Description

The 9FGV1004Q is a member of Renesas' PhiClock™ programmable clock generator family. The 9FGV1004Q provides 1 copy each of 2 integer-related frequencies, 2 copies of a fractional or spread spectrum frequency and 2 copies of the crystal reference input. Two select pins allow for hardware selection of the desired configuration, or two I^2C bits all easy software selection of the desired configuration. The user may configure any one of the four OTP configurations as the default when operating in I^2C mode. Four unique I^2C addresses are available, allowing easy I^2C access to multiple components.

Typical Applications

- HPC
- Storage
- 10G/25G Ethernet
- Fiber Optic Modules
- SSDs

Key Specifications

- 320fs rms typical phase jitter at 156.25MHz (12kHz–20MHz)
- PCIe Gen1–4 compliant (spread-spectrum off)
- PCIe Gen 1–3 compliant (spread-spectrum on)
- See AN-1001 for PCIe Gen4 applications requiring spread spectrum

PCIe Clocking Architectures

- Common Clocked (CC)
- Independent Reference without spread spectrum (SRnS)
- See AN-1001 for Independent Reference with spread spectrum (SRIS) applications

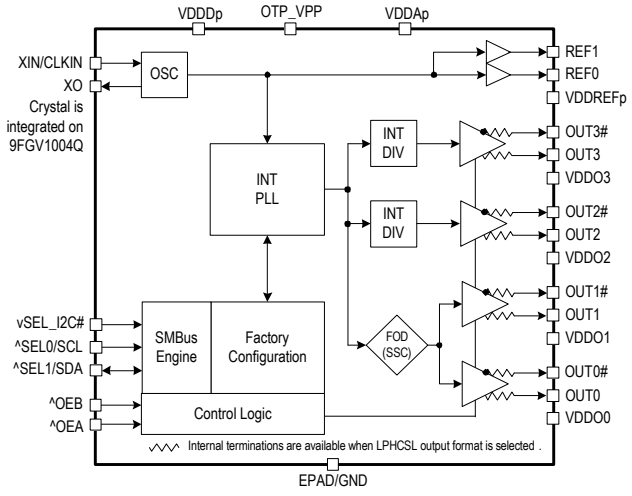
Features

- 1.8V–3.3V core V_{DD} and V_{DDREF}
- Individual 1.8V–3.3V V_{DDO} for each programmable output pair
- Supports HCSL, LVDS and LVCMOS I/O standards
- Supports LVPECL and CML logic with easy AC coupling – see application note AN-891 for alternate terminations
- HCSL utilizes Renesas LP-HCSL technology for improved performance, lower power and higher integration:
  - Programmable output impedance of 85Ω or 100Ω
- On-board OTP supports up to 4 complete configurations
- Configuration selected via strapping pins or I^2C
- Internal crystal load capacitors
- 125mW at 1.8V, 230mW at 3.3V; outputs running at 100MHz
- 4 programmable I^2C addresses: D0/D1, D2/D3, D4/D5, D6/D7 read/write
- Programmable spread spectrum modulation frequency and amount
- Supported by Renesas Timing Commander™ software
- Space saving 4 × 4 mm 24-LGA package with internal crystal

Output Features

- 4 programmable output pairs plus 2 LVCMOS outputs
- 2 integer output frequencies and 1 fractional or spread spectrum output frequency per configuration
- 10MHz–325MHz LVDS or LP-HCSL outputs
- 10MHz–200MHz LVCMOS outputs
- 10MHz–156.25MHz spread spectrum or fractional output

