

## SN65HVD63 AISG® On and Off Keying Coax Modem Transceiver

### 1 Features

- 3-V to 5.5-V Supply Range
- 1.6-V to 5.5-V Independent Logic Supply
- –15-dBm to +5-dBm Wide-Input Dynamic Range for Receiver
- 0-dBm to 6-dBm Adjustable Power Delivered by the Driver to the Coax
- AISG® V2.0-Compliant Output Emission Profile Also Conforms to Proposed AISG V3.0 Specifications
- Low-Power Standby Mode
- Direction Control Output for RS-485 Bus Arbitration
- Up to 115 kbps of Signaling Support
- 2.176-MHz Center Frequency for Integrated Active Bandpass Filter
- 3-mm × 3-mm 16-Pin VQFN Package

### 2 Applications

- AISG – Interface for Antenna Line Devices
- Tower-Mounted Amplifiers (TMA)
- General Modem Interfaces

### 3 Description

The SN65HVD63 transceiver modulates and demodulates signals between a logic (baseband) interface and a frequency suitable for long coaxial media, to facilitate wired data transfer among radio equipment.

The SN65HVD63 device is an integrated AISG transceiver designed to meet the requirements of the upcoming Antenna Interface Standards Group v3.0 specification.

The SN65HVD63 receiver integrates an active bandpass filter to enable demodulation of signals even in the presence of spurious frequency components. The filter has a 2.176-MHz center frequency.

The transmitter supports adjustable output power levels from 0 dBm to 6 dBm delivered to the 50-Ω coax cable. The SN65HVD63 transmitter is compliant with the spectrum emission requirement provided by the AISG standard.

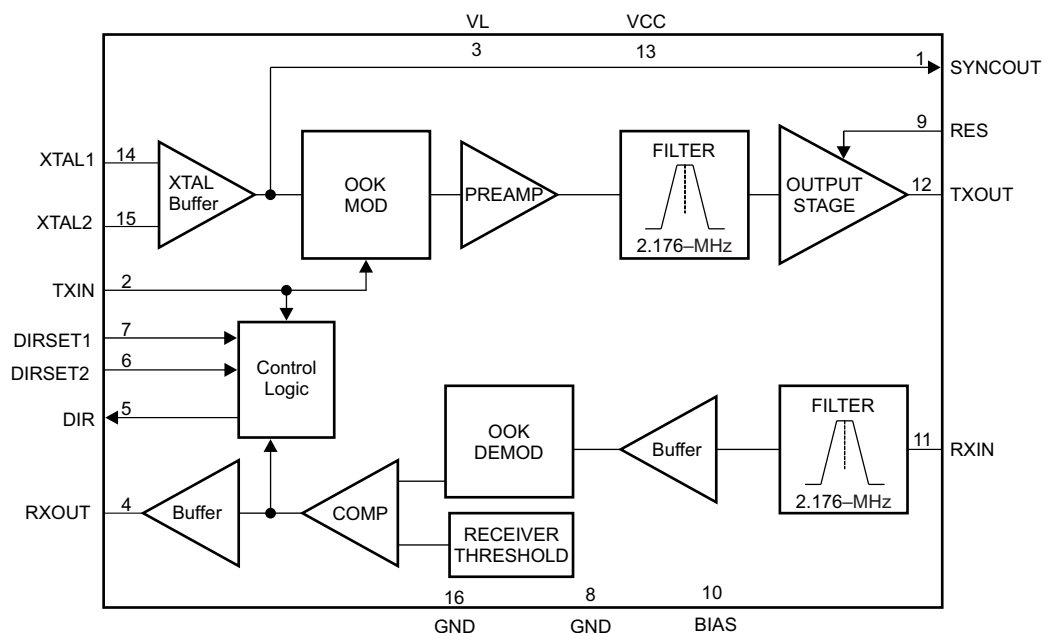
A direction control output facilitates bus arbitration for an RS-485 interface. This device integrates an oscillator input for a crystal, and also accepts standard clock inputs to the oscillator.

#### Device Information<sup>(1)</sup>

| PART NUMBER | PACKAGE   | BODY SIZE (NOM)   |
|-------------|-----------|-------------------|
| SN65HVD63   | VQFN (16) | 3.00 mm × 3.00 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

#### Block Diagram



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## 4 Revision History

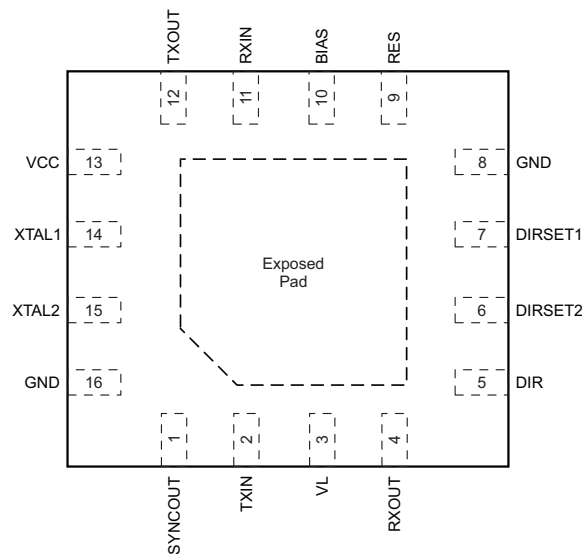
| DATE      | REVISION | NOTES            |
|-----------|----------|------------------|
| July 2015 | *        | Initial release. |

## 5 Device Comparison Table

| PART NUMBER | STANDARD SUPPORTED | SPURIOUS FREQUENCY RANGE | MAXIMUM LEVEL                   |
|-------------|--------------------|--------------------------|---------------------------------|
| SN65HVD62   | AISG 2.0           | $\leq 1.1$ MHz           | 2 dBm (793 mV <sub>pp</sub> )   |
|             |                    | $\leq 4.17$ MHz          | 2 dBm (793 mV <sub>pp</sub> )   |
| SN65HVD63   | AISG 3.0           | $\leq 1.35$ MHz          | –13 dBm (142 mV <sub>pp</sub> ) |
|             |                    | $\leq 3.5$ MHz           | –13 dBm (142 mV <sub>pp</sub> ) |

## 6 Pin Configuration and Functions

**RGT Package**  
**16-Pin VQFN With Exposed Thermal Pad**  
**Top View**



**Pin Functions**

| PIN             |     |      | DESCRIPTION                                                                                                                                              |
|-----------------|-----|------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME            | NO. | TYPE |                                                                                                                                                          |
| BIAS            | 10  | O    | Bias voltage output for setting driver output power by external resistors                                                                                |
| DIR             | 5   | O    | Direction control output signal for bus arbitration                                                                                                      |
| DIRSET1         | 7   | —    | DIRSET1 and DIRSET2: Bits to set the duration of DIR<br>DIRSET[2:1]: [L:L] = 9.6 kbps; [L:H] = 38.4 kbps; [H:L] = 115 kbps; [H:H] = standby mode         |
| DIRSET2         | 6   | —    |                                                                                                                                                          |
| GND             | 8   | —    | Ground                                                                                                                                                   |
|                 | 16  |      |                                                                                                                                                          |
| RES             | 9   | P    | Input voltage to adjust driver output power that is set by external resistors from BIAS pin to GND                                                       |
| RXIN            | 11  | I    | Modulated input signal to the receiver                                                                                                                   |
| RXOUT           | 4   | O    | Digital data bit stream from receiver                                                                                                                    |
| SYNCOUT         | 1   | O    | Open-drain output to synchronize other devices to the 4x-carrier oscillator at XTAL1 and XTAL2                                                           |
| TXIN            | 2   | I    | Digital data bit stream to driver                                                                                                                        |
| TXOUT           | 12  | O    | Modulated output signal from the driver                                                                                                                  |
| V <sub>CC</sub> | 13  | P    | Analog supply voltage for the device                                                                                                                     |
| VL              | 3   | P    | Logic supply voltage for the device                                                                                                                      |
| XTAL1           | 14  | I/O  | I/O pins of the crystal oscillator. Connect a $4 \times f_c$ crystal between these pins or connect XTAL1 to an 8.704-MHz clock and connect XTAL2 to GND. |
| XTAL2           | 15  |      |                                                                                                                                                          |
| EP              | —   | —    | Exposed pad. Connection to ground plane is recommended for best thermal conduction.                                                                      |

## 7 Specifications

### 7.1 Absolute Maximum Ratings<sup>(1)</sup>

|                                               | MIN                                         | MAX            | UNIT |
|-----------------------------------------------|---------------------------------------------|----------------|------|
| Supply voltage, $V_{CC}$ and $V_L$            | –0.5                                        | 6              | V    |
| Voltage at coax pins                          | –0.5                                        | 6              | V    |
| Voltage at logic pins                         | –0.3                                        | $V_{VL} + 0.3$ | V    |
| Logic output current                          | –20                                         | 20             | mA   |
| TXOUT output current                          | Internally limited                          |                |      |
| SYNCOUT output current                        | Internally limited                          |                |      |
| Junction temperature, $T_J$                   |                                             | 170            | °C   |
| Continuous total power dissipation            | See the <a href="#">Thermal Information</a> |                | °C   |
| Storage temperature, $T_{stg}$ <sup>(2)</sup> | –65                                         | 150            | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Applicable before the device is installed in the final product.

### 7.2 ESD Ratings

|                                                                                                       | VALUE | UNIT |
|-------------------------------------------------------------------------------------------------------|-------|------|
| $V_{(ESD)}$ Electrostatic discharge Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup> | ±2000 | V    |

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

### 7.3 Recommended Operating Conditions

|                                                            | MIN                                                    | NOM          | MAX          | UNIT            |
|------------------------------------------------------------|--------------------------------------------------------|--------------|--------------|-----------------|
| $V_{CC}$ Analog supply voltage                             | 3                                                      |              | 5.5          | V               |
| $V_L$ Logic supply voltage                                 | 1.6                                                    |              | 5.5          | V               |
| $V_{I(pp)}$ Input signal amplitude at RXIN                 |                                                        |              | 1.12         | V <sub>pp</sub> |
| $V_{IH}$ High-level input voltage                          | TXIN, DIRSET1, DIRSET2                                 | 70% $V_L$    | $V_L$        | V               |
|                                                            | XTAL1, XTAL2                                           | 70% $V_{CC}$ | $V_{CC}$     |                 |
| $V_{IL}$ Low-level input voltage                           | TXIN, DIRSET1, DIRSET2                                 | 0            | 30% $V_L$    | V               |
|                                                            | XTAL1, XTAL2                                           | 0            | 30% $V_{CC}$ |                 |
| $1/t_{UI}$ Data signaling rate                             | 9.6                                                    |              | 115          | kbps            |
| $F_{OSC}$ Oscillator frequency                             | –30 ppm                                                | 8.704        | 30 ppm       | MHz             |
| $Z_{LOAD}$                                                 | Load impedance between TXOUT to RXIN                   | 50           |              | Ω               |
|                                                            | Load impedance between RXIN and GND at $f_C$ (channel) | 50           |              | Ω               |
| R1 Bias resistor between BIAS and RES                      |                                                        | 4.1          |              | kΩ              |
| R2 Bias resistor between RES and GND                       |                                                        | 10           |              | kΩ              |
| $R_{SYNC}$ Pullup resistor between SYNCOUT and $V_{CC}$    |                                                        | 1            |              | kΩ              |
| $V_{RES}$ Voltage at RES pin                               | 0.7                                                    |              | 1.5          | V               |
| $C_C$ Coupling capacitance between RXIN and coax (channel) |                                                        | 220          |              | nF              |
| $C_{BIAS}$ Capacitance between BIAS and GND                |                                                        | 1            |              | μF              |
| $T_A$ Operating free-air temperature                       | –40                                                    |              | 105          | °C              |
| $T_J$ Junction temperature                                 | –40                                                    |              | 125          | °C              |

### 7.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup>                          | VQFN       | UNIT |
|--------------------------------------------------------|------------|------|
|                                                        | RGT16 Pins |      |
| $R_{\theta JA}$ Junction-to-ambient thermal resistance | 49.4       | °C/W |

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).



