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Ten LVCMOS Output Low Additive Jitter Fanout Buffer

Features

- 3 to 1 input Multiplexer: Two inputs accept any differential (LVPECL, HCSL, LVDS, SSTL, CML, LVCMOS) or a single ended signal and the third input accepts a crystal or a single ended signal
- Ten 1.5V/1.8V/2.5V/3.3V LVCMOS outputs
- Supports frequencies from 0 to 250MHz
- Ultra-low system level additive jitter: 17fs (12kHz to 20MHz)
- Ultra-low noise floor of -170dBc/Hz
- Supports crystals from 8MHz to 160MHz
- Supports 2.5V or 3.3V power supplies
- Output to output skew of 30ps (typical)
- Input to output delay of 2ns (typical)
- SPI or Hardware control

Ordering Information

ZL40240LDG1	32 Pin QFN	Trays
ZL40240LDF1	32 pin QFN	Tape and Reel

Package size: 5 x 5 mm
-40°C to +85°C

Applications

- General purpose clock distribution
- Low jitter clock trees
- Logic translation
- Clock and data signal restoration
- Wired and Wireless communications
- High performance microprocessor clock distribution
- Medical Imaging
- Test equipment

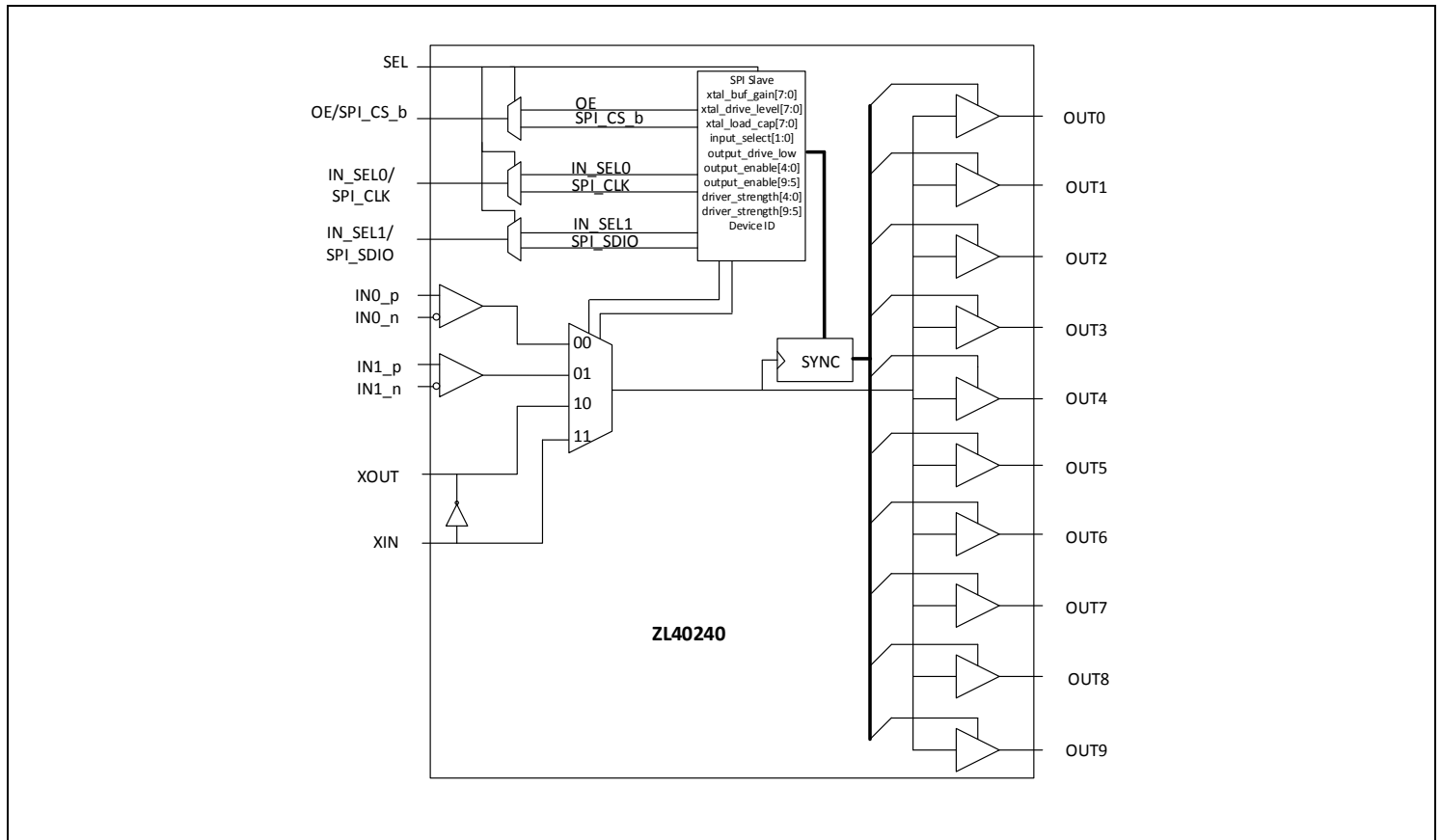


Figure 1. Functional Block Diagram

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Pin Diagram

The device is packaged in a 5x5mm 32-pin QFN.

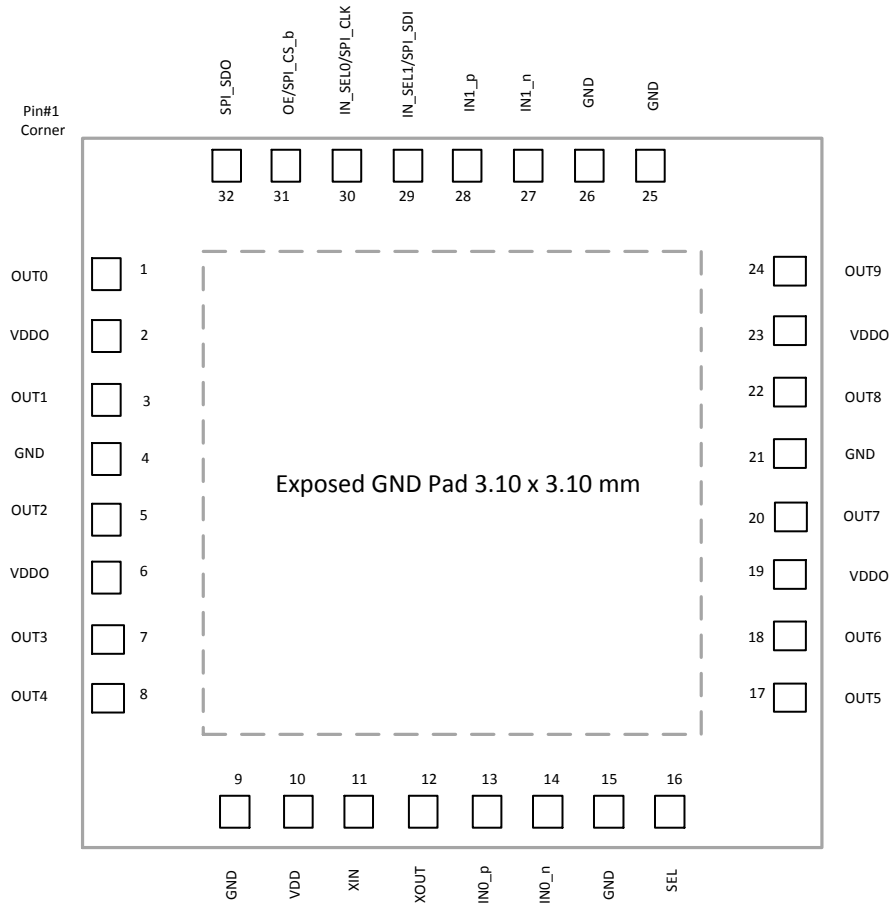


Figure 2. Pin Diagram

Pin Descriptions

All device inputs and outputs are LVPECL unless described otherwise. The I/O column uses the following symbols: I – input, I_{PU} – input with 300kΩ internal pull-up resistor, I_{PD} – input with 300kΩ internal pull-down resistor, I_{APU} – input with 30kΩ internal pull-up resistor, I_{APD} – input with 30kΩ internal pull-down resistor, I_{APU/APD} – input biased at VDD/2 with 60kΩ internal pull-up and 60kΩ pull-down resistors, O – output, I/O – Input/Output pin, P – power supply pin.

