AU5248 – Low Noise PLL Based Crystal Oscillator

General Description

The AU5248 is a PLL based programable crystal oscillator. The device is user programmable via I2C to configure any frequency between 200 KHz to 1 GHz. AU5248 is a low Noise PLL with Integrated XTAL which provides clocks with ultra low jitter of 85 fs.

AU5248 is factory-configurable for a wide range of user selectable option including the I2C address, and output format. With on chip NVM and factory programming, Aurasemi can satisfy customer requirements with very faster lead times.

Applications:

- 100G/200G/400G OTN, coherent optics
- 10G/40G/100G optical ethernet
- 3G-SDI/12G-SDI/24G-SDI broadcast video
- Datacenter
- Test and measurement
- Clock and data recovery
- FPGA/ASIC clocking

Features

- Output programmable to any frequency from 200KHz to 1GHz with 0.1ppb resolution. Selected frequencies between 1GHz to 1.5GHz are available on special order.
- Ultra Low Jitter: 85fs Typ Jrms (12 kHz-20 MHz)
- Fractional N fully integrated PLL
- VDD supply operation at 3.3 V, 2.5 V and 1.8 V
- I2C Interface supports Standard (100 KHz) and Fast Mode(400 KHz)
- Best in class PSRR performance of -85dBC typical
- Output Driver options: LVPECL, LVDS, HCSL-LP, LVDS-Boost, HCSL,CML.
- +/- 25 ppm stability (-40 °C to 85 °C)
- Available in 3.2 mm x 2.5 mm package

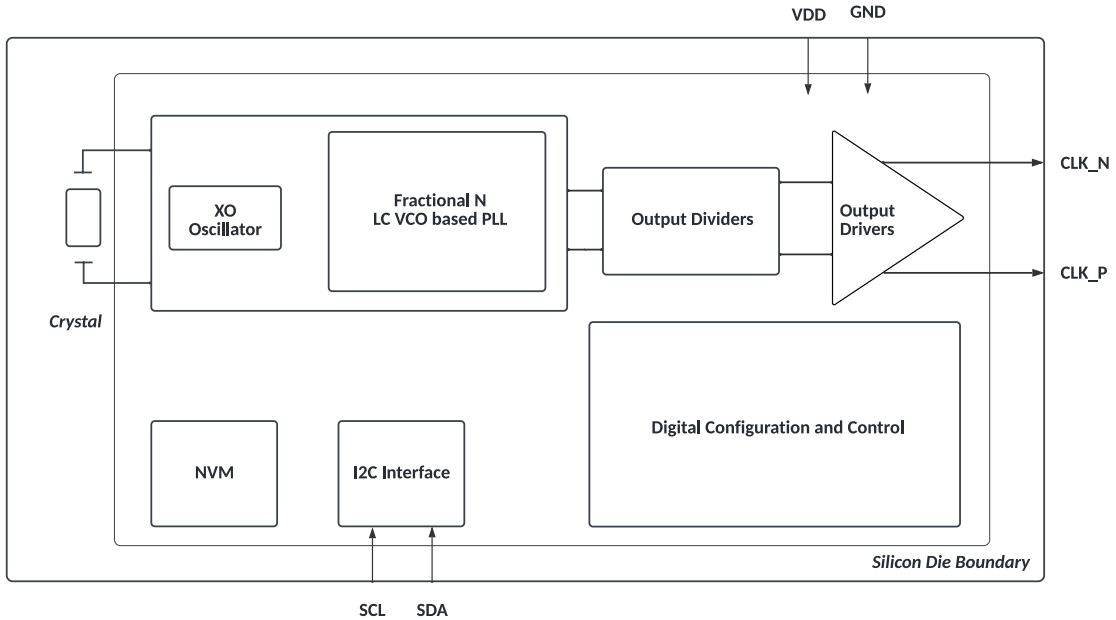

Figure 1 Functional Overview

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1 Pin Description

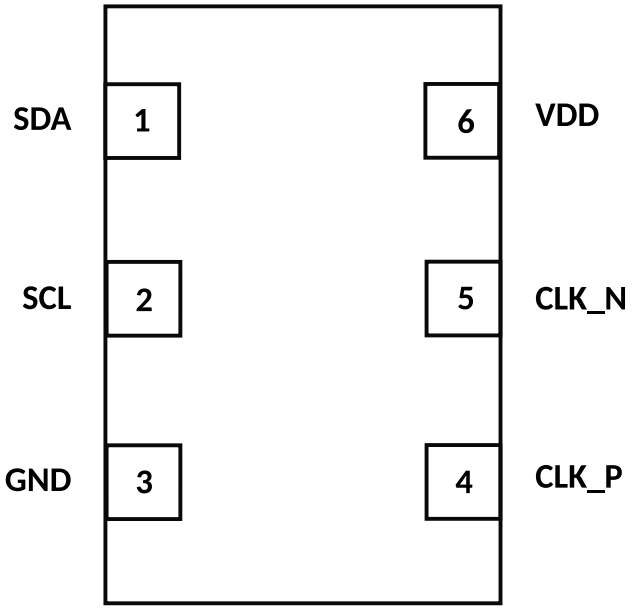

Figure 2 AU5248 Top View

Table 1 Pin Description

Pin Name	Pin No.	I/O Type	Function
SDA	1	Input/Output	I2C Serial Data
SCL	2	Input	I2C Serial Clock
GND	3	GND	GND
CLKP	4	Output	Clock + for differential Output.
CLKN	5	Output	Clock - for differential Output.
VDD	6	Power	Chip Power Supply

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2 Electrical Characteristics

Table 2 Absolute Maximum Ratings

Parameter	Conditions	Symbol	Min	Typ	Max	Units
~~Core~~ Supply voltage		V_{DD}	-0.5		+3.63	V
Input voltage, All Inputs	Relative to GND	V_{IN}	-0.5		+3.63	V
Storage temperature	Non-functional, Non-Condensing	T_S	-55		+150	°C
Programming Temperature		T_{PROG}	+15		+50	°C
Programming Voltage		V_{PROG}	2.375	2.5	2.625	V
ESD (human body model)	JEDEC JS-001-2012	ESD_{HBM}			2000	V
ESD (charged device model)	JEDEC JESD22-C101E	ESD_{CDM}			500	V

Notes:
1. Exceeding maximum ratings may shorten the useful life of the device.
2. 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 at any other conditions beyond those indicated under the DC Electrical Characteristics is not implied. Exposure to Absolute-Maximum-Rated conditions for extended periods may affect device reliability or cause permanent device damage.