**Thermal Information (continued)**

| THERMAL METRIC <sup>(1)</sup> |                                              | VQFN       | UNIT |
|-------------------------------|----------------------------------------------|------------|------|
|                               |                                              | RGT16 Pins |      |
| $R_{\theta JCtop}$            | Junction-to-case (top) thermal resistance    | 64.2       | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | 22.9       | °C/W |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter   | 1.7        | °C/W |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter | 22.9       | °C/W |
| $R_{\theta JCbot}$            | Junction-to-case (bottom) thermal resistance | 25         | °C/W |

## 7.5 Electrical Characteristics

over recommended operating conditions (unless otherwise noted)

| PARAMETER                 |                                                                                     | TEST CONDITIONS                                                                                                           | MIN                                | TYP                            | MAX  | UNIT            |      |
|---------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|------------------------------------|--------------------------------|------|-----------------|------|
| POWER SUPPLY              |                                                                                     |                                                                                                                           |                                    |                                |      |                 |      |
| I <sub>CC</sub>           | Supply current                                                                      | DIRSET1 = L<br>DIRSET2 = H                                                                                                | TXIN = L (active)                  | 28                             | 33   | mA              |      |
|                           |                                                                                     |                                                                                                                           | TXIN = H (quiescent)               | 25                             | 31   |                 |      |
|                           |                                                                                     |                                                                                                                           | TXIN = 115 kbps,<br>50% duty cycle | 27                             | 33   |                 |      |
|                           |                                                                                     | DIRSET1 = H, DIRSET2 = H (standby)                                                                                        |                                    | 12                             | 17   |                 |      |
| I <sub>VL</sub>           | Logic supply current                                                                | TXIN = H, RXIN = DC input                                                                                                 |                                    | 50                             |      | μA              |      |
| PSRR                      | Receiver power supply rejection ratio                                               | V <sub>TXIN</sub> = V <sub>L</sub>                                                                                        |                                    | 45                             | 60   | dB              |      |
| LOGIC PINS                |                                                                                     |                                                                                                                           |                                    |                                |      |                 |      |
| V <sub>OH</sub>           | High-level logic output voltage<br>(RXOUT, DIR)                                     | I <sub>OH</sub> = −4 mA for V <sub>L</sub> > 2.4 V,<br>I <sub>OH</sub> = −2 mA for V <sub>L</sub> < 2.4 V                 |                                    | 90%V <sub>VL</sub>             |      | V               |      |
| V <sub>OL</sub>           | Low-level logic output voltage<br>(RXOUT, DIR)                                      | I <sub>OL</sub> = 4 mA for V <sub>L</sub> > 2.4 V,<br>I <sub>OL</sub> = 2 mA for V <sub>L</sub> < 2.4 V                   |                                    | 10%V <sub>V</sub> <sub>L</sub> |      | V               |      |
| COAX DRIVER               |                                                                                     |                                                                                                                           |                                    |                                |      |                 |      |
| V <sub>O(PP)</sub>        | Peak-to-peak output voltage at device pin<br>TXOUT (see <a href="#">Figure 19</a> ) | V <sub>RES</sub> = 1.5 V (Maximum setting)                                                                                |                                    | 2.24                           | 2.5  | V <sub>PP</sub> |      |
|                           |                                                                                     | V <sub>RES</sub> = 0.7 V (Minimum setting)                                                                                |                                    | 1.17                           | 1.3  |                 |      |
| V <sub>O(PP)</sub>        | Peak-to-peak voltage at coax out<br>(see <a href="#">Figure 19</a> )                | V <sub>RES</sub> = 1.5 V                                                                                                  |                                    | 5                              | 6    | dBm             |      |
|                           |                                                                                     | V <sub>RES</sub> = 0.7 V                                                                                                  |                                    | −0.6                           | 0.3  |                 |      |
| V <sub>O(OFF)</sub>       | Off-state output voltage                                                            | At TXOUT                                                                                                                  |                                    | 1                              |      | mVpp            |      |
|                           |                                                                                     | At coax out                                                                                                               |                                    | −60                            |      | dBm             |      |
|                           | Output emissions                                                                    | Coupled to coaxial cable with characteristic<br>impedance of 50 Ω, as shown in <a href="#">Figure 1</a> <sup>(1)(2)</sup> |                                    |                                |      | N/A             |      |
| f <sub>O</sub>            | Output frequency                                                                    |                                                                                                                           |                                    | 2.176                          |      | MHz             |      |
| Δf                        | Output frequency variation                                                          |                                                                                                                           |                                    | −100                           | 100  | ppm             |      |
| Z <sub>O</sub>            | Output impedance                                                                    | At 100 kHz                                                                                                                |                                    | 0.03                           |      | Ω               |      |
|                           |                                                                                     | At 10 MHz                                                                                                                 |                                    | 3.5                            |      |                 |      |
| I <sub>OS</sub>           | Short-circuit output current                                                        | TXOUT is also protected by a thermal shutdown<br>circuit during short-circuit faults                                      |                                    | 300                            | 450  | mA              |      |
| COAX RECEIVER             |                                                                                     |                                                                                                                           |                                    |                                |      |                 |      |
| V <sub>IT</sub>           | Input threshold                                                                     | f <sub>IN</sub> = 2.176 MHz                                                                                               | 79                                 |                                | 112  | 158             | mVPP |
|                           |                                                                                     |                                                                                                                           | −18                                |                                | −15  | −12             | dBm  |
| Z <sub>IN</sub>           | Input impedance                                                                     | f = f <sub>O</sub>                                                                                                        |                                    | 11                             | 21   | kΩ              |      |
| RECEIVER FILTER           |                                                                                     |                                                                                                                           |                                    |                                |      |                 |      |
| f <sub>PB</sub>           | Passband                                                                            | VRXIN = 1.12VP_P                                                                                                          |                                    | 1.1                            | 4.17 | MHz             |      |
| f <sub>REJ</sub>          | Receiver rejection range                                                            | 2.176-MHz carrier amplitude of 112.4 mV <sub>PP</sub> , frequency<br>band of spurious components with 800 mVPP allowed.   |                                    | 1.1                            | 4.17 | MHz             |      |
| t <sub>noise filter</sub> | Receiver noise filter time (slow bit rate)                                          | DIRSET for 9.6 kbps                                                                                                       |                                    | 4                              |      | μs              |      |
|                           | Receiver noise filter time (fast bit rate)                                          | DIRSET for > 9.6 kbps                                                                                                     |                                    | 2                              |      | μs              |      |
| XTAL AND SYNC             |                                                                                     |                                                                                                                           |                                    |                                |      |                 |      |
| I <sub>I</sub>            | Input leakage current                                                               | XTAL1, XTAL2, 0V < V <sub>IN</sub> < V <sub>CC</sub>                                                                      |                                    | −15                            | 15   | μA              |      |
| V <sub>OL</sub>           | Output low voltage                                                                  | SYNCOUT, with 1-kΩ resistor from SYNCOUT to V <sub>CC</sub>                                                               |                                    | 0.4                            |      | V               |      |

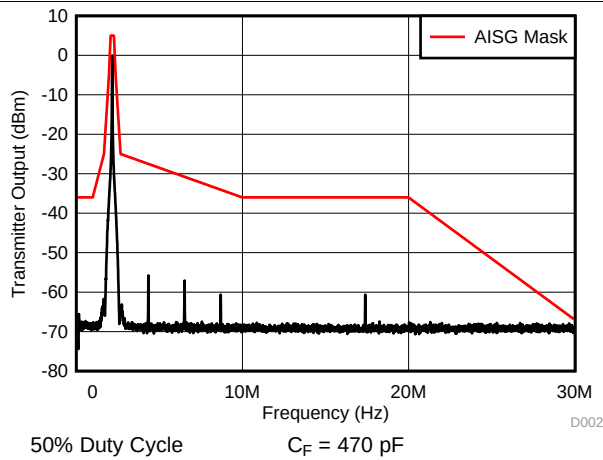
- (1) Specified by design with a recommended 470-pF capacitor between RXIN and GND. Measurements above 150 MHz are determined by setup.
- (2) Conforms to AISG spectrum emissions mask, 3GPP TS 25.461, see Figure 21.

## 7.6 Switching Characteristics

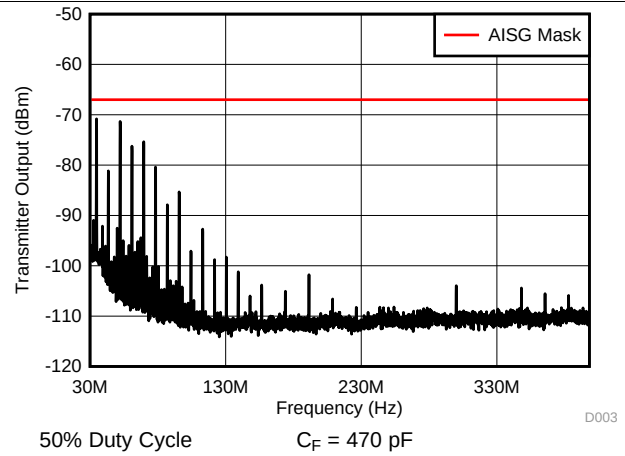
over recommended operating conditions (unless otherwise noted)

| PARAMETER                       |                                       | TEST CONDITIONS                                                                       | MIN | TYP  | MAX | UNIT    |
|---------------------------------|---------------------------------------|---------------------------------------------------------------------------------------|-----|------|-----|---------|
| $t_{pAQ}, t_{pQA}$              | Coax driver propagation delay         | See <a href="#">Figure 19</a>                                                         |     |      | 5   | $\mu s$ |
| $t_r, t_f$                      | Coax receiver output rise/fall time   | $C_L = 15 \text{ pF}$ , $R_L = 1 \text{ k}\Omega$ ; see <a href="#">Figure 19</a>     |     |      | 20  | ns      |
| $t_{PHL}, t_{PLH}$              | Receiver propagation delay            | See <a href="#">Figure 20</a>                                                         |     | 5.5  | 11  | $\mu s$ |
| Coax receiver output duty cycle |                                       | $V_{RXIN(ON)} = 630 \text{ mVpp}$ , $V_{RXIN(OFF)} < 5 \text{ mVpp}$ , 50% duty cycle | 40% |      | 60% |         |
|                                 |                                       | $V_{RXIN(ON)} = 200 \text{ mVpp}$ , $V_{RXIN(OFF)} < 5 \text{ mVpp}$ , 50% duty cycle | 40% |      | 60% |         |
| $t_{DIR}$                       | Direction control active duration     | $DIRSET2 = \text{GND or OPEN}$ , $DIRSET1 = \text{GND or OPEN}$                       |     | 1667 |     | $\mu s$ |
|                                 |                                       | $DIRSET2 = \text{GND}$ , $DIRSET1 = \text{VL}$                                        |     | 417  |     |         |
|                                 |                                       | $DIRSET2 = \text{VL}$ , $DIRSET1 = \text{VL}$                                         |     | 137  |     |         |
| $t_{DIRSKEW}$                   | Direction control skew (DIR to RXOUT) |                                                                                       | 270 |      |     | ns      |
| $t_{dis}$                       | Standby disable delay                 | 300 mV <sub>pp</sub> at 2.176 MHz on RXIN                                             |     | 2    |     | ms      |
| $t_{en}$                        | Standby enable delay                  | 300 mV <sub>pp</sub> at 2.176 MHz on RXIN                                             |     | 2    |     | ms      |

