | dBc  |
| ACPR <sub>1xcarr</sub> | ACPR - 1 carrier, NR 100MHz E-TM1.1 carrier f <sub>out</sub> = 4.9 GHz    | Atten=0dB, Pout=-13dBFS                      |     | -64.1 |     | dBc  |
|                        |                                                                           | Atten=20dB, Pout=-13dBFS                     |     | -60.4 |     | dBc  |
|                        |                                                                           | Atten=28dB, Pout=-13dBFS                     |     | -53.5 |     | dBc  |
|                        |                                                                           | Atten=39dB, Pout=-13dBFS                     |     | -42.5 |     | dBc  |
| ACPR <sub>1xcarr</sub> | ACPR - 1 carrier, NR 100MHz E-TM1.1 carrier f <sub>out</sub> = 8.1 GHz    | Atten=0dB, Pout=-13dBFS                      |     | -58   |     | dBc  |
|                        |                                                                           | Atten=20dB, Pout=-13dBFS                     |     | -53   |     | dBc  |
|                        |                                                                           | Atten=28dB, Pout=-13dBFS                     |     | -46   |     | dBc  |
|                        |                                                                           | Atten=39dB, Pout=-13dBFS                     |     | -36   |     | dBc  |

## 6.5 Transmitter Electrical Characteristics (continued)

Typical values at  $T_A = +25^\circ\text{C}$ , full temperature range is  $T_{A,\text{MIN}} = -40^\circ\text{C}$  to  $T_{A,\text{MAX}} = +110^\circ\text{C}$ ; TX Input Rate = 491.52MSPS below 6GHz and 1474.56MSPS above 6GHz,  $f_{\text{DAC}} = 11796.48\text{MSPS}$ ; PLL clock mode below 6GHz output frequency and External clock mode above 6GHz output frequency; interleave mode for 1<sup>st</sup> Nyquist, non-interleave mix mode for 2<sup>nd</sup> Nyquist, nominal power supplies; 1 tone at -1 dBFS; DSA Attenuation = 0dB; SerDes rate = 16.22Gbps, unless otherwise noted.

| PARAMETER              |                                                                               | TEST CONDITIONS                                                          | MIN | TYP    | MAX | UNIT    |
|------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------|-----|--------|-----|---------|
| ACPR <sub>1xcarr</sub> | ACPR - 1 carrier, NR 100MHz E-TM1.1 carrier $f_{\text{out}} = 9.6\text{ GHz}$ | Atten=0dB, Pout=-13dBFS                                                  |     | -57    |     | dBc     |
|                        |                                                                               | Atten=20dB, Pout=-13dBFS                                                 |     | -50    |     | dBc     |
|                        |                                                                               | Atten=28dB, Pout=-13dBFS                                                 |     | -42    |     | dBc     |
|                        |                                                                               | Atten=39dB, Pout=-13dBFS                                                 |     | -31    |     | dBc     |
| EVM                    | Error Vector Magnitude, 1x 20MHz E-TM3.1/3.1a, no ref. clock noise            | $F_{\text{out}} = 0.85\text{ GHz}$ , $P_{\text{OUT}} = -13\text{dBFS}$   |     | 0.2    |     | %       |
|                        |                                                                               | $F_{\text{out}} = 1.8425\text{ GHz}$ , $P_{\text{OUT}} = -13\text{dBFS}$ |     | 0.3    |     | %       |
|                        |                                                                               | $F_{\text{out}} = 2.6\text{ GHz}$ , $P_{\text{OUT}} = -13\text{dBFS}$    |     | 0.28   |     | %       |
|                        |                                                                               | $F_{\text{out}} = 3.5\text{ GHz}$ , $P_{\text{OUT}} = -13\text{dBFS}$    |     | 0.38   |     | %       |
|                        |                                                                               | $F_{\text{out}} = 4.9\text{ GHz}$ , $P_{\text{OUT}} = -13\text{dBFS}$    |     | 0.4    |     | %       |
| NSD <sub>dBFS</sub>    | Noise Spectral Density 20MHz offset $f_{\text{OUT}} = 0.85\text{ GHz}$        | Atten=0dB, $f_{\text{DAC}} = 5898.24\text{MSPS}$ , Pout=-13dBFS          |     | -157.6 |     | dBFS/Hz |
|                        |                                                                               | Atten=20dB, $f_{\text{DAC}} = 5898.24\text{MSPS}$ , Pout=-13dBFS         |     | -153.3 |     | dBFS/Hz |
|                        |                                                                               | Atten=28dB, $f_{\text{DAC}} = 5898.24\text{MSPS}$ , Pout=-13dBFS         |     | -147.9 |     | dBFS/Hz |
|                        |                                                                               | Atten=39dB, $f_{\text{DAC}} = 5898.24\text{MSPS}$ , Pout=-13dBFS         |     | -136.9 |     | dBFS/Hz |
| NSD <sub>dBFS</sub>    | Noise Spectral Density 20MHz offset $f_{\text{OUT}} = 1.8\text{ GHz}$         | Atten=0dB, $f_{\text{DAC}} = 5898.24\text{MSPS}$ , Pout=-13dBFS          |     | -158.4 |     | dBFS/Hz |
|                        |                                                                               | Atten=20dB, $f_{\text{DAC}} = 5898.24\text{MSPS}$ , Pout=-13dBFS         |     | -152.2 |     | dBFS/Hz |
|                        |                                                                               | Atten=28dB, $f_{\text{DAC}} = 5898.24\text{MSPS}$ , Pout=-13dBFS         |     | -145.6 |     | dBFS/Hz |
|                        |                                                                               | Atten=39dB, $f_{\text{DAC}} = 5898.24\text{MSPS}$ , Pout=-13dBFS         |     | -134.6 |     | dBFS/Hz |
| NSD <sub>dBFS</sub>    | Noise Spectral Density 20MHz offset $f_{\text{OUT}} = 2.6\text{ GHz}$         | Atten=0dB, $f_{\text{DAC}} = 8847.36\text{MSPS}$ , Pout=-13dBFS          |     | -157   |     | dBFS/Hz |
|                        |                                                                               | Atten=20dB, $f_{\text{DAC}} = 8847.36\text{MSPS}$ , Pout=-13dBFS         |     | -151   |     | dBFS/Hz |
|                        |                                                                               | Atten=28dB, $f_{\text{DAC}} = 8847.36\text{MSPS}$ , Pout=-13dBFS         |     | -144   |     | dBFS/Hz |
|                        |                                                                               | Atten=39dB, $f_{\text{DAC}} = 8847.36\text{MSPS}$ , Pout=-13dBFS         |     | -133.0 |     | dBFS/Hz |
| NSD <sub>dBFS</sub>    | Noise Spectral Density 20MHz offset $F_{\text{out}} = 3.5\text{ GHz}$         | Atten=0dB, Pout=-13dBFS                                                  |     | -158   |     | dBFS/Hz |
|                        |                                                                               | Atten=20dB, Pout=-13dBFS                                                 |     | -150   |     | dBFS/Hz |
|                        |                                                                               | Atten=28dB, Pout=-13dBFS                                                 |     | -143   |     | dBFS/Hz |
|                        |                                                                               | Atten=39dB, Pout=-13dBFS                                                 |     | -131.8 |     | dBFS/Hz |

## 6.5 Transmitter Electrical Characteristics (continued)

Typical values at  $T_A = +25^\circ\text{C}$ , full temperature range is  $T_{A,\text{MIN}} = -40^\circ\text{C}$  to  $T_{J,\text{MAX}} = +110^\circ\text{C}$ ; TX Input Rate = 491.52MSPS below 6GHz and 1474.56MSPS above 6GHz,  $f_{\text{DAC}} = 11796.48\text{MSPS}$ ; PLL clock mode below 6GHz output frequency and External clock mode above 6GHz output frequency; interleave mode for 1<sup>st</sup> Nyquist, non-interleave mix mode for 2<sup>nd</sup> Nyquist, nominal power supplies; 1 tone at -1 dBFS; DSA Attenuation = 0dB; SerDes rate = 16.22Gbps, unless otherwise noted.

