

Description

The 9FGV1002C / 9FGV1006C are members of the Renesas' PhiClock™ programmable clock generator family. These devices are optimized for low phase noise spread-spectrum applications such as PCIe® Express. Four user-defined configurations may be selected via two hardware select pins or two I²C bits, allowing easy software selection of the desired configuration. Any one of the four OTP configurations may be specified as the default when operating in I²C mode.

The 9FGV1002C is available in a version targeting automotive applications with the following characteristics:

- ISO9001 compliant
- AEC-Q100 qualified
- -40°C to +105°C (grade 2 equivalent) operation
- PPAP support

Cloud/Compute Applications

- High-performance Computing (HPC)
- Enterprise Storage including eSSDs
- 10G / 25G / 100G Ethernet
- Fiber Optic Modules
- NVLink

Automotive Applications

- Infotainment
- Gateway
- Domain Controller
- Zone Controller

PCIe Clocking Architectures

- Common Clocked (CC)
- Independent Reference (IR)
 - without spread spectrum (SRnS)
 - with spread spectrum (SRIS)

Output Features

- 2 or 4 programmable output pairs plus 1 or 2 LVCMOS REF outputs
- 1MHz–325MHz LVDS or LP-HCSL outputs
- 1MHz–200MHz LVCMOS outputs

Features

- 1.8V, 2.5V or 3.3V core power supplies
- Individual 1.8V, 2.5V or 3.3V V_{DDO} for each output pair
- -40°C to +85°C operation – standard product
- -40°C to +105°C operation – 9FGV1002C automotive product
- Direct connection to HCSL, LVDS and LVCMOS inputs
- Renesas' LP-HCSL technology improves performance, lowers power and provides higher integration:
 - Programmable output impedance of 85Ω or 100Ω
 - Easy AC-coupling to LVPECL and CML logic – see application note [AN-891](#) for alternate terminations
- On-board OTP supports up to 4 complete configurations
 - 1 integer, fractional or spread spectrum output frequency per configuration
 - Configuration selected via strapping pins or I²C
- Internal crystal load capacitors
- < 125mW (9FGV1002C – 1.8V with 100MHz LP-HCSL outputs)
- < 100mW (9FGV1006C – 1.8V with 100MHz LP-HCSL outputs)
- 4 programmable I²C addresses: D0, D2, D4, D6
- Easily configured with Renesas [Timing Commander™](#) software or Web Configuration tool
- 4 × 4 mm 24-VFQFPN with integrated crystal option
- 3 × 3 mm 16-LGA with integrated crystal option
- Programmable spread spectrum modulation frequency and amount

Key Specifications

- 276fs RMS 12kHz–20MHz typical phase jitter at 156.25MHz
- PCIe Gen7 CC < 41fs RMS (-0.5% SSC)

9FGV1002C / 9FGV1006C Block Diagram

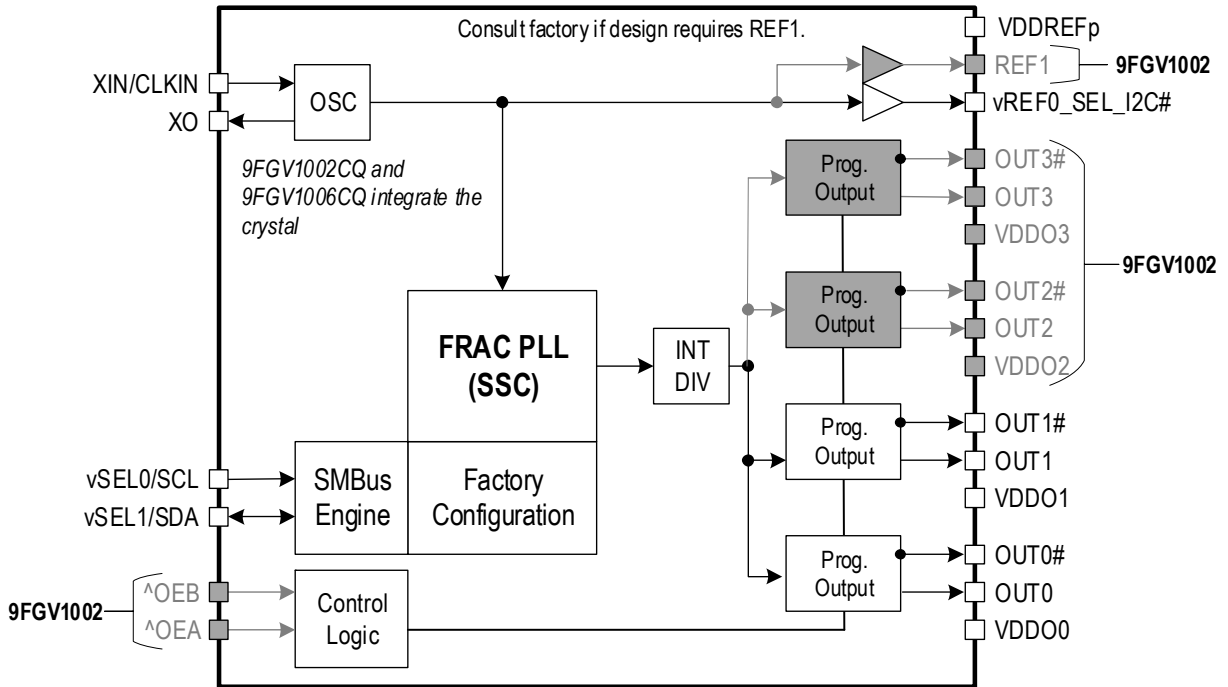


Table 1. OE Mapping

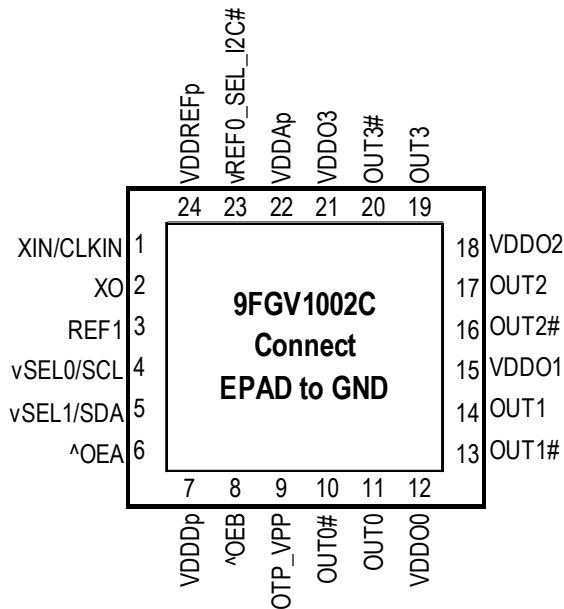
| OE[B:A] | OUT0 | OUT1 | OUT2 | OUT3 | REF0 | REF1 |
|---------|---------|---------|---------|---------|---------|---------|
| 00 | Running | Stopped | Stopped | Stopped | Running | Running |
| 01 | Running | Running | Stopped | Stopped | Running | Running |
| 10 | Running | Running | Running | Stopped | Running | Running |
| 11 | Running | Running | Running | Running | Running | Running |

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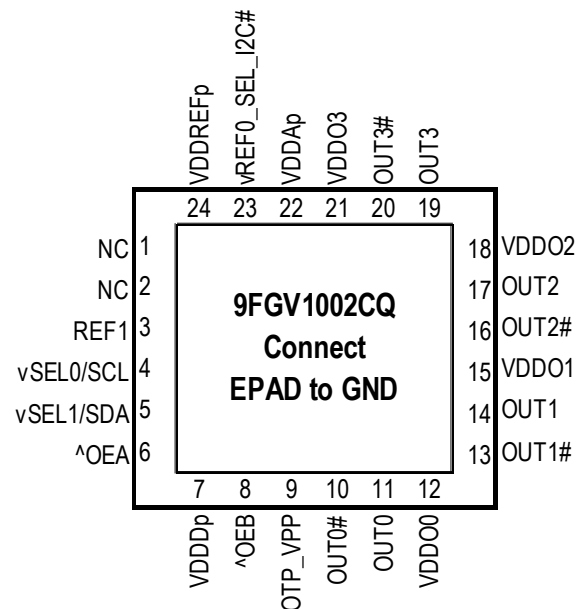
Pin Assignments

Figure 1. Pin Assignments for 9FGV1002C 4 × 4 mm 24-VFQFPN and 24-LGA Packages – Top View



4 × 4 mm 24-QFN, 0.5mm pitch

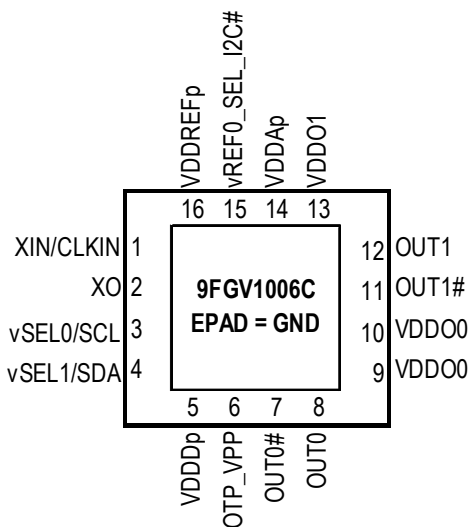
^ prefix indicates internal pull-up
 v prefix indicates internal pull-down resistor
 Note: The order of OUT3 is reversed from OUT[0:2]



4 × 4 mm 24-LGA, 0.5mm pitch

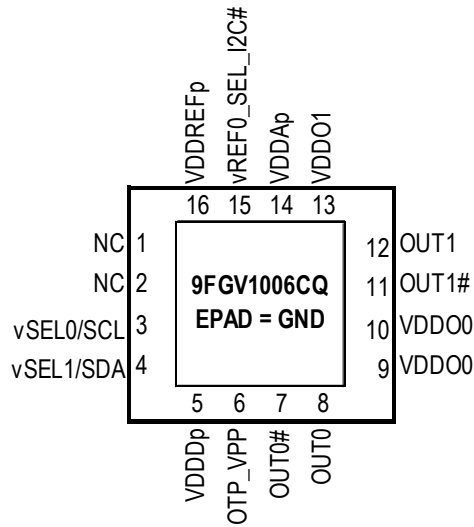
^ prefix indicates internal pull-up resistor
 v prefix indicates internal pull-down resistor
 Note: The order of OUT3 is reversed from OUT[0:2]

Figure 2. Pin Assignments for 9FGV1006C 3 × 3 mm 16-LGA Package – Top View



16-LGA 3 x 3 mm, 0.5mm pitch

^ prefix indicates internal pull-up resistor
 v prefix indicates internal pull-down resistor



16-LGA 3 x 3 mm, 0.5mm pitch

^ prefix indicates internal pull-up resistor
 v prefix indicates internal pull-down resistor

9FGV1002C Pin Descriptions

Note: Unused outputs can be programmed off and left floating. Output supplies V_{DDREF} and V_{DDO2} have to be connected. If OUT0 is used, V_{DDO1} must also be connected.

Table 2. 9FGV1002C Pin Descriptions

| Number | Name | Type | Description |
|------------------|----------------|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 ^[a] | XIN/CLKIN | Input | Crystal input or reference clock input. |
| 2 ^[a] | XO | Output | Crystal output. |
| 3 | REF1 | Output | LVC MOS reference output. |
| 4 | vSEL0/SCL | Input | Select pin for internal frequency configurations/I ² C clock pin. Function is determined by state of SEL_I2C# upon power-up. This pin has an internal pull-down. |
| 5 | vSEL1/SDA | I/O | Select pin for internal frequency configurations/I ² C data pin. Function is determined by state of SEL_I2C# upon power-up. This pin has an internal pull-down. |
| 6 | ^OE A | Input | Active high input for enabling outputs. This pin has an internal pull-up resistor. 0 = disable outputs, 1 = enable outputs. |
| 7 | VDDDp | Power | Digital power. Connect to 1.8V, 2.5V or 3.3V. |
| 8 | ^OE B | Input | Active high input for enabling outputs. This pin has an internal pull-up resistor. 0 = disable outputs, 1 = enable outputs. |
| 9 | OTP_VPP | Power | Voltage for programming OTP. During normal operation, this pin should be connected to the same power rail as V_{DD} . |
| 10 | OUT0# | Output | Complementary output clock 0. |
| 11 | OUT0 | Output | Output clock 0. |
| 12 | VDDO0 | Power | Power supply for output 0. |
| 13 | OUT1# | Output | Complementary output clock 1. |
| 14 | OUT1 | Output | Output clock 1. |
| 15 | VDDO1 | Power | Power supply for output 1. |
| 16 | OUT2# | Output | Complementary output clock 2. |
| 17 | OUT2 | Output | Output clock 2. |
| 18 | VDDO2 | Power | Power supply for output 2. |
| 19 | OUT3 | Output | Output clock 3. |
| 20 | OUT3# | Output | Complementary output clock 3. |
| 21 | VDDO3 | Power | Power supply for output 3. |
| 22 | VDDAp | Power | Analog power. Connect to same voltage as VDDDp, with proper filtering. |
| 23 | vREF0_SEL_I2C# | Latched I/O | Latched input/LVC MOS output. At power-up, the state of this pin is latched to select the state of the I ² C pins. After power-up, the pin acts as an LVC MOS reference output. This pin has an internal pull-down. 1 = SEL0/SEL1. 0 = SCL/SDA. |
| 24 | VDDREFp | Power | Power supply for REF outputs and the internal XO. Nominal voltages are 1.8V, 2.5V or 3.3V. |
| 25 | EPAD | GND | Connect to ground. |

[a] These pins are 'No Connect' on 9FGV1002Q integrated quartz versions and should have no stubs.