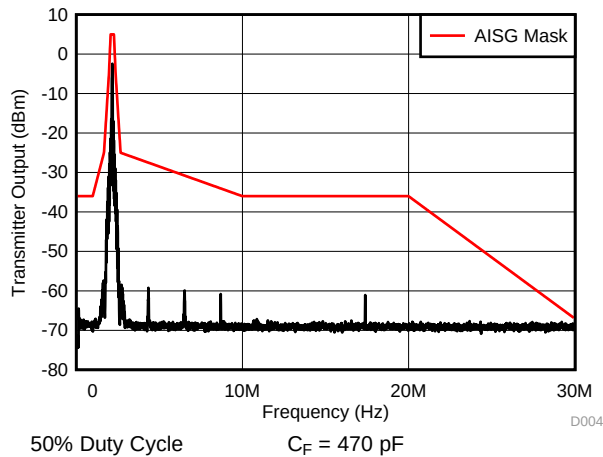
## 7.7 Typical Characteristics



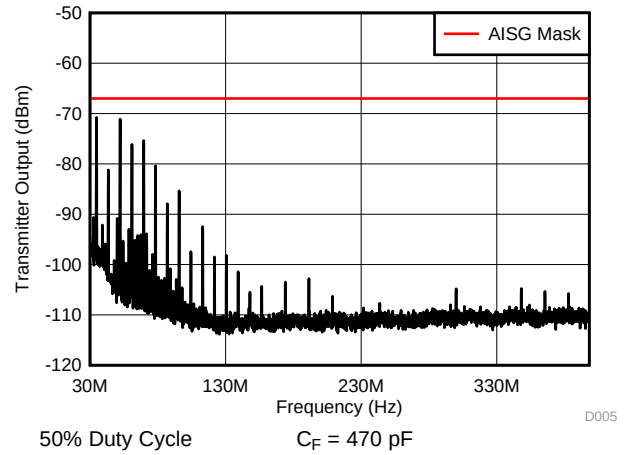
**Figure 1. Low-Frequency Emissions Spectrum With 9.6-kbps Signaling Rate**



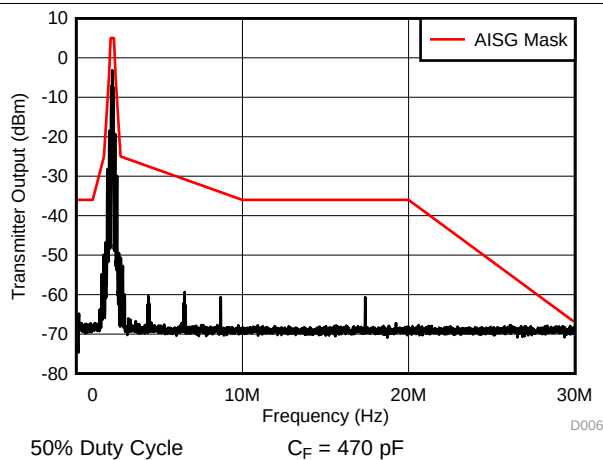
**Figure 2. High-Frequency Emissions Spectrum With 9.6-kbps Signaling Rate**



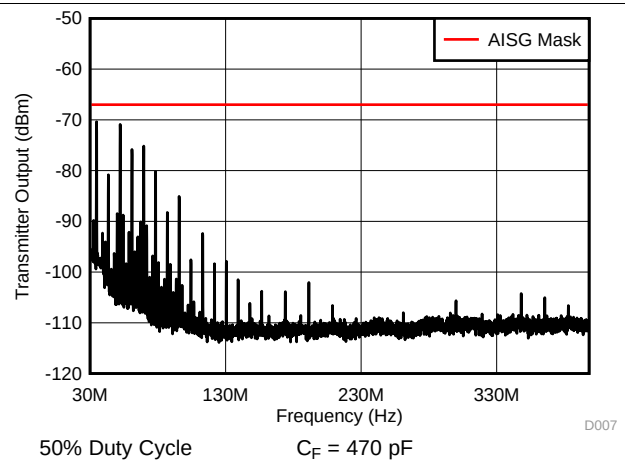
**Figure 3. Low-Frequency Emissions Spectrum With 38.4-kbps Signaling Rate**



**Figure 4. High-Frequency Emissions Spectrum With 38.4-kbps Signaling Rate**

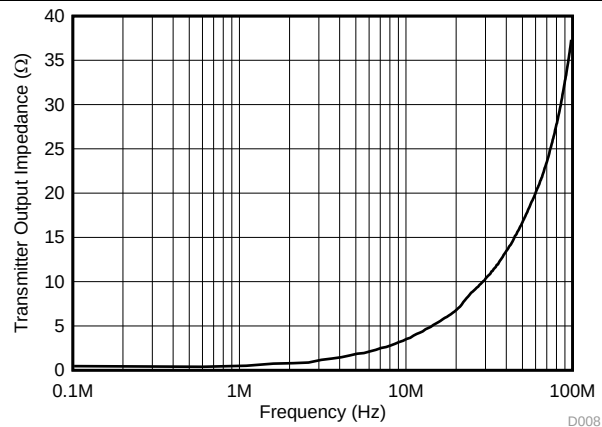


**Figure 5. Low-Frequency Emissions Spectrum With 115.2-kbps Signaling Rate**

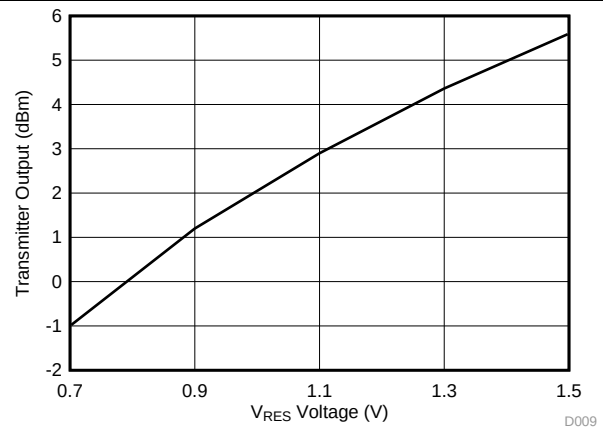


**Figure 6. High-Frequency Emissions Spectrum With 115.2-kbps Signaling Rate**

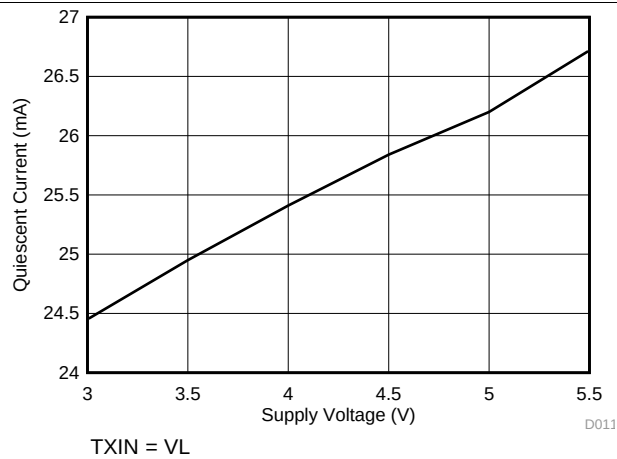
## Typical Characteristics (continued)



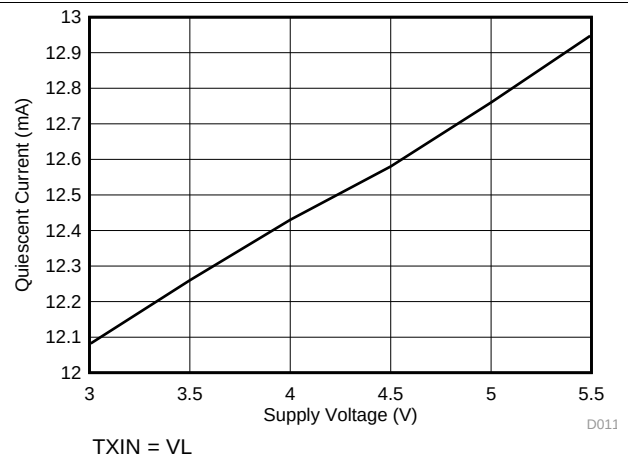
**Figure 7. Transmitter Output Impedance**



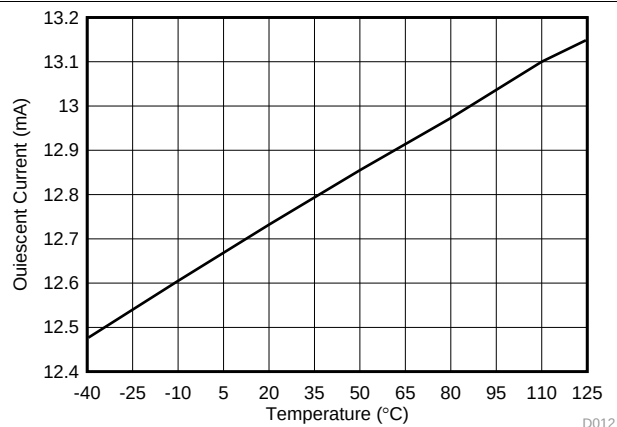
**Figure 8. Transmit Power Adjustment**



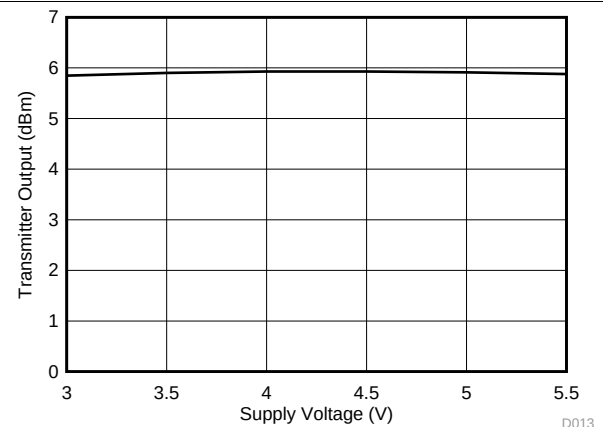
**Figure 9. Supply Current vs Supply Voltage While Transmitting**