Block Diagram



Contents

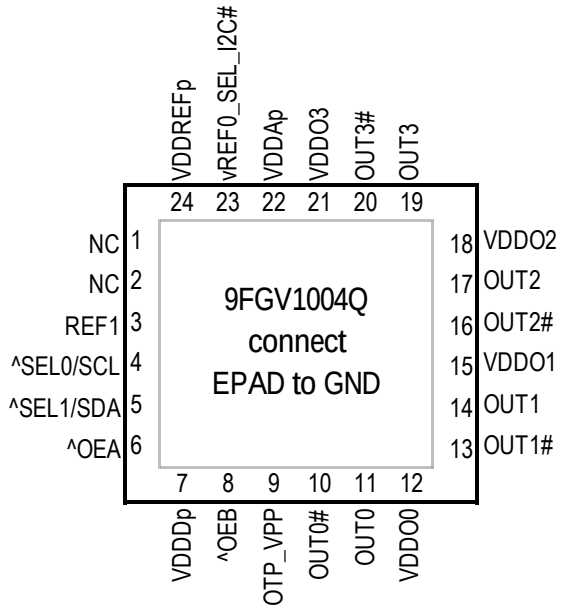
OE Mapping

Table 1. OE Mapping

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

Pin Assignments

Figure 1. Pin Assignments for 4 x 4 mm 24-LGA Package – Top View



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]

Pin Descriptions

Table 2. Pin Descriptions

Note: Unused outputs can be programmed off and left floating. VDDREFp and VDDO0 have to be connected.

Number	Name	Type	Description
1	NC	—	No connect.
2	NC	—	No connect.
3	REF1	Output	LVCMOS reference output.
4	^SEL0/SCL	Input	Select pin for internal frequency configurations/I^2C clock pin. Function is determined by state of SEL_I2C# upon power-up. This pin has an internal pull-up.
5	^SEL1/SDA	I/O	Select pin for internal frequency configurations/I^2C data pin. Function is determined by state of SEL_I2C# upon power-up. This pin has an internal pull-up.
6	^OEA	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. Nominal voltages are 1.8V to 3.3V. VDDAp and VDDDp should be connected to the same power supply.
8	^OEB	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_{DDD}.
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	Power supply for analog circuits. VDDAp and VDDDp should be connected to the same power supply. Nominal voltages are 1.8V, 2.5V or 3.3V.
23	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^2C pins. After power-up, the pin acts as a LVCMOS reference output. This pin has an internal pull-down. 1 = SEL0/SEL1. 0 = SCL/SDA.
24	VDDREFp	Power	Power supply for REF0 and REF1 and the internal XO. Nominal voltages are 1.8V, 2.5V or 3.3V.
25	EPAD	GND	Connect to ground.

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 9FGV1004Q at absolute maximum ratings is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Table 3. 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}
Outputs	
Outputs, V_{DDO} (LVCMOS)	-0.5V to V_{DDO} + 0.5V
Outputs, IO (SDA)	10mA

Thermal Characteristics

Table 4. Thermal Characteristics

Parameter	Symbol	Conditions	Package	Typical Values	Units	Notes
Thermal Resistance Q-series (devices with internal crystal)	θ_{JC}	Junction to case.	LTG24 (24-LGA)	57.3	°C/W	1
	θ_{Jb}	Junction to base.		24.3	°C/W	1
	θ_{JA0}	Junction to air, still air.		79.8	°C/W	1
	θ_{JA1}	Junction to air, 1 m/s air flow.		73.9	°C/W	1
	θ_{JA3}	Junction to air, 3 m/s air flow.		69.9	°C/W	1
	θ_{JA5}	Junction to air, 5 m/s air flow.		67.3	°C/W	1

[1] EPAD soldered to board.

Recommended Operating Conditions

Table 5. Recommended Operating Conditions

Symbol	Parameter	Minimum	Typical	Maximum	Units
V_{DDOx}	Power supply voltage for supporting 1.8V outputs.	1.71	1.8	1.89	V
	Power supply voltage for supporting 2.5V outputs.	2.375	2.5	2.625	V
	Power supply voltage for supporting 3.3V outputs.	3.135	3.3	3.465	V
V_{DDD}	Power supply voltage for core logic functions.	1.71		3.465	V
V_{DDA}	Analog power supply voltage. Use filtered analog power supply if available.	1.71		3.465	V
T_A	Operating temperature, ambient.	-40		85	°C
C_L	Maximum load capacitance (3.3V LVCMOS only).			15	pF
t_{PU}	Power up time for all V_{DD}s to reach minimum specified voltage (power ramps must be monotonic).	0.05		5	ms

Electrical Characteristics

V_{DDx} = 3.3V ±5%, 2.5V ±5%, 1.8V ±5%, T_A = -40°C to +85°C unless stated otherwise.