Table 3 Operating Temperature

Parameter	Conditions	Symbol	Min	Typ	Max	Units
Ambient temperature		TA	–40	–	+105	°C
Junction temperature		TJ			+125	°C

Table 4 DC Electrical Characteristics

Parameter	Condition	Symbol	Min	Typ	Max	Units
Supply Voltage	1.8 V range: ±5%	V_{DD}	1.71	1.80	1.89	V
	2.5 V range: ±5%		2.375	2.50	2.625	V
	3.3 V range: ±10%		2.97	3.3	3.63	V
Supply Current (Output Enabled)	LVPECL	I_{DD}		68		mA
	LVDS			47		
	LVDS-Boost			51		
	HCSL (Far End Termination)			59		
	HCSL-LP			50		
Power Up Time				15		ms

Table 5 Output RMS Jitter

Parameter	Conditions	Symbol	Min	Typ	Max	Units
RMS Jitter for 12 kHz – 20 MHz Integration Bandwidth	F_{OUT} = 622.08 MHz	RMS_{JIT}		85		fs rms
	F_{OUT} = 156.25 MHz					

Notes:
1. The RMS Jitter data is based on the simulation results. Final data will be populated based on lab ~~C~~characterization.

Table 6 Clock Output Phase Noise

Offset Frequency	156.25 MHz LVDS	622.08 MHz LVDS	Units
1 kHz	-120.7	-108.7	dBc/Hz
10 kHz	-132.7	-120.7	
100 kHz	-143.6	-131.6	
1 MHz	-151.8	-139.8	
10 MHz	-167.9	-159.1	
20 MHz	-170.6	-162.9	
Offset Frequency	**156.25MHz LVPECL**	**622.08 MHz LVPECL**	**Units**
1 kHz	-120.7	-108.7	dBc/Hz
10 kHz	-132.6	-120.7	
100 kHz	-143.6	-131.6	
1 MHz	-151.7	-139.8	
10 MHz	-166.3	-158.8	
20 MHz	-169.8	-162.9	

Notes:
1. The Clock Output Phase Noise data is based on the simulation. Final Phase Noise data will be populated based on lab Characterization.

Table 7 Power Supply Rejection

Parameter	Conditions	Symbol	Min	Typ	Max	Units
F_{OUT} = 156.25 MHz	100 kHz Sine Wave	$PSRR_{VDD}$		-85		dBc
	200 kHz Sine Wave					
	500 kHz Sine Wave					
	1 MHz Sine Wave					

Notes:
1. The PSRR is measured with a 50 mVpp sinusoid in series with the supply and checking the spurious level relative to the carrier on the output in terms of phase disturbance impact.
2. Output PSRR measured with LVDS standard which are the recommended standards for AC Coupled terminations.
3. The PSRR data is provided based on simulation worst case numbers.Final data will be provided based on lab characterization.

Table 8 Output Clock Specifications

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
DC Electrical Specifications – LVDS Outputs (VDD = 1.8 V, 2.5 V or 3.3 V range)						
Output Common-Mode Voltage	VDD = 2.5 V or 3.3 V range	V_{OCM}		1.2		V
Output Common-Mode Voltage	VDD = 1.8 V	V_{OCM}		0.85		
AC Electrical Specifications (LVPECL, LVDS, HCSL Far End Termination): Fout = 156.25 MHz						
Clock Output Frequency		f_{OUT}	0.2		1000	MHz
LVPECL Output Rise/Fall Time	20% to 80% of AC levels. Measured at 156.25 MHz for LVPECL outputs.	t_{RF}			350	ps
LVDS Output Rise/Fall Time	20% to 80% of AC levels. Measured at 156.25 MHz for LVDS outputs.	t_{RF}			350	ps
LVDS-Boost Output Rise/Fall Time	20% to 80% of AC levels. Measured at 156.25 MHz for LVDS outputs.	t_{RF}			350	ps
HCSL Far End Termination Output Rise/Fall Time	20% to 80% of AC levels. Measured at 156.25 MHz for HCSL outputs.	t_{RF}			350	ps
Output Duty Cycle	Measured at differential 50% level, 156.25 MHz	t_{ODC}	45	50	55	%

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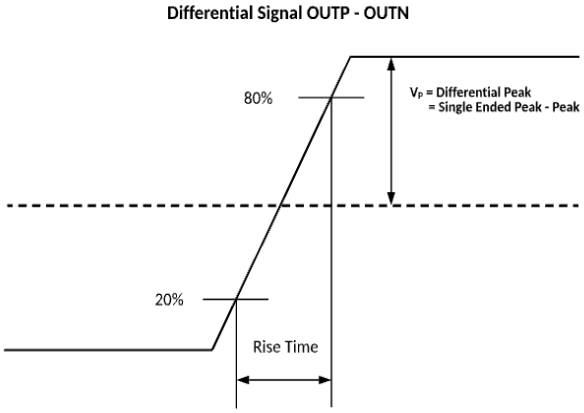
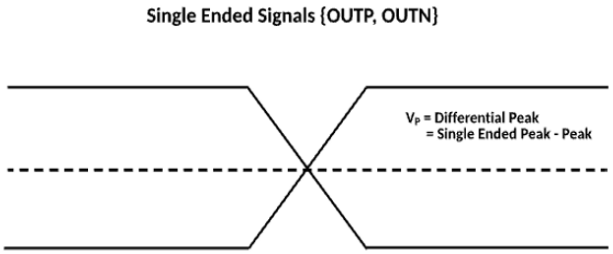
Parameter	Conditions	Symbol	Min	Typ	Max	Unit
LVPECL Output Differential peak	Measured at 156.25M Output	VP		750		mV
LVDS Output differential peak	Measured at 156.25M Output	VP		400		
LVDS-Boost Output differential peak	Measured at 156.25M Output	VP		790		
HCSL Far End Termination Output differential peak	Measured at 156.25M Output	VP		800		
AC Electrical Specifications (HCSL – LP)						
Slew Rate	Scope Averaging on	dV/dt	1		4	V/ns
Slew Rate Matching	Single-ended measurement.	ΔdV/dt			20	%
Maximum Voltage	Measurement on single ended signal using absolute value. (Scope averaging off).	V_{MAX}		850		mV
Minimum Voltage		V_{MIN}		0		mV
Crossing Voltage (abs)	Scope averaging off.	V_{cross_abs}		430		mV
Crossing Voltage (var)	Scope averaging off.	Δ-V_{cross}		9.6		mV
Differential Impedance		Z_{DIFF}		85/100		Ω