**Figure 10. Supply Current vs Supply Voltage in Standby Mode**



**Figure 11. Supply Current vs Temperature in Standby Mode**



**Figure 12. Transmitter Output Power vs Supply Voltage**

## Typical Characteristics (continued)

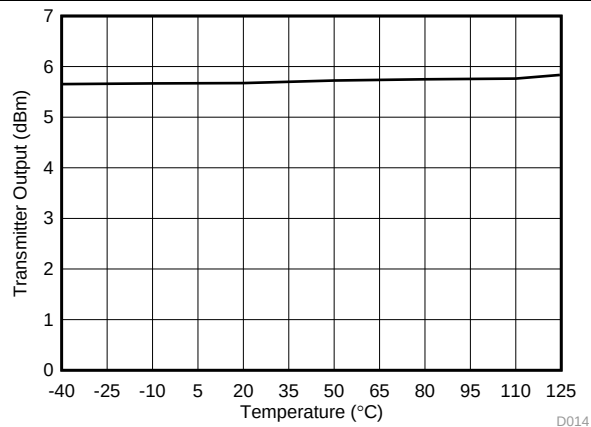


Figure 13. Transmitter Output Power vs Temperature

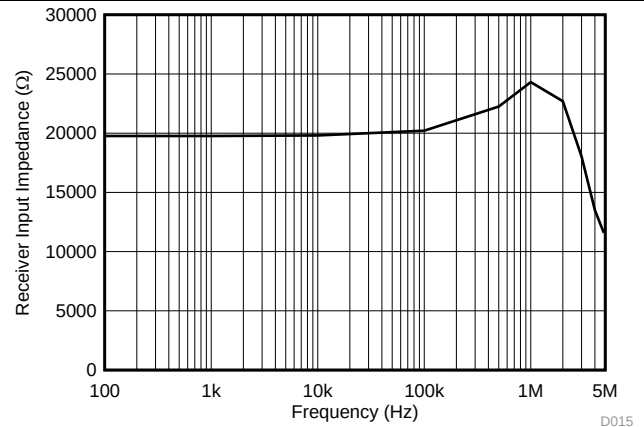


Figure 14. Receiver Input Impedance vs Frequency

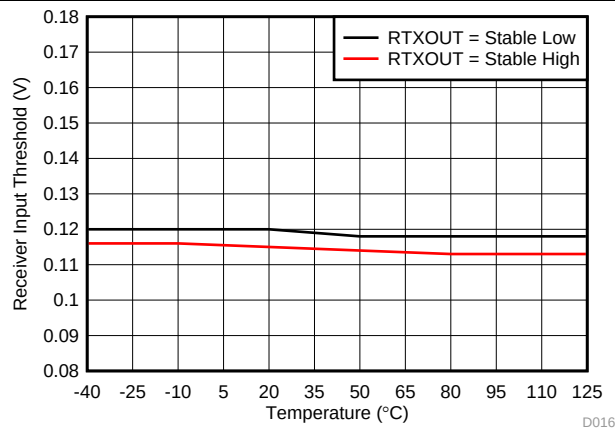


Figure 15. Receiver Input Threshold vs Temperature

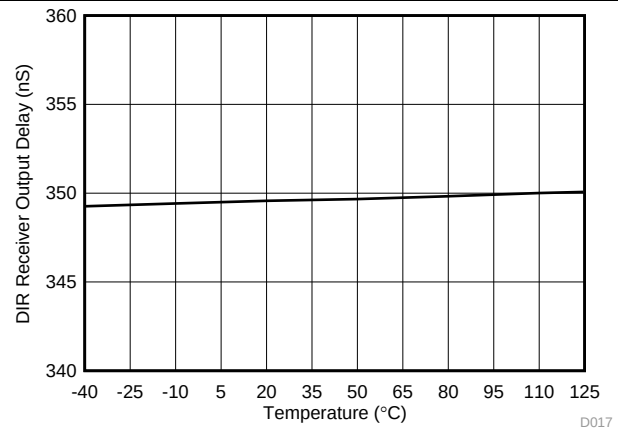


Figure 16. DIR Output Delay vs Temperature

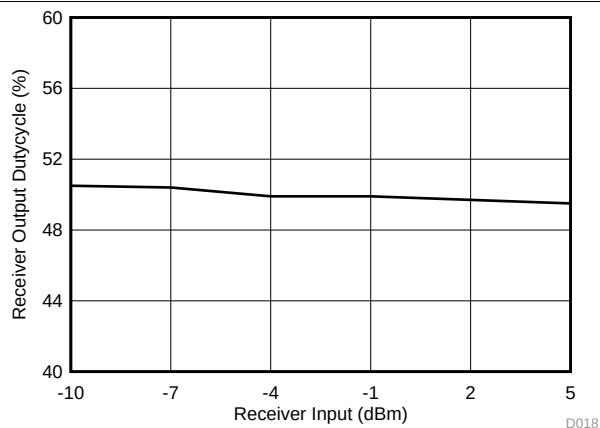


Figure 17. Receiver Duty Cycle  
With 9.6 kbps Signaling Rate

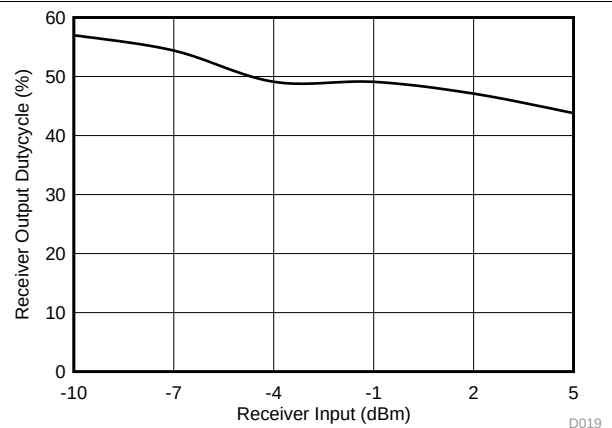
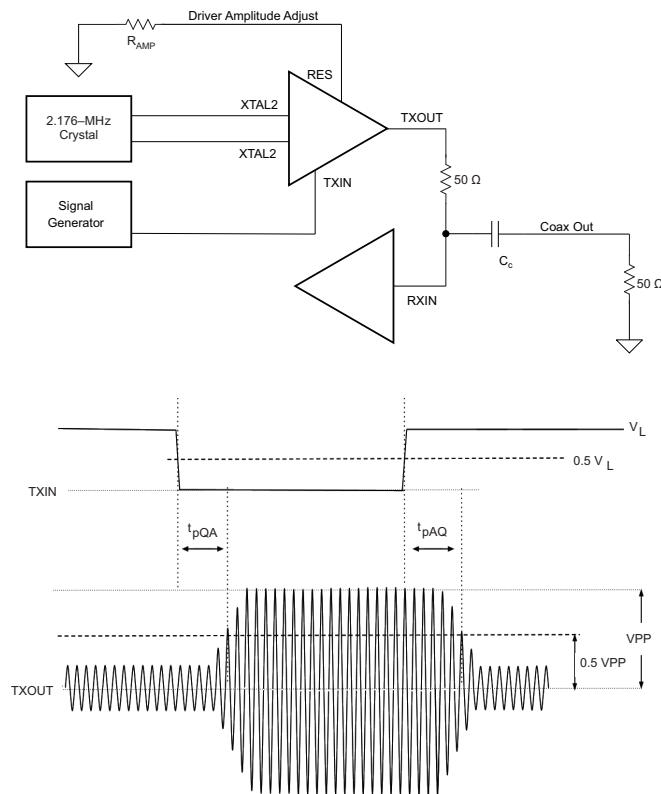


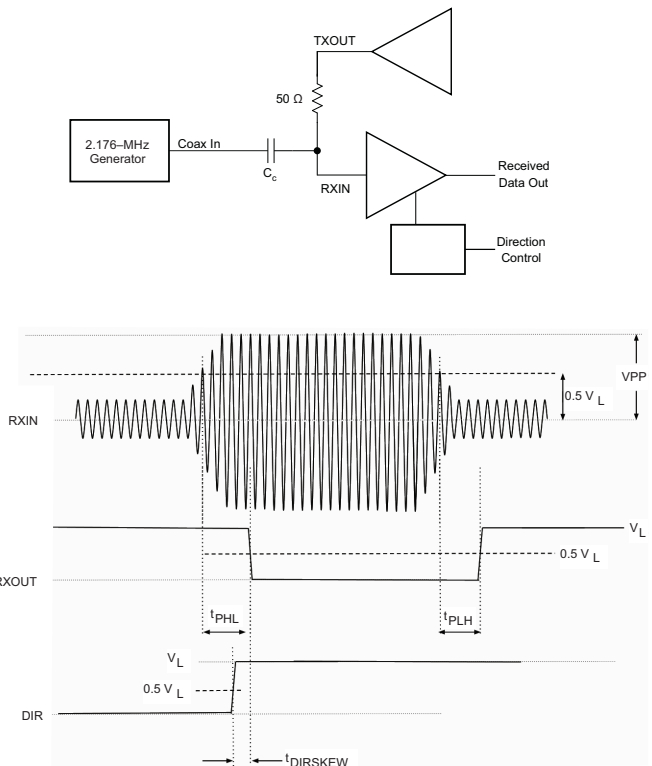
Figure 18. Receiver Duty Cycle  
With 115.2 kbps Signaling Rate

## 8 Parameter Measurement Information

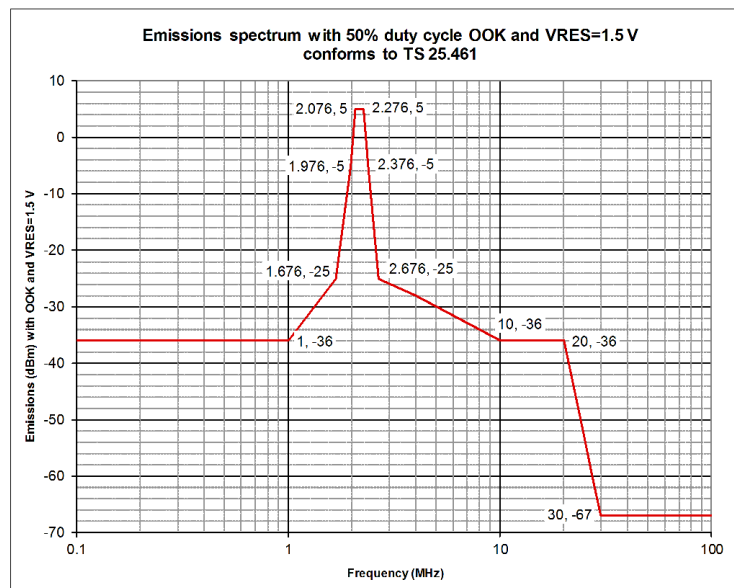
Signal generator rate is 115 kbps, 50% duty cycle. Rise and fall times are less than 6 ns, and nominal output levels are 0 V and 3 V. Coupling capacitor,  $C_C$ , is 220 nF.