Table 6. Common Electrical Characteristics

Parameter	Symbol	Conditions	Minimum	Typical	Maximum	Units	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).	10		325	MHz	
		Single-ended clock output (LVCMOS).	10		200	MHz	
		Spread spectrum configuration.	10		156.25	MHz	6
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].	0.7 x V_{DDD}		V_{DDD} + 0.3	V	
Input Low Voltage	V_{IL}	SEL[1:0].	GND - 0.3		0.8	V	
Input High Voltage	V_{IH}	REF/SEL_I2C#.	0.65 x 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	
Input Low Voltage	V_{IL}	XIN/CLKIN.	-0.3		0.4	V	
Input Rise/Fall Time	T_R/T_F	SEL1/SDA, SEL0/SCL.			300	ns	
Input Capacitance	C_{IN}	SEL[1:0].		3	7	pF	
Internal Pull-up Resistor	R_{UP}	SEL[1:0] at 25°C.	200	237	300	kΩ	
Internal Pull-down Resistor	R_{DOWN}	REF/SEL_I2C#.	200	237	300	kΩ	

Table 6. Common Electrical Characteristics (Cont.)

Parameter	Symbol	Conditions	Minimum	Typical	Maximum	Units	Notes
Programmable Capacitance at XIN and XO (XIN in parallel with XO)	C_L	XIN/CLKIN, XO.	0		8	pF	
Input Duty Cycle	t2	CLKIN, measured at $V_{DDREF}/2$.	40	50	60	%	
Output Duty Cycle	t3	LVCMOS, f_{OUT} > 156.25MHz.	40	50	60	%	
		LVCMOS, $f_{OUT} \leq$ 156.25MHz.	45	50	55	%	
		LVDS, LP-HCSL outputs.	45	49.9	55	%	
Clock Jitter	t6	Cycle-to-cycle jitter (Peak-to-Peak), See “Test Frequencies for Jitter Measurements in Common Electrical Characteristics” for configurations.		27		ps	4
		Reference clock RMS phase jitter (12kHz to 5MHz integration range). See “Test Frequencies for Jitter Measurements in Common Electrical Characteristics” for configurations.		250		fs rms	4
		OUTx RMS phase jitter(12kHz to 20MHz integration range) differential output. See “Test Frequencies for Jitter Measurements in Common Electrical Characteristics” for configurations.		320		fs rms	4
Output Skew	t7	Skew between the same frequencies, with outputs using the same driver format.		34		ps	7
Lock Time	t8	PLL lock time from V_{DD}s reaching 1.5V.		5	10	ms	2, 3

[1] Practical lower frequency is determined by loop filter settings.

[2] Includes loading the configuration bits from OTP to registers.

[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.

[6] With internal low pass filter enabled. When disabled, maximum frequency is 325MHz.

[7] OUT0 and OUT1.

Table 7. Test Frequencies for Jitter Measurements in Common Electrical Characteristics

Device	XIN/CLKIN	OUT0	OUT1	OUT2	OUT3	Unit	Notes
9FGV1004Q	50	100		125.00	156.25	MHZ	1,2

[1] All outputs measured with 100MHz outputs both spreading and non-spreading.

[2] Outputs configured as LVDS or LP-HCSL with REF output off unless noted.