Notes:
Convention for Wave Forms





3 Serial Programming Interface Description

The chip settings can be reconfigured using the I2C serial programming interface.

3.1 I2C protocol

Pin configuration of serial interface in I2C slave mode is as follows.

- SCL
- SDA

The device uses the SDA and SCL pins for a 2-wire serial interface that operates up to 400 Kb/s in Read and Write modes. It complies with the I2C bus standard. The I2C access protocol in device is both random and sequential access for Write and Read modes.

The I2C serial interface can operate at either Standard rate (100 Kbps) or Fast rate (400 Kbps).

The default I2C address will be 0x55, The Device will support to configure any I2C address through One Time Programming.

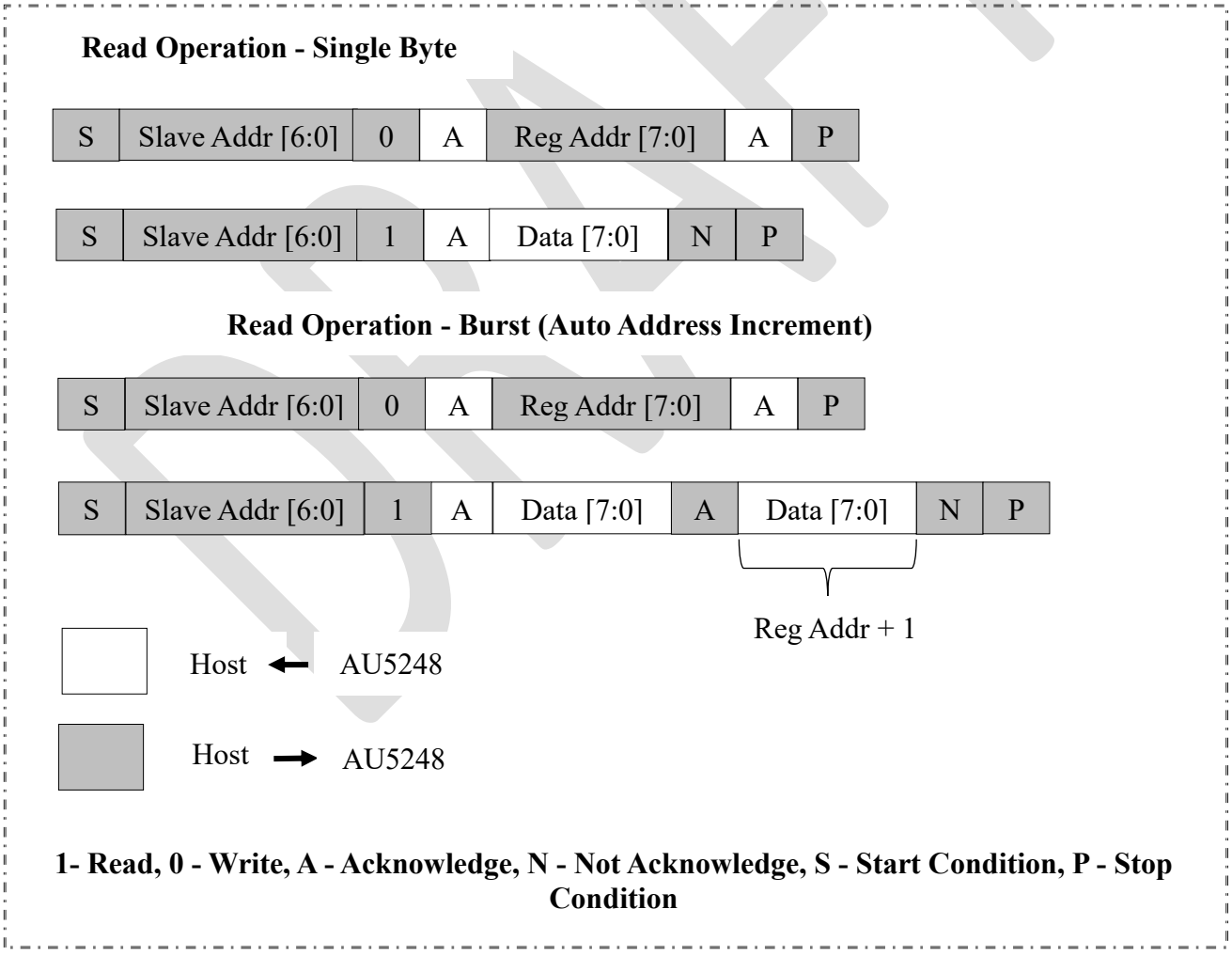


Figure 3 I2C Read Operation

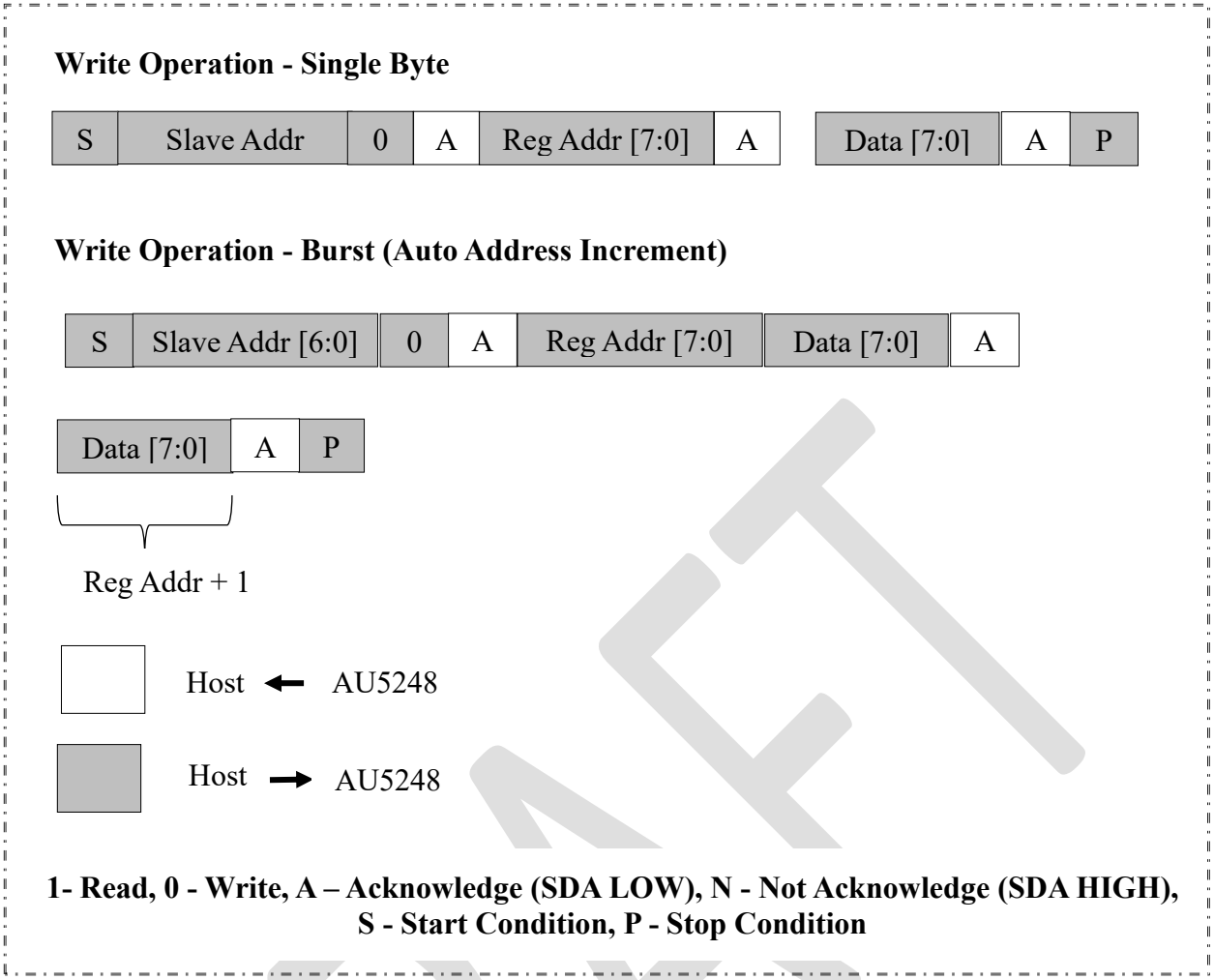


Figure 4 I2C Write Operation

3.1.1 Single Byte Write

- The master initiates the transaction by issuing a start condition, writes 7-bit slave address and then the read/write bit is written as 0 (write)
- The slave acknowledges by driving zero on the bus
- The master then writes the 8-bit register map address
- The slave acknowledges by driving zero on the bus
- The master then writes the 8-bit data to be written to the register map address specified
- The slave acknowledges by driving zero on the bus
- The master ends the transaction by issuing a stop condition

3.1.2 Multi Byte Write

- The master initiates the transaction by issuing a start condition, writes 7-bit slave address and then the read/write bit is written as 0 (write)
- The slave acknowledges by driving zero on the bus
- The master then writes the 8-bit register map address
- The slave acknowledges by driving zero on the bus
- The master then writes the 8-bit data to be written to the register map address specified
- The slave acknowledges by driving zero on the bus and increment the address by 1
- The master continuously writes the 8-bit data to the slave and the slave will acknowledge by driving zero for every byte.
- The master ends the transaction by issuing a stop condition