**Figure 19. Measurement of Modem Driver Output Voltage With 50-Ω Loads**



**Figure 20. Measurement of Modem Receiver Propagation Delays**



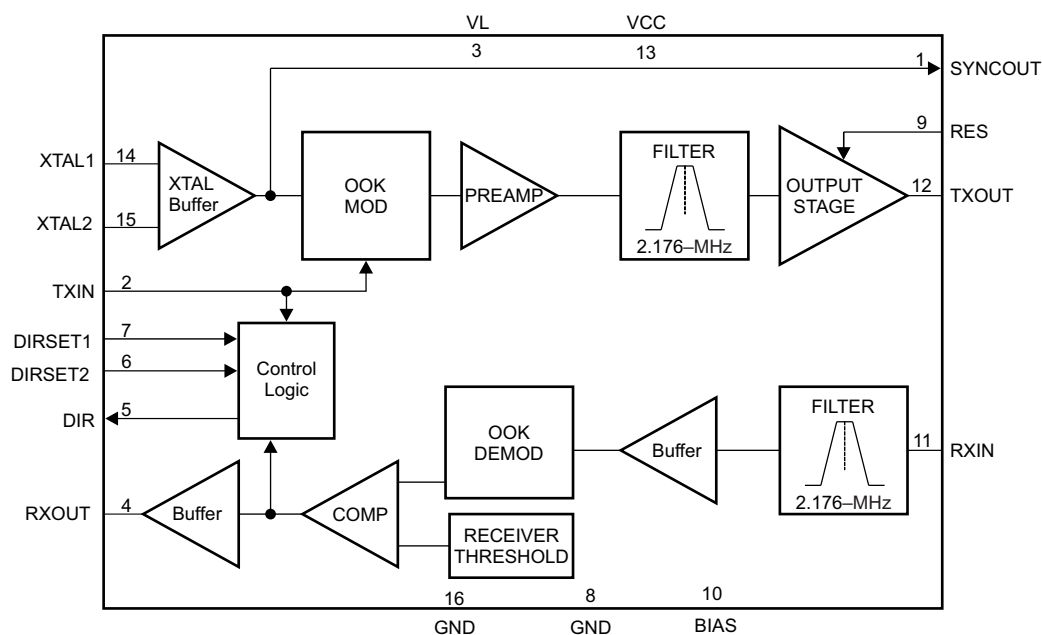
**Figure 21. AISG Emissions Template**

## 9 Detailed Description

### 9.1 Overview

The SN65HVD63 transceiver modulates and demodulates signals between the logic (baseband) and a frequency suitable for long coaxial media. The SN65HVD63 device is an integrated AISG transceiver designed to meet the requirements of the upcoming Antenna Interface Standards Group v3.0 specification. The SN65HVD63 receiver integrates an active bandpass filter to enable demodulation of signals even in the presence of spurious frequency components. The filter has a 2.176-MHz center frequency. The transmitter supports adjustable output power levels from 0 dBm to 6 dBm delivered to the 50-Ω coax cable. The SN65HVD63 transmitter is compliant with the spectrum emission requirement provided by the AISG standard. A direction control output facilitates bus arbitration for an RS-485 interface. This device integrates an oscillator input for a crystal, and also accepts standard clock inputs to the oscillator.

### 9.2 Functional Block Diagram



### 9.3 Feature Description

#### 9.3.1 Coaxial Interface

The SN65HVD63 transceiver enables the transfer of data between radio equipment by modulating baseband data to a carrier frequency of 2.176 MHz (per the AISG standard). The transmitter output amplitude can be configured from 0 dBm to 6 dBm in order to communicate over a variety of different links, and the output emissions spectrum is designed to be compliant to AISG limits. The receiver features an active bandpass filter circuit that helps to separate the carrier frequency data from other spurious frequency components.

#### 9.3.2 Reference Input

The 2.176-MHz modulation frequency is derived from an input reference that is nominally 8.704 MHz. The input reference can come either from a crystal or from an oscillator circuit with a tolerance of up to 30 ppm.

#### 9.3.3 RS-485 Direction Control

To facilitate bus arbitration of an RS-485 interface, the SN65HVD63 provides a direction control output that can be used to control the enable/disable controls of an RS-485 transceiver. The direction control output automatically toggles based on activity present on the coaxial input interface, and has an adjustable time constant (controlled by the DIRSET1 and DIRSET2 pins) in order to accommodate various signaling rates.



## 9.4 Device Functional Modes

If DIRSET1 and DIRSET2 are in a logic high state, the device will be in standby mode. While in standby mode, the receiver functions normally, detecting carrier frequency activity on the RXIN pin and setting the RXOUT state. The transmitter circuits are not active in standby mode, thus the TXOUT pin is idle regardless of the logic state of TXIN. The supply current in standby mode is significantly reduced, allowing power savings when the node is not transmitting.

When not in standby mode, the default power-on state is idle. When in idle mode, RXOUT is high, and TXOUT is quiet. The device transitions to receive mode when a valid modulated signal is detected on the RXIN line or the device transitions to transmit mode when TXIN goes low. The device stays in either receive or transmit mode until DIR time-out (nominal 16 bit times) after the last activity on RXOUT or TXIN.

When in receive mode:

- RXOUT responds to all valid modulated signals on RXIN, whether from the local transmitter, a remote transmitter, or long noise burst.
- TXOUT responds to TXIN, generating 2.176-MHz signals on TXOUT when TXIN is low, and TXOUT is quiet when TXIN is high. (In normal operation, TXIN is expected to remain high when the device is in receive mode.)
- The device stays in receive mode until 16 bit times after the last rising edge on RXOUT, caused by valid modulated signal on the RXIN line.

When in transmit mode:

- RXOUT stays high, regardless of the input signal on RXIN.
- TXOUT responds to TXIN, generating 2.176-MHz signals on TXOUT when TXIN is low, and TXOUT is quiet when TXIN is high.
- The device stays in transmit mode until 16 bit times after TXIN goes high.

Table 1 shows the driver functions. Table 2 shows the receiver functions. Figure 22 shows the transitions between each state.

**Table 1. Driver Function Table**

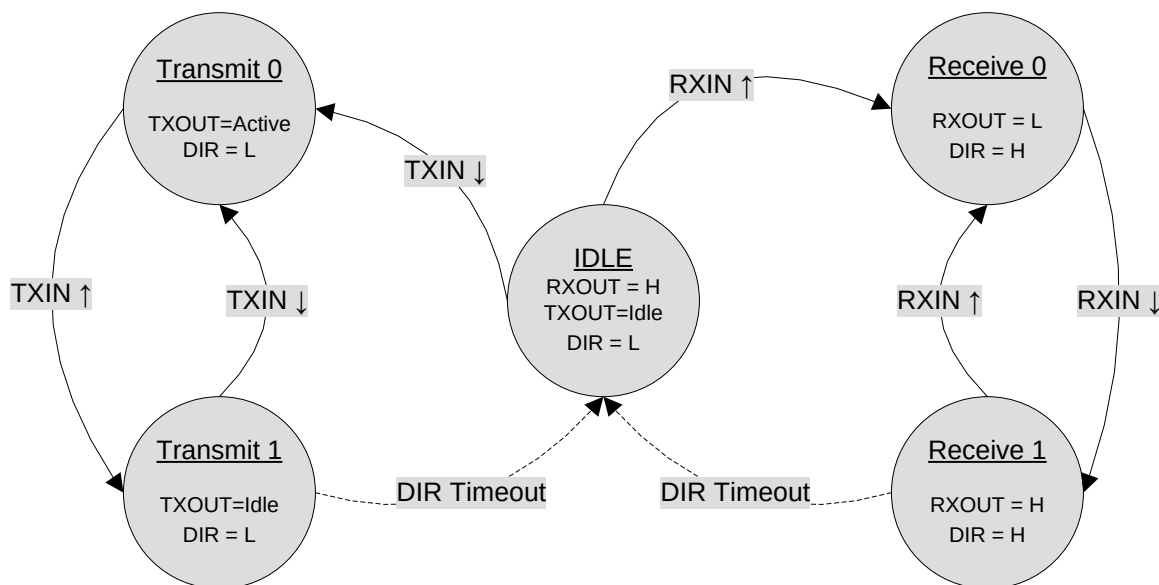
| TXIN <sup>(1)</sup> | [DIRSET1, DIRSET2]    | TXOUT                             | COMMENT           |
|---------------------|-----------------------|-----------------------------------|-------------------|
| H                   | [L,L], [L,H] or [H,L] | < 1 mV <sub>pp</sub> at 2.176 MHz | Driver not active |
| L                   |                       | V <sub>OPP</sub> at 2.176 MHz     | Driver active     |
| X                   | [H,H]                 | < 1 mV <sub>pp</sub> at 2.176 MHz | Standby mode      |

(1) H = High, L = Low, X = Indeterminate

**Table 2. Receiver and DIR Function Table**

| RXIN <sup>(1)</sup>                                                      | RXOUT | DIR | COMMENT (see Figure 22)                          |
|--------------------------------------------------------------------------|-------|-----|--------------------------------------------------|
| <b>IDLE mode (not transmitting or receiving)</b>                         |       |     |                                                  |
| < V <sub>IT</sub> at 2.176 MHz for longer than DIR time-out              | H     | L   | No outgoing or incoming signal                   |
| <b>RECEIVE mode (not already transmitting)</b>                           |       |     |                                                  |
| < V <sub>IT</sub> at 2.176 MHz for less than t <sub>DIR</sub> time-out   | H     | H   | Incoming 1 bit, DIR stays HIGH for DIR time-out  |
| > V <sub>IT</sub> at 2.176 MHz for longer than t <sub>noise filter</sub> | L     | H   | Incoming 0 bit, DIR output is HIGH               |
| <b>TRANSMIT mode (not already receiving)</b>                             |       |     |                                                  |
| X                                                                        | H     | L   | Outgoing message, DIR stays LOW for DIR time-out |