Table 8. LVCMOS Output Electrical Characteristics

Parameter	Symbol	Conditions	Minimum	Typical	Maximum	Units	Notes
Slew Rate	S_R	3.3V ±5%, 20% to 80% of V_{DDO} (output load = 4.7pF).	2.5	3.7	4.6	V/ns	
		2.5V ±5%, 20% to 80% of V_{DDO} (output load = 4.7pF).	1.5	2.4	4.6	V/ns	
		1.8V ±5%, 20% to 80% of V_{DDO} (output load = 4.7pF).	0.8	1.7	3.5	V/ns	
Output High Voltage	V_{OH}	I_{OH} = -15mA at 3.3V. I_{OH} = -12mA at 2.5V. I_{OH} = -8mA at 1.8V.	0.8 x V_{DDO}		V_{DDO}	V	
Output Low Voltage	V_{OL}	I_{OL} = 15mA at 3.3V. I_{OL} = 12mA at 2.5V. I_{OL} = 8mA at 1.8V.		0.22	0.4	V	
Output Leakage Current	I_{OZDD}	Programmable outputs, tri-state outputs, V_{DDO} = 3.465V.		0	5	µA	
		REF outputs, tri-state outputs, V_{DDREF} = 3.465V.		0	5	µA	
CMOS Output Driver Impedance	R_{OUT}	T_A = 25°C.		17		Ω	

Table 9. LVDS Output Electrical Characteristics

Parameter	Symbol	Minimum	Typical	Maximum	Units	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) at 3.3V +5% & 2.5V +5%	V_{OS}	1.125	1.19	1.55	V	
Output Common Mode Voltage (Offset Voltage) at 1.8V +5%	V_{OS}	0.8	0.86	0.95	V	
Change in V_{OS} between Complementary Output States	ΔV_{OS}		0	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		257	400	ps	
Fall Times Tested at 80% – 20%	T_F		287	400	ps	

Table 10. Low-Power (LP) Push-Pull HCSL Differential Outputs

V_{DDO} = 3.3V ±5%, 2.5V ±5%, 1.8V ±5%, T_A = -40°C to +85°C unless stated otherwise.

Parameter	Symbol	Conditions	Minimum	Typical	Maximum	Units	Notes
Slew Rate	$T_{R/F}$	Scope averaging on.	1	2.5	4	V/ns	2,3,16
Slew Rate Matching	$\Delta T_{R/F}$			9	20	%	1,14,16
Crossing Voltage (abs)	V_{CROSS}	Scope averaging off.	250	424	550	mV	1,4,5,16
Crossing Voltage (var)	ΔV_{CROSS}	Scope averaging off.		16	140	mV	1,4,9,16
Voltage High	V_{HIGH}		660	785	850	mV	1
Voltage Low	V_{LOW}		-150	13	150		1
Absolute Maximum Voltage	V_{MAX}			808	1150	mV	1,7,15
Absolute Minimum Voltage	V_{MIN}		-300	-54			1,8,15

[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 4.0 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 C_L. 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] T_{STABLE} is the time the differential clock must maintain a minimum ±150mV differential voltage after rising/falling edges before it is allowed to droop back into the VRB ±100mV differential range.

[13] “ppm” refers to parts per million and is a DC absolute period accuracy specification. 1 ppm is 1/1,000,000th of 100.000000MHz exactly or 100Hz. For 300ppm, there is an error budget of 100Hz/ppm × 300 ppm = 30kHz. The period is to be measured with a frequency counter with measurement window set to 100ms or greater. The ±300 ppm 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 2,500 ppm nominal shift in maximum period resulting from the 0.5% down spread resulting in a maximum average period specification of +2,800 ppm.

[14] Matching applies to rising edge rate for REFCLK+ and falling edge rate for REFCLK-. It is measured using a ±75mV 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] Guaranteed by design and characterization.

Table 11. Filtered Phase Jitter Parameters – PCIe Common Clocked (CC) Architectures

T_{AMB} = over the specified operating range. Supply Voltages per normal operation conditions; see Test Loads for loading conditions.