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3.1.3 Single Byte Read

- The master initiates the transaction by issuing a start condition, writes 7-bit slave address and then the read/write bit is written as 0 (write)
- The slave acknowledges by driving zero on the bus
- The master then writes the 8-bit register map address
- The slave acknowledges by driving zero on the bus
- The master ends the transaction by issuing a stop condition
- The master re-initiates the transaction by issuing a start condition, writes 7-bit slave address and then the read/write bit is written as 1 (read)
- The slave then writes the 8-bit data to be written to the register map address specified
- The master does not acknowledge this transaction as the slave may assume a multi-byte read operation and there is a risk of slave holding the bus low
- The master ends the transaction by issuing a stop condition

3.1.4 Multi Byte Read

The multi-byte read mode is used to read a continuous segment of the register map. The multi-byte read is faster than performing multiple single byte reads as the device address and register map address need not be specified for every byte read from the register map

- The master initiates the transaction by issuing a start condition, writes 7-bit slave address and then the read/write bit is written as 0 (write)
- The slave acknowledges by driving zero on the bus
- The master then writes the 8-bit register map address
- The slave acknowledges by driving zero on the bus
- The master ends the transaction by issuing a stop condition
- The master re-initiates the transaction by issuing a start condition, writes 7-bit slave address and then the read/write bit is written as 1 (read)
- The slave then writes the 8-bit data to be written to the register map address specified
- The master acknowledges by driving zero on the bus
- The slave automatically increments the register map address and writes the data in at that address to the bus and the master acknowledges
- When all bytes of data are read, master ends the operation by not acknowledging the last read
- The master then ends the transaction by issuing a stop condition.