| PARAMETER           |                                                                          | TEST CONDITIONS                                                                            | MIN | TYP    | MAX | UNIT        |
|---------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----|--------|-----|-------------|
| NSD <sub>dBFS</sub> | Noise Spectral Density 20MHz offset<br>$F_{\text{out}} = 4.9\text{ GHz}$ | Atten=0dB, Pout=-13dBFS                                                                    |     | -155.5 |     | dBFS/<br>Hz |
|                     |                                                                          | Atten=20dB, Pout=-13dBFS                                                                   |     | -147.8 |     | dBFS/<br>Hz |
|                     |                                                                          | Atten=28dB, Pout=-13dBFS                                                                   |     | -140.8 |     | dBFS/<br>Hz |
|                     |                                                                          | Atten=39dB, Pout=-13dBFS                                                                   |     | -129.6 |     | dBFS/<br>Hz |
| NSD <sub>dBFS</sub> | Noise Spectral Density 50MHz offset<br>$F_{\text{out}} = 8.1\text{ GHz}$ | Atten=0dB, Pout=-13dBFS                                                                    |     | -153   |     | dBFS/<br>Hz |
|                     |                                                                          | Atten=20dB, Pout=-13dBFS                                                                   |     | -147   |     | dBFS/<br>Hz |
|                     |                                                                          | Atten=28dB, Pout=-13dBFS                                                                   |     | -140   |     | dBFS/<br>Hz |
|                     |                                                                          | Atten=39dB, Pout=-13dBFS                                                                   |     | -129   |     | dBFS/<br>Hz |
| NSD <sub>dBFS</sub> | Noise Spectral Density 50MHz offset<br>$F_{\text{out}} = 9.6\text{ GHz}$ | Atten=0dB, Pout=-13dBFS                                                                    |     | -152   |     | dBFS/<br>Hz |
|                     |                                                                          | Atten=20dB, Pout=-13dBFS                                                                   |     | -147   |     | dBFS/<br>Hz |
|                     |                                                                          | Atten=28dB, Pout=-13dBFS                                                                   |     | -140   |     | dBFS/<br>Hz |
|                     |                                                                          | Atten=39dB, Pout=-13dBFS                                                                   |     | -129   |     | dBFS/<br>Hz |
| S22                 | Output Return Loss, <6GHz, +/- fc * 10%                                  | with matching                                                                              |     | -17    |     | dB          |
|                     | Output Return Loss, >8GHz, +/- fc * 10%                                  | with matching                                                                              |     | -10    |     | dB          |
| Isolation           | Near Channel:<br>1TXOUT to 2TXOUT or 3TXOUT to 4TXOUT <sup>(1)</sup>     | $f_{\text{out}} = 900\text{ MHz}$ , $f_{\text{DAC}} = 8847.36\text{MSPS}$ , straight mode  |     | -49    |     | dB          |
|                     |                                                                          | $f_{\text{out}} = 1850\text{ MHz}$ , $f_{\text{DAC}} = 8847.36\text{MSPS}$ , straight mode |     | -59    |     | dB          |
|                     |                                                                          | $f_{\text{out}} = 2600\text{ MHz}$ , $f_{\text{DAC}} = 8847.36\text{MSPS}$ , straight mode |     | -65    |     | dB          |
|                     |                                                                          | $f_{\text{out}} = 3500\text{ MHz}$ , $f_{\text{DAC}} = 8847.36\text{MSPS}$ , straight mode |     | -66    |     | dB          |
|                     |                                                                          | $f_{\text{out}} = 4900\text{ MHz}$ , $f_{\text{DAC}} = 8847.36\text{MSPS}$ , straight mode |     | -60    |     | dB          |
|                     |                                                                          | $f_{\text{out}} = 900\text{ MHz}$ , $f_{\text{DAC}} = 8847.36\text{MSPS}$ , straight mode  |     | -90    |     | dB          |
|                     |                                                                          | $f_{\text{out}} = 1850\text{ MHz}$ , $f_{\text{DAC}} = 8847.36\text{MSPS}$ , straight mode |     | -91    |     | dB          |
|                     |                                                                          | $f_{\text{out}} = 2600\text{ MHz}$ , $f_{\text{DAC}} = 8847.36\text{MSPS}$ , straight mode |     | -93    |     | dB          |
|                     |                                                                          | $f_{\text{out}} = 3500\text{ MHz}$ , $f_{\text{DAC}} = 8847.36\text{MSPS}$ , straight mode |     | -94    |     | dB          |
|                     |                                                                          | $f_{\text{out}} = 4900\text{ MHz}$ , $f_{\text{DAC}} = 8847.36\text{MSPS}$ , straight mode |     | -83    |     | dB          |

## 6.5 Transmitter Electrical Characteristics (continued)

Typical values at  $T_A = +25^\circ\text{C}$ , full temperature range is  $T_{A,\text{MIN}} = -40^\circ\text{C}$  to  $T_{J,\text{MAX}} = +110^\circ\text{C}$ ; TX Input Rate = 491.52MSPS below 6GHz and 1474.56MSPS above 6GHz,  $f_{\text{DAC}} = 11796.48\text{MSPS}$ ; PLL clock mode below 6GHz output frequency and External clock mode above 6GHz output frequency; interleave mode for 1<sup>st</sup> Nyquist, non-interleave mix mode for 2<sup>nd</sup> Nyquist, nominal power supplies; 1 tone at -1 dBFS; DSA Attenuation = 0dB; SerDes rate = 16.22Gbps, unless otherwise noted.

| PARAMETER           |                                                         | TEST CONDITIONS                                                        | MIN | TYP  | MAX | UNIT   |
|---------------------|---------------------------------------------------------|------------------------------------------------------------------------|-----|------|-----|--------|
| PN <sub>TXADD</sub> | Additive Phase Noise External Clock Mode <sup>(3)</sup> | $f_{\text{out}} = 9.6\text{GHz}$ , $f_{\text{OFFSET}} = 100\text{Hz}$  |     | -88  |     | dBc/Hz |
|                     |                                                         | $f_{\text{out}} = 9.6\text{GHz}$ , $f_{\text{OFFSET}} = 1\text{kHz}$   |     | -102 |     | dBc/Hz |
|                     |                                                         | $f_{\text{out}} = 9.6\text{GHz}$ , $f_{\text{OFFSET}} = 10\text{kHz}$  |     | -110 |     | dBc/Hz |
|                     |                                                         | $f_{\text{out}} = 9.6\text{GHz}$ , $f_{\text{OFFSET}} = 100\text{kHz}$ |     | -123 |     | dBc/Hz |
|                     |                                                         | $f_{\text{out}} = 9.6\text{GHz}$ , $f_{\text{OFFSET}} = 1\text{MHz}$   |     | -136 |     | dBc/Hz |
|                     |                                                         | $f_{\text{out}} = 9.6\text{GHz}$ , $f_{\text{OFFSET}} = 10\text{MHz}$  |     | -143 |     | dBc/Hz |
|                     |                                                         | $f_{\text{out}} = 9.6\text{GHz}$ , $f_{\text{OFFSET}} = 100\text{MHz}$ |     | -146 |     | dBc/Hz |

- (1) Measured with differential 50 ohm across TxP/M. The DC bias to 1.8V to each TxP/M at each pin remains and is not removed. Other external components on the TX paths are disconnected.
- (2) After DSA calibration procedure
- (3) Single side band, input clock phase noise subtracted.