9FGV1006C Pin Descriptions

Note: Unused outputs can be programmed off and left floating. Output supplies V_{DDREF} and V_{DDO1} have to be connected. This means that if only one output is to be used, it must be OUT1. If OUT0 is used, both pins 9 and 10 must be connected. They may share the same power filter.

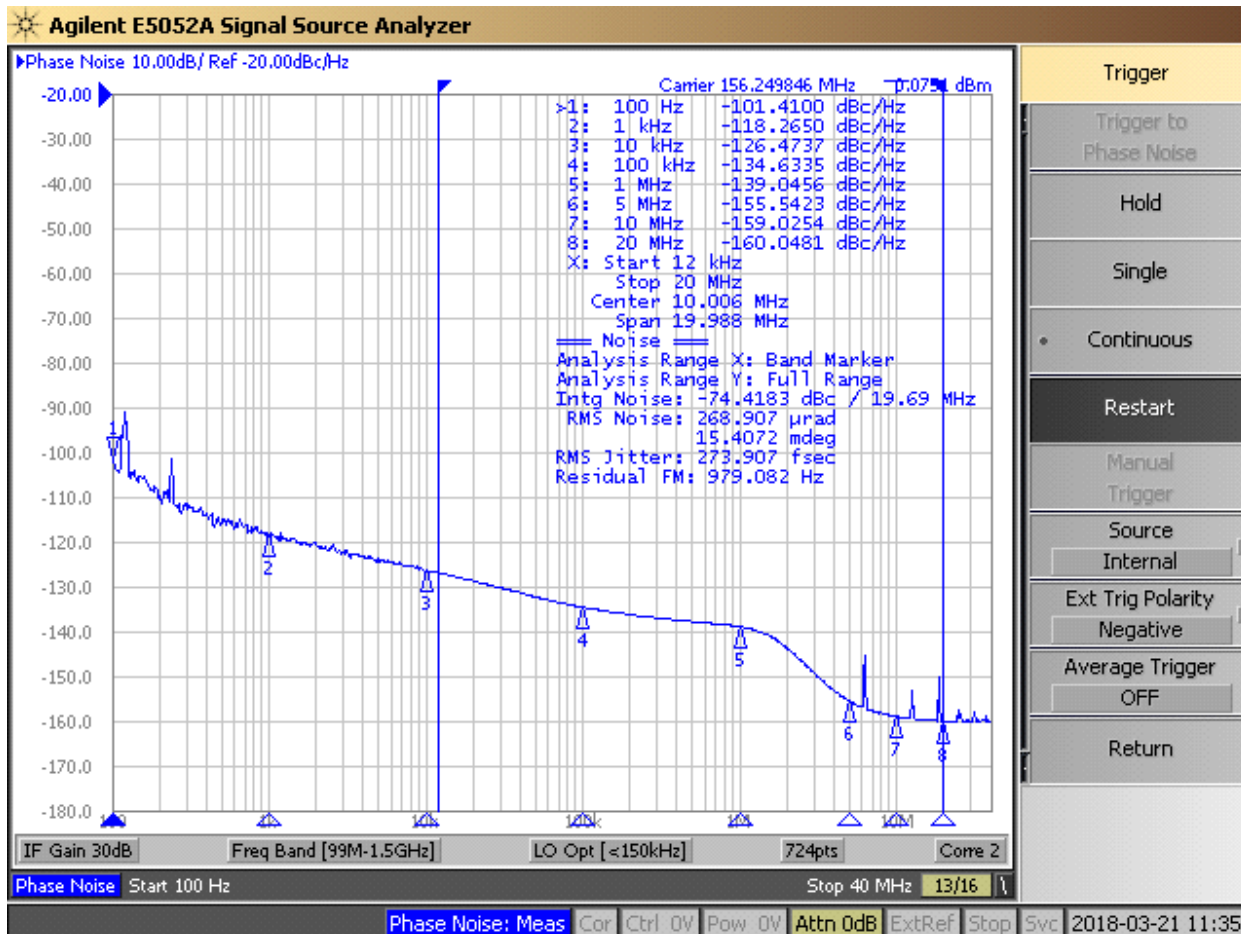
Table 3. 9FGV1006C Pin Descriptions

| Number | Name | Type | Description |
|------------------|----------------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 ^[a] | XIN/CLKIN | Input | Crystal input or reference clock input. |
| 2 ^[a] | XO | Output | Crystal output. |
| 3 | vSEL0/SCL | Input | Select pin for internal frequency configurations/I ² C Clock pin. Function is determined by state of SEL_I2C# upon power-up. This pin has an internal pull-down. |
| 4 | vSEL1/SDA | I/O | Select pin for internal frequency configurations/I ² C Data pin. Function is determined by state of SEL_I2C# upon power-up. This pin has an internal pull-down. |
| 5 | VDDDp | Power | Digital power. Connect to 1.8V, 2.5V or 3.3V. |
| 6 | OTP_VPP | Power | Voltage for programming OTP. During normal operation, this pin should be connected to the same power rail as V_{DD} . |
| 7 | OUT0# | Output | Complementary output clock 0. |
| 8 | OUT0 | Output | Output clock 0. |
| 9 | VDDO0 | Power | Power supply for output 0. |
| 10 | VDDO0 | Power | Power supply for output 0. |
| 11 | OUT1# | Output | Complementary output clock 1. |
| 12 | OUT1 | Output | Output clock 1. |
| 13 | VDDO1 | Power | Power supply for output 1. |
| 14 | VDDAp | Power | Analog power. Connect to same voltage as VDDDp, with proper filtering. |
| 15 | vREF0_SEL_I2C# | Latched I/O | Latched input/LVCMOS output. At power-up, the state of this pin is latched to select the state of the I ² C pins. After power-up, the pin acts as an LVCMOS reference output. This pin has an internal pull-down. 1 = SEL0/SEL1. 0 = SCL/SDA. |
| 16 | VDDREFp | Power | Power supply for REF outputs and the internal XO. Nominal voltages are 1.8V, 2.5V or 3.3V. |
| 17 | EPAD | GND | Connect to ground. |

[a] These pins are 'No Connect' on 9FGV1006Q integrated quartz version and should have no stubs.

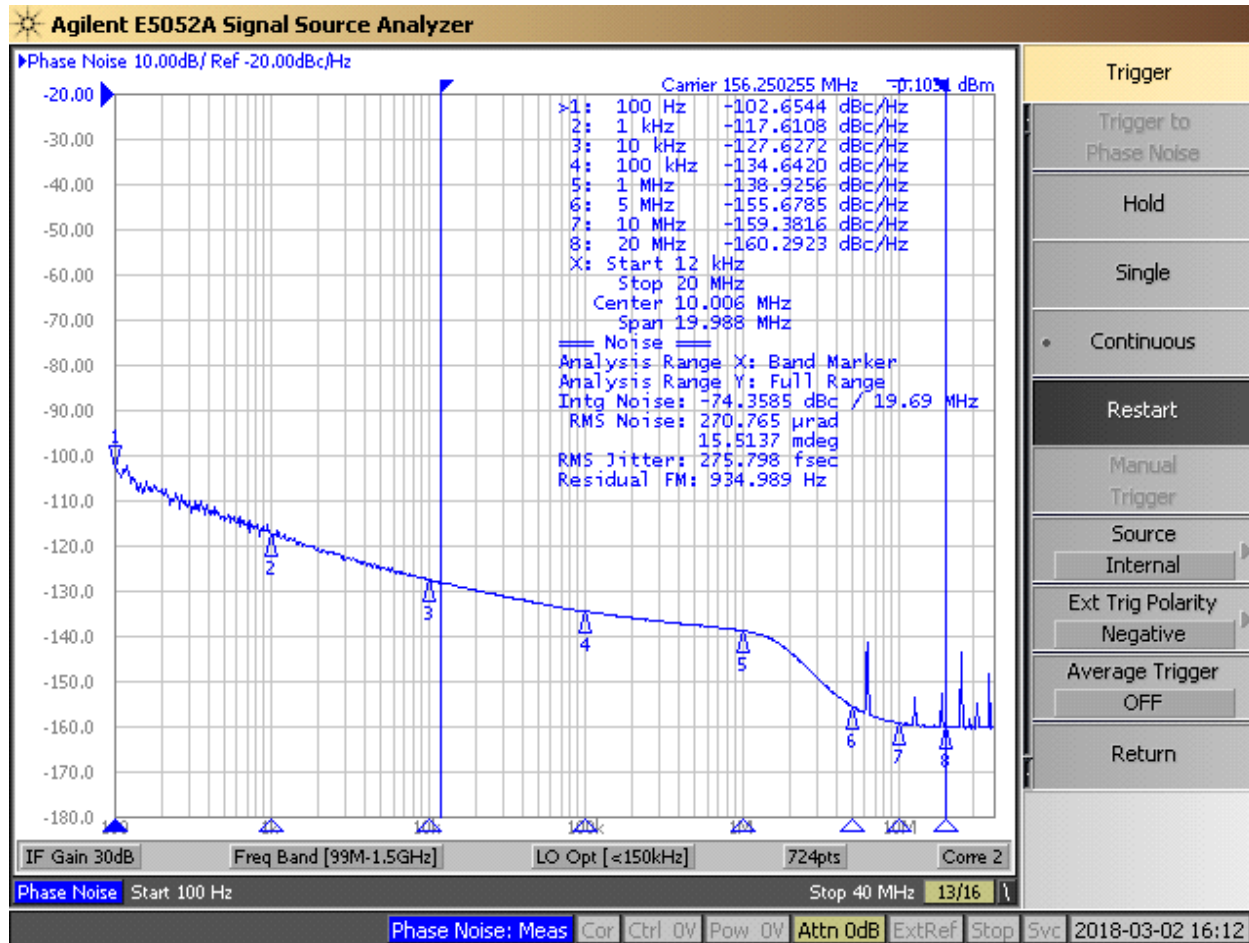
Phase Noise Plots

Figure 3. 9FGV1002C Phase Noise Plot¹, 3.3V, 25°C.



¹ See Test Frequencies for Jitter Measurements table for details.

Figure 4. 9FGV1006C Phase Noise Plot¹, 3.3V, 25°C.



¹ See Test Frequencies for Jitter Measurements table for details.

Absolute Maximum Ratings

The absolute maximum ratings are stress ratings only. Stresses greater than those listed below can cause permanent damage to the device. Functional operation of the 9FGV1002C / 9FGV1006C at absolute maximum ratings is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Table 4. Absolute Maximum Ratings

| Parameter | Rating |
|---------------------------------------------------|---------------------------|
| Supply Voltage, V_{DDA} , V_{DDD} , V_{DDO} | 3.9V |
| Storage Temperature, T_{STG} | -65°C to +150°C |
| ESD Human Body Model | 2000V |
| Junction Temperature | 125°C |
| Inputs | |
| XIN/CLKIN | 0V to 1.2V voltage swing |
| Other Inputs | -0.5V to $V_{DDD} + 0.3V$ |
| Outputs | |
| Outputs, V_{DDO} (LVCMOS) | -0.5V to $V_{DDO} + 0.5V$ |
| Outputs, IO (SDA) | 10mA |

Thermal Characteristics

Table 5. Thermal Characteristics for 24-pin Devices (ePAD soldered to board)

| Parameter | Symbol | Conditions | Package | Typical Values | Unit |
|----------------------------------------------------------------|----------------|----------------------------------|---------|----------------|------|
| Thermal Resistance (devices with external crystal) | θ_{JC} | Junction to case. | NBG24 | 52 | °C/W |
| | θ_{Jb} | Junction to base. | | 2.3 | °C/W |
| | θ_{JA0} | Junction to air, still air. | | 44 | °C/W |
| | θ_{JA1} | Junction to air, 1 m/s air flow. | | 37 | °C/W |
| | θ_{JA3} | Junction to air, 3 m/s air flow. | | 33 | °C/W |
| | θ_{JA5} | Junction to air, 5 m/s air flow. | | 32 | °C/W |
| Thermal Resistance Q-series (devices with internal crystal) | θ_{JC} | Junction to case. | LTG24 | 57.3 | °C/W |
| | θ_{Jb} | Junction to base. | | 24.3 | °C/W |
| | θ_{JA0} | Junction to air, still air. | | 79.8 | °C/W |
| | θ_{JA1} | Junction to air, 1 m/s air flow. | | 73.9 | °C/W |
| | θ_{JA3} | Junction to air, 3 m/s air flow. | | 69.9 | °C/W |
| | θ_{JA5} | Junction to air, 5 m/s air flow. | | 67.3 | °C/W |