(1) H = High, L = Low, X = Indeterminate



**Figure 22. State Transition Diagram**

## 10 Application and Implementation

### NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 10.1 Application Information

#### 10.1.1 Driver Amplitude Adjust

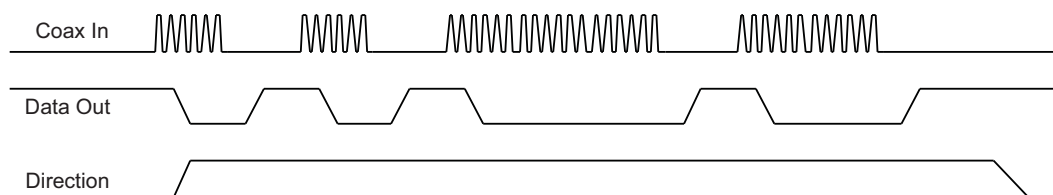
The SN65HVD63 device can provide up to 2.5 V of peak-to-peak output signal at the TXOUT pin to compensate for potential loss within the external filter, cable, connections, and termination. External resistors are used to set the amplitude of the modulated driver output signal. Resistors connected across RES and BIAS set the output amplitude. The maximum peak-to-peak voltage at TXOUT is 2.5 V, corresponding to 6 dBm on the coaxial cable. The TXOUT voltage level can be adjusted by choice of resistors to set the voltage at the RES pin. according to the following equation:

$$V_{TXOUT}(V_{PP}) = (2.5 V_{PP} \times V_{RES}(V)) / 1.5 V \quad V_{RES}(V) = 1.5 V \times R2 / (R1 + R2) \quad V_{TXOUT}(V_{PP}) = 2.5 V_{PP} \times R2 / (R1 + R2) \quad (1)$$

The voltage at the RES pin should be from 0.7 V to 1.5 V. Connect RES directly to the BIAS ( $R1 = 0 \Omega$ ) for maximum output level of 2.5 VPP. This gives a minimum voltage level at TXOUT of 1.2 VPP, corresponding to about 0 dBm at the coaxial cable. A 1- $\mu$ F capacitor should be connected between the BIAS pin and GND. To obtain a nominal power level of 3 dBm at the feeder cable as the AISG standard requires, use  $R1 = 4.1 \text{ k}\Omega$  and  $R2 = 10 \text{ k}\Omega$  that provide 1.78 VPP at TXOUT.

#### 10.1.2 Direction Control

In many applications the mast-top modem that receives data from the base distributes the received data through an RS-485 network to several mast-top devices. When the mast-top modem receives the first logic 0 bit (active modulated signal) it takes control of the mast-top RS-485 network by asserting the direction control signal. The duration of the direction control assertion should be optimized to pass a complete message of length B bits at the known signaling rate ( $1/t_{BIT}$ ) before relinquishing control of the mast-top RS-485 network. For example, if the messages are 10 bits in length ( $B=10$ ) and the signaling rate is 9600 bits per second ( $t_{BIT} = 0.104 \text{ ms}$ ) then a positive pulse of duration 1.7 ms is sufficient (with margin to allow for network propagation delays) to enable the mast-top RS-485 drivers to distribute each received message. Figure 23 shows the assertion of direction control.



**Figure 23. Assertion of Direction Control**

#### 10.1.3 Direction Control Time Constant

The time constant for the direction control function can be set by the control mode pins, DIRSET1 and DIRSET2. These pins should be set to correspond to the desired data rate. With no external connections to the control mode pins, the internal time constant is set to the maximum value, corresponding to the minimum data rate.

## Application Information (continued)

### 10.1.4 Conversion Between dBm and Peak-to-Peak Voltage

$$\text{dBm} = 20 \times \text{LOG}_{10} [\text{Volts-pp} / \text{SQRT}(0.008 \times Z_0)] = 20 \times \text{LOG}_{10} [\text{VPP} / 0.63] \text{ for } Z_0 = 50 \, \Omega \quad (2)$$

$$\text{VPP} = \text{SQRT}(0.008 \times Z_0) \times 10^{(\text{dBm}/20)} = 0.63 \times 10^{(\text{dBm}/20)} \text{ for } Z_0 = 50 \, \Omega \quad (3)$$

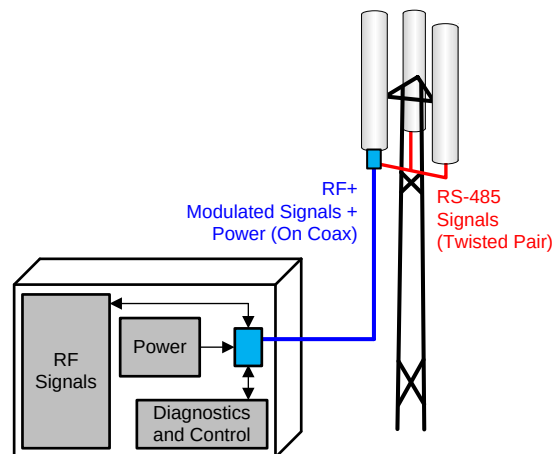
Table 3 shows conversions between dBm and peak-to-peak voltage with a 50-Ω load, for various levels of interest including reference levels from the 3GPP TS 25.461 Technical Specification.

**Table 3. Conversions Between dBm and Peak-to-Peak Voltage**

| SIGNAL ON COAX                  | dBm | V <sub>pp</sub> |
|---------------------------------|-----|-----------------|
| Maximum Driver ON Signal        | 5   | 1.12            |
| Nominal Driver ON Signal        | 3   | 0.89            |
| Minimum Driver ON Signal        | 1   | 0.71            |
| AISG Maximum Receiver Threshold | –12 | 0.16            |
| Nominal Receiver Threshold      | –15 | 0.11            |
| Minimum Receiver Threshold      | –18 | 0.08            |
| Maximum Driver OFF Signal       | –40 | 0.006           |

## 10.2 Typical Application

The AISG On-Off Keying (OOK) interface allows for command, control, and diagnostic information to be communicated between a base station and the corresponding tower-mounted antennae. Figure 24 shows a typical application.



**Figure 24. Typical AISG Application**

### 10.2.1 Design Requirements

An AISG transceiver is used to convert between digital logic-level signals and RF signals. The AISG standard requires an RF carrier frequency of 2.176 MHz with 100-ppm accuracy. The output signal of the driver, when active, should be from 1 dBm to 5 dBm. The receiver must be designed such that the input threshold is from –18 dBm to –12 dBm.

### 10.2.2 Detailed Design Procedure

To ensure accuracy of the carrier frequency, an input reference frequency equal to four times the carrier (that is, 8.704 MHz) should be connected to the XTAL1 or XTAL2 inputs. This signal can come from a crystal (connected between XTAL1 and XTAL2) or from a PLL/clock generator circuit (connected to XTAL1 with XTAL2 grounded). The frequency accuracy must be within 100 ppm.

## Typical Application (continued)

The driver output power level of the SN65HVD63 device can be adjusted through use of the RES pin. To align with AISG requirements, a nominal power level of 3 dBm should be configured by connecting a 4.1-k $\Omega$  resistor between RES and BIAS and a 10-k $\Omega$  resistor between RES and GND. Figure 25 shows an example schematic.

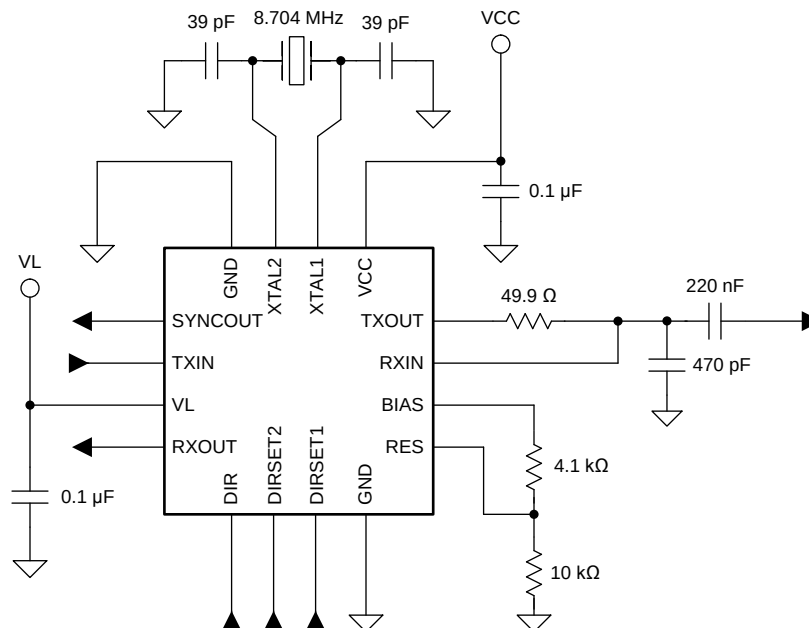


Figure 25. SN65HVD63 Schematic

### 10.2.3 Application Curve

Figure 26 shows the application curve for the SN65HVD63 device.

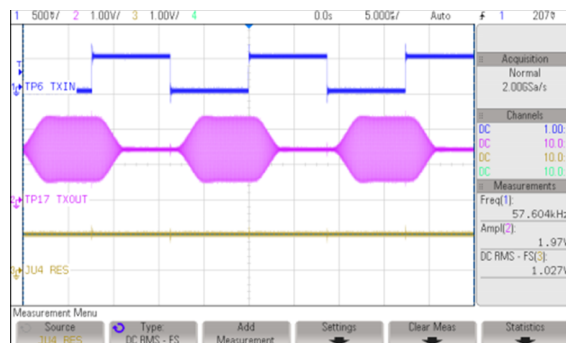


Figure 26. SN65HVD63 Application Curve

## 11 Power Supply Recommendations

The SN65HVD63 device has two power supply pins:  $V_{CC}$ , which provides power to the analog circuitry, and  $V_L$ , which is a logic supply.  $V_{CC}$  should be operated from 3 V to 5.5 V, while  $V_L$  can range from 1.6 V to 5.5 V to interface to different logic levels. Power supply decoupling capacitances of at least 0.1  $\mu\text{F}$  should be placed as close as possible to each power supply pin.

## 12 Layout

### 12.1 Layout Guidelines

Best practices for high-speed PCB design should be observed because the coax interface to the SN65HVD63 device operates at RF. The RF signaling traces should have a controlled characteristic impedance that is well-matched to the coaxial line. A continuous reference plane should be used to avoid impedance discontinuities. Power and ground distribution should be done through planes rather than traces to decrease series resistance and increase the effective decoupling capacitance on the power rails.