## 6.6 PLL/VCO/Clock Electrical Characteristics

Typical values at TA = +25°C, full temperature range is T<sub>A,MIN</sub> = -40°C to T<sub>J,MAX</sub> = +110°C; Reference clock input frequency 491.52MHz (unless otherwise noted), f<sub>DAC</sub> = f<sub>VCO</sub>, f<sub>OUT</sub> = f<sub>DAC</sub>/4, normalized to f<sub>VCO</sub>.

| PARAMETER                |                                                                                     | TEST CONDITIONS                                | MIN   | TYP                | MAX  | UNIT    |
|--------------------------|-------------------------------------------------------------------------------------|------------------------------------------------|-------|--------------------|------|---------|
| f <sub>VCO1</sub>        | VCO1 min frequency                                                                  |                                                |       |                    | 7.2  | GHz     |
|                          | VCO1 max frequency                                                                  |                                                | 7.68  |                    |      | GHz     |
| f <sub>VCO2</sub>        | VCO2 min frequency                                                                  |                                                |       |                    | 8.8  | GHz     |
|                          | VCO2 max frequency                                                                  |                                                | 9.1   |                    |      | GHz     |
| f <sub>VCO3</sub>        | VCO3 min frequency                                                                  |                                                |       |                    | 9.7  | GHz     |
|                          | VCO3 max frequency                                                                  |                                                | 10.24 |                    |      | GHz     |
| f <sub>VCO4</sub>        | VCO4 min frequency                                                                  |                                                |       |                    | 11.6 | GHz     |
|                          | VCO4 max frequency                                                                  |                                                | 12.08 |                    |      | GHz     |
| DIV <sub>DAC</sub>       | DAC sample rate divider                                                             |                                                |       | 1, 2 or 3          |      |         |
| DIV <sub>FBAD</sub><br>C | ADC sample rate divider from DAC sample rate                                        |                                                |       | 1, 2, 3, 4, 6 or 8 |      |         |
| DIV <sub>RXAD</sub><br>C | ADC sample rate divider                                                             |                                                |       | 1, 2, 3, 4, 6 or 8 |      |         |
| PN <sub>VCO</sub>        | Closed Loop Phase Noise F <sub>PLL</sub> = 11.79848 GHz F <sub>REF</sub> =491.52MHz | 600kHz                                         |       | -113               |      | dBc/Hz  |
|                          |                                                                                     | 800kHz                                         |       | -116               |      | dBc/Hz  |
|                          |                                                                                     | 1MHz                                           |       | -119               |      | dBc/Hz  |
|                          |                                                                                     | 1.8MHz                                         |       | -125               |      | dBc/Hz  |
|                          |                                                                                     | 5MHz                                           |       | -133               |      | dBc/Hz  |
|                          |                                                                                     | 50MHz                                          |       | -141               |      | dBc/Hz  |
|                          | Closed Loop Phase Noise F <sub>PLL</sub> =8.84736 GHz F <sub>REF</sub> =491.52MHz   | 600kHz                                         |       | -114               |      | dBc/Hz  |
|                          |                                                                                     | 800kHz                                         |       | -118               |      | dBc/Hz  |
|                          |                                                                                     | 1MHz                                           |       | -120               |      | dBc/Hz  |
|                          |                                                                                     | 1.8MHz                                         |       | -127               |      | dBc/Hz  |
|                          |                                                                                     | 5MHz                                           |       | -135               |      | dBc/Hz  |
|                          |                                                                                     | 50MHz                                          |       | -142               |      | dBc/Hz  |
|                          | Closed Loop Phase Noise F <sub>PLL</sub> = 9.8403 GHz F <sub>REF</sub> =491.52MHz   | 600kHz                                         |       | -113               |      | dBc/Hz  |
|                          |                                                                                     | 800kHz                                         |       | -116               |      | dBc/Hz  |
|                          |                                                                                     | 1MHz                                           |       | -119               |      | dBc/Hz  |
|                          |                                                                                     | 1.8MHz                                         |       | -125               |      | dBc/Hz  |
|                          |                                                                                     | 5MHz                                           |       | -134               |      | dBc/Hz  |
|                          |                                                                                     | 50MHz                                          |       | -140               |      | dBc/Hz  |
|                          | Closed Loop Phase Noise F <sub>PLL</sub> = 7.86432GHz F <sub>REF</sub> =491.52MHz   | 600kHz                                         |       | -116               |      | dBc/Hz  |
|                          |                                                                                     | 800kHz                                         |       | -119               |      | dBc/Hz  |
|                          |                                                                                     | 1MHz                                           |       | -122               |      | dBc/Hz  |
|                          |                                                                                     | 1.8MHz                                         |       | -127               |      | dBc/Hz  |
|                          |                                                                                     | 5MHz                                           |       | -136               |      | dBc/Hz  |
|                          |                                                                                     | 50MHz                                          |       | -143               |      | dBc/Hz  |
| F <sub>rms</sub>         | Clock PLL integrated phase error <sup>(1)</sup>                                     | f <sub>PLL</sub> =11.79848 GHz, [1KHz, 100MHz] |       | -43.4              |      | dBc/Hz  |
|                          |                                                                                     | f <sub>PLL</sub> =8.8536 GHz, [1KHz, 100MHz]   |       | -47.6              |      | dBc/Hz  |
|                          |                                                                                     | f <sub>PLL</sub> =9.8304 GHz, [1KHz, 100MHz]   |       | -46.2              |      | dBc/Hz  |
| f <sub>PFD</sub>         | PFD frequency                                                                       |                                                | 100   |                    | 500  | MHz     |
| PN <sub>pll_flat</sub>   | Normalized PLL flat Noise                                                           | f <sub>VCO</sub> = 11796.48MHz                 |       | -226.5             |      | dBc/Hz  |
| F <sub>REF</sub>         | Input Clock frequency                                                               |                                                | 0.1   |                    | 12   | GHz     |
| V <sub>SS</sub>          | Input Clock level                                                                   |                                                | 0.6   |                    | 1.8  | Vppdiff |

## 6.6 PLL/VCO/Clock Electrical Characteristics (continued)

Typical values at TA = +25°C, full temperature range is T<sub>A,MIN</sub> = -40°C to T<sub>J,MAX</sub> = +110°C; Reference clock input frequency 491.52MHz (unless otherwise noted), f<sub>DAC</sub> = f<sub>VCO</sub>, f<sub>OUT</sub> = f<sub>DAC</sub>/4, normalized to f<sub>VCO</sub>.

| PARAMETER |                                       | TEST CONDITIONS      | MIN | TYP                    | MAX | UNIT |
|-----------|---------------------------------------|----------------------|-----|------------------------|-----|------|
| Coupling  |                                       |                      |     | AC<br>Coupling<br>Only |     |      |
|           | REFCLK input impedance <sup>(2)</sup> | Parallel resistance  |     | 100                    |     | Ω    |
|           |                                       | Parallel capacitance |     | 0.5                    |     | pF   |

(1) Single Sideband, not including the reference clock contribution

(2) Refer to S11 data available from TI for impedance vs frequency

## 6.7 Digital Electrical Characteristics

Typical values at TA = +25°C, full temperature range is T<sub>A,MIN</sub> = -40°C to T<sub>J,MAX</sub> = +110°C (unless otherwise noted)