Table 6. Thermal Characteristics for 16-pin devices (ePAD soldered to board)

| Parameter | Symbol | Conditions | Package | Typical Values | Unit |
|----------------------------------------------------------------|----------------|----------------------------------|---------|----------------|------|
| Thermal Resistance (devices with external crystal) | θ_{JC} | Junction to case. | LTG16 | 66 | °C/W |
| | θ_{Jb} | Junction to base. | | 5.1 | °C/W |
| | θ_{JA0} | Junction to air, still air. | | 63 | °C/W |
| | θ_{JA1} | Junction to air, 1 m/s air flow. | | 56 | °C/W |
| | θ_{JA3} | Junction to air, 3 m/s air flow. | | 51 | °C/W |
| | θ_{JA5} | Junction to air, 5 m/s air flow. | | 49 | °C/W |
| Thermal Resistance Q-series (devices with internal crystal) | θ_{JC} | Junction to case. | LTG16 | 82.1 | °C/W |
| | θ_{Jb} | Junction to base. | | 42.3 | °C/W |
| | θ_{JA0} | Junction to air, still air. | | 93.6 | °C/W |
| | θ_{JA1} | Junction to air, 1 m/s air flow. | | 87.1 | °C/W |
| | θ_{JA3} | Junction to air, 3 m/s air flow. | | 83.3 | °C/W |

Recommended Operating Conditions

Table 7. Recommended Operating Conditions

Use filtered analog power supply, if available, for V_{DDA} .

| Symbol | Parameter | Minimum | Typical | Maximum | Unit |
|--------------|-----------------------------------------------------------------------------------------------------|---------|---------|---------|------|
| V_{DD0x} , | 1.8V power supply voltage. | 1.71 | 1.8 | 1.89 | V |
| V_{DDD} , | 2.5V power supply voltage. | 2.375 | 2.5 | 2.625 | V |
| V_{DDA} | 3.3V power supply voltage. | 3.135 | 3.3 | 3.465 | V |
| T_A | Ambient operating temperature, standard product. | -40 | - | +85 | °C |
| | Ambient operating temperature, automotive device (9FGV1002CnnnNBG2). | -40 | - | +105 | °C |
| C_L | Maximum load capacitance (3.3V LVCMOS only). | - | - | 15 | pF |
| t_{PU} | Power-up time for all V_{DDs} to reach minimum specified voltage (power ramps must be monotonic). | 0.05 | - | 5 | ms |

Electrical Characteristics

$V_{DDX} = 3.3V \pm 5\%$, $2.5V \pm 5\%$, $1.8V \pm 5\%$, $T_{AMB} = -40^{\circ}C$ to $+85^{\circ}C$ and $-40^{\circ}C$ to $+105^{\circ}C$ unless noted otherwise.

Table 8. Common Electrical Characteristics

| Parameter | Symbol | Conditions | Minimum | Typical | Maximum | Unit | Notes |
|------------------------------------------------------------------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|---------|-------------------|------------|-------|
| Input Frequency | f_{IN} | Crystal input frequency. | 8 | - | 50 | MHz | 1 |
| | | CLKIN input frequency. | 1 | - | 240 | MHz | 5 |
| Output Frequency | f_{OUT} | Differential clock output (LVDS/LP-HCSL). | 1 | - | 325 | MHz | - |
| | | Single-ended clock output (LVCMOS). | 1 | - | 200 | MHz | - |
| VCO Frequency | f_{VCO} | VCO operating frequency range. | 2400 | 2500 | 2600 | MHz | - |
| Loop Bandwidth | f_{BW} | Input frequency = 25MHz. | 0.06 | - | 0.9 | MHz | - |
| Input High Voltage | V_{IH} | SEL[1:0], OE[B:A]. | $0.7 \times V_{DDD}$ | - | $V_{DDD} + 0.3$ | V | - |
| Input Low Voltage | V_{IL} | SEL[1:0], OE[B:A]. | GND - 0.3 | - | 0.8 | V | - |
| Input High Voltage | V_{IH} | REF/SEL_I2C#. | $0.65 \times V_{DDREF}$ | - | $V_{DDREF} + 0.3$ | V | - |
| Input Low Voltage | V_{IL} | REF/SEL_I2C#. | -0.3 | - | 0.4 | V | - |
| Input High Voltage | V_{IH} | XIN/CLKIN. | 0.8 | - | 1.2 | V | - |
| | | XIN/CLKIN. | -0.3 | - | 0.4 | V | - |
| Input Rise/Fall Time | T_R/T_F | OEA, OEB (when present) | - | - | 10 | ns | - |
| | | SEL1/SDA, SEL0/SCL | - | - | 300 | | - |
| Input Capacitance | C_{IN} | SEL[1:0]. | - | 3 | 7 | pF | - |
| Internal Pull-up Resistor | R_{UP} | | 165 | 229 | 320 | k Ω | - |
| Internal Pull-down Resistor | R_{DOWN} | | 150 | 212 | 290 | k Ω | - |
| Programmable Capacitance at XIN and XO (XIN in parallel with XO) | C_L | XIN/CLKIN, XO. | 0 | - | 8 | pF | - |
| Input Duty Cycle | t_2 | CLKIN, measured at $V_{DDREF}/2$. | 40 | 50 | 60 | % | - |
| Output Duty Cycle | t_3 | LVCMOS, $f_{OUT} > 156.25MHz$. | 40 | 50 | 60 | % | - |
| | | LVCMOS, $f_{OUT} \leq 156.25MHz$. | 45 | 50 | 55 | % | - |
| | | LVDS, LP-HCSL outputs. | 45 | 50.2 | 55 | % | - |
| Clock Jitter (-40°C to +85°C) | t_6 | Cycle-to-cycle jitter (Peak-to-Peak), See Test Frequencies for Jitter Measurements for configurations. | - | 24 | - | ps | 4 |
| | | Reference clock RMS phase jitter (12kHz to 20MHz integration range). See Test Frequencies for Jitter Measurements for configurations. | - | 245 | - | fs rms | 4 |
| | | OUTx RMS phase jitter(12kHz to 20MHz integration range) differential output. See Test Frequencies for Jitter Measurements for configurations. | - | 276 | - | fs rms | 4 |

Table 8. Common Electrical Characteristics (Cont.)

| Parameter | Symbol | Conditions | Minimum | Typical | Maximum | Unit | Notes |
|----------------------------------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------|---------|--------|-------|
| Clock Jitter (-40°C to +105°C) | t6 | Cycle-to-cycle jitter (Peak-to-Peak), See Test Frequencies for Jitter Measurements for configurations. | - | 35 | - | ps | 4 |
| | | Reference clock RMS phase jitter (12kHz to 20MHz integration range). See Test Frequencies for Jitter Measurements for configurations. | - | 287 | - | fs rms | 4 |
| | | OUTx RMS phase jitter(12kHz to 20MHz integration range) differential output. See Test Frequencies for Jitter Measurements for configurations. | - | 355 | - | fs rms | 4 |
| Output Skew - 9FGV1006C (-40°C to +85°C) | t7 | All outputs using the same driver format same V _{DDO} voltage. | - | 38 | 60 | ps | - |
| Output skew - 9FGV1002C (-40°C to +85°C) | t7 | All outputs using the same driver format and same V _{DDO} voltage. | - | 62 | 100 | | - |
| Output skew - 9FGV1002C (-40°C to +105°C) | | | - | 62 | 120 | | |
| Lock Time | t8a | PLL outputs valid from V _{DDs} reaching 1.5V. | - | 5 | 10 | ms | 2,3 |
| | t8b | REF outputs valid from V _{DDs} reaching 1.5V. | - | 5 | 11 | ms | 2,3 |

¹ Practical lower frequency is determined by loop filter settings.

² Includes loading the configuration bits from OTP to registers. This time also applies when changing configuration select.

³ Actual PLL lock time depends on the loop configuration.

⁴ Actual jitter is configuration dependent. These values are representative of what the device can achieve.

⁵ Input doubler off. Maximum input frequency with input doubler on is 160MHz.

Table 9. Test Frequencies for Jitter Measurements

V_{DDx} = 3.3V±5%, 2.5V±5%, 1.8V±5%, T_{AMB} = -40°C to +85°C and -40°C to +105°C unless noted otherwise.

| XIN/CLKIN | OUT0 | OUT1 | OUT2 | OUT3 | Unit | Notes |
|-----------|--------|------|------|------|------|-------|
| 50 | 156.25 | | | | MHZ | 3,4 |
| | 100 | | | | MHZ | 1,2,3 |

¹ This configuration is used for 12kHz–20MHz REF phase jitter measurement, SSC off.

² This configuration is used for PCIe filtered phase jitter measurements with SSC on and off.

³ Outputs configured as LP-HCSL or LVDS with REF output off, unless noted.

⁴ This configuration is used for 12kHz–20MHz OUT phase jitter measurement. REF off, SSC off.

Table 10. LVC MOS Output Electrical Characteristics -40°C to +85°C

$V_{DDx} = 3.3V \pm 5\%, 2.5V \pm 5\%, 1.8V \pm 5\%$.

| Parameter | Symbol | Conditions | Minimum | Typical | Maximum | Unit | Notes |
|------------------------------|------------|-----------------------------------------------------------------|----------------------|---------|-----------|----------|-------|
| Slew Rate | S_R | 3.3V $\pm 5\%$, 20% to 80% of V_{DDO} (output load = 4.7pF). | 2.6 | 3.7 | 4.7 | V/ns | - |
| | | 2.5V $\pm 5\%$, 20% to 80% of V_{DDO} (output load = 4.7pF). | 1.5 | 2.4 | 4.7 | | - |
| | | 1.8V $\pm 5\%$, 20% to 80% of V_{DDO} (output load = 4.7pF). | 1.0 | 1.7 | 3.2 | | - |
| Output High Voltage | V_{OH} | $I_{OH} = -15mA$ at 3.3V. | $0.8 \times V_{DDO}$ | - | V_{DDO} | V | - |
| | | $I_{OH} = -12mA$ at 2.5V. | | | | | - |
| | | $I_{OH} = -8mA$ at 1.8V. | | | | | - |
| Output Low Voltage | V_{OL} | $I_{OL} = 15mA$ at 3.3V. | - | 0.22 | 0.4 | V | - |
| | | $I_{OL} = 12mA$ at 2.5V. | | | | | - |
| | | $I_{OL} = 8mA$ at 1.8V. | | | | | - |
| Output Leakage Current | I_{OZDD} | Outputs, tri-stated, $V_{DDO}, V_{DDREF} = 3.465V$. | - | 0 | 5 | μA | - |
| CMOS Output Driver Impedance | R_{OUT} | $T_A = 25^\circ C$. | - | 17 | - | Ω | - |

Table 11. LVC MOS Output Electrical Characteristics -40°C to +105°C

$V_{DDx} = 3.3V \pm 5\%, 2.5V \pm 5\%, 1.8V \pm 5\%$.

| Parameter | Symbol | Conditions | Minimum | Typical | Maximum | Unit | Notes |
|------------------------------|------------|-----------------------------------------------------------------|-----------------------|---------|-----------|----------|-------|
| Slew Rate | S_R | 3.3V $\pm 5\%$, 20% to 80% of V_{DDO} (output load = 4.7pF). | 2.5 | 3.4 | 4.6 | V/ns | - |
| | | 2.5V $\pm 5\%$, 20% to 80% of V_{DDO} (output load = 4.7pF). | 1.5 | 2.4 | 4.6 | | - |
| | | 1.8V $\pm 5\%$, 20% to 80% of V_{DDO} (output load = 4.7pF). | 0.9 | 1.7 | 2.6 | | - |
| Output High Voltage | V_{OH} | $I_{OH} = -15mA$ at 3.3V. | $0.75 \times V_{DDO}$ | - | V_{DDO} | V | - |
| | | $I_{OH} = -12mA$ at 2.5V. | | | | | - |
| | | $I_{OH} = -8mA$ at 1.8V. | | | | | - |
| Output Low Voltage | V_{OL} | $I_{OL} = 15mA$ at 3.3V. | - | 0.24 | 0.5 | V | - |
| | | $I_{OL} = 12mA$ at 2.5V. | | | | | - |
| | | $I_{OL} = 8mA$ at 1.8V. | | | | | - |
| Output Leakage Current | I_{OZDD} | Outputs, tri-stated, $V_{DDO}, V_{DDREF} = 3.465V$. | - | 0 | 5 | μA | - |
| CMOS Output Driver Impedance | R_{OUT} | $T_A = 25^\circ C$. | - | 17 | - | Ω | - |