### 12.2 Layout Example

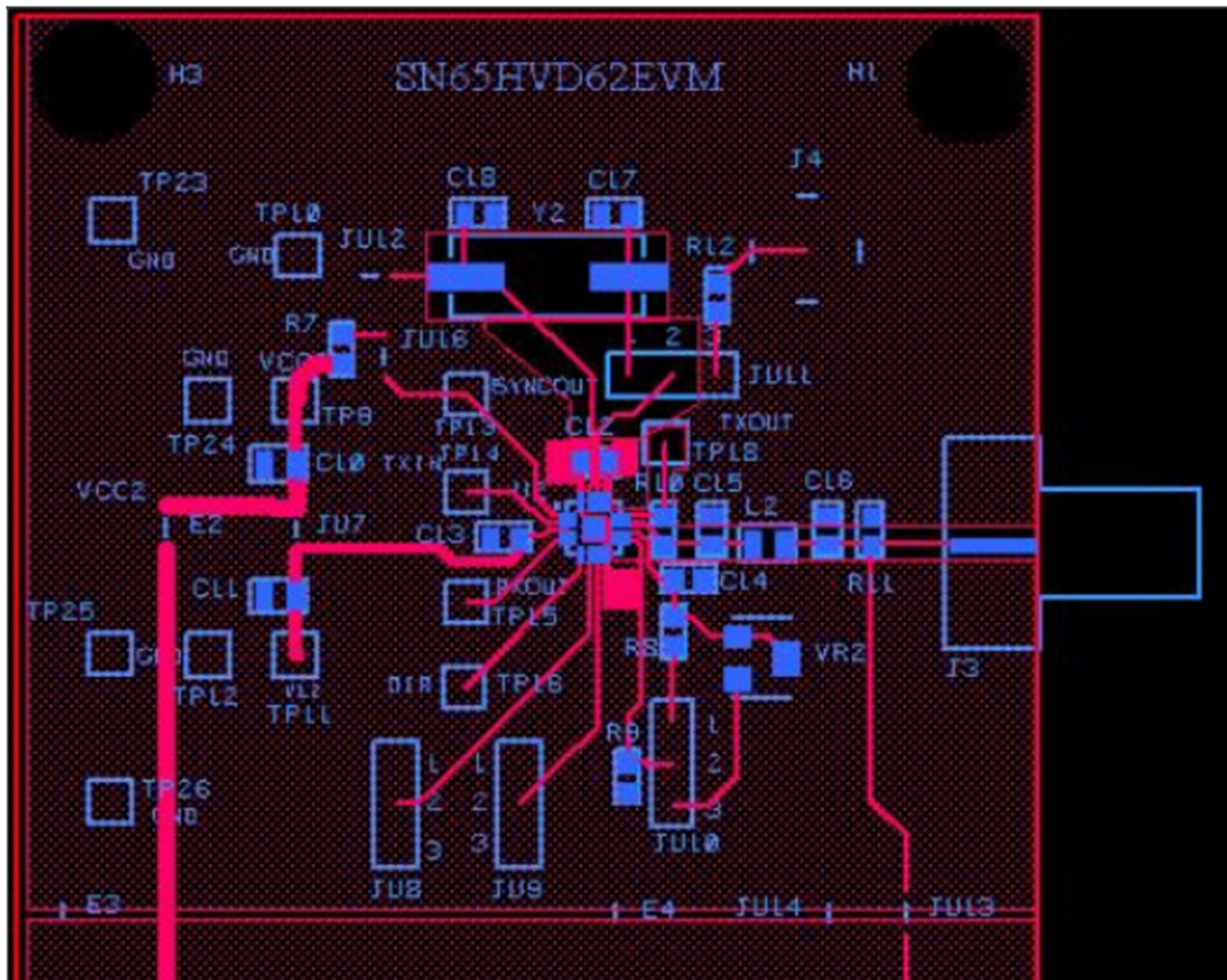


Figure 27. SN65HVD63 Layout



## 13 Device and Documentation Support

### 13.1 Related Documentation

[Control Interface for Antenna Line Devices](#), Antenna Interface Standards Group, Standard No. AISG v2.0

### 13.2 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At [e2e.ti.com](http://e2e.ti.com), you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 13.3 Trademarks

E2E is a trademark of Texas Instruments.

AISG is a registered trademark of Antenna Interface Standards Group, Ltd.

All other trademarks are the property of their respective owners.

### 13.4 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### 13.5 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 14 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="#">SN65HVD63RGTR</a> | Active        | Production           | VQFN (RGT)   16 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 105   | HVD63               |
| SN65HVD63RGTR.A               | Active        | Production           | VQFN (RGT)   16 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 105   | HVD63               |
| SN65HVD63RGTRG4               | Active        | Production           | VQFN (RGT)   16 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 105   | HVD63               |
| SN65HVD63RGTRG4.A             | Active        | Production           | VQFN (RGT)   16 | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 105   | HVD63               |
| <a href="#">SN65HVD63RGTT</a> | Active        | Production           | VQFN (RGT)   16 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 105   | HVD63               |
| SN65HVD63RGTT.A               | Active        | Production           | VQFN (RGT)   16 | 250   SMALL T&R       | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 105   | HVD63               |

<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.

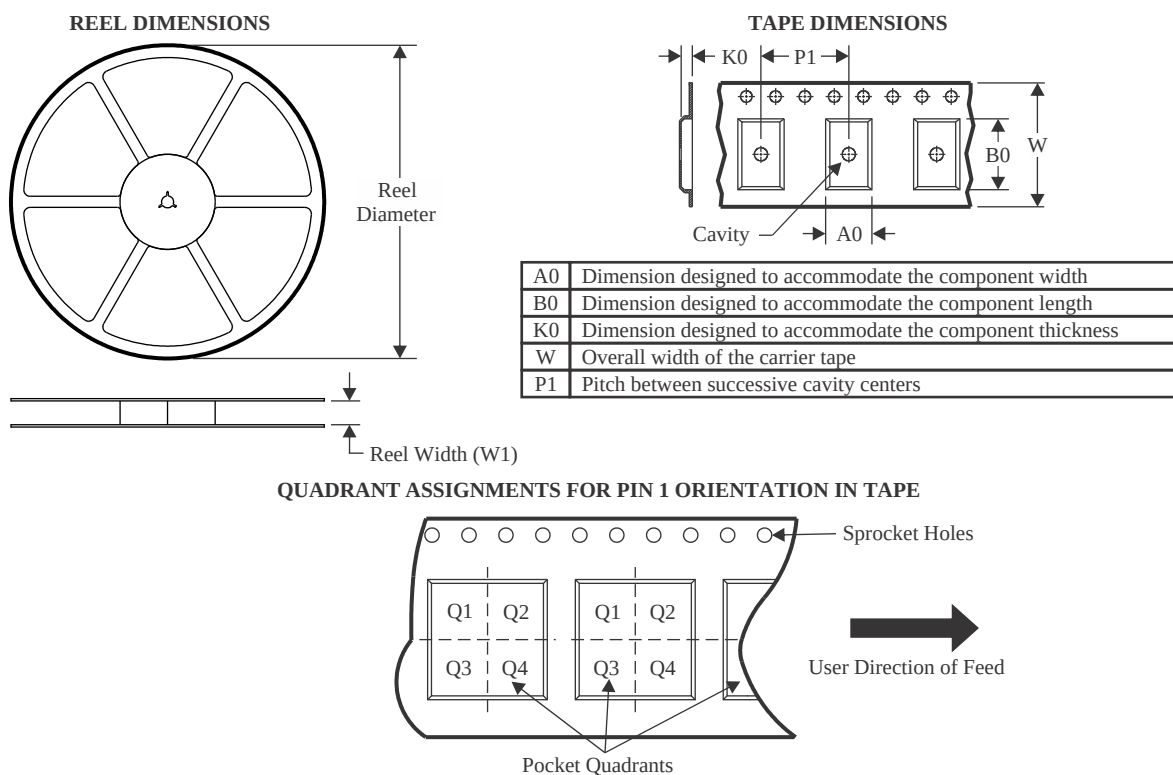
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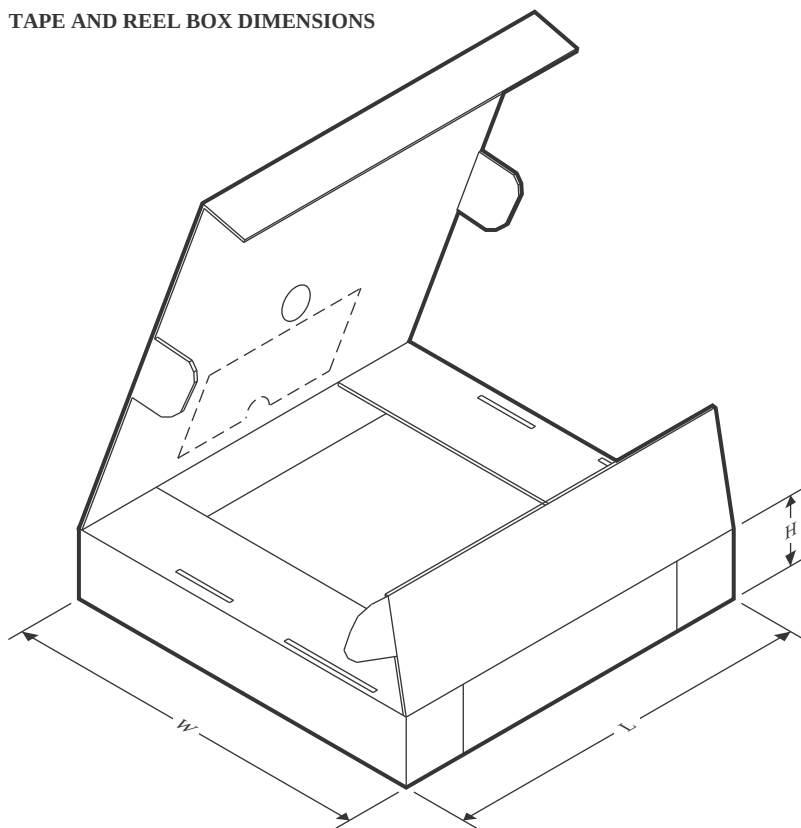
## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device          | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| SN65HVD63RGTR   | VQFN         | RGT             | 16   | 3000 | 330.0              | 12.4               | 3.3     | 3.3     | 1.1     | 8.0     | 12.0   | Q2            |
| SN65HVD63RGTRG4 | VQFN         | RGT             | 16   | 3000 | 330.0              | 12.4               | 3.3     | 3.3     | 1.1     | 8.0     | 12.0   | Q2            |
| SN65HVD63RGTT   | VQFN         | RGT             | 16   | 250  | 180.0              | 12.4               | 3.3     | 3.3     | 1.1     | 8.0     | 12.0   | Q2            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

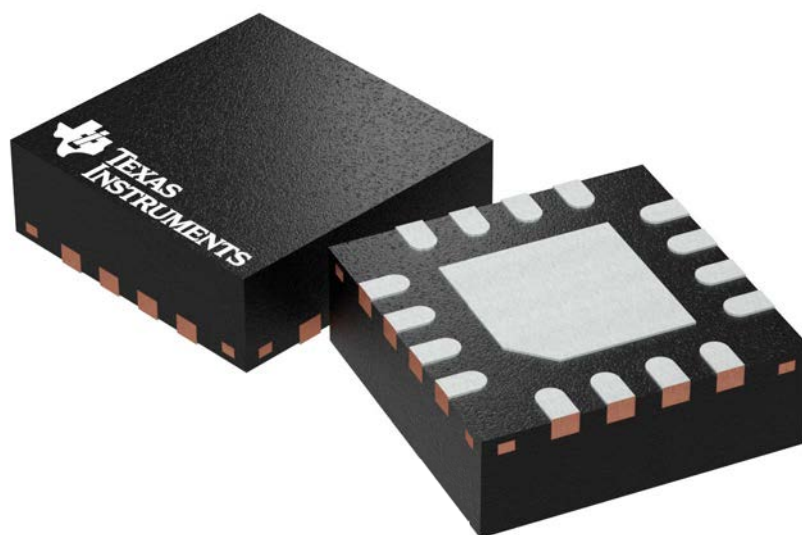
| Device          | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| SN65HVD63RGTR   | VQFN         | RGT             | 16   | 3000 | 346.0       | 346.0      | 33.0        |
| SN65HVD63RGTRG4 | VQFN         | RGT             | 16   | 3000 | 346.0       | 346.0      | 33.0        |
| SN65HVD63RGTT   | VQFN         | RGT             | 16   | 250  | 210.0       | 185.0      | 35.0        |