| PARAMETER                                                                               |                                                         | TEST CONDITIONS           | MIN                | TYP                          | MAX   | UNIT                   |
|-----------------------------------------------------------------------------------------|---------------------------------------------------------|---------------------------|--------------------|------------------------------|-------|------------------------|
| <b>CML SerDes Inputs [8:1]SRX+/-</b>                                                    |                                                         |                           |                    |                              |       |                        |
| V <sub>SRDIFF</sub>                                                                     | SerDes Receiver Input Amplitude                         | differential              | 100                |                              | 1200  | mVpp                   |
| V <sub>SRCOM</sub>                                                                      | SerDes Input Common Mode                                |                           | 0.4                | 0.5                          | 0.6   | V                      |
| Z <sub>SRdiff</sub>                                                                     | SerDes Internal Differential Termination <sup>(1)</sup> |                           |                    | 100                          |       | Ω                      |
| F <sub>SerDes</sub>                                                                     | SerDes Bit Rate                                         | Full rate mode            | 19                 |                              | 29.5  | Gbps                   |
|                                                                                         |                                                         | Half rate mode            | 9.5                |                              | 16.25 | Gbps                   |
|                                                                                         |                                                         | Quarter rate mode         | 4.75               |                              | 8.125 | Gbps                   |
|                                                                                         | Insertion Loss Tolerance <sup>(2)</sup>                 | Serdes supply = 1.8V      |                    | 25                           |       | dB                     |
| TJ                                                                                      | Total Jitter Tolerance                                  |                           |                    |                              | 0.42  | UI                     |
| <b>CMOS I/O: GPIO{B/C/D/E}x, SPICLK, SPIDIO, SPISDO, SPISEN, RESETZ, BISTB0, BISTB1</b> |                                                         |                           |                    |                              |       |                        |
| V <sub>IH</sub>                                                                         | High-Level Input Voltage                                |                           | 0.6×VDD1<br>P8GPIO |                              |       | V                      |
| V <sub>IL</sub>                                                                         | Low-Level Input Voltage                                 |                           | 0.4×VDD1<br>P8GPIO |                              |       | V                      |
| I <sub>IH</sub>                                                                         | High-Level Input Current                                |                           | -250               |                              | 250   | μA                     |
| I <sub>IL</sub>                                                                         | Low-Level Input Current                                 |                           | -250               |                              | 250   | μA                     |
| C <sub>L</sub>                                                                          | CMOS input capacitance                                  |                           |                    | 2                            |       | pF                     |
| V <sub>OH</sub>                                                                         | High-Level Output Voltage                               |                           | VDD1P8G<br>PIO-0.2 |                              |       | V                      |
| V <sub>OL</sub>                                                                         | Low-Level Output Voltage                                |                           |                    |                              | 0.2   | V                      |
| <b>Differential Inputs: SYSREF+/- Mode A</b>                                            |                                                         |                           |                    |                              |       |                        |
| Clock <sub>MODE</sub>                                                                   |                                                         |                           |                    | PLL<br>Clock<br>Mode<br>Only |       |                        |
| F <sub>SYSREFMAX</sub>                                                                  | SYSREF Input Frequency Maximum                          |                           |                    | 40                           |       | MHz                    |
| V <sub>SWINGSRMAX</sub>                                                                 | SYSREF Input Swing Maximum                              |                           |                    | 1.8                          |       | Vppdiff <sup>(3)</sup> |
| V <sub>SWINGSRMIN</sub>                                                                 | SYSREF Input Swing Minimum                              | f <sub>REF</sub> < 500MHz |                    | 0.3                          |       | Vppdiff <sup>(3)</sup> |
| V <sub>SWINGSRMIN</sub>                                                                 | SYSREF Input Swing Minimum                              | f <sub>REF</sub> > 500MHz |                    | 0.6                          |       | Vppdiff <sup>(3)</sup> |
| V <sub>COMSRMAX</sub>                                                                   | SYSREF Input Common Mode Voltage Maximum                |                           |                    | 0.8                          |       | V                      |
| V <sub>COMSRMIN</sub>                                                                   | SYSREF Input Common Mode Voltage Minimum                |                           |                    | 0.6                          |       | V                      |
| Z <sub>T</sub>                                                                          | Input termination                                       | differential              |                    | 100 <sup>(1)</sup>           |       | Ω                      |
| C <sub>L</sub>                                                                          | Input capacitance                                       | Each pin to GND           |                    | 0.5                          |       | pF                     |
| <b>LVDS Inputs: 0SYNCIN+/- and 1SYNCIN+/-</b>                                           |                                                         |                           |                    |                              |       |                        |
| V <sub>ICOM</sub>                                                                       | Input Common Voltage                                    |                           |                    | 1.2                          |       | V                      |
| V <sub>ID</sub>                                                                         | Differential Input Voltage swing                        |                           |                    | 450                          |       | Vppdiff <sup>(3)</sup> |
| Z <sub>T</sub>                                                                          | Input termination                                       | differential              |                    | 100                          |       | Ω                      |
| <b>LVDS Outputs: 0SYNCOUT+/- and 1SYNCOUT+/-</b>                                        |                                                         |                           |                    |                              |       |                        |
| V <sub>OCOM</sub>                                                                       | Output Common Voltage                                   |                           |                    | 1.2                          |       | V                      |
| V <sub>OD</sub>                                                                         | Differential Output Voltage swing                       |                           |                    | 500                          |       | Vppdiff <sup>(3)</sup> |
| Z <sub>T</sub>                                                                          | Internal Termination                                    |                           |                    | 100                          |       | Ω                      |

(1) SYSREF termination is programmable between 100Ω, 150Ω and 300Ω

(2) Loss tolerance is bump to bump from STX to SRX

- (3)  $V_{ppdiff}$  is the difference between the maximum differential voltage (positive value) and minimum differential voltage (negative value).

## 6.8 Power Supply Electrical Characteristics

Typical values at  $T_A = +25^\circ\text{C}$ , full temperature range is  $T_{A,\text{MIN}} = -40^\circ\text{C}$  to  $T_{J,\text{MAX}} = +110^\circ\text{C}$ ; TX Input Rate = 500MSPS, RX Output Rate = 500MSPS,  $f_{\text{DAC}} = 9000\text{MSPS}$  interleave mode;  $f_{\text{ADC}} = 3000\text{MSPS}$ ; nominal power supplies; 1 tone at -1 dBFS; DSA Attenuation = 0dB; SerDes rate = 20Gbps; unless otherwise noted.

| PARAMETER           |                                                                                                     | TEST CONDITIONS                                                                                                                                                                      | MIN | TYP  | MAX | UNIT |
|---------------------|-----------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------|-----|------|
| $I_{\text{VDD1P8}}$ | Group 3A: VDD1P8FB + VDD1P8RX + VDD1P8TX                                                            | Mode 1: 4TX<br>TX Dual Band: 96x Int, TX Rate 125 MSPS<br>$f_{\text{DAC}} = 12\text{ GSPS}$ , $f_{\text{TX}} = 1.85 + 2.15\text{ GHz}$<br>JESD: 8/10 coding, 20Gbps<br>TX: 2-16-16-1 |     | 564  |     | mA   |
|                     | Group 3B: VDD1P8FBCLK + VDD1P8RXCLK + VDD1P8TXDAC + VDD1P8GPIO + VDDA1P8                            |                                                                                                                                                                                      |     | 274  |     | mA   |
|                     | Group 3C: VDD1P8PLL + VDD1P8PLLCO                                                                   |                                                                                                                                                                                      |     | 71   |     | mA   |
| $I_{\text{VDD1P2}}$ | Group 2: VDD1P2FB, VDD1P2RX, VDD1P2TXCLK, VDD1P2TXENC, VDD1P2FBCML, VDD1P2RXCML and VDD1P2PLLCLKREF |                                                                                                                                                                                      |     | 953  |     | mA   |
| $I_{\text{VDD0P9}}$ | Group 1A: DVDD0P9 + VDDT0P9                                                                         |                                                                                                                                                                                      |     | 1747 |     | mA   |
| $P_{\text{diss}}$   | Power Dissipation                                                                                   |                                                                                                                                                                                      |     | 4396 |     | mW   |
| $I_{\text{VDD1P8}}$ | Group 3A: VDD1P8FB + VDD1P8RX + VDD1P8TX                                                            | Mode 2: 4TX<br>TX Single Band: 24x Int, TX Rate 500 MSPS<br>$f_{\text{DAC}} = 12\text{ GSPS}$ , $f_{\text{TX}} = 2.75\text{ GHz}$<br>JESD: 8/10 coding, 20Gbps<br>TX: 4-8-4-1        |     | 570  |     | mA   |
|                     | Group 3B: VDD1P8FBCLK + VDD1P8RXCLK + VDD1P8TXDAC + VDD1P8GPIO + VDDA1P8                            |                                                                                                                                                                                      |     | 382  |     | mA   |
|                     | Group 3C: VDD1P8PLL + VDD1P8PLLCO                                                                   |                                                                                                                                                                                      |     | 72   |     | mA   |
| $I_{\text{VDD1P2}}$ | Group 2: VDD1P2FB, VDD1P2RX, VDD1P2TXCLK, VDD1P2TXENC, VDD1P2FBCML, VDD1P2RXCML and VDD1P2PLLCLKREF |                                                                                                                                                                                      |     | 967  |     | mA   |
| $I_{\text{VDD0P9}}$ | Group 1A: DVDD0P9 + VDDT0P9                                                                         |                                                                                                                                                                                      |     | 2172 |     | mA   |
| $P_{\text{diss}}$   | Power Dissipation                                                                                   |                                                                                                                                                                                      |     | 5011 |     | mW   |
| $I_{\text{VDD1P8}}$ | Group 3A: VDD1P8FB + VDD1P8RX + VDD1P8TX                                                            | Mode 3: 4TX<br>TX Single Band: 12x Int, TX Rate 1 GSPS<br>$f_{\text{DAC}} = 12\text{ GSPS}$ , $f_{\text{TX}} = 2.75\text{ GHz}$<br>JESD: 8/10 coding, 20Gbps<br>TX: 8-8-2-1          |     | 571  |     | mA   |
|                     | Group 3B: VDD1P8FBCLK + VDD1P8RXCLK + VDD1P8TXDAC + VDD1P8GPIO + VDDA1P8                            |                                                                                                                                                                                      |     | 495  |     | mA   |
|                     | Group 3C: VDD1P8PLL + VDD1P8PLLCO                                                                   |                                                                                                                                                                                      |     | 72   |     | mA   |
| $I_{\text{VDD1P2}}$ | Group 2: VDD1P2FB, VDD1P2RX, VDD1P2TXCLK, VDD1P2TXENC, VDD1P2FBCML, VDD1P2RXCML and VDD1P2PLLCLKREF |                                                                                                                                                                                      |     | 969  |     | mA   |
| $I_{\text{VDD0P9}}$ | Group 1A: DVDD0P9 + VDDT0P9                                                                         |                                                                                                                                                                                      |     | 2465 |     | mA   |
| $P_{\text{diss}}$   | Power Dissipation                                                                                   |                                                                                                                                                                                      |     | 5490 |     | mW   |