Table 12. LVDS Output Electrical Characteristics

$V_{DDO} = 3.3V \pm 5\%$, $2.5V \pm 5\%$, $1.8V \pm 5\%$, $T_{AMB} = -40^{\circ}C$ to $+85^{\circ}C$ and $-40^{\circ}C$ to $+105^{\circ}C$ unless noted otherwise.

| Parameter | Symbol | Conditions | Minimum | Typical | Maximum | Unit | Notes |
|--------------------------------------------------------------------------|-----------------|--------------------------------------------|---------|---------|---------|------|-------|
| Differential Output Voltage for the TRUE Binary State | $V_{OT (+)}$ | - | 247 | 328 | 454 | mV | - |
| Differential Output Voltage for the FALSE Binary State | $V_{OT (-)}$ | - | -454 | -332 | -247 | mV | - |
| Change in V_{OT} between Complementary Output States | ΔV_{OT} | - | - | - | 50 | mV | - |
| Output Common Mode Voltage (Offset Voltage) | V_{OS} | $V_{DDO} = 2.5V \pm 5\%$ or $3.3V \pm 5\%$ | 1.125 | 1.19 | 1.55 | V | - |
| Output Common Mode Voltage (Offset Voltage) | V_{OS} | $V_{DDO} = 1.8V \pm 5\%$ | 0.8 | 0.9 | 0.95 | V | - |
| Change in V_{OS} between Complementary Output States | ΔV_{OS} | - | - | - | 50 | mV | - |
| Outputs Short Circuit Current, V_{OUT+} or $V_{OUT-} = 0V$ or V_{DD} | I_{OS} | - | - | 6 | 12 | mA | - |
| Differential Outputs Short Circuit Current, $V_{OUT+} = V_{OUT-}$ | I_{OSD} | - | - | 3 | 12 | mA | - |
| Rise Times Tested at 20% – 80% | T_R | -40°C to +85°C | - | 257 | 375 | ps | - |
| Fall Times Tested at 80% – 20% | T_F | | - | 287 | 375 | ps | - |
| Rise Times Tested at 20% – 80% | T_R | -40°C to +105°C | - | 315 | 400 | ps | - |
| Fall Times Tested at 80% – 20% | T_F | | - | 332 | 400 | ps | - |

Table 13. Low-Power (LP) Push-Pull HCSL Differential Outputs

V_{DDO} = 3.3V ±5%, 2.5V ±5%, 1.8V ±5%, T_{AMB} = -40°C to +85°C and -40°C to +105°C unless noted otherwise. See [Test Loads](#).

| Parameter | Symbol | Conditions | Minimum | Typical | Maximum | Specification Limit | Unit | Notes |
|---------------------------------|-------------------------|----------------------------------------------|---------|---------|---------|---------------------|------|------------|
| Slew Rate | T _{R/F} | Scope averaging on. | 1.25 | 2.5 | 4 | 1 to 4 | V/ns | 2,3,16 |
| Slew Rate Matching | ΔT _{R/F} | - | - | 9 | 20 | 20 | % | 1,14,16 |
| Crossing Voltage (abs) | V _{CROSS} | Scope averaging off. | 250 | 424 | 550 | 250 to 550 | mV | 1,4,5,16 |
| Crossing Voltage (var) | ΔV _{CROSS} | Scope averaging off. | - | 16 | 50 | 140 | mV | 1,4,9,16 |
| Average Clock Period Accuracy | T _{PERIOD_AVG} | Outputs set to 100MHz for PCIe applications. | -100 | 0 | +2600 | -100 to +2600 | - | 2,10,12,13 |
| Absolute Period | T _{PERIOD_ABS} | Includes jitter and spread modulation. | 9.998 | 10 | 10.06 | 9.949 to 10.101 | - | 2,6 |
| Absolute Maximum Output Voltage | V _{MAX} | - | - | - | 888 | 1150 | mV | 1,7,15 |
| Absolute Minimum Output Voltage | V _{MIN} | - | -148 | - | - | -300 | mV | 1,8,15 |
| Output Voltage Swing | V _{SWING} | V _{DDO} = 3.3V ± 5% | 1320 | 1520 | 1720 | MIN = 300mV | mV | 2 |
| | | V _{DDO} = 2.5V ± 5% | 1260 | 1460 | 1660 | | | |
| | | V _{DDO} = 1.8V ± 5% | 1180 | 1380 | 1560 | | | |

¹ Measured from single-ended waveform.

² Measured from differential waveform.

³ Measured from -150mV to +150mV on the differential waveform (derived from REFCLK+ minus REFCLK-). The signal must be monotonic through the measurement region for rise and fall time. The 300mV measurement window is centered on the differential zero crossing.

⁴ Measured at crossing point where the instantaneous voltage value of the rising edge of REFCLK+ equals the falling edge of REFCLK-.

⁵ Refers to the total variation from the lowest crossing point to the highest, regardless of which edge is crossing. Refers to all crossing points for this measurement.

⁶ Defined as the absolute minimum or maximum instantaneous period. This includes cycle to cycle jitter, relative ppm tolerance, and spread spectrum modulation.

⁷ Defined as the maximum instantaneous voltage including overshoot.

⁸ Defined as the minimum instantaneous voltage including undershoot.

⁹ Defined as the total variation of all crossing voltages of rising REFCLK+ and falling REFCLK-. This is the maximum allowed variance in V_{CROSS} for any particular system.

¹⁰ Refer to Section 8.6 of the PCI Express Base Specification, Revision 6.0 for information regarding PPM considerations.

¹¹ System board compliance measurements must use the test load. REFCLK+ and REFCLK- are to be measured at the load capacitors CL. Single ended probes must be used for measurements requiring single ended measurements. Either single ended probes with math or differential probe can be used for differential measurements. Test load C_L = 2pF.

¹² PCIe Gen1 through Gen4 specify ±300ppm frequency tolerances. The PhiClock devices already meet the tighter ±100ppm frequency tolerances for PCIe Gen5 and Gen6.

¹³ "ppm" refers to parts per million and is a DC absolute period accuracy specification. 1ppm is 1/1,000,000th of 100.000000MHz exactly or 100Hz. For 100ppm, then we have an error budget of 100Hz/ppm × 100ppm = 10kHz. The period is to be measured with a frequency counter with measurement window set to 100ms or greater. The ±100ppm applies to systems that do not employ Spread Spectrum clocking, or that use common clock source. For systems employing Spread Spectrum Clocking, there is an additional 2,500ppm nominal shift in maximum period resulting from the 0.5% down spread resulting in a maximum average period specification of +2,600ppm for Common Clock architectures. Separate Reference Clock architectures may have a lower allowed spread percentage.

¹⁴ Matching applies to rising edge rate for REFCLK+ and falling edge rate for REFCLK-. It is measured using a $\pm 75\text{mV}$ window centered on the median cross point where REFCLK+ rising meets REFCLK- falling. The median cross point is used to calculate the voltage thresholds the oscilloscope is to use for the edge rate calculations. The rise edge rate of REFCLK+ should be compared to the fall edge rate of REFCLK-; the maximum allowed difference should not exceed 20% of the slowest edge rate.

¹⁵ At default amplitude settings.

¹⁶ Confirmed by design and characterization.

Table 14. PCIe REFCLK Phase Jitter - 2.5V/3.3V Operation

Supply Voltages = 2.5V/3.3V $\pm 5\%$, T_{AMB} = -40°C to +85°C and -40°C to +105°C. See [Test Loads](#).

| Parameter | Symbol | Conditions | Typical | Maximum | Specification Limits | Unit | Notes |
|------------------------------|----------------------------------|-------------------------------------------------|---------|---------|----------------------|----------|---------------|
| PCIe Gen1 (2.5 GT/s) | $t_{\text{jph}}\text{PCIeG1-CC}$ | Common Clocked Architecture SSC = 0.0% (off) | 3578 | 9836 | 86,000 | fs pk-pk | 1, 2, 9 |
| PCIe Gen2 Hi-Band (5.0 GT/s) | $t_{\text{jph}}\text{PCIeG2-CC}$ | | 299 | 823 | 3,000 | fs RMS | 1, 2, 9 |
| PCIe Gen2 Lo-Band (5.0 GT/s) | | | 89 | 139 | 3,100 | fs RMS | 1, 2, 9 |
| PCIe Gen3 (8.0 GT/s) | $t_{\text{jph}}\text{PCIeG3-CC}$ | | 101 | 278 | 1,000 | fs RMS | 1, 2, 9 |
| PCIe Gen4 (16.0 GT/s) | $t_{\text{jph}}\text{PCIeG4-CC}$ | | 101 | 278 | 500 | fs RMS | 1, 2, 3, 4, 9 |
| PCIe Gen5 (32.0 GT/s) | $t_{\text{jph}}\text{PCIeG5-CC}$ | | 42 | 119 | 150 | fs RMS | 1, 2, 3, 5, 9 |
| PCIe Gen6 (64.0 GT/s) | $t_{\text{jph}}\text{PCIeG6-CC}$ | | 23 | 64 | 100 | fs RMS | 1, 2, 3, 6, 9 |
| PCIe Gen7 (128.0 GT/s) | $t_{\text{jph}}\text{PCIeG7-CC}$ | | 16 | 45 | 67 | fs RMS | 1, 2, 3, 7, 9 |
| PCIe Gen1 (2.5 GT/s) | $t_{\text{jph}}\text{PCIeG1-CC}$ | Common Clocked Architecture SSC = -0.5%. | 5305 | 9922 | 86,000 | fs pk-pk | 1, 2, 9 |
| PCIe Gen2 Hi-Band (5.0 GT/s) | $t_{\text{jph}}\text{PCIeG2-CC}$ | | 343 | 678 | 3,000 | fs RMS | 1, 2, 9 |
| PCIe Gen2 Lo-Band (5.0 GT/s) | | | 376 | 749 | 3,100 | fs RMS | 1, 2, 9 |
| PCIe Gen3 (8.0 GT/s) | $t_{\text{jph}}\text{PCIeG3-CC}$ | | 125 | 235 | 1,000 | fs RMS | 1, 2, 9 |
| PCIe Gen4 (16.0 GT/s) | $t_{\text{jph}}\text{PCIeG4-CC}$ | | 125 | 235 | 500 | fs RMS | 1, 2, 3, 4, 9 |
| PCIe Gen5 (32.0 GT/s) | $t_{\text{jph}}\text{PCIeG5-CC}$ | | 48 | 96 | 150 | fs RMS | 1, 2, 3, 5, 9 |
| PCIe Gen6 (64.0 GT/s) | $t_{\text{jph}}\text{PCIeG6-CC}$ | | 28 | 54 | 100 | fs RMS | 1, 2, 3, 6, 9 |
| PCIe Gen7 (128.0 GT/s) | $t_{\text{jph}}\text{PCIeG7-CC}$ | | 29 | 38 | 67 | fs RMS | 1, 2, 3, 7, 9 |
| PCIe Gen2 IR (5.0 GT/s) | $t_{\text{jph}}\text{PCIeG2-IR}$ | IR (SRNS) Architecture SSC = 0% | 211 | 492 | N/A | fs RMS | 1, 2, 8, 9 |
| PCIe Gen3 IR (8.0 GT/s) | $t_{\text{jph}}\text{PCIeG3-IR}$ | | 84 | 193 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen4 IR (16.0 GT/s) | $t_{\text{jph}}\text{PCIeG4-IR}$ | | 85 | 195 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen5 IR (32.0 GT/s) | $t_{\text{jph}}\text{PCIeG5-IR}$ | | 28 | 72 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen6 IR (64.0 GT/s) | $t_{\text{jph}}\text{PCIeG6-IR}$ | | 17 | 39 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen7 IR (128.0 GT/s) | $t_{\text{jph}}\text{PCIeG7-IR}$ | | 12 | 27 | | fs RMS | 1, 2, 8, 9 |

Table 14. PCIe REFCLK Phase Jitter - 2.5V/3.3V Operation (Cont.)

Supply Voltages = 2.5V/3.3V ±5%, T_{AMB} = -40°C to +85°C and -40°C to +105°C. See [Test Loads](#).

| Parameter | Symbol | Conditions | Typical | Maximum | Specification Limits | Unit | Notes |
|---------------------------|---------------------------|----------------------------------------|---------|---------|----------------------|--------|----------------|
| PCIe Gen2 IR (5.0 GT/s) | t _{jphPCIeG2-IR} | IR (SRIS) Architecture SSC = -0.5%. | 1379 | 1511 | N/A | fs RMS | 1, 2, 8, 9 |
| PCIe Gen3 IR (8.0 GT/s) | t _{jphPCIeG3-IR} | | 534 | 584 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen4 IR (16.0 GT/s) | t _{jphPCIeG4-IR} | | 359 | 443 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen5 IR (32.0 GT/s) | t _{jphPCIeG5-IR} | IR (SRIS) Architecture SSC = -0.3% | 95 | 124 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen6 IR (64.0 GT/s) | t _{jphPCIeG6-IR} | | 72 | 92 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen7 IR (128.0 GT/s) | t _{jphPCIeG7-IR} | IR (SRIS) Architecture SSC = -0.1% | 43 | 72 | | fs RMS | 1, 2, 8, 9, 10 |

¹ The REFCLK jitter is measured after applying the filter functions found in PCI Express Base Specification 7, Revision 0.7. See the [Test Loads](#) section of the data sheet for the exact measurement setup. The worst case results for each data rate are summarized in this table. Equipment noise is removed from all measurements.