**RGT 16**

**GENERIC PACKAGE VIEW**

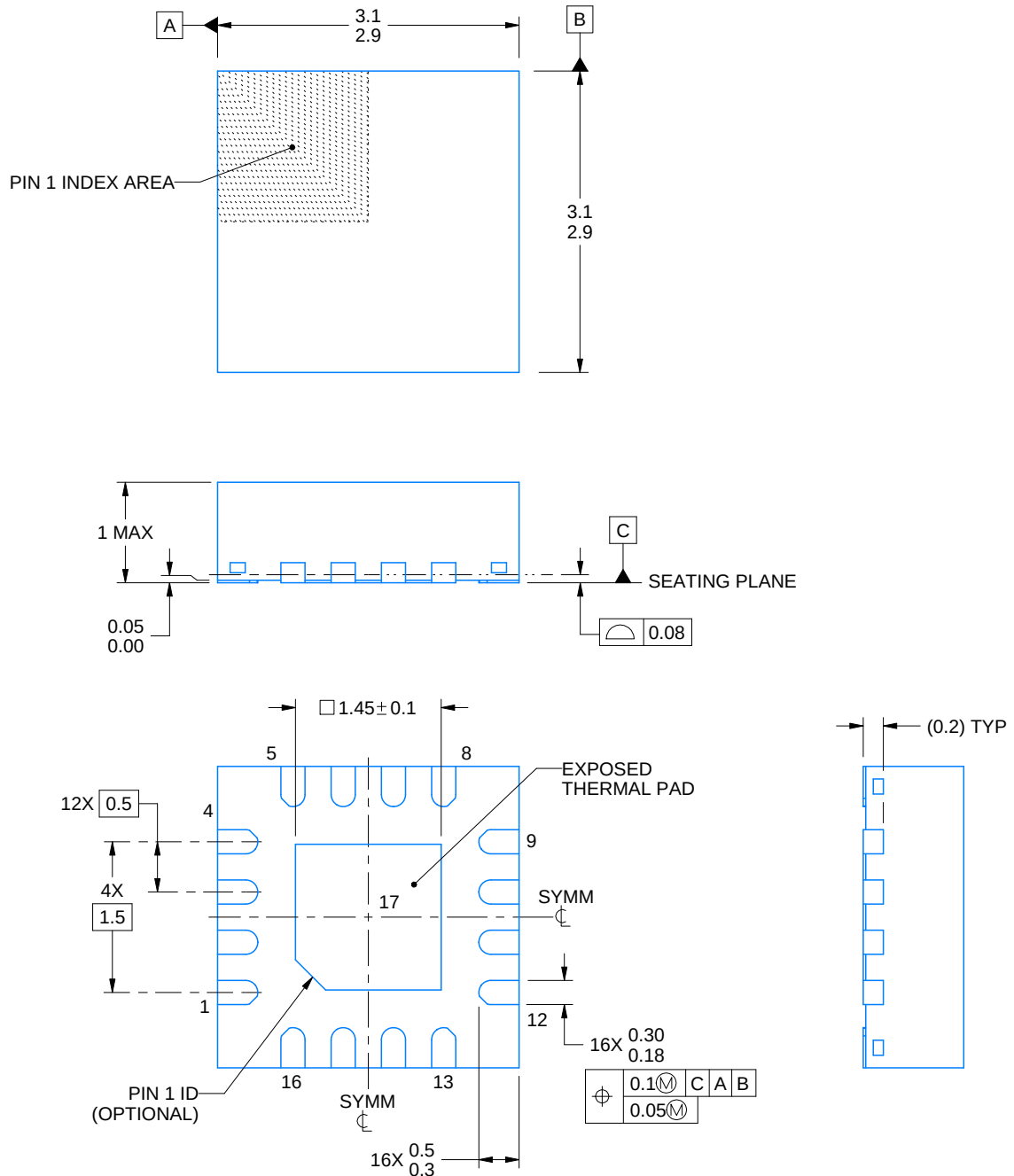
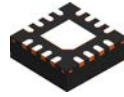
**VQFN - 1 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

4203495/1



4219032/A 02/2017

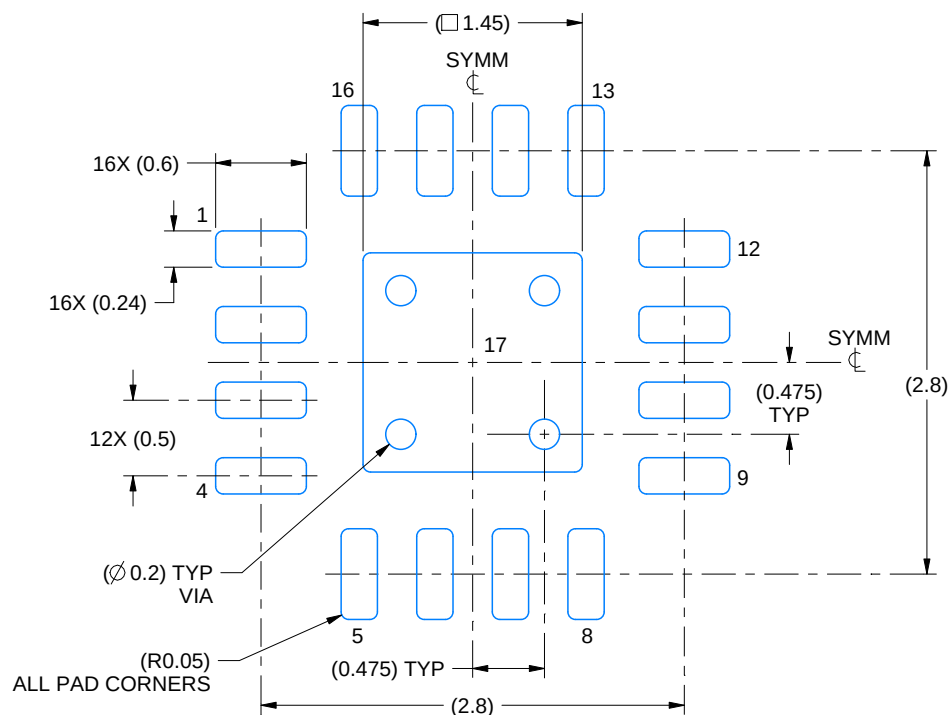
## NOTES:

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. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.
4. Reference JEDEC registration MO-220

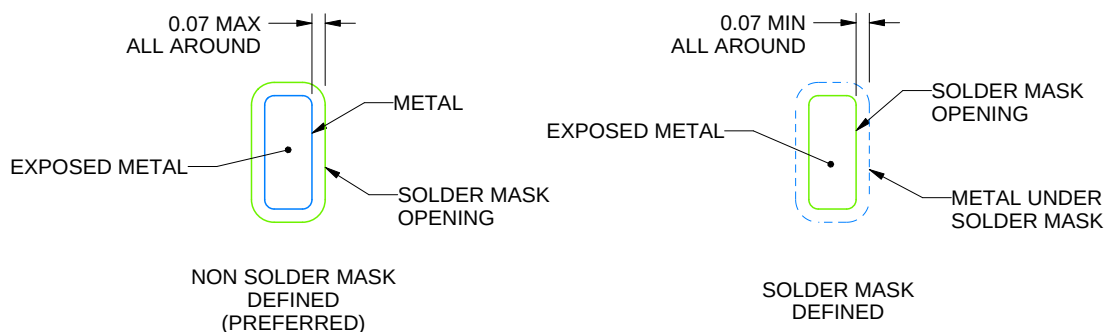
**RGT0016A**

**VQFN - 1 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:20X



## SOLDER MASK DETAILS

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NOTES: (continued)

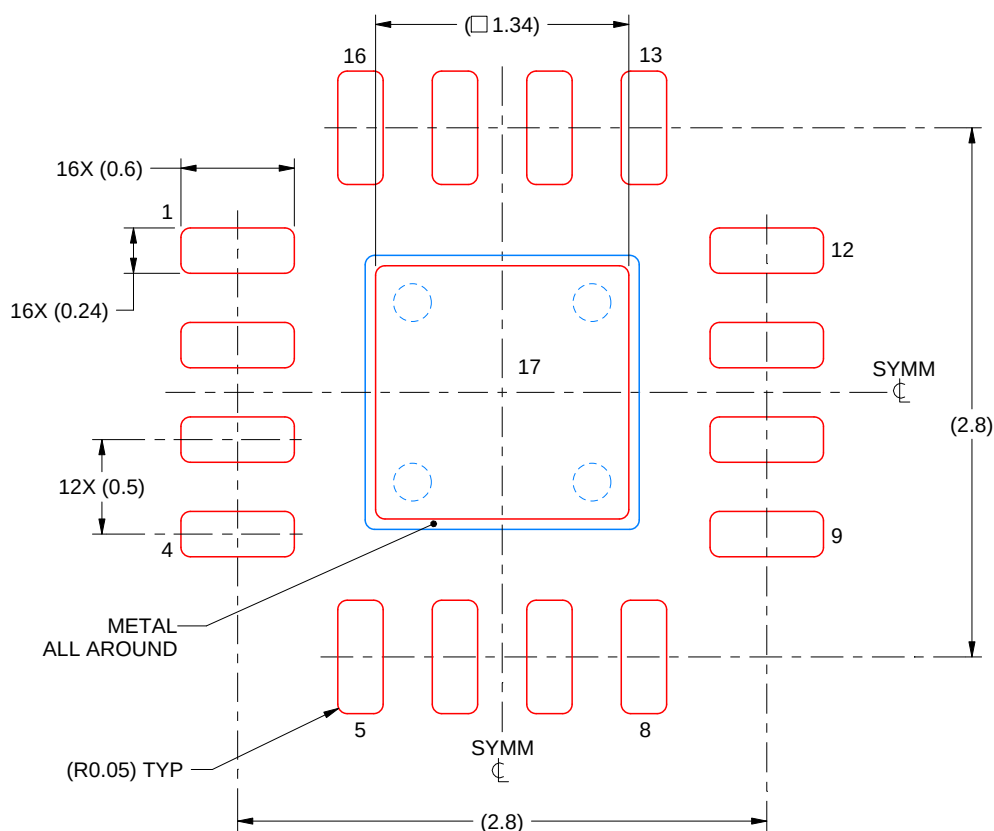
5. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
6. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

RGT0016A

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



**SOLDER PASTE EXAMPLE**  
 BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 17:  
 86% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
 SCALE:25X

4219032/A 02/2017

NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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