Typical values at  $T_A = +25^\circ\text{C}$ , full temperature range is  $T_{A,\text{MIN}} = -40^\circ\text{C}$  to  $T_{J,\text{MAX}} = +110^\circ\text{C}$ ; TX Input Rate = 500MSPS, RX Output Rate = 500MSPS,  $f_{\text{DAC}} = 9000\text{MSPS}$  interleave mode;  $f_{\text{ADC}} = 3000\text{MSPS}$ ; nominal power supplies; 1 tone at -1 dBFS; DSA Attenuation = 0dB; SerDes rate = 20Gbps; unless otherwise noted.

| PARAMETER           |                                                                                                     | TEST CONDITIONS                                                                                                                                                                   | MIN | TYP  | MAX | UNIT |
|---------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------|-----|------|
| $I_{\text{VDD1P8}}$ | Group 3A: VDD1P8FB + VDD1P8RX + VDD1P8TX                                                            | Mode 4: 4TX<br>TX Single Band: 8x Int, TX Rate 1500 MSPS<br>$f_{\text{DAC}} = 12\text{ GSPS}$ , $f_{\text{TX}} = 2.75\text{ GHz}$<br>JESD: 64/66 coding, 24.75Gbps<br>TX: 8-8-2-1 |     | 569  |     | mA   |
|                     | Group 3B: VDD1P8FBCLK + VDD1P8RXCLK + VDD1P8TXDAC + VDD1P8GPIO + VDDA1P8                            |                                                                                                                                                                                   |     | 521  |     | mA   |
|                     | Group 3C: VDD1P8PLL + VDD1P8PLLVC0                                                                  |                                                                                                                                                                                   |     | 73   |     | mA   |
| $I_{\text{VDD1P2}}$ | Group 2: VDD1P2FB, VDD1P2RX, VDD1P2TXCLK, VDD1P2TXENC, VDD1P2FBCML, VDD1P2RXCML and VDD1P2PLLCLKREF |                                                                                                                                                                                   |     | 981  |     | mA   |
| $I_{\text{VDD0P9}}$ | Group 1A: DVDD0P9 + VDDT0P9                                                                         |                                                                                                                                                                                   |     | 2719 |     | mA   |
| $P_{\text{diss}}$   | Power Dissipation                                                                                   |                                                                                                                                                                                   |     | 5786 |     | mW   |
| $I_{\text{VDD1P8}}$ | Group 3A: VDD1P8FB + VDD1P8RX + VDD1P8TX                                                            | Mode 5: 2TX<br>TX Single Band: 4x Int, TX Rate 3000 MSPS<br>$f_{\text{DAC}} = 12\text{ GSPS}$ , $f_{\text{TX}} = 2.75\text{ GHz}$<br>JESD: 64/66 coding, 24.75Gbps<br>TX: 8-4-1-1 |     | 297  |     | mA   |
|                     | Group 3B: VDD1P8FBCLK + VDD1P8RXCLK + VDD1P8TXDAC + VDD1P8GPIO + VDDA1P8                            |                                                                                                                                                                                   |     | 446  |     | mA   |
|                     | Group 3C: VDD1P8PLL + VDD1P8PLLVC0                                                                  |                                                                                                                                                                                   |     | 72   |     | mA   |
| $I_{\text{VDD1P2}}$ | Group 2: VDD1P2FB, VDD1P2RX, VDD1P2TXCLK, VDD1P2TXENC, VDD1P2FBCML, VDD1P2RXCML and VDD1P2PLLCLKREF |                                                                                                                                                                                   |     | 544  |     | mA   |
| $I_{\text{VDD0P9}}$ | Group 1A: DVDD0P9 + VDDT0P9                                                                         |                                                                                                                                                                                   |     | 1575 |     | mA   |
| $P_{\text{diss}}$   | Power Dissipation                                                                                   |                                                                                                                                                                                   |     | 3577 |     | mW   |
| $I_{\text{VDD1P8}}$ | Group 3A: VDD1P8FB + VDD1P8RX + VDD1P8TX                                                            | Mode 6: Same as Mode 5 in Sleep mode with Sleep pin pulled high.                                                                                                                  |     | 96   |     | mA   |
| $I_{\text{VDD1P8}}$ | Group 3B: VDD1P8FBCLK + VDD1P8RXCLK + VDD1P8TXDAC + VDD1P8GPIO + VDDA1P8                            |                                                                                                                                                                                   |     | 330  |     | mA   |
| $I_{\text{VDD1P8}}$ | Group 3C: VDD1P8PLL + VDD1P8PLLVC0                                                                  |                                                                                                                                                                                   |     | 16   |     | mA   |
| $I_{\text{VDD1P2}}$ | Group 2: VDD1P2FB, VDD1P2RX, VDD1P2TXCLK, VDD1P2TXENC, VDD1P2FBCML, VDD1P2RXCML and VDD1P2PLLCLKREF |                                                                                                                                                                                   |     | 48   |     | mA   |
| $I_{\text{VDD0P9}}$ | Group 1A: DVDD0P9 + VDDT0P9                                                                         |                                                                                                                                                                                   |     | 302  |     | mA   |
| $P_{\text{diss}}$   | Power Dissipation                                                                                   |                                                                                                                                                                                   |     | 1132 |     | mW   |

## 6.9 Timing Requirements

Typical values at  $T_A = +25^\circ\text{C}$ , full temperature range is  $T_{A,\text{MIN}} = -40^\circ\text{C}$  to  $T_{J,\text{MAX}} = +110^\circ\text{C}$ ; TX Input Rate = 491.52MSPS,  $f_{\text{DAC}} = 8847.36\text{MSPS}$ ;  $f_{\text{ADC}} = 2949.12\text{MSPS}$ ; nominal power supplies; 1 tone at -1 dBFS; DSA Attenuation = 0dB; SerDes rate = 24.33Gbps; unless otherwise noted.