² Jitter measurements shall be made with a capture of at least 100,000 clock cycles captured by a real-time oscilloscope (RTO) with a sample rate of 20 GS/s or greater. Broadband oscilloscope noise must be minimized in the measurement. The measured PP jitter is used (no extrapolation) for RTO measurements. Alternately, jitter measurements may be used with a Phase Noise Analyzer (PNA) extending (flat) and integrating and folding the frequency content up to an offset from the carrier frequency of at least 200MHz (at 300MHz absolute frequency) below the Nyquist frequency. For PNA measurements for the 2.5 GT/s data rate, the RMS jitter is converted to peak to peak jitter using a multiplication factor of 8.83. In the case where real-time oscilloscope and PNA measurements have both been done and produce different results, the RTO result must be used.

³ SSC spurs from the fundamental and harmonics are removed up to a cutoff frequency of 2MHz taking care to minimize removal of any non-SSC content.

⁴ Note that 700fs RMS is to be used in channel simulations to account for additional noise in a real system.

⁵ Note that 250fs RMS is to be used in channel simulations to account for additional noise in a real system.

⁶ Note that 150fs RMS is to be used in channel simulations to account for additional noise in a real system.

⁷ Note that 100fs RMS is to be used in channel simulations to account for additional noise in a real system.

⁸ The PCI Express Base Specification 7.0, Revision 0.7 provides the filters necessary to calculate IR jitter values; it does not provide specification limits, therefore, the reference to this footnote in the Limit column. IR values are informative only. A common practice is to split the common clock budget in half. For 16GT/s data rates and above, the user must choose whether to use the output jitter specification, or the input jitter specification, which includes an allocation for the jitter added by the channel. Using 32GT/s, the Refclk jitter budget is 150fs RMS. One half of the Refclk jitter budget is 106fs RMS. At the clock input, the system must deliver 250fs RMS. One half of this value is 177fs RMS. If the clock is placed next to the PCIe device in an IR system, the channel is very short and the user may choose to use this more relaxed value for their jitter limit.

⁹ 9FGV1002C or 9FGV1006C with 001, 015, Q505 or Q515 configurations. See [Table 23](#) or [Table 24](#) table for details and a selection of off-the-shelf configurations supporting PCI Express clocks.

¹⁰ The PCI Express Base Specification 7, Revision 0.7 calls out *less than* -0.15% spread. -0.1% is a valid spread amount.

Table 15. PCIe Refclk Phase Jitter – 1.8V Operation

Supply Voltages = 1.8V ±5%, T_{AMB} = -40°C to +85°C and -40°C to +105°C. See [Test Loads](#).

| Parameter | Symbol | Conditions | Typical | Maximum | Specification Limits | Unit | Notes |
|------------------------------|----------------------------|-------------------------------------------------|---------|---------|----------------------|----------|----------------|
| PCIe Gen1 (2.5 GT/s) | t _{jph} PCIeG1-CC | Common Clocked Architecture SSC = 0.0% (off) | 3955 | 10274 | 86,000 | fs pk-pk | 1, 2, 9 |
| PCIe Gen2 Hi-Band (5.0 GT/s) | t _{jph} PCIeG2-CC | | 332 | 858 | 3,000 | fs RMS | 1, 2, 9 |
| PCIe Gen2 Lo-Band (5.0 GT/s) | | | 99 | 151 | 3,100 | fs RMS | 1, 2, 9 |
| PCIe Gen3 (8.0 GT/s) | t _{jph} PCIeG3-CC | | 112 | 289 | 1,000 | fs RMS | 1, 2, 9 |
| PCIe Gen4 (16.0 GT/s) | t _{jph} PCIeG4-CC | | 112 | 289 | 500 | fs RMS | 1, 2, 3, 4, 9 |
| PCIe Gen5 (32.0 GT/s) | t _{jph} PCIeG5-CC | | 46 | 124 | 150 | fs RMS | 1, 2, 3, 5, 9 |
| PCIe Gen6 (64.0 GT/s) | t _{jph} PCIeG6-CC | | 26 | 67 | 100 | fs RMS | 1, 2, 3, 6, 9 |
| PCIe Gen7 (128.0 GT/s) | t _{jph} PCIeG7-CC | | 18 | 47 | 67 | fs RMS | 1, 2, 3, 7, 9 |
| PCIe Gen1 (2.5 GT/s) | t _{jph} PCIeG1-CC | Common Clocked Architecture SSC = -0.5%. | 5180 | 9367 | 86,000 | fs pk-pk | 1, 2, 9 |
| PCIe Gen2 Hi-Band (5.0 GT/s) | t _{jph} PCIeG2-CC | | 361 | 763 | 3,000 | fs RMS | 1, 2, 9 |
| PCIe Gen2 Lo-Band (5.0 GT/s) | | | 343 | 643 | 3,100 | fs RMS | 1, 2, 9 |
| PCIe Gen3 (8.0 GT/s) | t _{jph} PCIeG3-CC | | 128 | 253 | 1,000 | fs RMS | 1, 2, 9 |
| PCIe Gen4 (16.0 GT/s) | t _{jph} PCIeG4-CC | | 128 | 253 | 500 | fs RMS | 1, 2, 3, 4, 9 |
| PCIe Gen5 (32.0 GT/s) | t _{jph} PCIeG5-CC | | 50 | 109 | 150 | fs RMS | 1, 2, 3, 5, 9 |
| PCIe Gen6 (64.0 GT/s) | t _{jph} PCIeG6-CC | | 29 | 59 | 100 | fs RMS | 1, 2, 3, 6, 9 |
| PCIe Gen7 (128.0 GT/s) | t _{jph} PCIeG7-CC | | 21 | 41 | 67 | fs RMS | 1, 2, 3, 7, 9 |
| PCIe Gen2 IR (5.0 GT/s) | t _{jph} PCIeG2-IR | IR (SRNS) Architecture SSC = 0% | 242 | 512 | N/A | fs RMS | 1, 2, 8, 9 |
| PCIe Gen3 IR (8.0 GT/s) | t _{jph} PCIeG3-IR | | 96 | 202 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen4 IR (16.0 GT/s) | t _{jph} PCIeG4-IR | | 99 | 204 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen5 IR (32.0 GT/s) | t _{jph} PCIeG5-IR | | 31 | 75 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen6 IR (64.0 GT/s) | t _{jph} PCIeG6-IR | | 20 | 41 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen7 IR (128.0 GT/s) | t _{jph} PCIeG7-IR | | 14 | 28 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen2 IR (5.0 GT/s) | t _{jph} PCIeG2-IR | IR (SRIS) Architecture SSC = -0.5%. | 1373 | 1478 | N/A | fs RMS | 1, 2, 8, 9 |
| PCIe Gen3 IR (8.0 GT/s) | t _{jph} PCIeG3-IR | | 533 | 576 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen4 IR (16.0 GT/s) | t _{jph} PCIeG4-IR | | 355 | 422 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen5 IR (32.0 GT/s) | t _{jph} PCIeG5-IR | IR (SRIS) Architecture SSC = -0.3% | 91 | 116 | N/A | fs RMS | 1, 2, 8, 9 |
| PCIe Gen6 IR (64.0 GT/s) | t _{jph} PCIeG6-IR | | 69 | 83 | | fs RMS | 1, 2, 8, 9 |
| PCIe Gen7 IR (128.0 GT/s) | t _{jph} PCIeG7-IR | IR (SRIS) Architecture SSC = -0.1% | 38 | 67 | | fs RMS | 1, 2, 8, 9, 10 |

¹ The REFCLK jitter is measured after applying the filter functions found in PCI Express Base Specification 7, Revision 0.7. See the [Test Loads](#) section of the data sheet for the exact measurement setup. The worst case results for each data rate are summarized in this table. Equipment noise is removed from all measurements.

² Jitter measurements shall be made with a capture of at least 100,000 clock cycles captured by a real-time oscilloscope (RTO) with a sample rate of 20 GS/s or greater. Broadband oscilloscope noise must be minimized in the measurement. The measured PP jitter is used (no extrapolation) for RTO measurements. Alternately, jitter measurements may be used with a Phase Noise Analyzer (PNA) extending (flat) and integrating and folding

the frequency content up to an offset from the carrier frequency of at least 200MHz (at 300MHz absolute frequency) below the Nyquist frequency. For PNA measurements for the 2.5 GT/s data rate, the RMS jitter is converted to peak to peak jitter using a multiplication factor of 8.83. In the case where real-time oscilloscope and PNA measurements have both been done and produce different results, the RTO result must be used.

³ SSC spurs from the fundamental and harmonics are removed up to a cutoff frequency of 2MHz taking care to minimize removal of any non-SSC content.

⁴ Note that 700fs RMS is to be used in channel simulations to account for additional noise in a real system.

⁵ Note that 250fs RMS is to be used in channel simulations to account for additional noise in a real system.

⁶ Note that 150fs RMS is to be used in channel simulations to account for additional noise in a real system.

⁷ Note that 100fs RMS is to be used in channel simulations to account for additional noise in a real system.

⁸ The PCI Express Base Specification 7.0, Revision 0.7 provides the filters necessary to calculate IR jitter values; it does not provide specification limits, therefore, the reference to this footnote in the Limit column. IR values are informative only. A common practice is to split the common clock budget in half. For 16GT/s data rates and above, the user must choose whether to use the output jitter specification, or the input jitter specification, which includes an allocation for the jitter added by the channel. Using 32GT/s, the Refclk jitter budget is 150fs RMS. One half of the Refclk jitter budget is 106fs RMS. At the clock input, the system must deliver 250fs RMS. One half of this value is 177fs RMS. If the clock is placed next to the PCIe device in an IR system, the channel is very short and the user may choose to use this more relaxed value for their jitter limit.

⁹ 9FGV1002C or 9FGV1006C with 001, 015, Q505 or Q515 configurations. See [Table 23](#) or [Table 24](#) table for details and a selection of off-the-shelf configurations supporting PCI Express clocks.

¹⁰ The PCI Express Base Specification 7, Revision 0.7 calls out *less than* -0.15% spread. -0.1% is a valid spread amount.

Table 16. 9FGV1002C Current Consumption -40°C to +85°C

Supply Voltages = 3.3V ±5%, 2.5V ±5%, 1.8V ±5%.

| Parameter | Symbol | Conditions | Minimum | Typical | Maximum | Unit | Notes |
|------------------------------------------------------------------------------------------------|---------------------|----------------------------------------------------|---------|---------|---------|------|-------|
| V _{DDREF} Supply Current | I _{DDREF} | 50MHz REFCL, subtract 3mA for 25MHz REFCLK. | - | 7 | 11 | mA | - |
| Core Supply Current | I _{DDCORE} | 2400MHz VCO. | - | 37 | 49 | mA | 3 |
| Output Buffer Supply Current V _{DDO3} | I _{DDOx} | LVDS, 325MHz. | - | 6 | 9 | mA | 2 |
| | | LP-HCSL, 100MHz. | - | 6 | 7 | mA | 2 |
| | | LVC MOS, 50MHz. | - | 4 | 6 | mA | 1, 2 |
| | | LVC MOS, 200MHz. | - | 12 | 21 | mA | 1, 2 |
| Output Buffer Supply Current V _{DDO2} (includes output divider) | | LVDS, 325MHz. | - | 17 | 24 | mA | 2 |
| | | LP-HCSL, 100MHz. | - | 16 | 20 | mA | 2 |
| | | LVC MOS, 50MHz. | - | 14 | 18 | mA | 1, 2 |
| | | LVC MOS, 200MHz. | - | 23 | 35 | mA | 1, 2 |
| Output Buffer Supply Current V _{DDO1} (this pin must be connected if OUT0 is used) | | LVDS, 325MHz. | - | 13 | 20 | mA | 2 |
| | | LP-HCSL, 100MHz. | - | 7 | 13 | mA | 2 |
| | | LVC MOS, 50MHz. | - | 4 | 14 | mA | 1, 2 |
| | | LVC MOS, 200MHz. | - | 13 | 22 | mA | 1, 2 |
| Output Buffer Supply Current V _{DDO0} | LVDS, 325MHz. | - | 6 | 9 | mA | 2 | |
| | LP-HCSL, 100MHz. | - | 6 | 7 | mA | 2 | |
| | LVC MOS, 50MHz. | - | 4 | 6 | mA | 1, 2 | |
| | LVC MOS, 200MHz. | - | 12 | 22 | mA | 1, 2 | |
| Total Power Down Current | I _{DDPD} | Programmable outputs in HCSL mode, B37[0] = 0. | - | 20 | 27 | mA | 2 |
| | | Programmable outputs in LVDS mode, B37[0] = 0. | - | 33 | 45 | mA | 2 |
| | | Programmable outputs in LVC MOS1 mode, B37[0] = 0. | - | 16 | 22 | mA | 2 |

¹ Single CMOS driver active for each output pair.