3.1.5 I2C Bus Timing Specifications

Table 9 I2C Bus Timing Specification

Description	Symbol	Standard Mode		Fast Mode		Units
		Min	Max	Min	Max	
SCL clock frequency	f_{SCL}	–	100	–	400	kHz
Hold time START condition	$t_{HD:STA}$	0.4	–	0.6	–	µs
Low period of the SCK clock	t_{LOW}	4.7	–	1.3	–	µs
High period of the SCK clock	t_{HIGH}	4.0	–	0.6	–	µs
Setup time for a repeated START condition	$t_{SU:STA}$	4.7	–	0.6	–	µs
Data hold time	$t_{HD:DAT}$	300	–	300	–	ns
Data setup time	$t_{SU:DAT}$	100	–	–	–	ns
Rise time	t_R	–	1000	–	300	ns
Fall time	t_F	–	300	–	300	ns
Setup time for STOP condition	$t_{SU:STO}$	4.0	–	0.6	–	µs
Bus-free time between STOP and START conditions	t_{BUF}	4.7	–	1.3	–	µs

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Description	Symbol	Standard Mode		Fast Mode		Units
		Min	Max	Min	Max	
Data valid time	$t_{VD;DAT}$	–	3.45	–	0.9	µs
Data valid acknowledge time	$t_{VD;ACK}$	–	0.9	–	0.9	µs

Note:

- In I2C mode, the serial data and clock have an on-chip 25 kΩ pull up resistor to VDDIO. Please refer Figure 5 for the nomenclature of these parameters.