Table 1 · Pin Descriptions

#	Name	I/O	Description															
Input Reference																		
13 14 28 27	IN0_p IN0_n IN1_p IN1_n	I _{APD} I _{APU/APD} I _{APD} I _{APU/APD}	<p>Input Differential or Single Ended References 0 and 1</p> <p>Input frequency range 0Hz to 250MHz.</p> <p>Non inverting inputs (_p) are pulled down with internal 30kΩ pull-down resistors. Inverting inputs (_n) are biased at VDD/2 with 60kΩ pull-up and pull-down resistors to keep inverting input voltages at VDD/2 when inverting inputs are left floating (device fed with a single ended reference).</p>															
Output Clocks																		
1 3 5 7 8 17 18 20 22 24	OUT0 OUT1 OUT2 OUT3 OUT4 OUT5 OUT6 OUT7 OUT8 OUT9	O	<p>Ultra Low Additive Jitter LVCMOS Outputs 0 to 9</p> <p>Output frequency range 0Hz to 250MHz</p>															
Control																		
30	IN_SEL0/SPI_CLK	I _{PD} or I _{PU}	<p>Input Select 0/ Clock for Serial Interface. When SEL pin is low this pin is Input Select 0 hardware control input pin and it is pulled-low with 300 kΩ resistor. When SEL pin is high this pin provides clock for serial micro-port interface and it is pulled-up with 300 kΩ resistor.</p> <table border="1"> <thead> <tr> <th>IN_SEL1</th> <th>IN_SEL0</th> <th>OUTN</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>Input 0 (IN0)</td> </tr> <tr> <td>0</td> <td>1</td> <td>Input 1 (IN1)</td> </tr> <tr> <td>1</td> <td>0</td> <td>Crystal Oscillator or overdrive</td> </tr> <tr> <td>1</td> <td>1</td> <td>Crystal Bypass</td> </tr> </tbody> </table>	IN_SEL1	IN_SEL0	OUTN	0	0	Input 0 (IN0)	0	1	Input 1 (IN1)	1	0	Crystal Oscillator or overdrive	1	1	Crystal Bypass
IN_SEL1	IN_SEL0	OUTN																
0	0	Input 0 (IN0)																
0	1	Input 1 (IN1)																
1	0	Crystal Oscillator or overdrive																
1	1	Crystal Bypass																

29	IN_SEL1/SPI_SDI	I_{PD} or I_{PU}	<p>Input Select 1/ Serial Interface Input. When SEL pin is low this pin is Input Select 1 hardware control pin and it is pulled down with 300 kΩ resistor.</p> <p>When SEL pin is high this pin is serial interface input stream and it is pulled-up with 300 kΩ resistor.. The serial data stream holds the access command, the address and the write data bits.</p> <p>Note: this input has low threshold voltage ($V_{IH} = 1.2V$) so it can be driven by low output voltage device from 1.5V or higher up to VDD</p>
32	SPI_SDO	I/O	<p>Serial Interface Output. Serial interface output stream. As an output the serial stream holds the read data bits.</p>
31	OE/SPI_CS_b	I_{PD} or I_{PU}	<p>Output Enable/Chip Select for Serial Interface. When SEL pin is low this pin is Output Enable hardware control input and it is pulled-down with 300 kΩ resistor.</p> <p>When SEL is high this pin is serial interface chip select and it is pulled-up with 300 kΩ resistor--this is an active low signal.</p>
Crystal Oscillator			
11	XIN	I	Crystal Oscillator Input or crystal bypass mode or crystal overdrive mode
12	XOUT	O	Crystal Oscillator Output
Hardware/SPI Control selection			
16	SEL	I_{PD}	<p>Select control.</p> <p>When this pin is low, the device is controlled via hardware pins, IN_SEL0/1 and OE. When this pin is high, the device is controlled via SPI port.</p> <p>Any change of SEL pin value requires power cycle. Hence, SEL pin cannot be changed on the fly.</p>
Power and Ground			
10	VDD	P	<p>Positive Supply Voltage. Connect to 3.3V or 2.5V supply. VDD voltage must be higher or equal to VDDO.</p>
2 6 19	VDDO	P	<p>Positive Supply Voltage for LVC MOS Outputs Connect 3.3V, 2.5V, 1.8V or 1.5V power supply</p>

23			
4 9 15 21 26 25	GND	P	Ground Connect to ground
E-Pad	GND	P	Ground. Connect to ground

Functional Description

The ZL40240 is a programmable or hardware pin controlled low additive jitter, low power 3 x 10 LVCMOS fanout buffer.

Two inputs can accept signal in differential (LVPECL, SSTL, LVDS, HSTL, CML) or single ended (LVPECL or LVCMOS) format and the third input can accept a single ended signal or it can be used to build a crystal oscillator by connecting an external crystal resonator between its XIN and XOUT pins. All the other components for building crystal oscillator are built in device such as load capacitance, series and shunt resistors.

The ZL40240 has ten LVCMOS outputs which can be powered from 3.3V, 2.5V, 1.8V or 1.5V supply. Each output can be independently enabled/disabled via SPI bus. In addition, the strength of each output can be programmed.

The device operates from 2.5V+/-5% or 3.3V+/-5% supply. Its operation is guaranteed over the industrial temperature range -40°C to +85°C.

Clock Inputs

The following blocks diagram shows how to terminate different signals fed to the ZL40240 inputs.

Figure 3 shows how to terminate a single ended output such as LVCMOS. Ideally, resistors R1 and R2 should be 100Ω each so that the transmission line is terminated with matched impedance (50Ω). However, if the driving strength of the output driver is not sufficient resistor values should be increased