² See [Test Loads](#) for details.

³ I_{DDCORE} = I_{DDA} + I_{DD}. For integer, fractional or spread spectrum PLL.

Table 17. 9FGV1002C Current Consumption -40°C to +105°C

Supply Voltages = 3.3V ±5%, 2.5V ±5%, 1.8V ±5%.

| Parameter | Symbol | Conditions | Minimum | Typical | Maximum | Unit | Notes |
|------------------------------------------------------------------------------------------------|---------------------|----------------------------------------------------|---------|---------|---------|------|-------|
| V _{DDREF} Supply Current | I _{DDREF} | 50MHz REFCL, subtract 3mA for 25MHz REFCLK. | - | 7 | 11 | mA | - |
| Core Supply Current | I _{DDCORE} | 2400MHz VCO. | - | 43 | 49 | mA | 3 |
| Output Buffer Supply Current V _{DDO3} | I _{DDOx} | LVDS, 325MHz. | - | 6 | 9 | mA | 2 |
| | | LP-HCSL, 100MHz. | - | 6 | 7 | mA | 2 |
| | | LVC MOS, 50MHz. | - | 4 | 6 | mA | 1, 2 |
| | | LVC MOS, 200MHz. | - | 12 | 21 | mA | 1, 2 |
| Output Buffer Supply Current V _{DDO2} (includes output divider) | | LVDS, 325MHz. | - | 17 | 24 | mA | 2 |
| | | LP-HCSL, 100MHz. | - | 16 | 20 | mA | 2 |
| | | LVC MOS, 50MHz. | - | 14 | 18 | mA | 1, 2 |
| | | LVC MOS, 200MHz. | - | 23 | 35 | mA | 1, 2 |
| Output Buffer Supply Current V _{DDO1} (this pin must be connected if OUT0 is used) | | LVDS, 325MHz. | - | 13 | 20 | mA | 2 |
| | | LP-HCSL, 100MHz. | - | 7 | 13 | mA | 2 |
| | | LVC MOS, 50MHz. | - | 4 | 14 | mA | 1, 2 |
| | | LVC MOS, 200MHz. | - | 13 | 22 | mA | 1, 2 |
| Output Buffer Supply Current V _{DDO0} | LVDS, 325MHz. | - | 6 | 9 | mA | 2 | |
| | LP-HCSL, 100MHz. | - | 6 | 7 | mA | 2 | |
| | LVC MOS, 50MHz. | - | 4 | 6 | mA | 1, 2 | |
| | LVC MOS, 200MHz. | - | 12 | 22 | mA | 1, 2 | |
| Total Power Down Current | I _{DDPD} | Programmable outputs in HCSL mode, B37[0] = 0. | - | 21 | 27 | mA | 2 |
| | | Programmable outputs in LVDS mode, B37[0] = 0. | - | 33 | 45 | mA | 2 |
| | | Programmable outputs in LVC MOS1 mode, B37[0] = 0. | - | 20 | 27 | mA | 2 |

¹ Single CMOS driver active for each output pair.

² See [Test Loads](#) for details.

³ I_{DDCORE} = I_{DDA} + I_{DD}. For integer, fractional or spread spectrum PLL.

Table 18. 9FGV1006C Current Consumption -40°C to +85°C

Supply Voltages = 3.3V ±5%, 2.5V ±5%, 1.8V ±5%.

| Parameter | Symbol | Conditions | Minimum | Typical | Maximum | Unit | Notes |
|--------------------------------------------------------------------------------|---------------------|----------------------------------------------------|---------|---------|---------|------|-------|
| V _{DDREF} Supply Current | I _{DDREF} | 50MHz REFCLK. | - | 3 | 7 | mA | - |
| Core Supply Current | I _{DDCORE} | 2400MHz VCO. | - | 37 | 48 | mA | 3 |
| Output Buffer Supply Current (V _{DDO1}) | I _{DDOx} | LVDS, 350MHz. | - | 19 | 24 | mA | 2 |
| | | LP-HCSL, 100MHz. | - | 16 | 20 | mA | 2 |
| | | LVC MOS, 50MHz. | - | 14 | 19 | mA | 1,2 |
| | | LVC MOS, 200MHz. | - | 22 | 34 | mA | 1,2 |
| Output Buffer Supply Current (V _{DDO0} – the total for pins 9 and 10) | I _{DDOx} | LVDS, 350MHz. | - | 7 | 11 | mA | 2 |
| | | LP-HCSL, 100MHz. | - | 8 | 10 | mA | 2 |
| | | LVC MOS, 50MHz. | - | 8 | 13 | mA | 1,2 |
| | | LVC MOS, 200MHz. | - | 8 | 14 | mA | 1,2 |
| Total Power Down Current | I _{DDPD} | Programmable outputs in HCSL mode, B37[0] = 0. | - | 19 | 25 | mA | 2 |
| | | Programmable outputs in LVDS mode, B37[0] = 0. | - | 25 | 34 | mA | 2 |
| | | Programmable outputs in LVC MOS1 mode, B37[0] = 0. | - | 16 | 22 | mA | 2 |

¹ Single CMOS driver active for each output pair.

² See [Test Loads](#) for details.

³ I_{DDCORE} = I_{DDA} + I_{DDD} + I_{DDAO}.

Table 19. Spread Spectrum Generation Specifications

V_{DDO} = 3.3V ±5%, 2.5V ±5%, 1.8V ±5%, T_{AMB} = -40°C to +85°C and -40°C to +105°C unless noted otherwise.

| Parameter | Symbol | Conditions | Minimum | Typical | Maximum | Unit |
|---------------|----------------------|--------------------------------------------------------|---------|---------|---------|------|
| Mod Frequency | f _{MODPCle} | PCle Compliant -0.5% spread modulation. | 30 | 31.5 | 33 | kHz |
| Mod Frequency | f _{MOD} | Modulation frequency. | 30 | 31.5 | 63 | kHz |
| Spread% | SSC% | Amount of spread value (programmable) – down spread. | -0.1 | -0.5 | -3.0 | % |
| | | Amount of spread value (programmable) – center spread. | ±0.05 | - | ±1.5 | |

I²C Bus Characteristics

Table 20. I²C Bus DC Characteristics

V_{DDx} = 3.3V ±5%, 2.5V ±5%, 1.8V ±5%, T_{AMB} = -40°C to +85°C and -40°C to +105°C unless noted otherwise.

| Parameter | Symbol | Conditions | Minimum | Typical | Maximum | Unit |
|-----------------------|------------------|------------------------|-------------------------|---------|------------------------|------|
| Input High Level | V _{IH} | - | 0.7 x V _{DDD} | - | - | V |
| Input Low Level | V _{IL} | - | | - | 0.3 x V _{DDD} | V |
| Hysteresis of Inputs | V _{HYS} | - | 0.05 x V _{DDD} | - | - | V |
| Input Leakage Current | I _{IN} | - | 12 | - | 25 | μA |
| Output Low Voltage | V _{OL} | I _{OL} = 3mA. | - | - | 0.4 | V |

Table 21. I²C Bus AC Characteristics

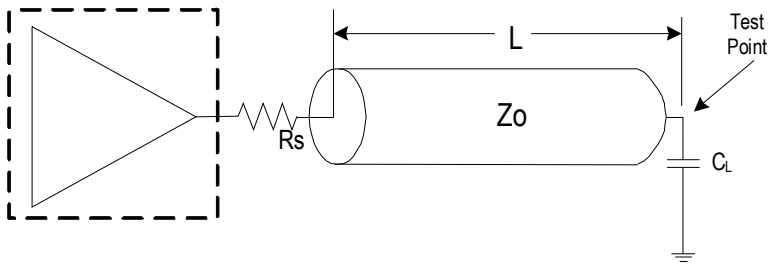
V_{DDx} = 3.3V ±5%, 2.5V ±5%, 1.8V ±5%, T_{AMB} = -40°C to +85°C and -40°C to +105°C unless noted otherwise.

| Parameter | Symbol | Conditions | Minimum | Typical | Maximum | Unit |
|--------------------------------------|-----------------------|------------|---------------------------|---------|---------|------|
| Serial Clock Frequency (SCL) | F _{SCLK} | - | 10 | - | 400 | kHz |
| Bus free time between STOP and START | t _{BUF} | - | 1.3 | - | - | μs |
| Setup Time, START | t _{SU:START} | - | 0.6 | - | - | μs |
| Hold Time, START | t _{HD:START} | - | 0.6 | - | - | μs |
| Setup Time, Data Input (SDA) | t _{SU:DATA} | - | 0.1 | - | - | μs |
| Hold Time, Data Input (SDA) 1 | t _{HD:DATA} | - | 0 | - | - | μs |
| Output Data Valid from Clock | t _{OVD} | - | - | - | 0.9 | μs |
| Capacitive Load for Each Bus Line | C _B | - | - | - | 400 | pF |
| Rise Time, Data and Clock (SDA, SCL) | t _R | - | 20 + 0.1 x C _B | - | 300 | ns |
| Fall Time, Data and Clock (SDA, SCL) | t _F | - | 20 + 0.1 x C _B | - | 300 | ns |
| HIGH Time, Clock (SCL) | t _{HIGH} | - | 0.6 | - | - | μs |
| LOW Time, Clock (SCL) | t _{LOW} | - | 1.3 | - | - | μs |
| Setup Time, STOP | t _{SU:STOP} | - | 0.6 | - | - | μs |

Note: A device must internally provide a hold time of at least 300ns for the SDA signal (referred to the V_{IH(MIN)} of the SCL signal) to bridge the undefined region of the falling edge of SCL.

Test Loads

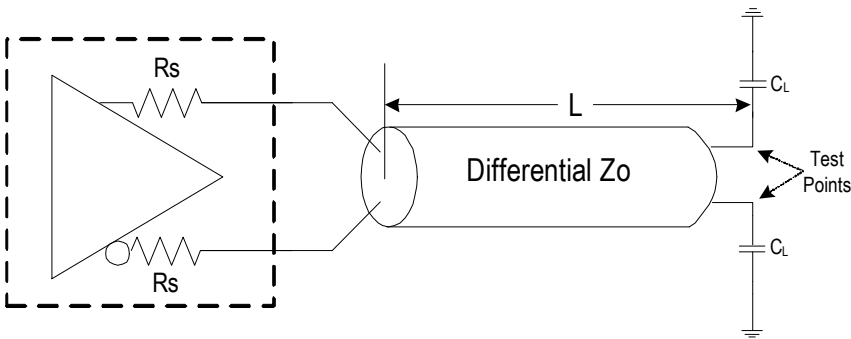
Figure 5. LVCMOS AC/DC Test Load



| R_s | Z_o | L | C_L |
|------------|------------|----------|----------------|
| 33Ω | 50Ω | 5 inches | 4.7pF |

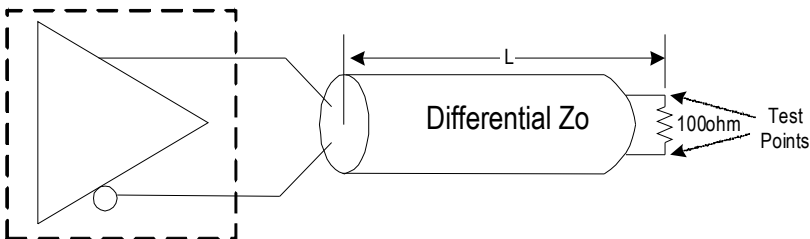
Figure 6. LP-HCSL AC/DC Test Load

(Standard PCIe source-terminated test load)



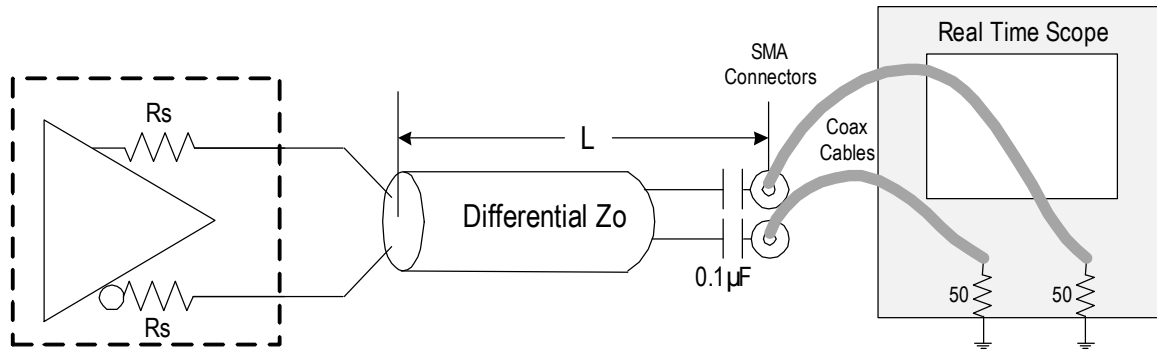
| R_s | Z_o | L | C_L |
|----------|-------------|----------|--------------|
| Internal | 100Ω | 5 inches | 2pF |
| Internal | 85Ω | 5 inches | 2pF |