Parameter	Symbol	Conditions	Minimum	Typical	Maximum	Industry Limits	Units	Notes
PCIe Phase Jitter	$t_{jphPCIeG1-CC}$	PCIe Gen1.		19	47	86	ps (p-p)	1,2,3
	$t_{jphPCIeG2-CC}$	PCIe Gen2 Low Band 10kHz < f < 1.5MHz (PLL BW of 5–16MHz, 8–16MHz, CDR = 5MHz).		0.4	1.3	3	ps (rms)	1,2
		PCIe Gen2 High Band 1.5MHz < f < Nyquist (50MHz) (PLL BW of 5–16MHz, 8–16MHz, CDR = 5MHz).		1.6	2.7	3.1	ps (rms)	1,2
	$t_{jphPCIeG3-CC}$	PCIe Gen3 (PLL BW of 2–4MHz, 2–5MHz, CDR = 10MHz).		0.4	0.64	1	ps (rms)	1,2
	$t_{jphPCIeG4-CC}$	PCIe Gen4 (SSC off) (PLL BW of 2–4MHz, 2–5MHz, CDR = 10MHz).		0.35	0.44	0.5	ps (rms)	1,2,6

Table 12. Filtered Phase Jitter Parameters – PCIe Independent Reference (IR) Architectures

T_{AMB} = over the specified operating range. Supply Voltages per normal operation conditions; see Test Loads for loading conditions.

Parameter	Symbol	Conditions	Minimum	Typical	Maximum	Industry Limits	Units	Notes
PCIe Phase Jitter	$t_{jphPCIeG2-SRnS}$	PCIe Gen2 (SSC off) (PLL BW of 16MHz, CDR = 5MHz).		1.2	1.50	2	ps (rms)	1,2,4, 5
	$t_{jphPCIeG3-SRnS}$	PCIe Gen3 (SSC off) (PLL BW of 2–4MHz, CDR = 10MHz).		0.4	0.44	0.7	ps (rms)	1,2,4, 5

Notes for all PCIe Filtered Phase Jitter tables:

[1] Applies to all differential outputs, guaranteed by design and characterization.

[2] Based on PCIe Base Specification Rev4.0 version 1.0. See http://www.pcisig.com for latest specifications.

[3] Sample size of at least 100K cycles. This figure extrapolates to 108ps pk-pk at 1M cycles for a BER of 1^{-12}.

[4] IR is the new name for Separate Reference Independent Spread (SRIS) and Separate Reference no Spread (SRNS) PCIe clock architectures.

[5] According to the PCIe Base Specification Rev4.0 version 1.0, the jitter transfer functions and corresponding jitter limits are not defined for the IR clock architecture. Widely accepted *industry* limits using widely accepted *industry* filters are used to populate this table. There are no accepted filters or limits for IR clock architectures at PCIe Gen1 or Gen4 data rates.

[6] For PCIe Gen4 performance with SSC on, see application note AN-1001.

Table 13. Current Consumption

V_{DDO} = 3.3V ±5%, 2.5V ±5%, 1.8V ±5%, T_A = -40°C to +85°C unless stated otherwise.

Parameter	Symbol	Conditions	Minimum	Typical	Maximum	Units	Notes
V_{DDREF} Supply Current	I_{DDREF}	50MHz REFCLK, subtract 3mA for 25MHz REFCLK.		7	11	mA	
Core Supply Current	I_{DDCORE}	2500MHz VCO, 50 MHz REFCLK.		30	42	mA	3
Output Buffer Supply Current (V_{DDO3})	I_{DDOx}	LVDS, 325MHz.		18	24	mA	2
		LP-HCSL, 100MHz.		12	21	mA	2
		LVCMOS, 50MHz.		14	19	mA	1,2
		LVCMOS, 200MHz.		21	35	mA	1,2
Output Buffer Supply Current (V_{DDO2})	I_{DDOx}	LVDS, 325MHz.		18	24	mA	2
		LP-HCSL, 100MHz.		16	21	mA	2
		LVCMOS, 50MHz.		14	19	mA	1,2
		LVCMOS, 200MHz.		21	35	mA	1,2
Output Buffer Supply Current (V_{DDO1})	I_{DDOx}	LVDS, 325MHz, SSC Off.		8	11	mA	2
		LP-HCSL, 100MHz, SSC Off.		6	8	mA	2
		LP-HCSL, 100MHz, SSC On.		14	18	mA	2
		LVCMOS, 50MHz, SSC Off.		5	7	mA	1,2
		LVCMOS, 50MHz, SSC On.		9	12	mA	1,2
		LVCMOS, 200MHz, SSC Off.		13	24	mA	1,2
Output Buffer Supply Current (V_{DDO0})	I_{DDOx}	LVDS, 325MHz.		16	21	mA	2
		LP-HCSL, 100MHz.		15	18	mA	2
		LVCMOS, 50MHz.		13	17	mA	1,2
		LVCMOS, 200MHz.		21	34	mA	1,2
Total Power Down Current	I_{DDPD}	Programmable outputs in HCSL mode, B37[0] = 0.		20	26	mA	1,2
		Programmable outputs in LVDS mode, B37[0] = 0.		31	43	mA	1,2
		Programmable outputs in LVCMOS1 mode, B37[0] = 0.		16	20	mA	1,2
		Programmable outputs in HCSL mode, B37[6,0] = 0.		10	16	mA	1,2
		Programmable outputs in LVDS mode, B37[6,0] = 0.		18	31	mA	1,2
		Programmable outputs in LVCMOS1 mode, B37[6,0] = 0.		6	9	mA	1,2