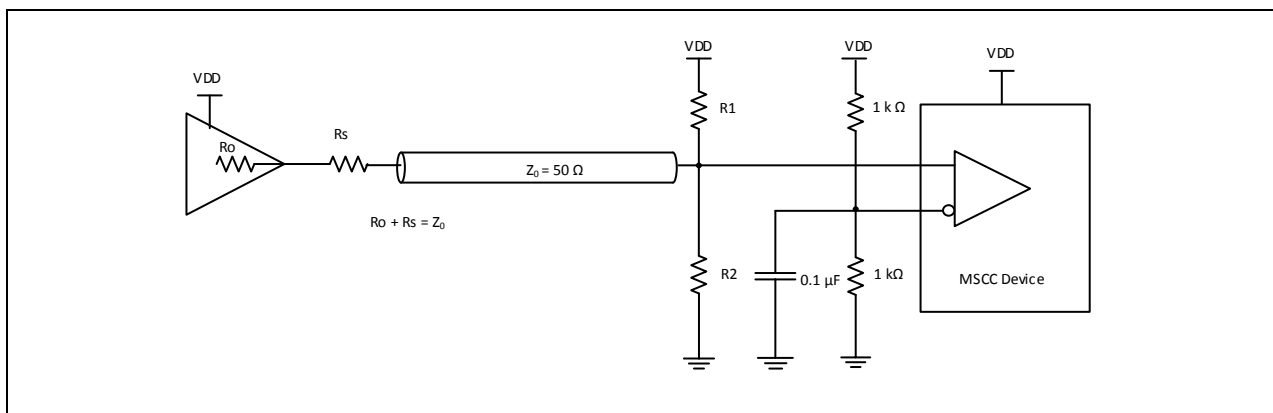


Figure 3. Input driven by a single ended output

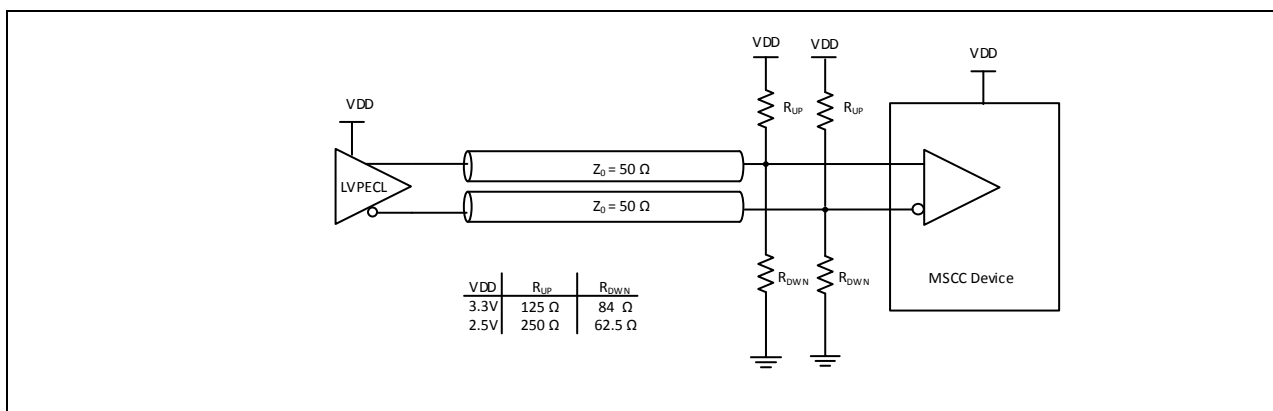


Figure 4. Input driven by DC coupled LVPEVCL output

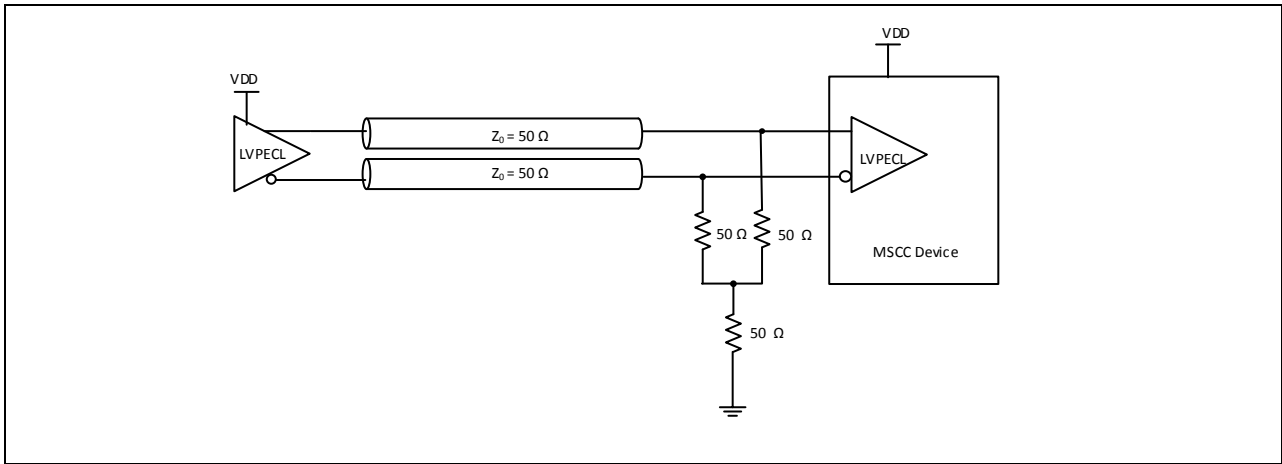


Figure 5. Input driven by DC coupled LVPEVCL output (alternative termination)