|                                  |                                                               | MIN | NOM | MAX                   | UNIT |
|----------------------------------|---------------------------------------------------------------|-----|-----|-----------------------|------|
| <b>Timing: SYSREF+/-</b>         |                                                               |     |     |                       |      |
| $t_{\text{s}}(\text{SYSREF})$    | Setup Time, SYSREF+/- Valid to Rising Edge of CLK+/-          |     | 50  |                       | ps   |
| $t_{\text{h}}(\text{SYSREF})$    | Hold Time, SYSREF+/- Valid after Rising Edge of CLK+/-        |     | 50  |                       | ps   |
| <b>Timing: Serial ports</b>      |                                                               |     |     |                       |      |
| $t_{\text{s}}(\text{SENB})$      | Setup Time, SENB to Rising Edge of SCLK                       |     |     | 15                    | ns   |
| $t_{\text{h}}(\text{SENB})$      | Hold Time, SENB after last Rising Edge of SCLK <sup>(1)</sup> |     |     | $5 + t_{\text{SCLK}}$ | ns   |
| $t_{\text{s}}(\text{SDIO})$      | Setup Time, SDIO valid to Rising Edge of SCLK                 |     |     | 15                    | ns   |
| $t_{\text{h}}(\text{SDIO})$      | Hold Time, SDIO valid after Rising Edge of SCLK               |     |     | 5                     | ns   |
| $t_{\text{SCLK\_W}}$             | Minimum SCLK period: registers write                          |     |     | 25                    | ns   |
| $t_{\text{SCLK\_R}}$             | Minimum SCLK period: registers read                           |     |     | 50                    | ns   |
| $t_{\text{d}}(\text{data\_out})$ | Minimum Data Output delay after Falling Edge of SCLK          |     |     | 0                     | ns   |
|                                  | Maximum Data Output delay after Falling Edge of SCLK          |     |     | 15                    | ns   |
| $t_{\text{RESET}}$               | Minimum RESETZ Pulse Width                                    |     | 1   |                       | ms   |

(1) SDEN\ need to be held one more extra clock cycle with the last SCLK edge

## 6.10 Switching Characteristics

Typical values at  $T_A = +25^\circ\text{C}$ , full temperature range is  $T_{A,\text{MIN}} = -40^\circ\text{C}$  to  $T_{J,\text{MAX}} = +110^\circ\text{C}$ ; TX Input Rate = 491.52MSPS,  $f_{\text{DAC}} = 8847.36\text{MSPS}$ ;  $f_{\text{ADC}} = 2949.12\text{MSPS}$ ; nominal power supplies; 1 tone at -1 dBFS; DSA Attenuation = 0dB; SerDes rate = 24.33Gbps; unless otherwise noted.

| PARAMETER                 |                              | TEST CONDITIONS                                                                               | MIN | TYP | MAX | UNIT                                  |
|---------------------------|------------------------------|-----------------------------------------------------------------------------------------------|-----|-----|-----|---------------------------------------|
| <b>TX Channel Latency</b> |                              |                                                                                               |     |     |     |                                       |
|                           | SerDes Receiver Analog Delay | Full rate                                                                                     |     | 2.8 |     | ns                                    |
| $t_{\text{JESD TX}}$      | JESD to TX output Latency    | LMFSHd=2-8-8-1, 368.64 MSPS input rate, 24x Interpolation, Serdes rate = 16.22Gbps (JESD204C) |     | 152 |     | interface clock cycles <sup>(1)</sup> |
|                           |                              | LMFSHd=8-16-4-1, 491.52 MSPS 24x Interpolation, Serdes rate = 16.22Gbps (JESD204C)            |     | 176 |     |                                       |
|                           |                              | LMFSHd=4-16-8-1, 245.76 MSPS 48x Interpolation, Serdes rate = 16.22Gbps (JESD204C)            |     | 124 |     |                                       |
|                           |                              | LMFSHd=2-16-16-1, 122.88 MSPS 96x Interpolation, Serdes rate = 16.22Gbps (JESD204C)           |     | 97  |     |                                       |

(1) Interface clock cycles is the period of the digital interface sample rate, e.g. 1GSPS = 1ns.

## 7 Device and Documentation Support

### 7.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 7.2 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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### 7.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

### 7.4 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 7.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 8 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## PACKAGING INFORMATION

| Orderable part number       | Status<br>(1) | Material type<br>(2) | Package   Pins    | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|-----------------------------|---------------|----------------------|-------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">AFE7954IABJ</a> | Active        | Production           | FCBGA (ABJ)   400 | 90   JEDEC TRAY (5+1) | Yes         | SNAGCU   SNAGCU                      | Level-3-260C-168 HR               | -40 to 85    | AFE7954I            |
| AFE7954IABJ.B               | Active        | Production           | FCBGA (ABJ)   400 | 90   JEDEC TRAY (5+1) | -           | Call TI                              | Call TI                           | -40 to 85    |                     |
| <a href="#">AFE7954IALK</a> | Active        | Production           | FCBGA (ALK)   400 | 90   JEDEC TRAY (5+1) | No          | Call TI                              | Level-3-220C-168 HR               | -40 to 85    | AFE7954<br>SNPB     |
| AFE7954IALK.B               | Active        | Production           | FCBGA (ALK)   400 | 90   JEDEC TRAY (5+1) | -           | Call TI                              | Call TI                           | -40 to 85    |                     |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

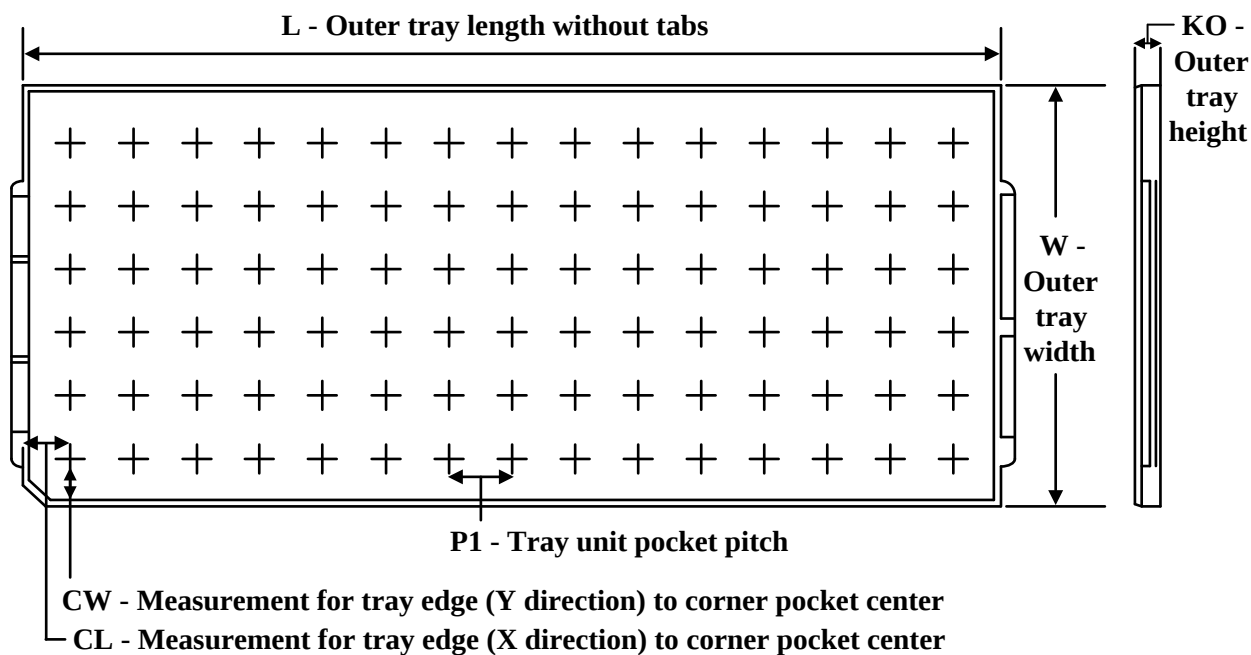
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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## TRAY



Chamfer on Tray corner indicates Pin 1 orientation of packed units.