Figure 7. LVDS AC/DC Test Load



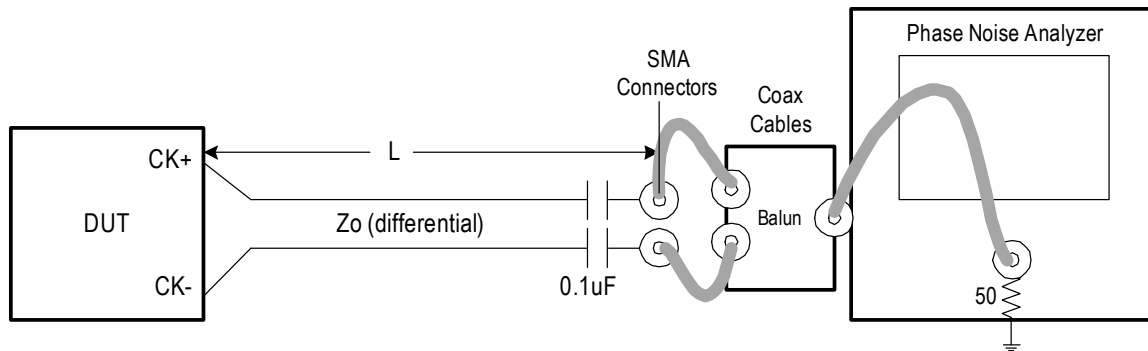
| R_s | Z_o | L | C_L |
|-------|-------------|----------|-------|
| N/A | 100Ω | 5 inches | N/A |

Figure 8. Test Setup for PCIe Measurement Using a Real-Time Scope



| R_s | Z_o | L | C_L |
|----------|-------|----------|-------|
| Internal | 100Ω | 5 inches | N/A |

Figure 9. Test Setup for PCIe Measurement Using a Phase Noise Analyzer



| R_s | Z_o | L | C_L |
|----------|-------|----------|-------|
| Internal | 100Ω | 5 inches | N/A |

Crystal Characteristics

Table 22. Recommended Crystal Characteristics

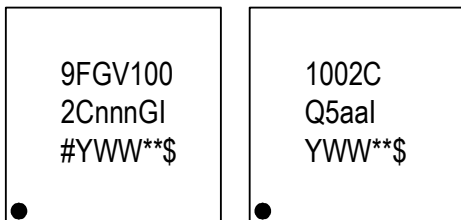
| Parameter | Value | Unit |
|-------------------------------------------------------------------|-------------|-------------|
| Frequency | 8–50 | MHz |
| Resonance Mode | Fundamental | - |
| Frequency Tolerance at 25°C | ±20 | ppm maximum |
| Frequency Stability, REF at 25°C Over Operating Temperature Range | ±20 | ppm maximum |
| Temperature Range (commercial) | 0 to +70 | °C |
| Temperature Range (industrial) | -40 to +85 | °C |
| Temperature Range (automotive) | -40 to +105 | °C |
| Equivalent Series Resistance (ESR) | 50 | Ω maximum |
| Shunt Capacitance (C _O) | 7 | pF maximum |
| Load Capacitance (C _L) | 8 | pF maximum |
| Drive Level | 0.1 | mW maximum |
| Aging Per Year | ±5 | ppm maximum |

Package Outline Drawings

The package outline drawings are located at the end of this document and are accessible from the Renesas website (see [Ordering Information](#) for POD links). The package information is the most current data available and is subject to change without revision of this document.

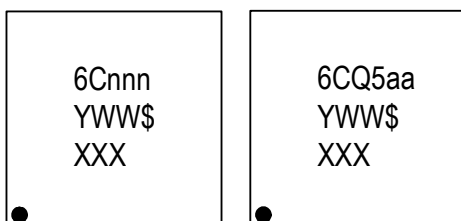
Marking Diagrams

Figure 10. 9FGV1002C Marking Diagrams



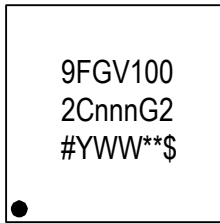
- Lines 1 and 2 are the truncated part number:
 - “nnn” denotes the decimal digits indicating a specific configuration.
 - “aa” denotes the alphanumeric digits indicating a specific Q5 configuration.
- Line 3:
 - “#” denotes the stepping number.
 - “YWW” denotes the last digits of the year and week the part was assembled.
 - “***” denotes the lot sequence; “\$” denotes the mark code.

Figure 11. 9FGV1006C Marking Diagrams



- Line 1: truncated part number
 - “nnn” denotes the decimal digits indicating a specific configuration.
 - “aa” denotes the alphanumeric digits indicating a specific Q5 configuration.
- Line 2: “YWW” denotes the last digits of the year and week the part was assembled; “\$” denotes mark code.
- Line 3: “XXX” denotes the last three characters of the lot number.

Figure 12. 9FGV1002C Marking Diagram - Automotive Device



- Lines 1 and 2 are the truncated part number:
 - “nnn” denotes the decimal digits indicating a specific configuration..
- Line 3:
 - “#” denotes the stepping number.
 - “YWW” denotes the last digits of the year and week the part was assembled.
 - “**” denotes the lot sequence; “\$” denotes the mark code.

Standard Configurations

Table 23. 9FGV1002C/9FGV1006C Standard Configurations - Industrial Grade (-40°C to +85°C)

| Supply Voltage—all pins (V) | Output Impedance (ohms) | Number of PCIe Clock Outputs | XTAL Frequency (MHz) | Orderable Part Number (Bulk) | Orderable Part Number (Tape and Reel) |
|-----------------------------|-------------------------|------------------------------|----------------------|------------------------------|---------------------------------------|
| 3.3 | 100 | 4 | 25 – external | 9FGV1002C001NBGI | 9FGV1002C001NBGI8 |
| | | | 50 – internal | 9FGV1002CQ505LTGI | 9FGV1002CQ505LTGI8 |
| | | 2 | 25 – external | 9FGV1006C001LTGI | 9FGV1006C001LTGI8 |
| | | | 50 – internal | 9FGV1006CQ505LTGI | 9FGV1006CQ505LTGI8 |
| | 85 | 4 | 25 – external | 9FGV1002C015NBGI | 9FGV1002C015NBGI8 |
| | | | 50 – internal | 9FGV1002CQ515LTGI | 9FGV1002CQ515LTGI8 |
| | | 2 | 25 – external | 9FGV1006C015LTGI | 9FGV1006C015LTGI8 |
| | | | 50 – internal | 9FGV1006CQ515LTGI | 9FGV1006CQ515LTGI8 |
| 1.8 | 100 | 4 | 25 – external | 9FGV1002C002NBGI | 9FGV1002C002NBGI8 |
| | | | 50 – internal | 9FGV1002CQ506LTGI | 9FGV1002CQ506LTGI8 |
| | | 2 | 25 – external | 9FGV1006C002LTGI | 9FGV1006C002LTGI8 |
| | | | 50 – internal | 9FGV1006CQ506LTGI | 9FGV1006CQ506LTGI8 |

Table 24. 9FGV1002C Standard Configurations - Automotive Grade (-40°C to +105°C)

| Supply Voltage—all pins (V) | Output Impedance (ohms) | Number of PCIe Clock Outputs | XTAL Frequency (MHz) | Orderable Part Number (Bulk) | Orderable Part Number (Tape and Reel) |
|-----------------------------|-------------------------|------------------------------|----------------------|------------------------------|---------------------------------------|
| 3.3 | 100 | 4 | 25 – external | 9FGV1002C001NBG2 | 9FGV1002C001NBG28 |
| | 85 | | 25 – external | 9FGV1002C015NBG2 | 9FGV1002C015NBG28 |
| 1.8 | 100 | | 25 – external | 9FGV1002C002NBG2 | 9FGV1002C002NBG28 |

Table 25. Common Features of Standard Configurations

| Output Frequency (MHz) | Output Type | REF Outputs | Configuration | SSC amount (%) | CC | SRNS, SRIS |
|------------------------|-------------|-------------|---------------|----------------|-------------|-------------|
| 100 | LP-HCSL | Off | 0 | 0 | PCIe Gen1–6 | PCIe Gen1–6 |
| | | | 1 | -0.1 | PCIe Gen1–6 | PCIe Gen1–6 |
| | | | 2 | -0.3 | PCIe Gen1–6 | PCIe Gen1–6 |
| | | | 3 | -0.5 | PCIe Gen1–6 | PCIe Gen1–4 |

Ordering Information

| Part Number | Carrier Type | Package | Temperature Range | Crystal |
|--------------------|---------------|-------------------------------------------------|-------------------|----------------|
| 9FGV1002CnnnNBG2 | Tray | 4 × 4 mm, 0.5mm pitch 24-VFQFPN | -40 to +105°C | External |
| 9FGV1002CnnnNBG28 | Tape and Reel | | | |
| 9FGV1002CnnnNBGI | Tray | 4 × 4 mm, 0.5mm pitch 24-VFQFPN | -40 to +85°C | External |
| 9FGV1002CnnnNBGI8 | Tape and Reel | | | |
| 9FGV1002CQ5aaLTGI | Tray | 4 × 4 mm, 0.5mm pitch 24-LGA | -40 to +85°C | 50MHz Internal |
| 9FGV1002CQ5aaLTGI8 | Tape and Reel | | | |
| 9FGV1006CnnnLTGI | Tray | 3 × 3 mm, 0.5mm pitch 16-LGA | -40 to +85°C | External |
| 9FGV1006CnnnLTGI8 | Tape and Reel | | | |
| 9FGV1006CQ5aaLTGI | Tray | 3 × 3 mm, 0.5mm pitch 16-LGA | -40 to +85°C | 50MHz Internal |
| 9FGV1006CQ5aaLTGI8 | Tape and Reel | | | |

“G” indicates RoHS 6.6 compliance.

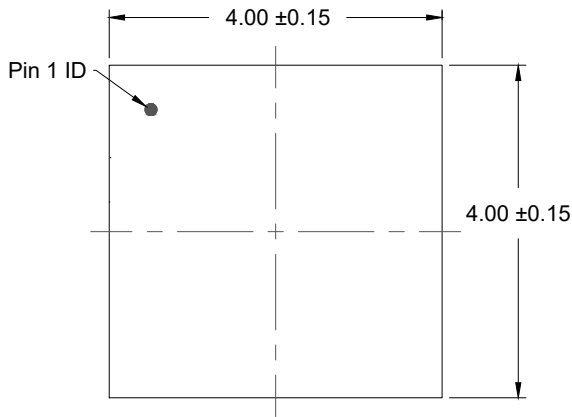
“nnn” are decimal digits indicating a specific configuration.

“aa” are alphanumeric digits indicating a specific configuration.

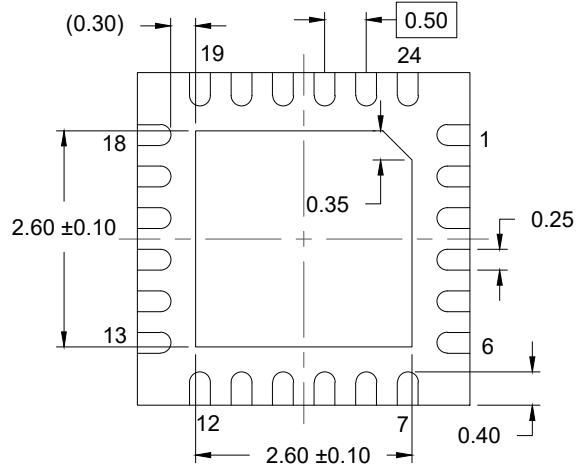
“Q5” indicates internal 50MHz crystal.