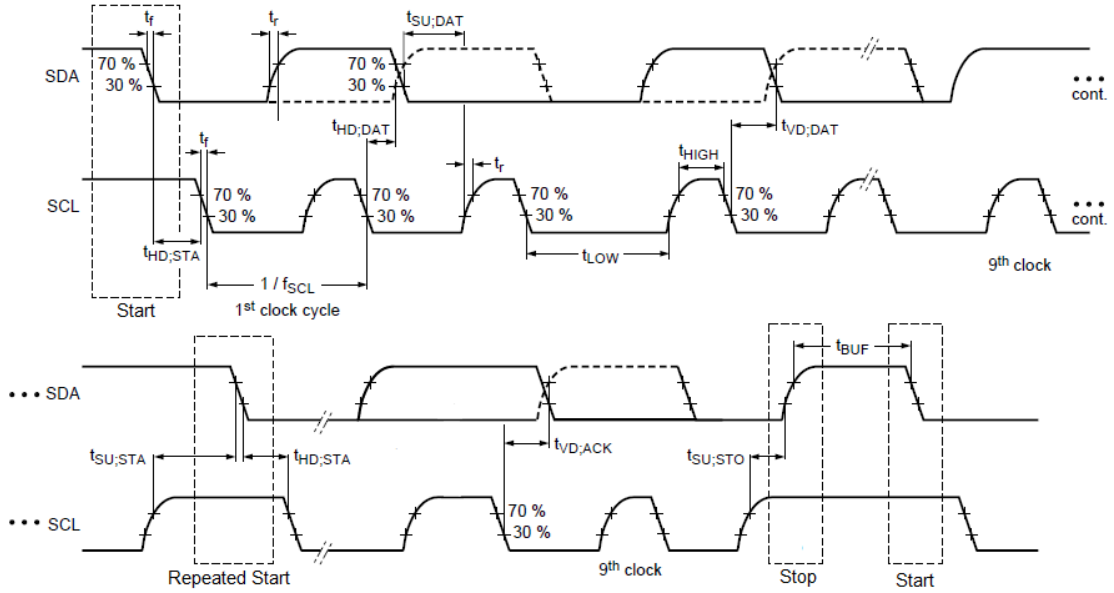

Figure 5 I2C Timing Waveform

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4 Package Information

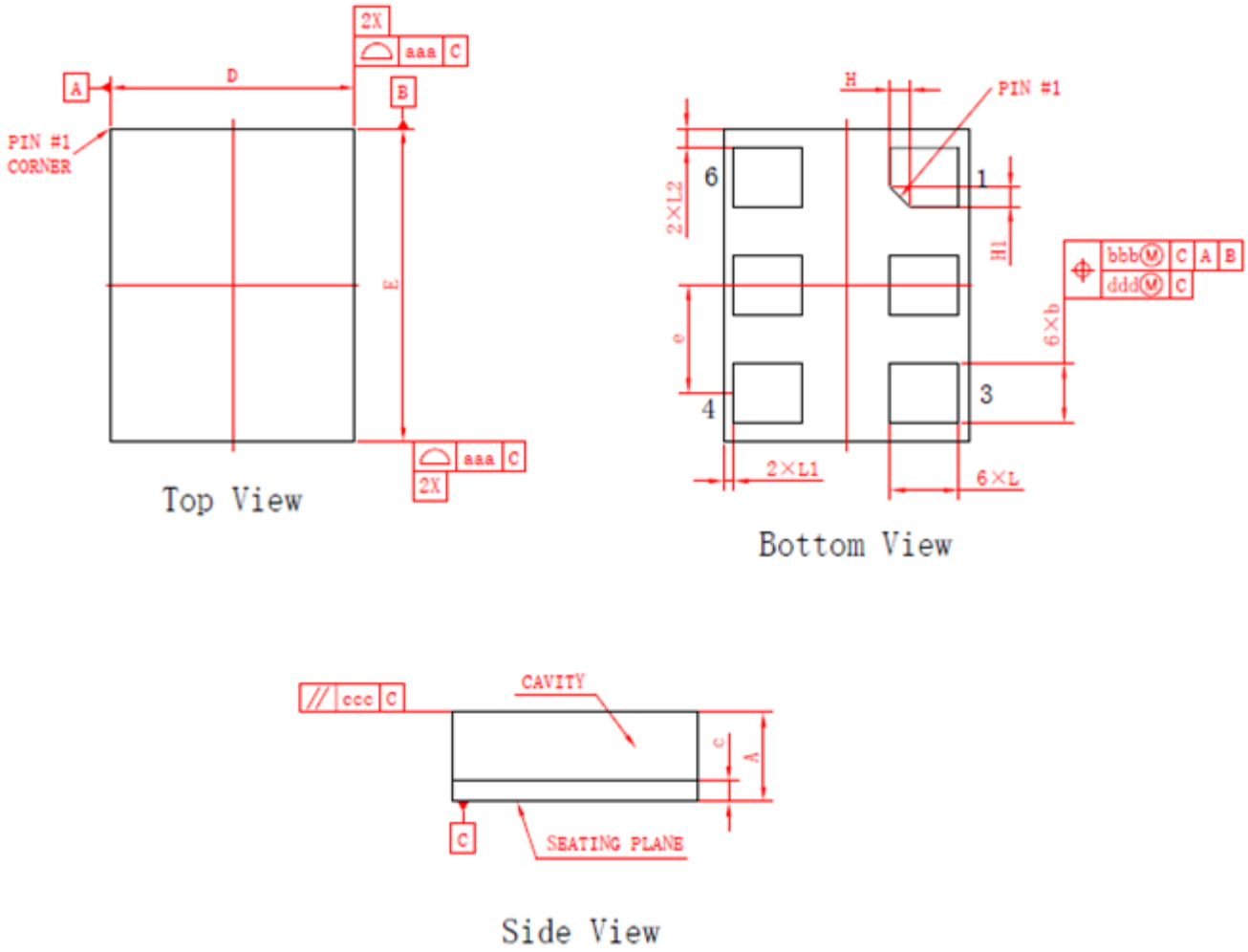


Figure 6 Package Diagram (3.2 mm x 2.5 mm)

Symbol	Millimeter		
	MIN	NOM	MAX
A	0.810	0.910	1.010
c	0.170	0.210	0.250
D	2.450	2.500	2.550
E	3.150	3.200	3.250
H	-	0.200	-
H1	-	0.200	-
L	0.625	0.700	0.775
L1	0.025	0.100	0.175
L2	0.125	0.200	0.275
e	-	1.100	-
b	0.550	0.600	0.650
aaa	0.150		
bbb	0.150		
ccc	0.100		
ddd	0.080		

5 Output Termination Information

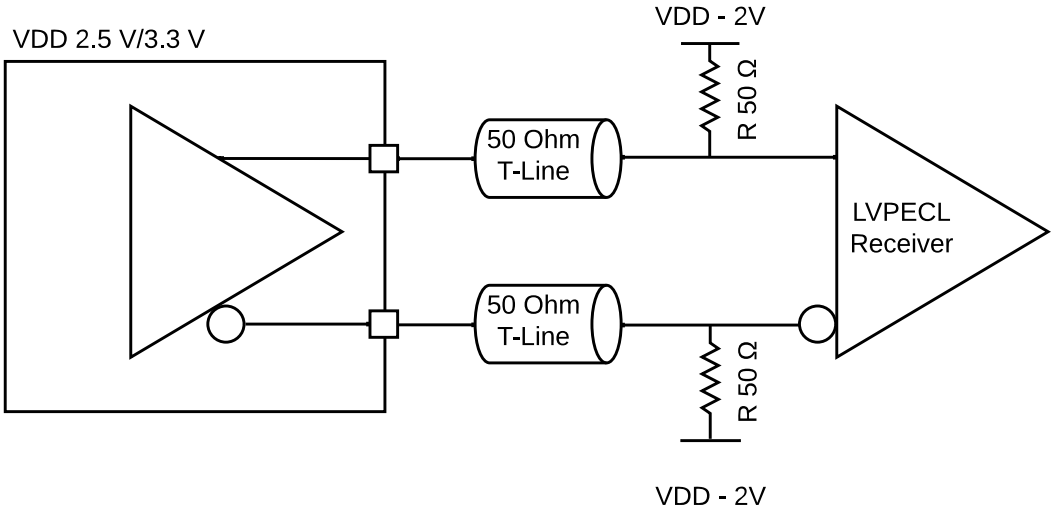
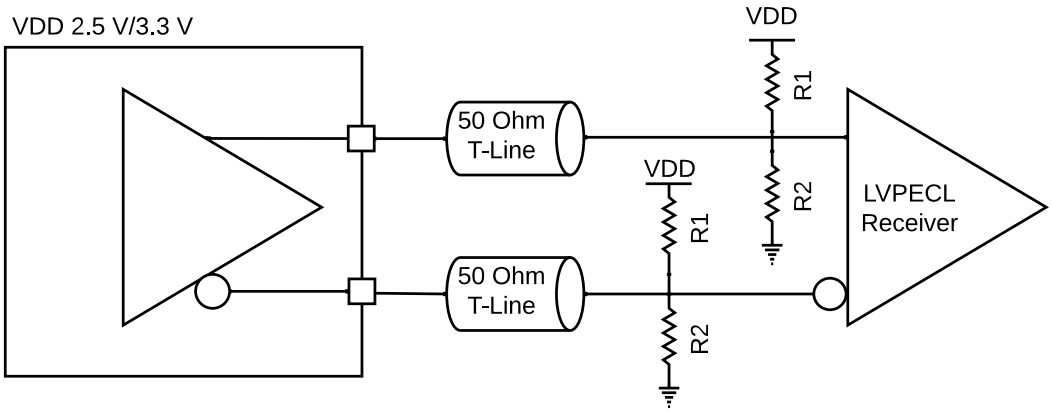


Figure 7 LVPECL Output Driver used with traditional DC Coupled LVPECL receiver



VDD	R1	R2
2.5 V	250 Ω	62.5 Ω
3.3 V	127 Ω	82.5 Ω

Figure 8 LVPECL Output Driver with DC Coupled LVPECL receiver: Thevenin Equivalent