[1] Single CMOS driver active for each output pair.

[2] See Test Loads for details; maximum frequency for SSC outputs is 156.25MHz.

[3] $I_{DDCORE} = I_{DDA} + I_{DDD}$.

Table 14. Spread Spectrum Generation Specifications

Parameter	Symbol	Conditions	Minimum	Typical	Maximum	Units
Output Frequency	f_{OUT}	Output frequency range of spread spectrum outputs.	10		156.25	MHz
Mod Frequency	f_{MOD}	Modulation frequency.	30 to 60			kHz
Spread%	SSC%	Amount of spread value (programmable) – down spread.	-0.1 to -3.0			%
Spread%	SSC%	Amount of spread value (programmable) – center spread.	±0.05 to ±1.5			%

I²C Bus Characteristics

Table 15. I²C Bus DC Characteristics

Parameter	Symbol	Conditions	Minimum	Typical	Maximum	Units
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}		-1		30	µA
Output Low Voltage	V_{OL}	I_{OL} = 3mA.			0.4	V

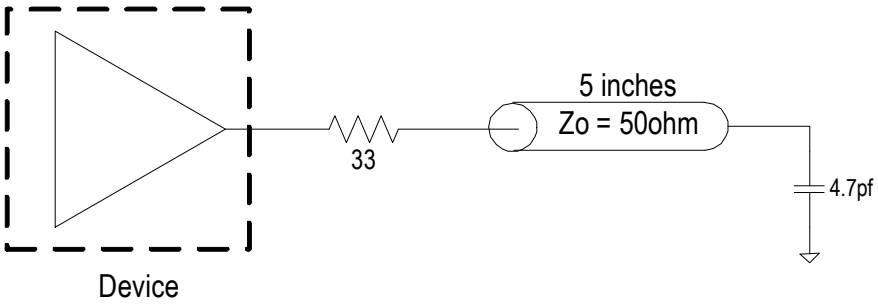
Table 16. I²C Bus AC Characteristics

Parameter	Symbol	Conditions	Minimum	Typical	Maximum	Units
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

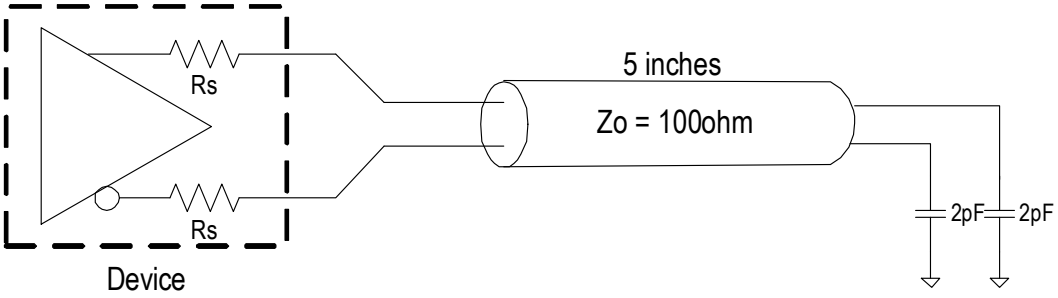
[1] A device must internally provide a hold time of at least 300ns for the SDA signal (referred to the $V_{IH(MIN)}$ of the SCL signal) to bridge the undefined region of the falling edge of SCL.