Revision History

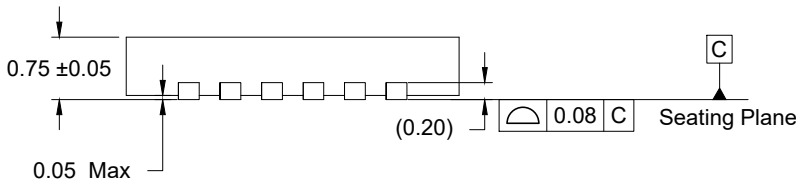
| Date | Description of Change |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| January 10, 2025 | <ul style="list-style-type: none"> ▪ Added PCIe Gen7 support which required the following updates: <ul style="list-style-type: none"> • Minor updates to front page text. • Added PCIe Gen7 CC and Gen7 IR values to Table 14 and Table 15. • Rearranged SSC conditions to conform to PCIe SIG specifications for the various data rates. • Corrected earlier calculation errors in Gen5 IR and Gen6 IR calculations. |
| July 15, 2024 | <ul style="list-style-type: none"> ▪ Renamed Table 23 to “9FGV1002C/9FGV1006C Standard Configurations - Industrial Grade (-40°C to +85°C)” ▪ Inserted Table 24 “9FGV1002C Standard Configurations - Automotive Grade (-40°C to +105°C)” ▪ Rearranged cells in Ordering Information for clarity. |
| June 23, 2023 | <ul style="list-style-type: none"> ▪ Added 9FGV1002nnnNBG2/8 automotive device to data sheet. ▪ Updated front page text. ▪ Updated existing electrical tables where necessary and added separate tables for -40°C to +105°C where necessary. ▪ Added marking diagram and ordering information. |
| March 29, 2023 | Updated footnote 2 in Table 8 . |
| March 23, 2022 | <ul style="list-style-type: none"> ▪ Separated PCIe Refclk Jitter table into separate 3.3V and 1.8V tables (Table 13 and Table 15). ▪ Updated both tables to show PCIe Gen6 support. ▪ Minor updates to front page text. |
| January 24, 2022 | <ul style="list-style-type: none"> ▪ Typo correction: changed unit specification in Key Specifications from 276ps to 276fs. ▪ Updated Package Outline Drawings section; moved package drawing links to Ordering Information. |
| November 30, 2020 | Removed “Output Frequency” parameter from Spread Spectrum Generation Specifications table. |
| October 29, 2020 | Updated pin descriptions for VDDAp and VDDDp. |
| October 9, 2020 | Added a condition and values for REF outputs to the Lock Time parameter. |
| September 28, 2020 | Removed “PCIe Gen5” from the standard configuration tables titles and the relative heading title. |
| August 18, 2020 | Updated 9FGV1006CQ marking diagram. |
| August 14, 2020 | Updated Slew Rate 1.8V minimum value from 0.8 to 1.0V/ns. |
| August 13, 2020 | Updated Carrier Type in Ordering Information table from “Cut-Tape” to “Tray”. |
| July 16, 2020 | Corrected internal resistors on SEL0/SCL and SEL1/SDA to be pull-downs. |
| July 10, 2020 | Initial release. |



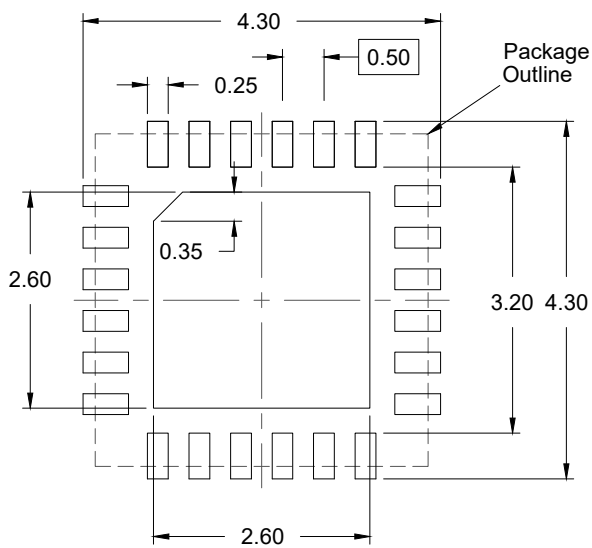
TOP VIEW



BOTTOM VIEW



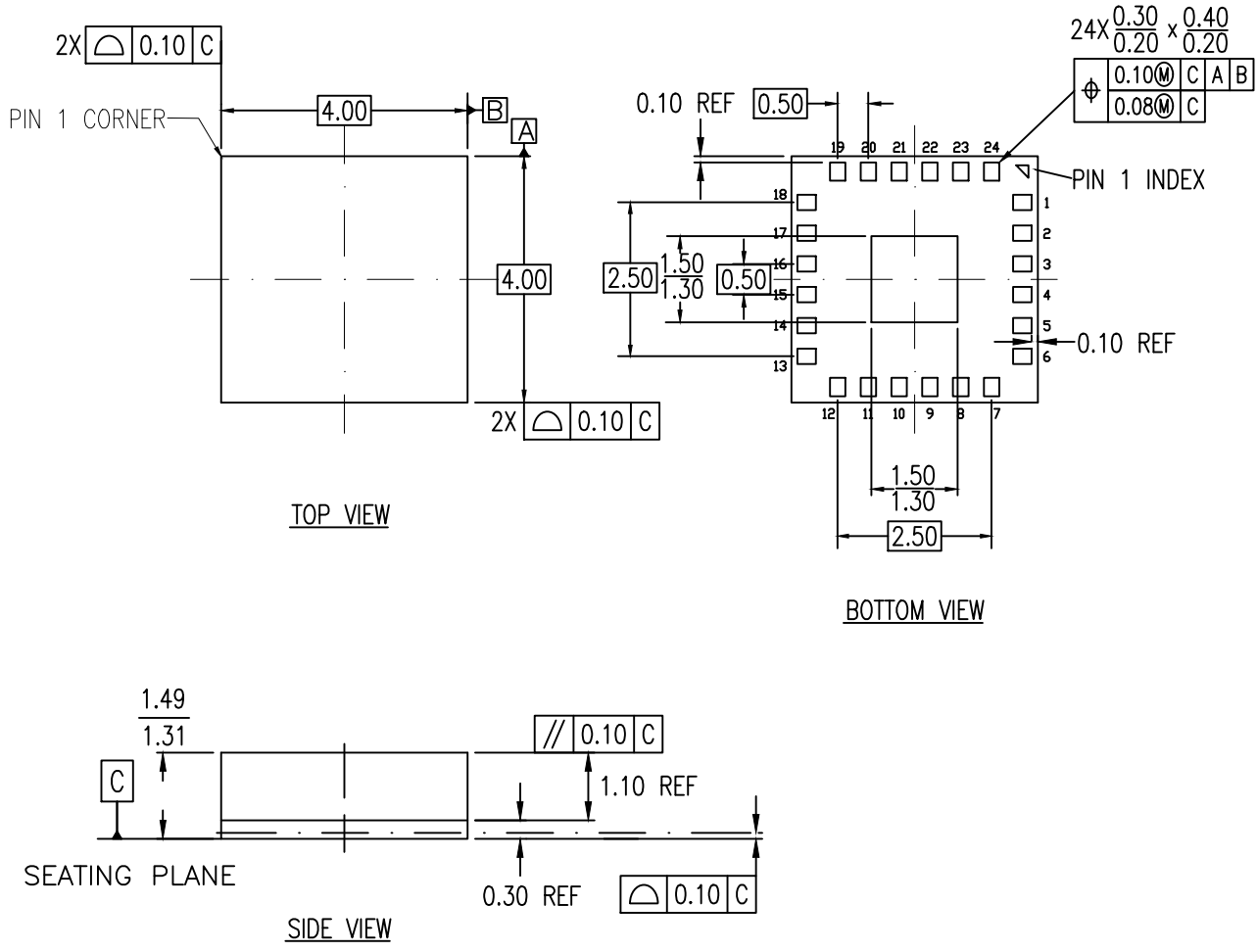
SIDE VIEW



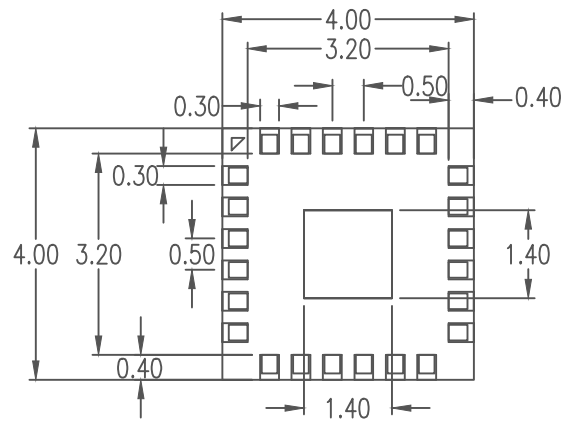
RECOMMENDED LAND PATTERN
 (PCB Top View, NSMD Design)

NOTES:

1. JEDEC compatible.
2. All dimensions are in mm and angles are in degrees.
3. Use ± 0.05 mm for the non-toleranced dimensions.
4. Numbers in () are for references only.



- NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
 2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M 1994.

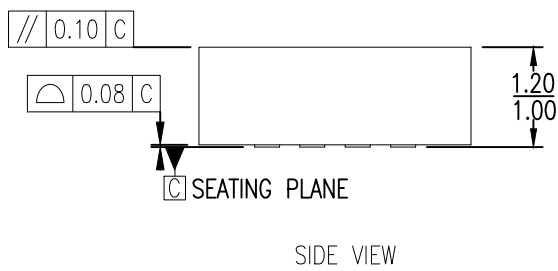
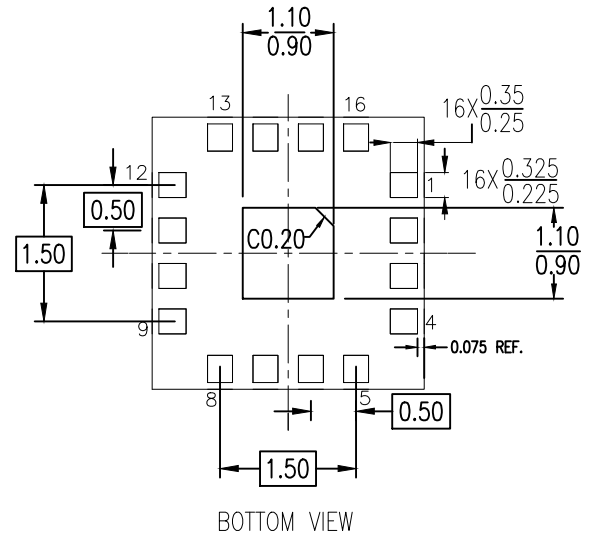
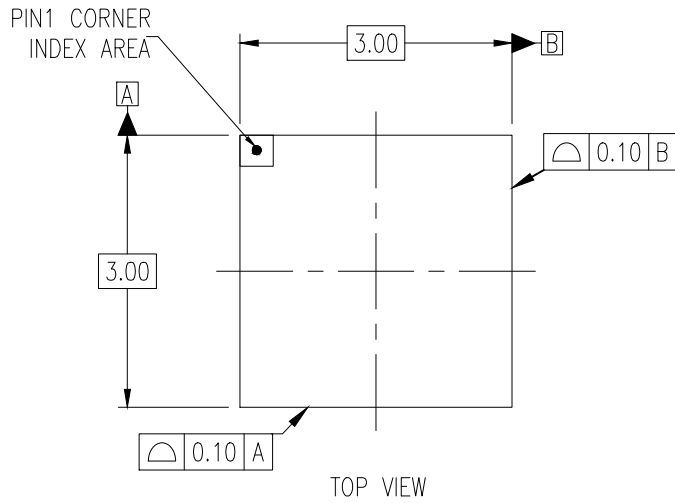


RECOMMENDED LAND PATTERN DIMENSION

NOTES:

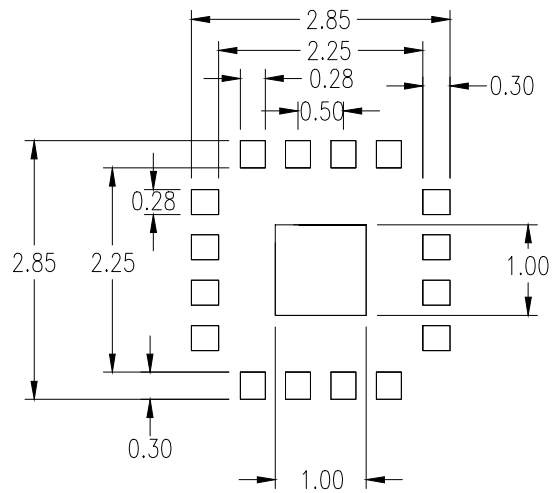
1. ALL DIMENSION ARE IN mm. ANGLES IN DEGREES.
2. TOP DOWN VIEW. AS VIEWED ON PCB.
3. LAND PATTERN RECOMMENDATION PER IPC-7351B GENERIC REQUIREMENT FOR SURFACE MOUNT DESIGN AND LAND PATTERN.

| Package Revision History | | |
|--------------------------|---------|-----------------|
| Date Created | Rev No. | Description |
| Sept 15, 2017 | Rev 00 | Initial Release |



NOTES:

1. ALL DIMENSIONING AND TOLERANCING CONFORM TO ANSI Y14.5M-1982.
2. ALL DIMENSIONS ARE IN MILLIMETERS.



RECOMMENDED LAND PATTERN DIMENSION

NOTES:

1. ALL DIMENSION ARE IN mm. ANGLES IN DEGREES.
2. TOP DOWN VIEW. AS VIEWED ON PCB.
3. LAND PATTERN RECOMMENDATION PER IPC-7351B GENERIC REQUIREMENT FOR SURFACE MOUNT DESIGN AND LAND PATTERN.

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