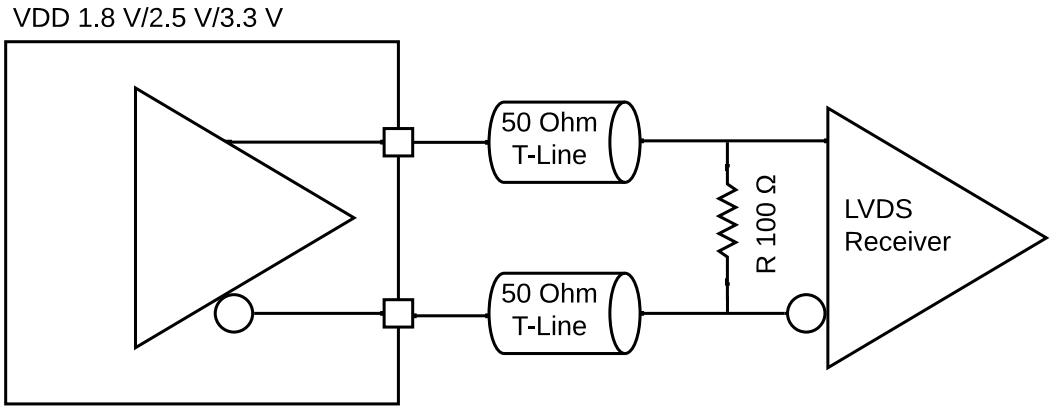


Figure 9 LVDS Output Driver used with traditional DC Coupled LVDS receiver

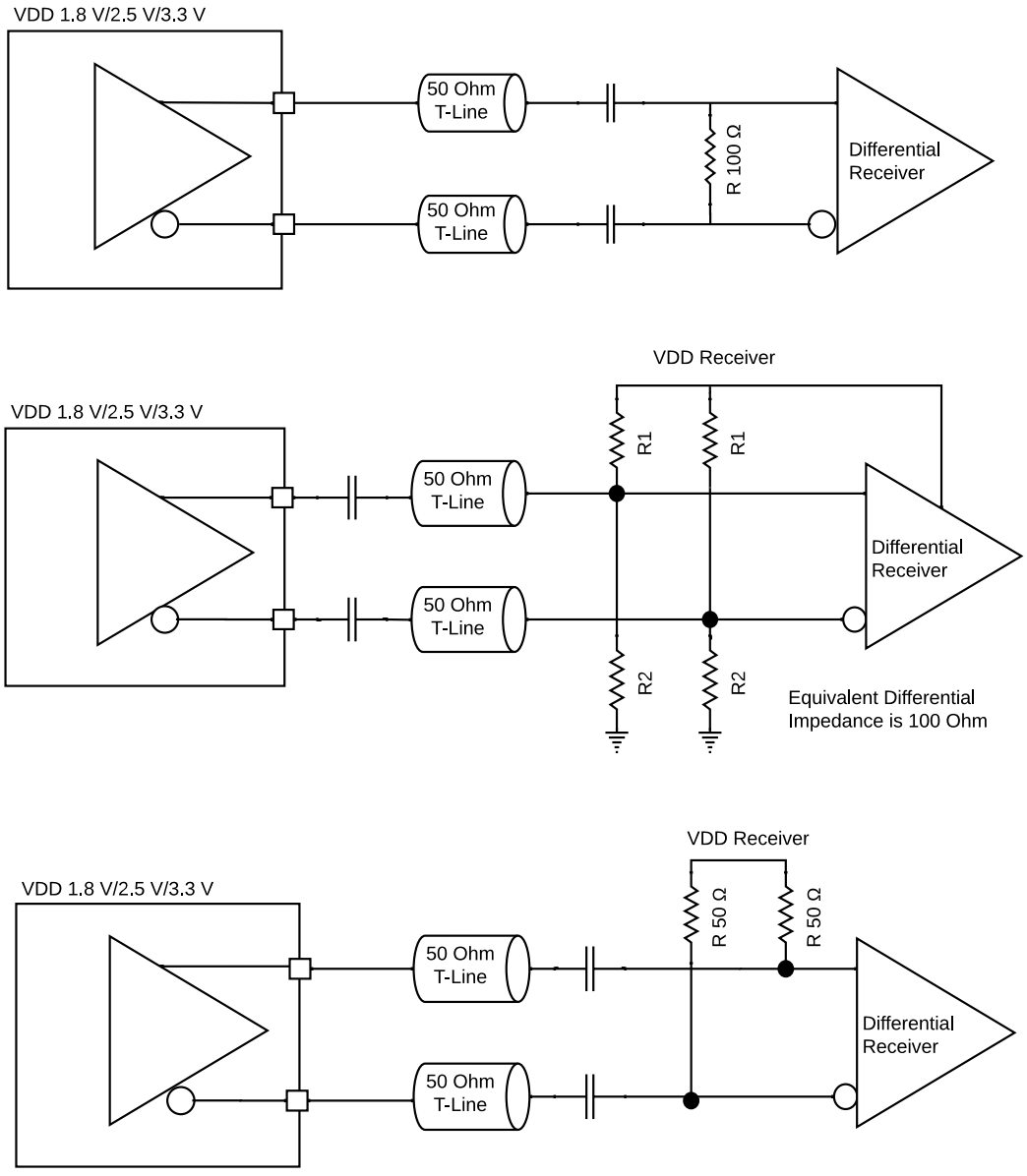


Figure 10 LVDS Output Driver used with AC Coupled terminations for various receivers