\*All dimensions are nominal

| Device      | Package Name | Package Type | Pins | SPQ | Unit array matrix | Max temperature (°C) | L (mm) | W (mm) | K0 (μm) | P1 (mm) | CL (mm) | CW (mm) |
|-------------|--------------|--------------|------|-----|-------------------|----------------------|--------|--------|---------|---------|---------|---------|
| AFE7954IABJ | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7954IABJ | ABJ          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7954IALK | ALK          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |
| AFE7954IALK | ALK          | FCBGA        | 400  | 90  | 6 x 15            | 150                  | 315    | 135.9  | 7620    | 19.5    | 21      | 19.2    |



**FCBGA - 2.65 mm max height**

[illegible]

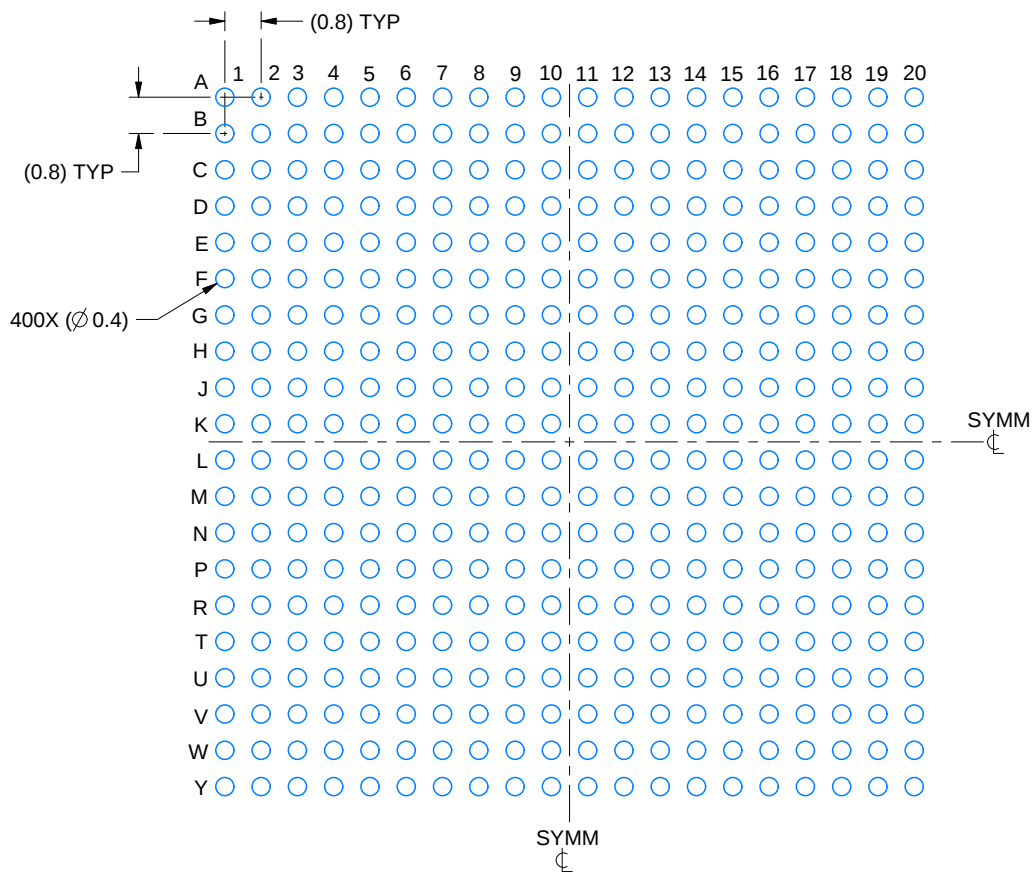
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Dimension is measured at the maximum solder ball diameter, parallel to primary datum C.
4. Primary datum C and seating plane are defined by the spherical crowns of the solder balls.
5. The lids are electrically floating (e.g. not tied to GND).

# EXAMPLE BOARD LAYOUT

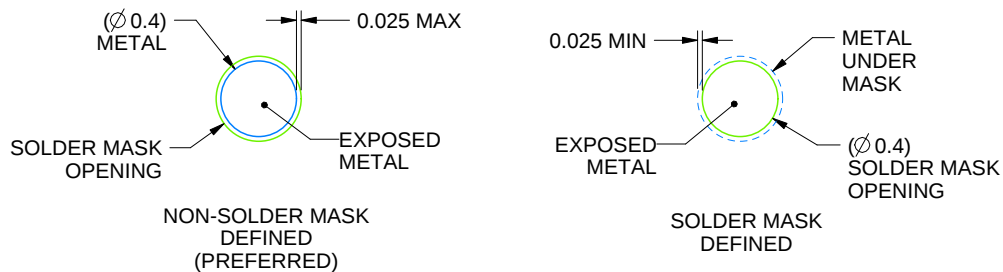
ABJ0400A

FCBGA - 2.65 mm max height

BALL GRID ARRAY



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:6X



SOLDER MASK DETAILS  
NOT TO SCALE

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NOTES: (continued)

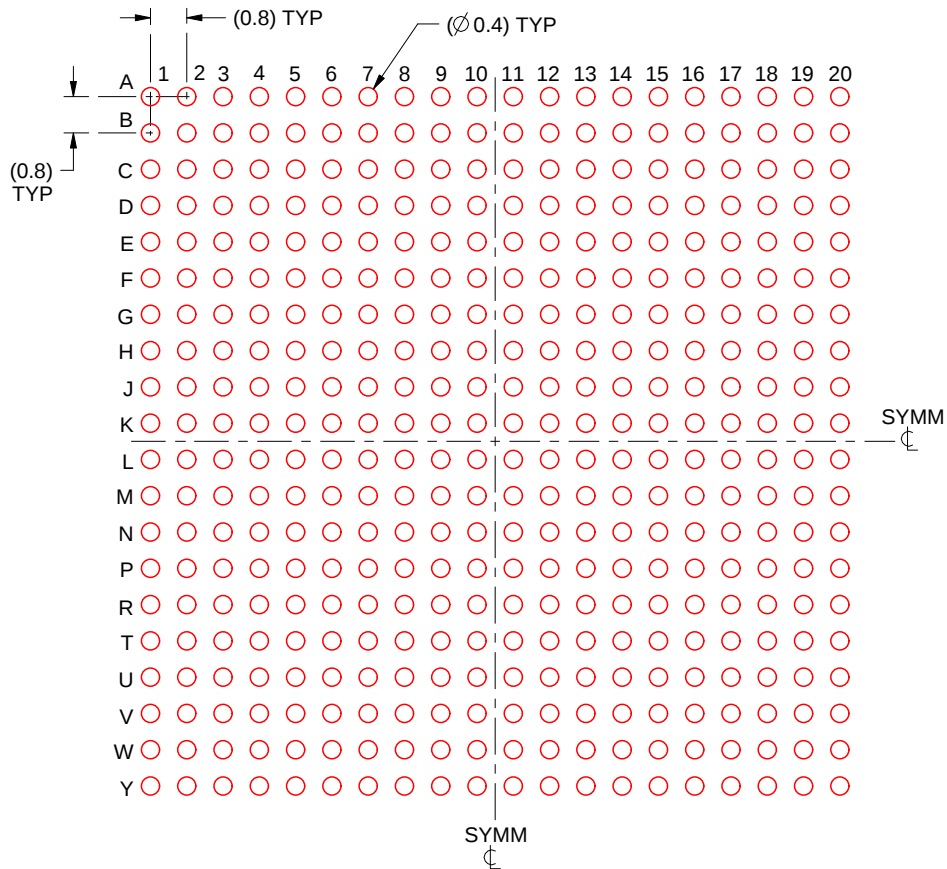
- Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. For more information, see Texas Instruments literature number SPRU811 ([www.ti.com/lit/spru811](http://www.ti.com/lit/spru811)).