Test Loads

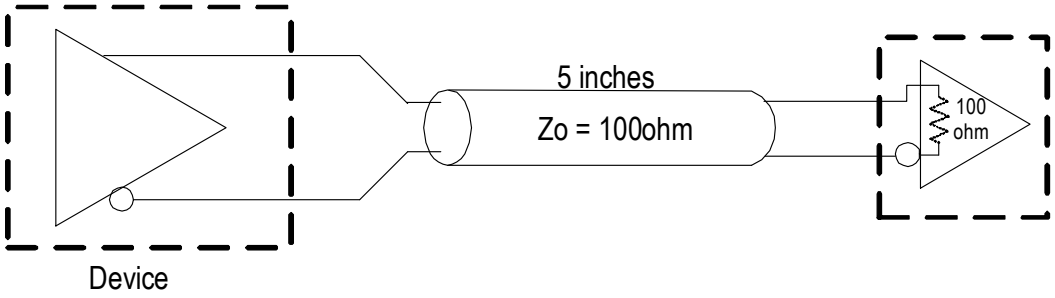
LVCMOS Test Load



LPHCSL Test Load for 100MHz PCIe



LVDS Test Load



Crystal Characteristics

Table 17. Recommended Crystal Characteristics

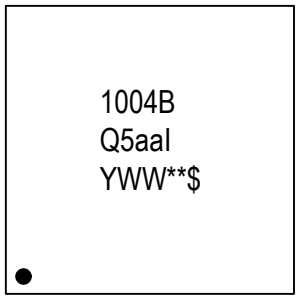
Parameter	Value	Units
Frequency	8–50	MHz
Resonance Mode	Fundamental	—
Frequency Tolerance at 25°C	±20	ppm maximum
Frequency Stability, REF at 25°C Over Operating Temperature Range	±20	ppm maximum
Temperature Range (commercial)	0 to +70	°C
Temperature Range (industrial)	-40 to +85	°C
Equivalent Series Resistance (ESR)	50	Ω maximum
Shunt Capacitance (C_O)	7	pF maximum
Load Capacitance (C_L)	8	pF maximum
Drive Level	0.3	mW maximum
Aging per year	±5	ppm maximum

Package Outline Drawings

The package outline drawings are appended at the end of this document and are accessible from the link below. The package information is the most current data available.

www.idt.com/document/psc/24-lga-package-outline-drawing-40-x-40-x-140-mm-body-05mm-pitch-ltg24t2

Marking Diagrams



- Lines 1 and 2 are the truncated part number.
- "#" 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.