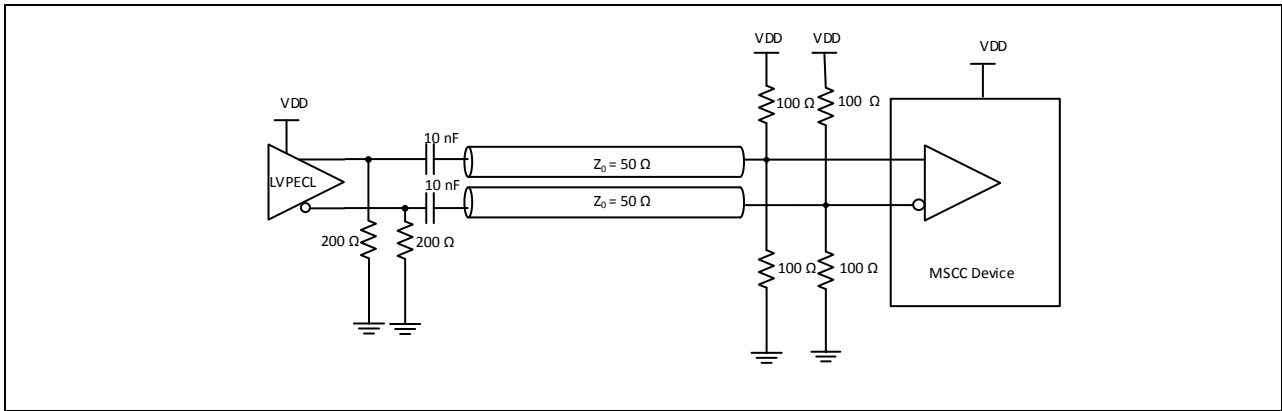


Figure 6. Input driven by AC coupled LVPEVCL output

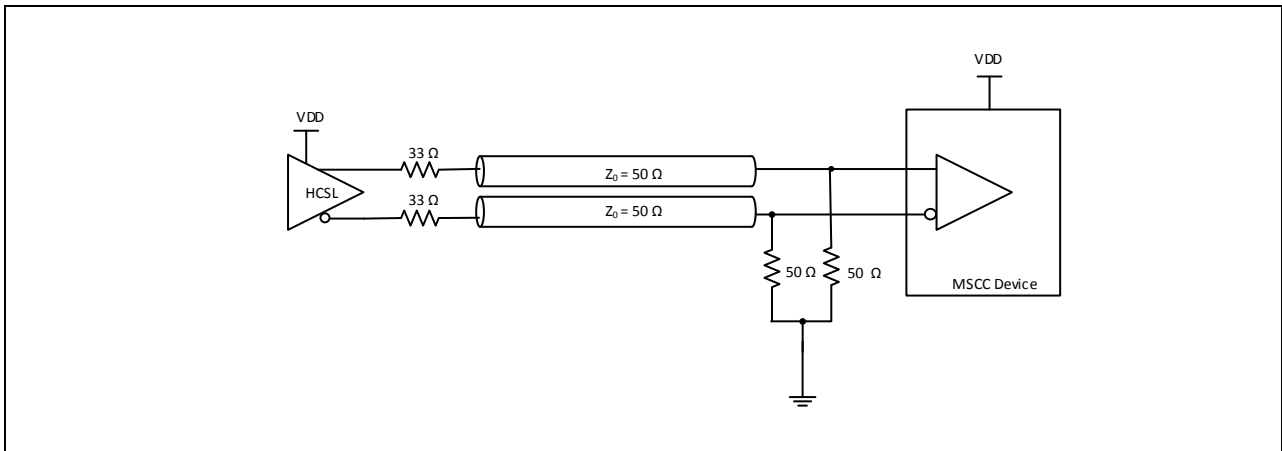


Figure 7. Input driven by HCSL output

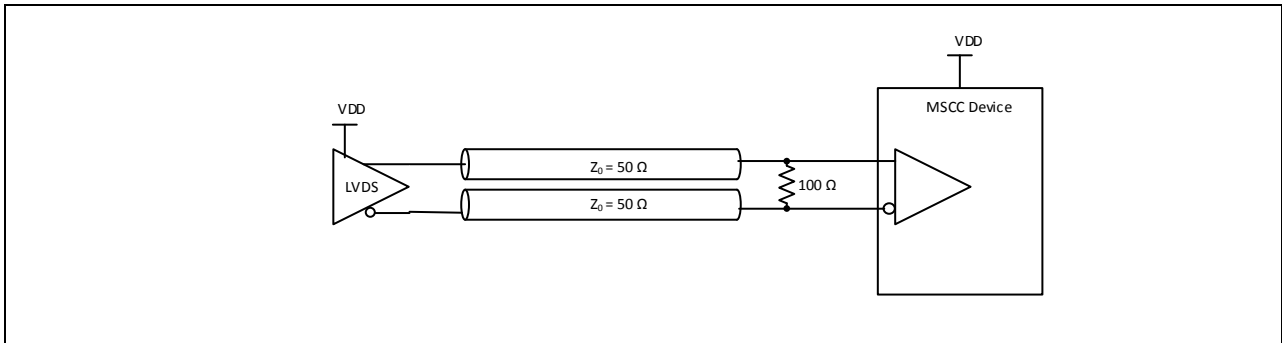


Figure 8. Input driven by LVDS output

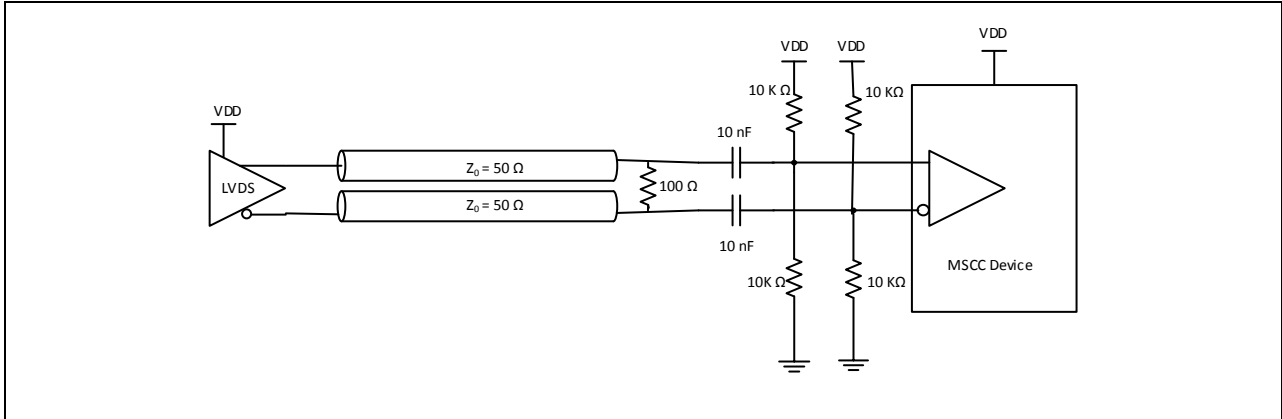


Figure 9. Input driven by AC coupled LVDS

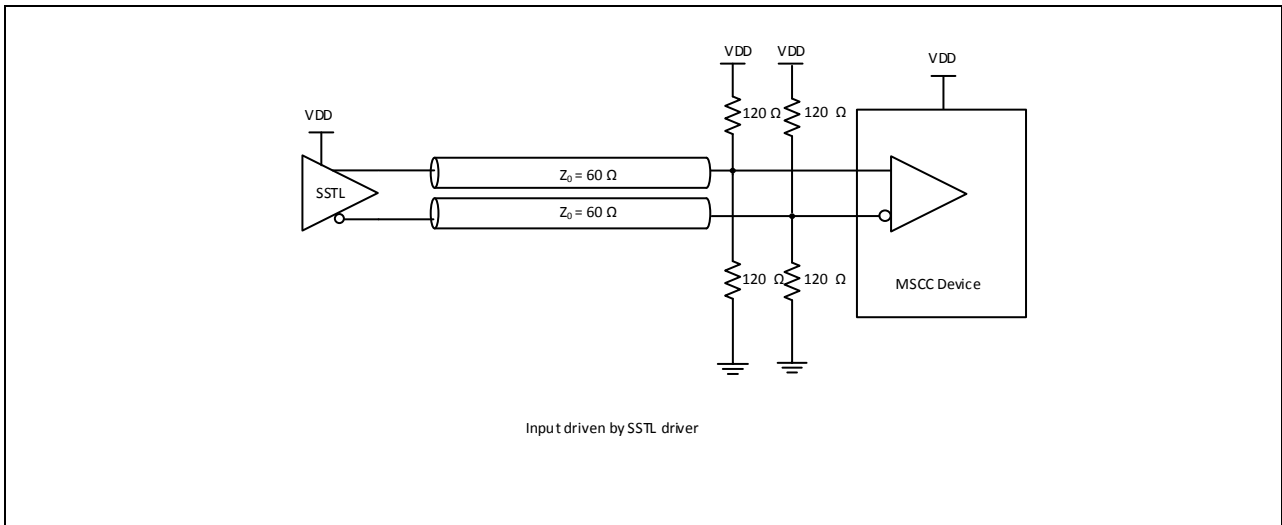


Figure 10. Input driven by an SSTL output

Clock Outputs

LVC MOS outputs require only series termination resistor whose value is depending on LVC MOS output voltage as shown in Figure 11. The recommended series termination depends on programmed strength of the driver (low or high) and on the output driver supply voltage.

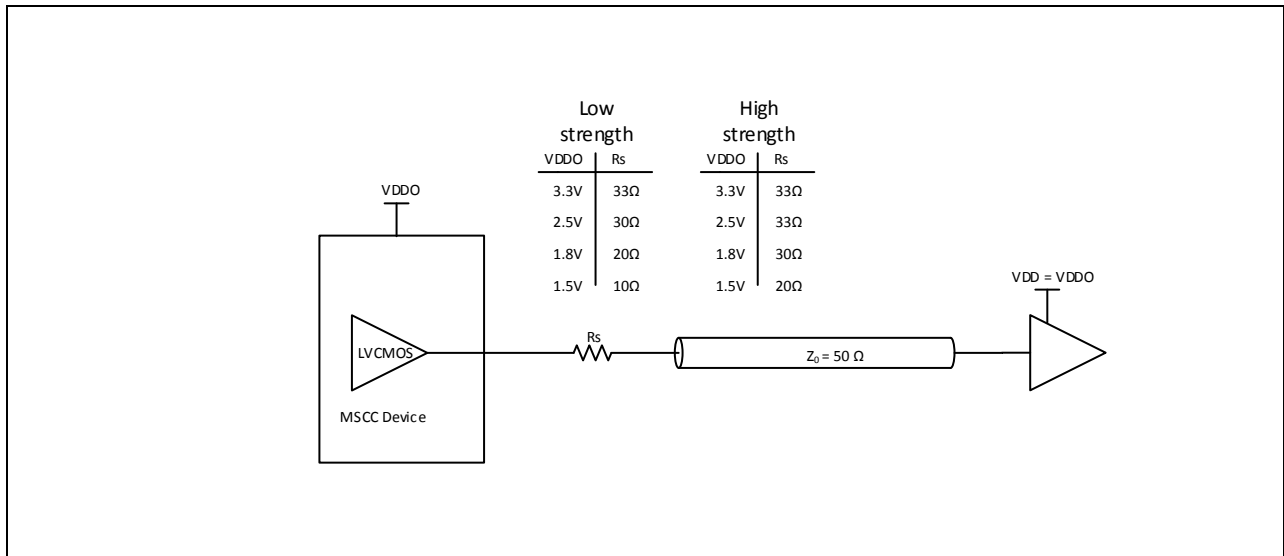


Figure 11. Termination for LVC MOS outputs

Crystal Oscillator Input

The crystal oscillator circuit can work with crystal resonators from 8MHz to 160MHz. As can be seen in the following figure only crystal resonator is required and all the other components are built-in the device. To be able support crystal resonators with different characteristics all internal components are programmable in SPI Controlled mode.