# EXAMPLE STENCIL DESIGN

ABJ0400A

FCBGA - 2.65 mm max height

BALL GRID ARRAY



SOLDER PASTE EXAMPLE  
 BASED ON 0.15 mm THICK STENCIL  
 SCALE:6X

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NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.



**FCBGA - 2.65 mm max height**

[illegible]

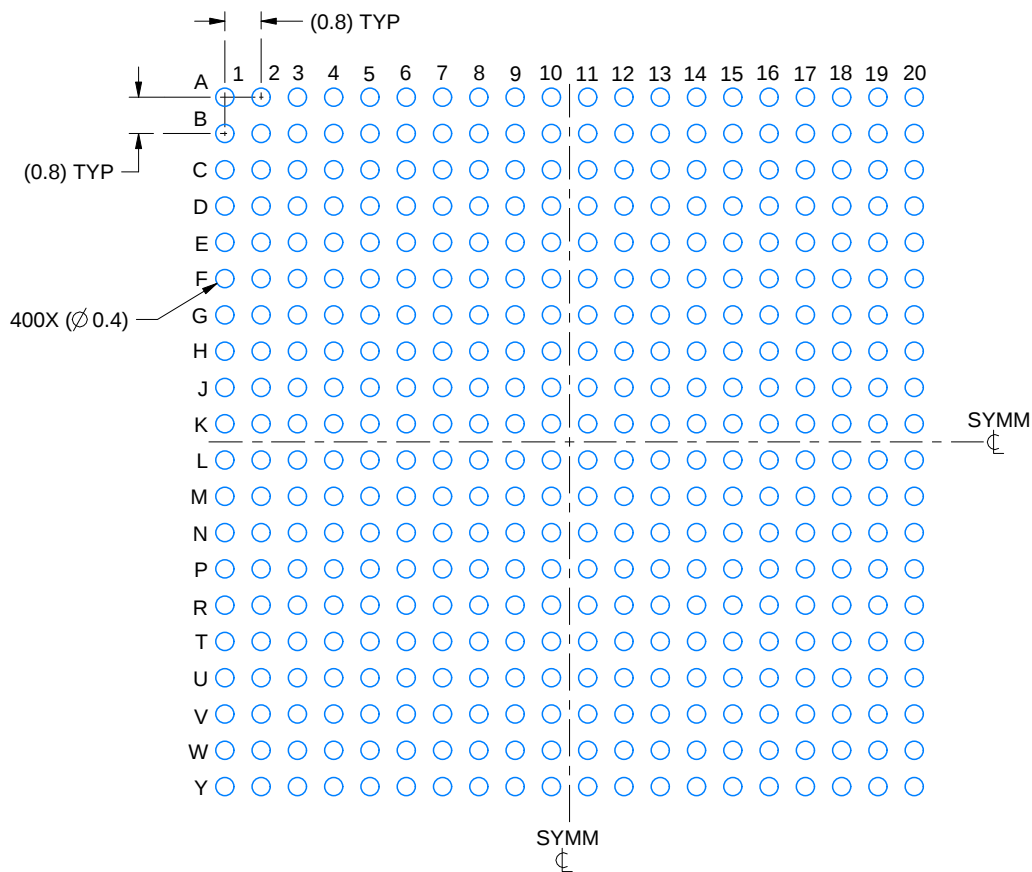
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Dimension is measured at the maximum solder ball diameter, parallel to primary datum C.
4. Primary datum C and seating plane are defined by the spherical crowns of the solder balls.
5. Pb-Free die bump and SnPb solder ball.
6. The lids are electrically floating (e.g. not tied to GND).

# EXAMPLE BOARD LAYOUT

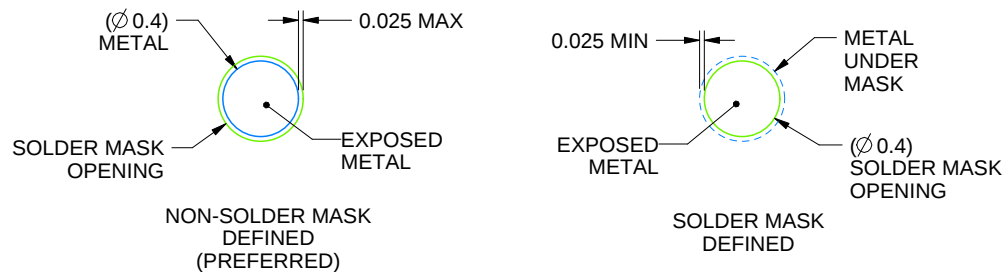
ALK0400A

FCBGA - 2.65 mm max height

BALL GRID ARRAY



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:6X



SOLDER MASK DETAILS  
NOT TO SCALE

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NOTES: (continued)

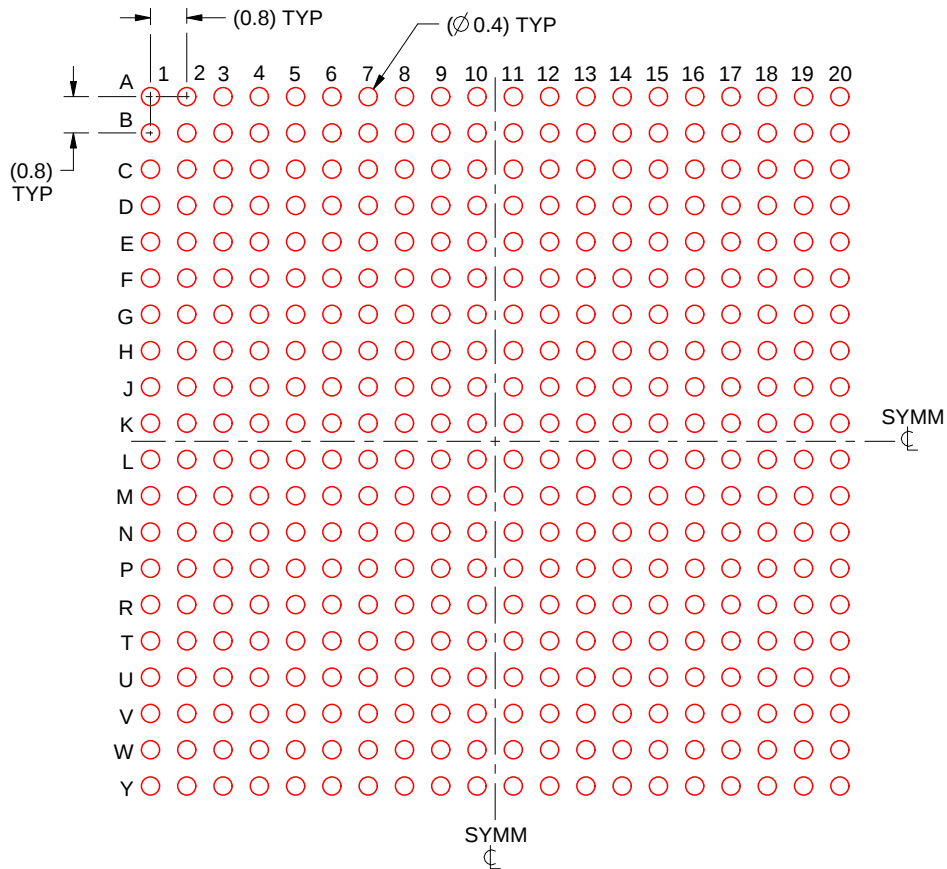
- Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. For more information, see Texas Instruments literature number SPRU811 ([www.ti.com/lit/spru811](http://www.ti.com/lit/spru811)).

# EXAMPLE STENCIL DESIGN

ALK0400A

FCBGA - 2.65 mm max height

BALL GRID ARRAY



SOLDER PASTE EXAMPLE  
 BASED ON 0.15 mm THICK STENCIL  
 SCALE:6X

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NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

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