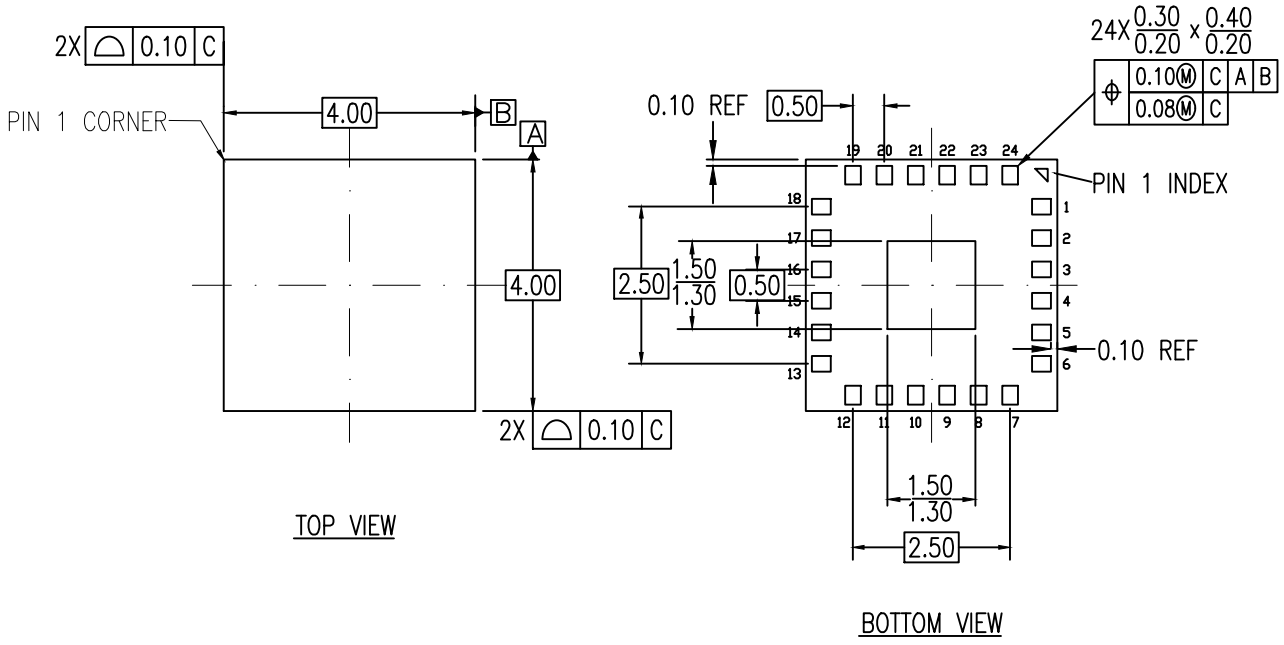
Ordering Information

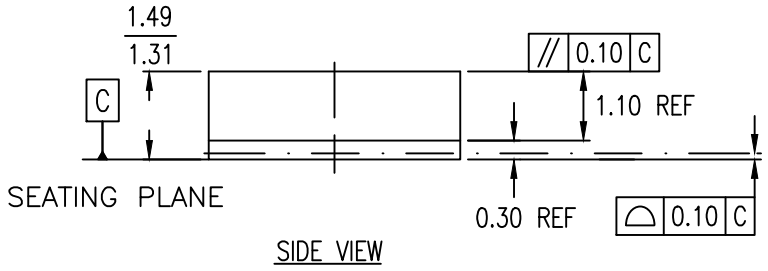
Orderable Part Number	Package	Carrier Type	Temperature	Crystal
9FGV1004BQ5aaLTGI	4 × 4 mm, 0.5mm pitch 24-LGA	Trays	-40 to +85°C	50MHz Internal
9FGV1004BQ5aaLTGI8	4 × 4 mm, 0.5mm pitch 24-LGA	Reel	-40 to +85°C	50MHz Internal

“G” indicates RoHS 6.6 compliance.
“aa” are alphanumeric digits indicating a specific configuration.
“Q5” indicates internal 50MHz crystal.

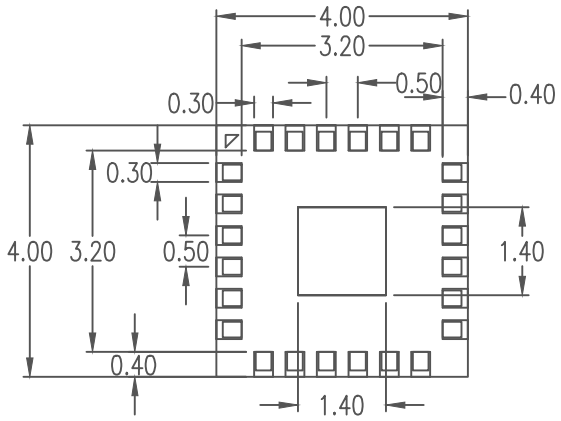
Revision History

Revision Date	Description of Change
February 19, 2020	Removed BQ2 part number and information.
March 27, 2019	Initial release.





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

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