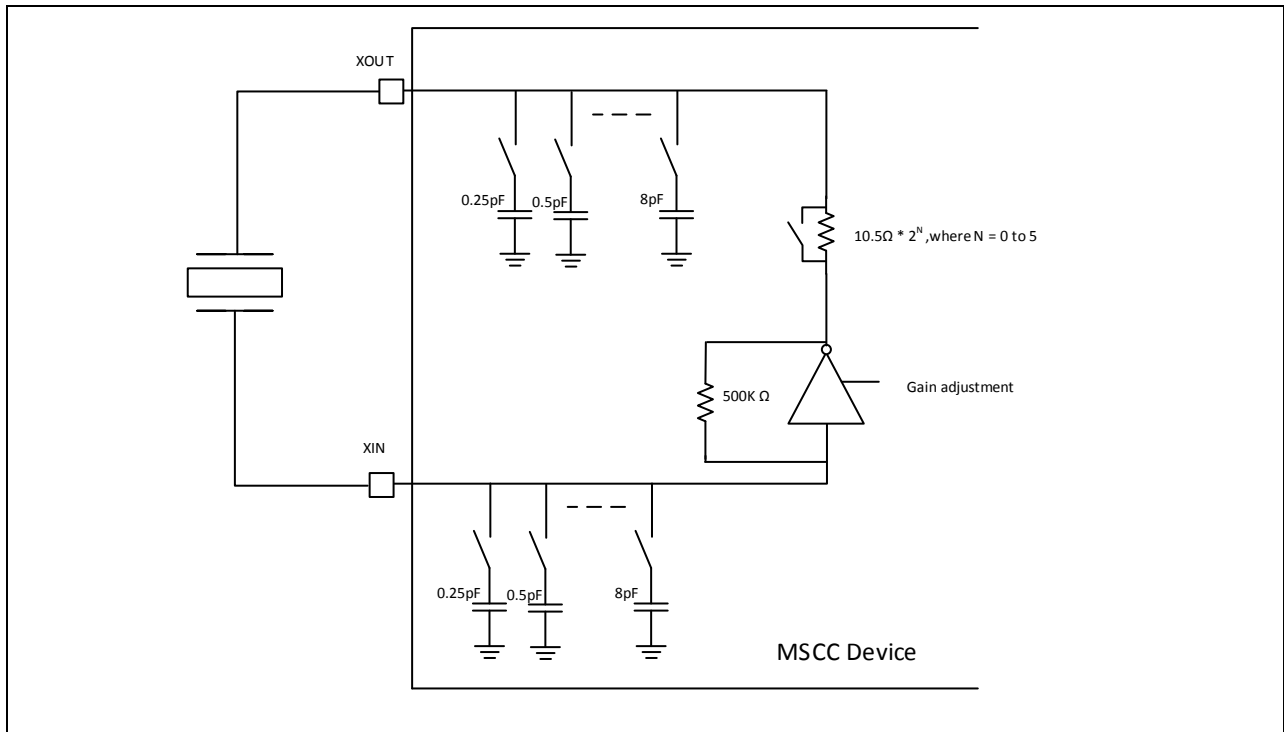


Figure 12. Crystal Oscillator Circuit in SPI Controlled Mode

Load capacitors can be programmed from 0 to 21.75 pF with resolution of 0.25pF which not only meets load requirement for most crystal resonator but also allows for fine tuning of the crystal resonator frequency. The amplifier gain can be adjusted in eight steps and the series resistor in six steps. Shunt resistor has fixed value of 500KΩ.

In Hardware Controlled mode the capacitive load is set at 8pF and cannot be changed. For Crystal requiring higher load additional capacitance can be added externally as shown in the Figure 13.

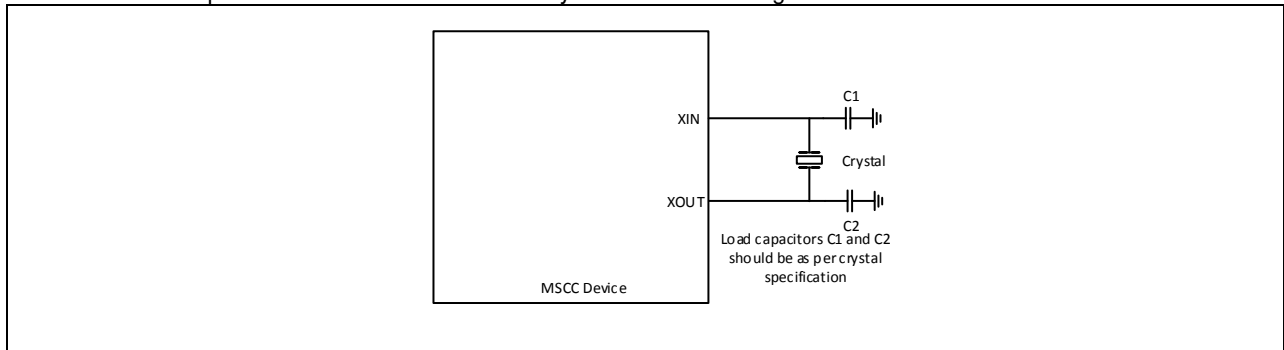


Figure 13. Crystal Oscillator Circuit in Hardware Controlled Mode

The phase noise plot for 25MHz crystal is shown in Figure 14. The phase noise floor of the device is below -170dBc/Hz as can be seen on the figure.

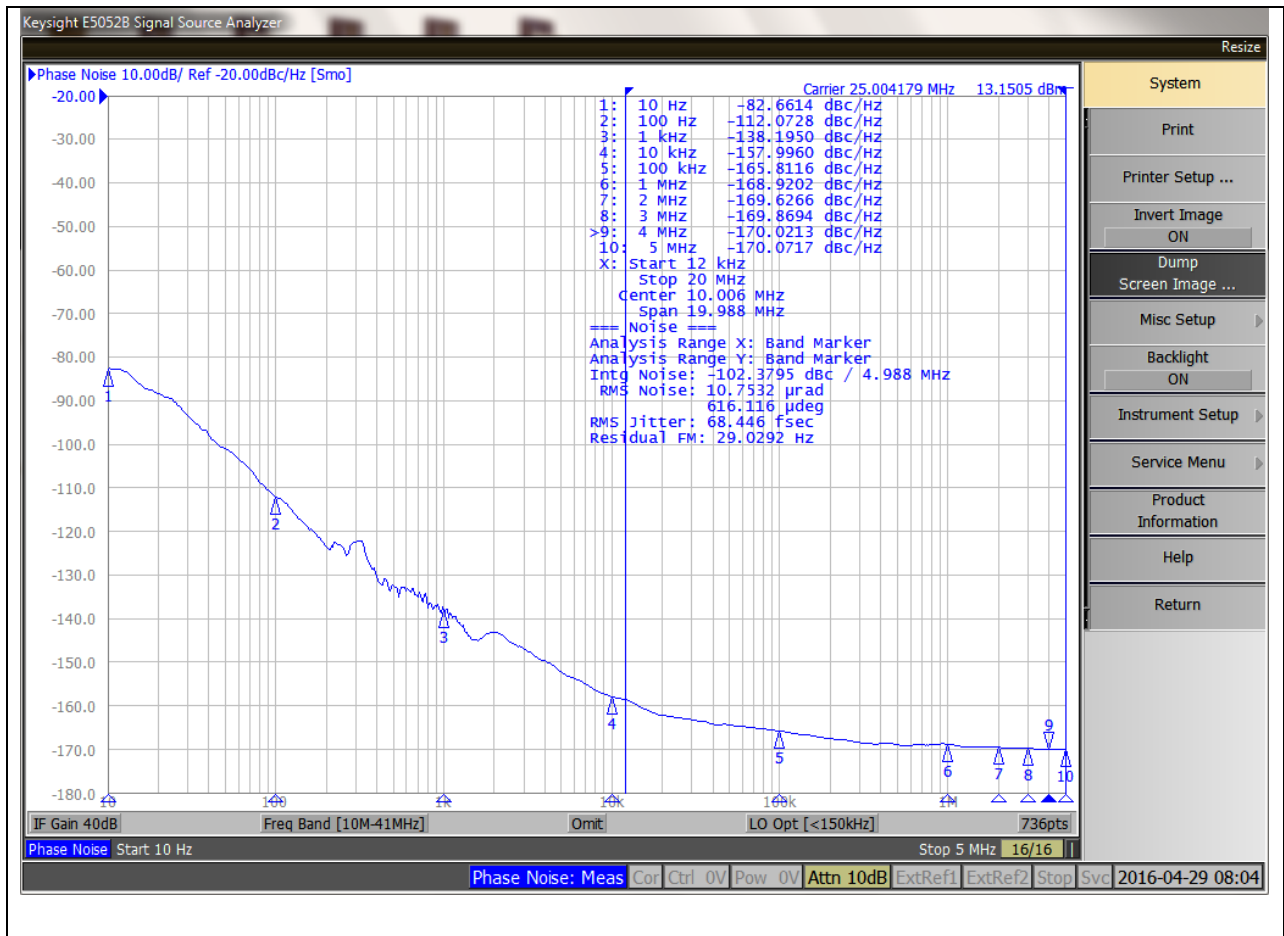


Figure 14. Phase Noise Plot with 25MHz Crystal

Figure 15 shows the phase noise plot with 125MHz crystal.