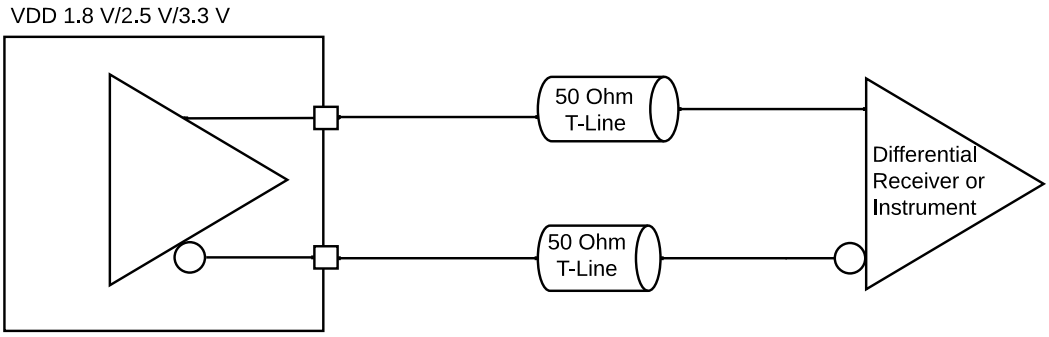


Figure 11 HCSL-LP (Low Power) DC Coupled

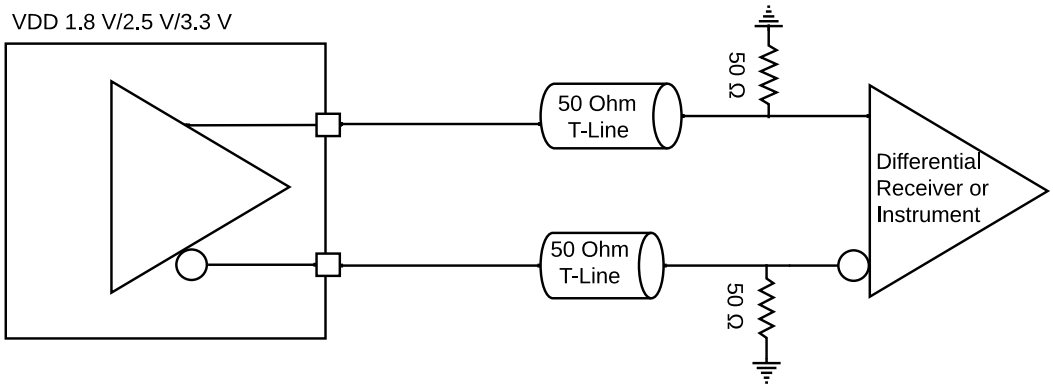


Figure 12 HCSL DC Coupled - Far End Termination

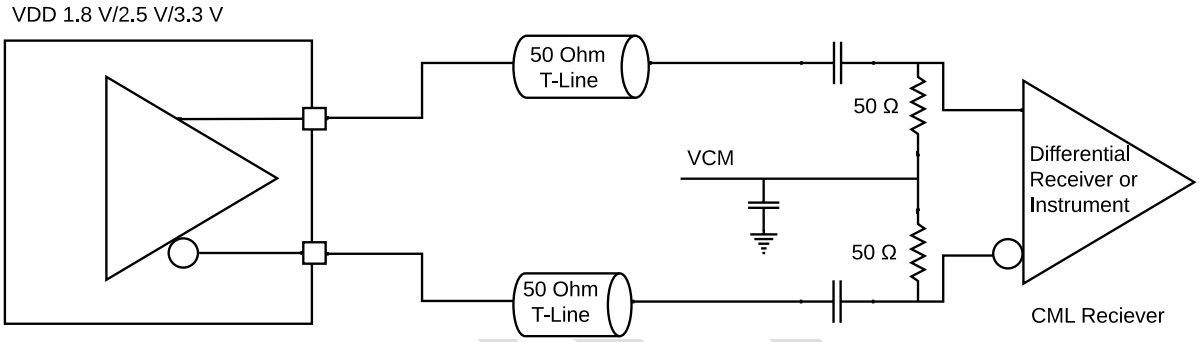


Figure 13 Output Driver with AC Coupled CML receiver

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6 Ordering Information

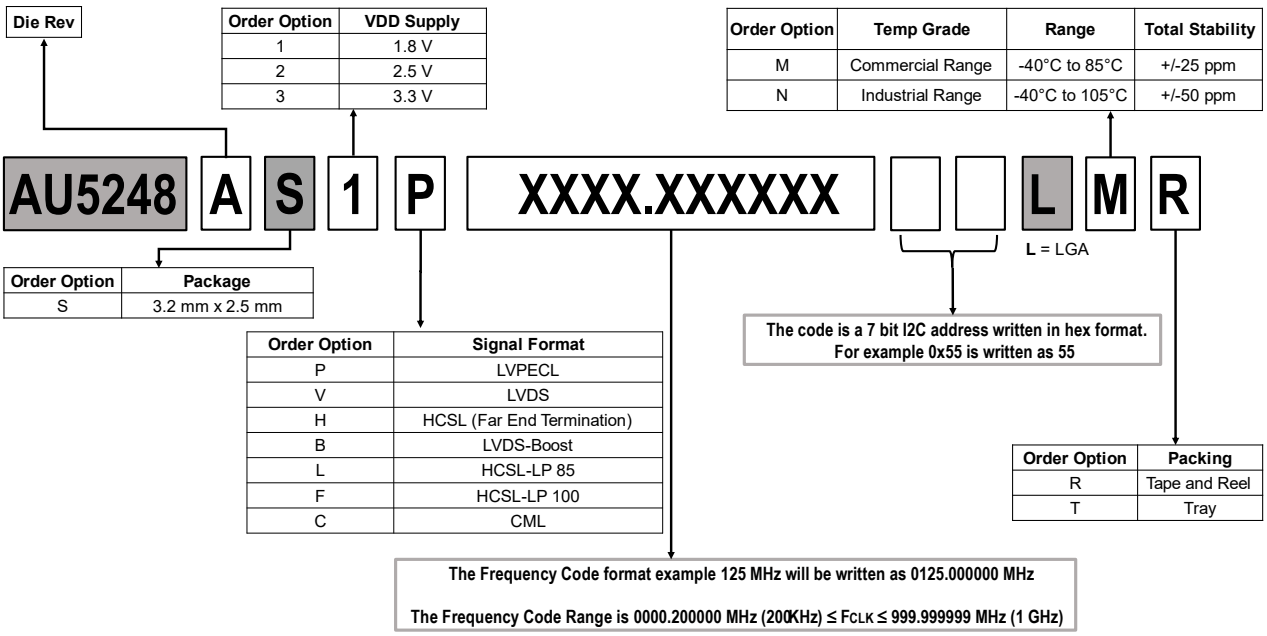

Figure 14 Ordering Information

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7 Revision History

Table 10 Revision History

Version	Date	Description	Author
0.1	11th Jan 2023	AU5248 Advanced Datasheet First Draft Created	Aurasemi

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