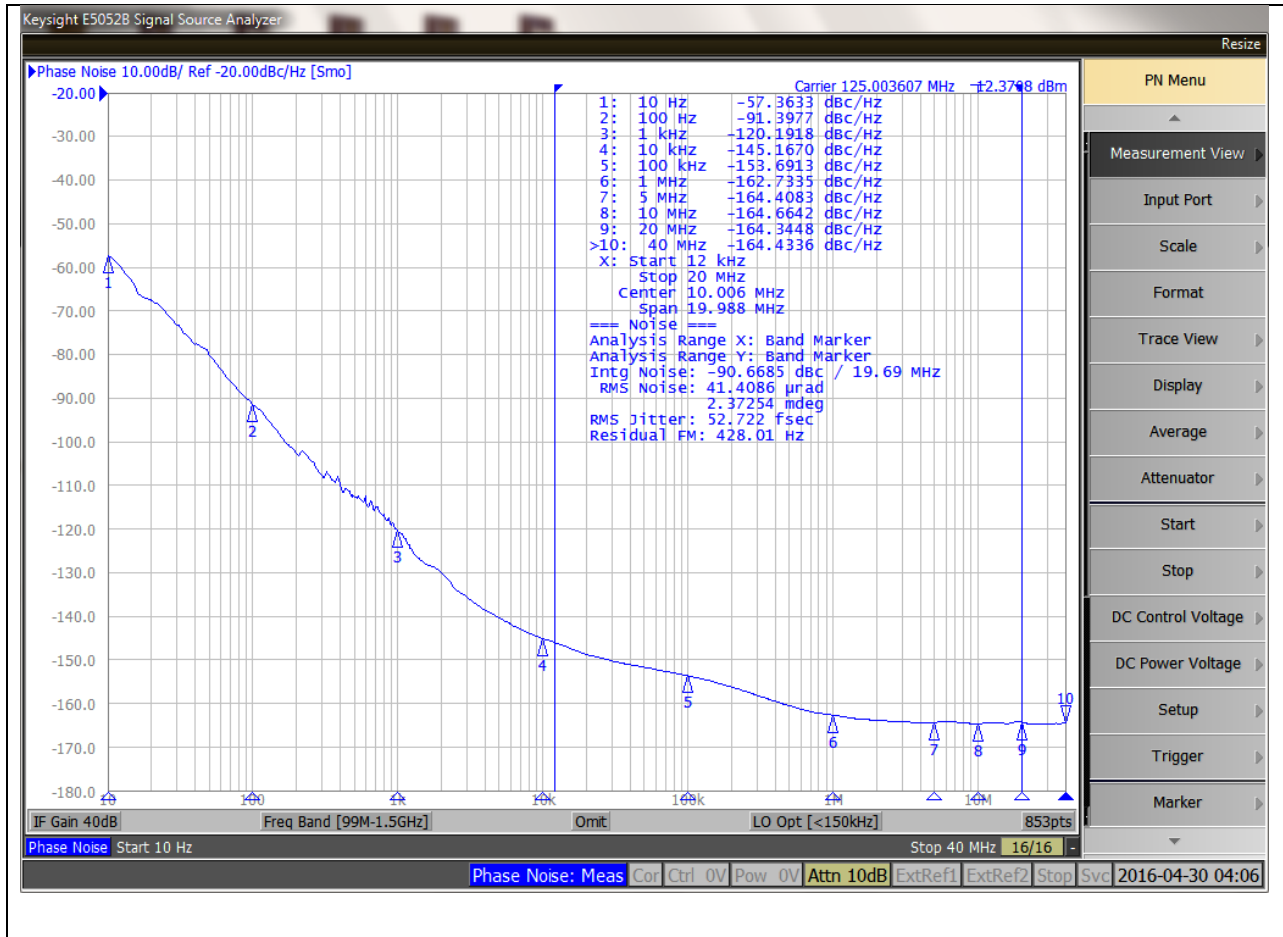


Figure 15. Phase Noise Plot with 125 MHz Crystal

Termination of unused inputs and outputs

Unused inputs can be left unconnected or alternatively IN_0/1 can be pulled-down by 1K Ω resistor. Unused outputs should be left unconnected.

Power Consumption

The total device power consumption can be calculated as:

$$P_T = P_S + P_{XTAL} + P_C + P_D$$

Where:

$$P_S = V_{DD} \times I_S$$

is static power consumed by input buffers. If XTAL is running this power should be set to zero. where the static current (I_S) is specified in Table 5 .

$$P_{XTAL} = V_{DD} \times I_{DD_XTAL}$$

is power consumption of XTAL circuit. The current of the XTAL circuit is provided in Table 5 . If XTAL is not used the power consumption is equal to zero.

$$P_C = V_{DDO} \times I_{DDC}$$

Common output power shared among all ten outputs. The current (I_{DDC}) is specified in Table 5 .

$$P_D = V_{DDO} \times (I_{DD} \times n \times f / 100\text{MHz} + V_{DDO} \times C_{LOAD} \times f \times n)$$

Dynamic power where dynamic current (I_{DD}) is specified in Table 5 . , C_{LOAD} is capacitive load driven by an output, f is frequency of the output clock and n is number of active outputs.

The power consumption for different clock frequencies and power supply voltages can be quickly estimated from Figure 16, Figure 17 and Figure 17.

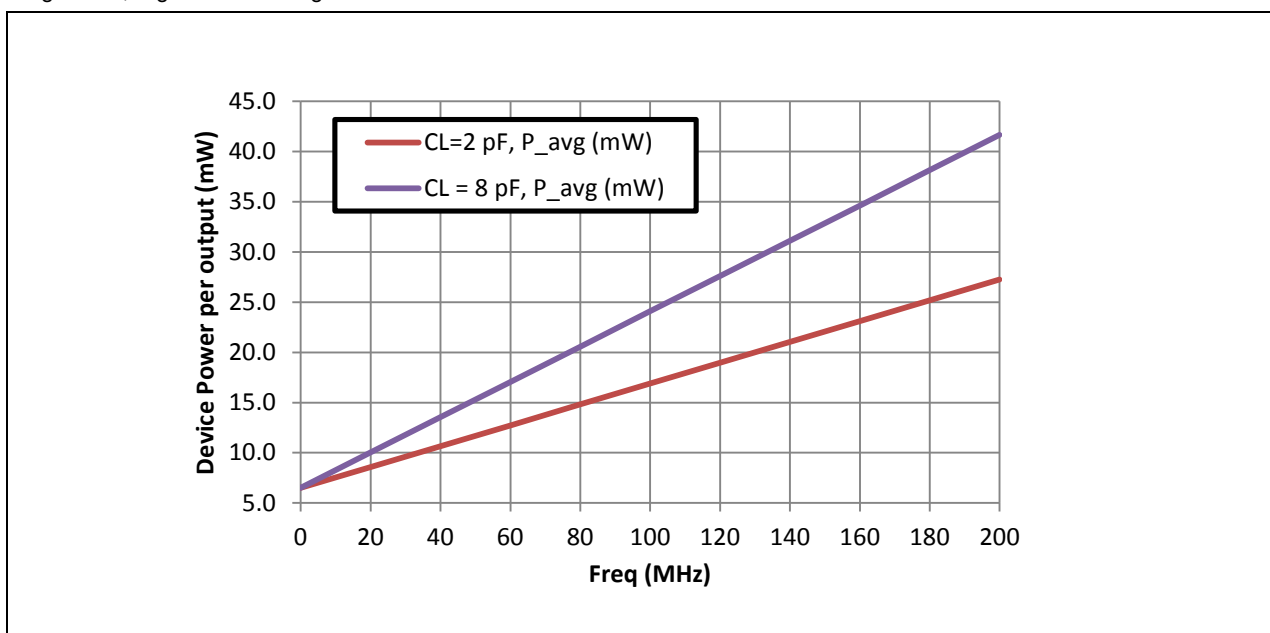


Figure 16. Device power consumption per output for $V_{DD} = V_{DDO} = 3.465\text{V}$

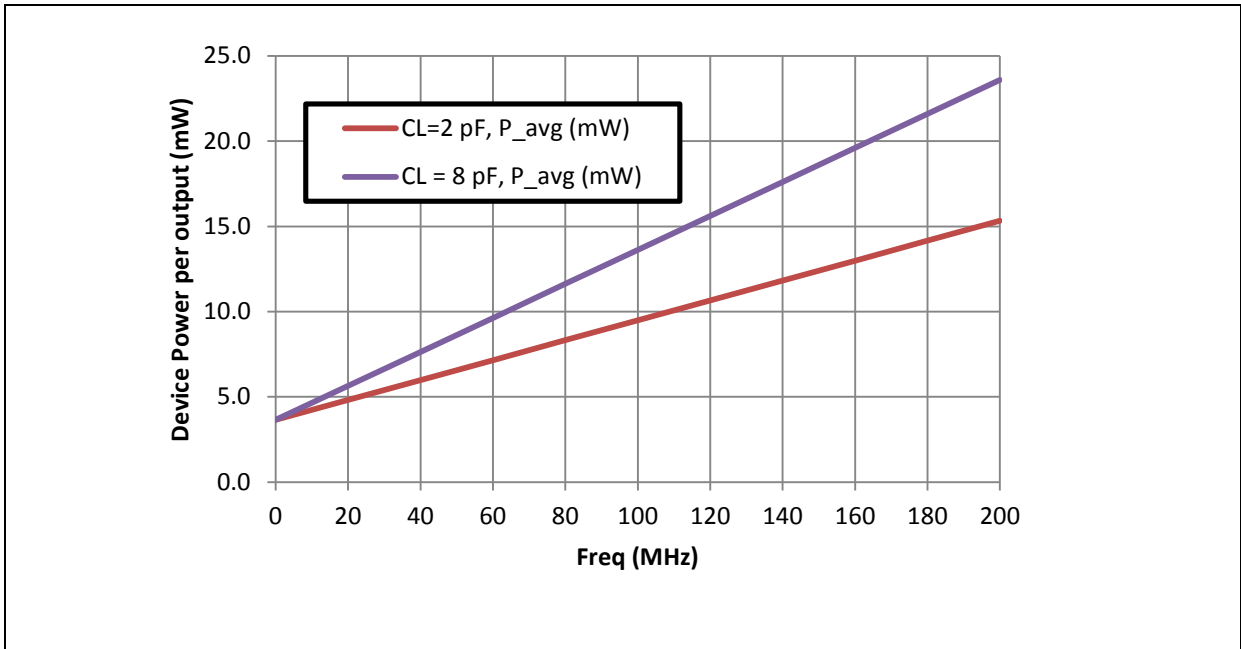


Figure 17. Device power consumption per output for $V_{DD} = V_{DDO} = 2.625V$

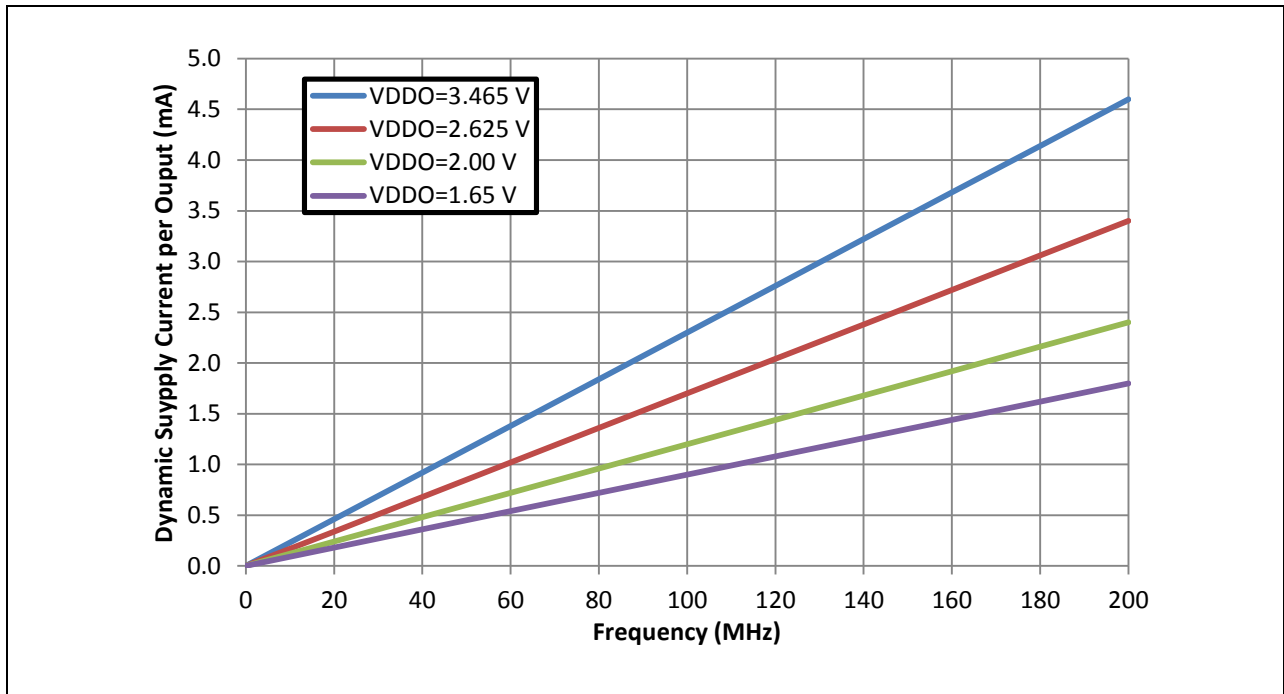


Figure 18. Dynamic supply current per output for different output supply voltages

Power Supply Filtering

Each power pin (VDD and VDDO) should be decoupled with 0.1 μ F capacitor with minimum equivalent series resistance (ESR) and minimum series inductance (ESL). For example 0402 X5R Ceramic Capacitors with 6.3V minimum rating could be used. These capacitors should be placed as close as possible to the power pins. To reduce the power noise from adjacent digital components on the board each power supply could be further insulated with low resistance ferrite bead with two capacitors. The ferrite bead will also insulate adjacent component from the noise generated from the device. Following figure shows recommended decoupling for each power pin.

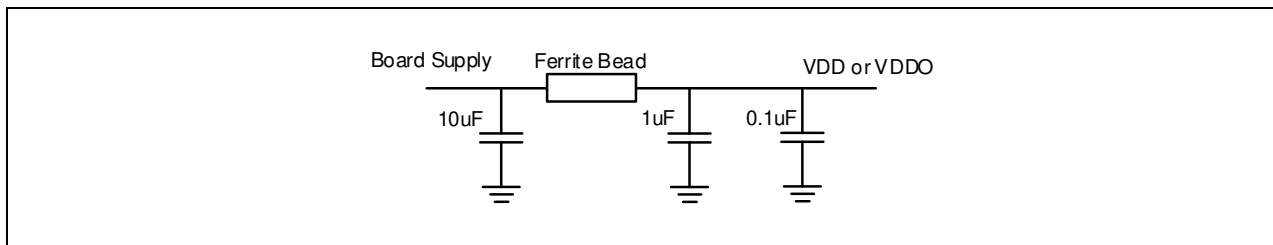


Figure 19. Power Supply Filtering

Device Control

ZL30240 can be controlled via hardware pins (SEL pin tied low) or via SPI port (SEL pin tied high). The mode shall be selected during power up and it cannot be changed on the fly.

Hardware Control Mode

In this mode, ZL40240 is controlled via Output Enable (OE) and Input Select (SEL0/1) input pins. Output is disabled synchronously on the falling edge of the input (t_2) as shown in Figure 20.

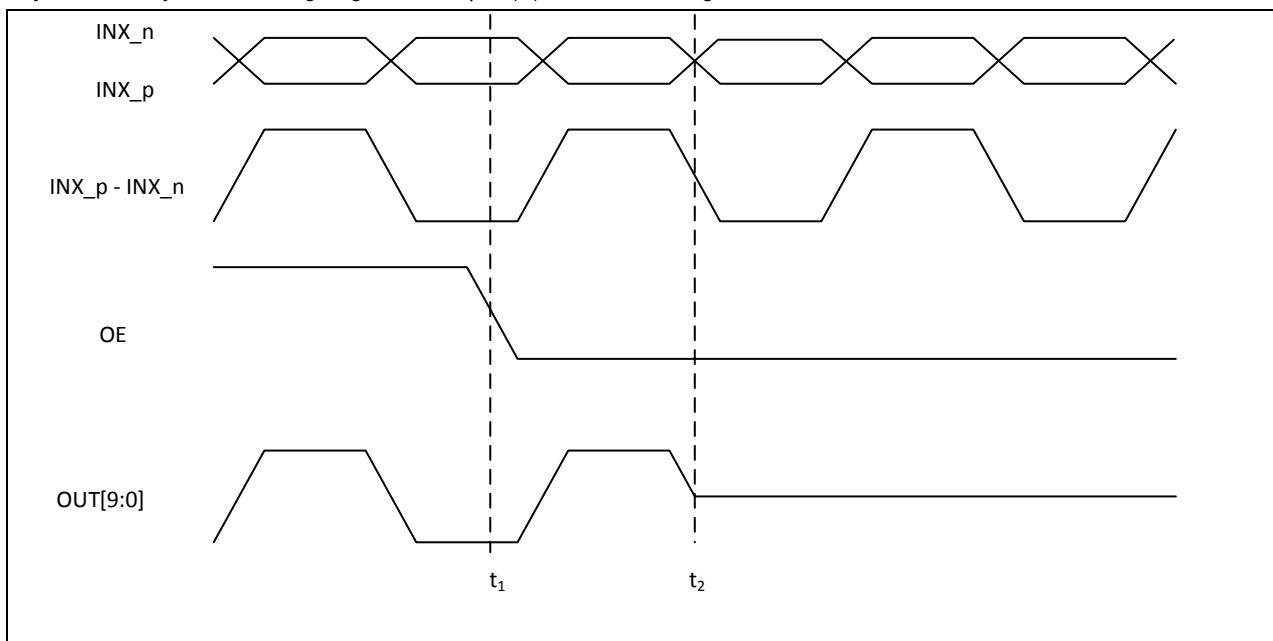
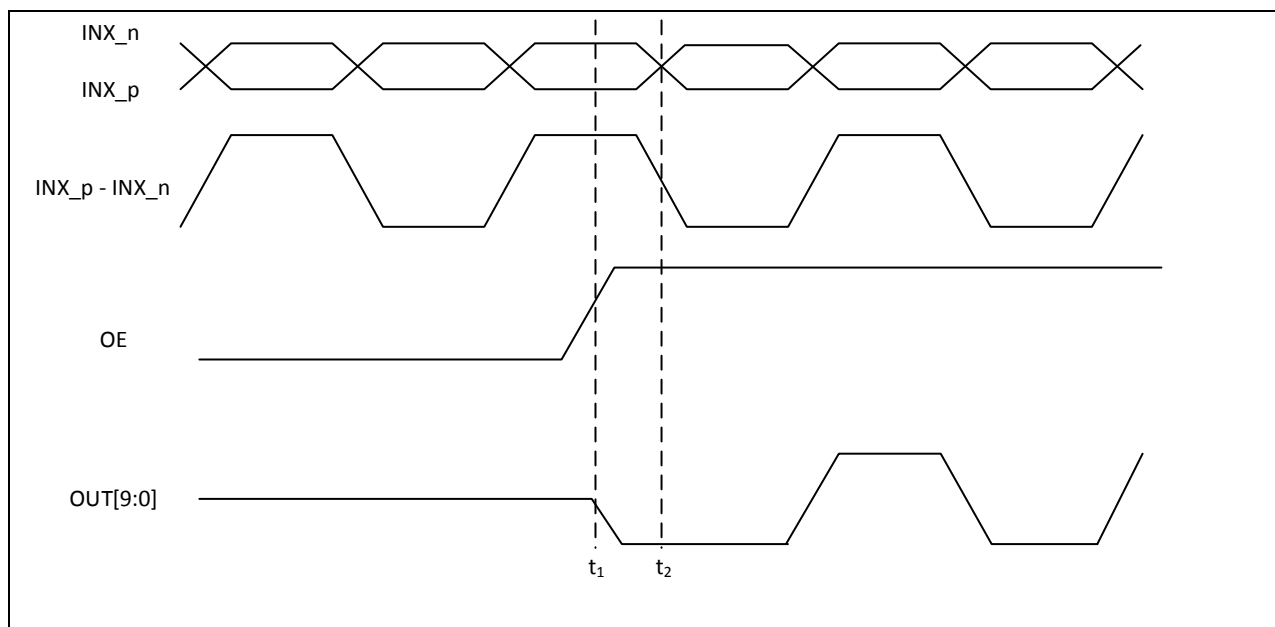


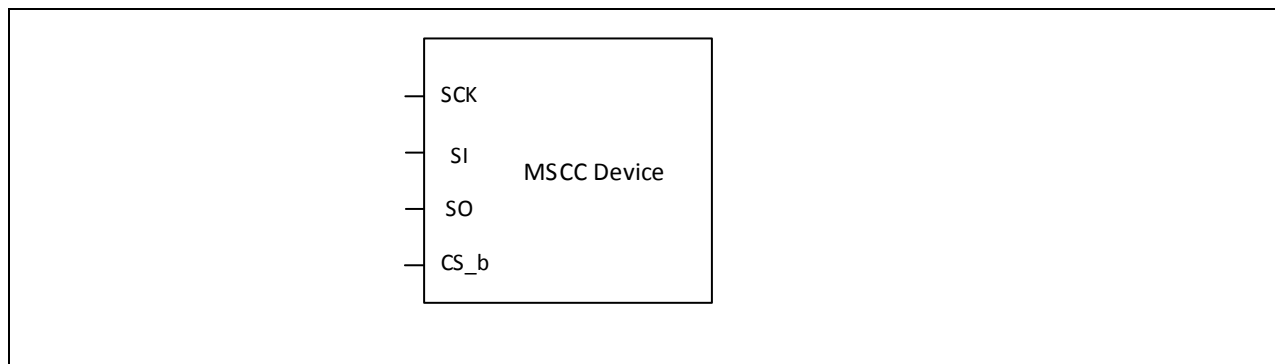
Figure 20. OE Output Disable

Outputs can be enabled by toggling OE pin high. As soon as OE pin goes high (t_1) the outputs will go from high-Z to low and will start to track the input after the first falling edge (t_2) of the input signal as shown in Figure 21.


Figure 21. OE Output Enable

SPI Controlled Mode

In this mode ZL40240 is controlled via four pin SPI slave interface as shown in the following figure.

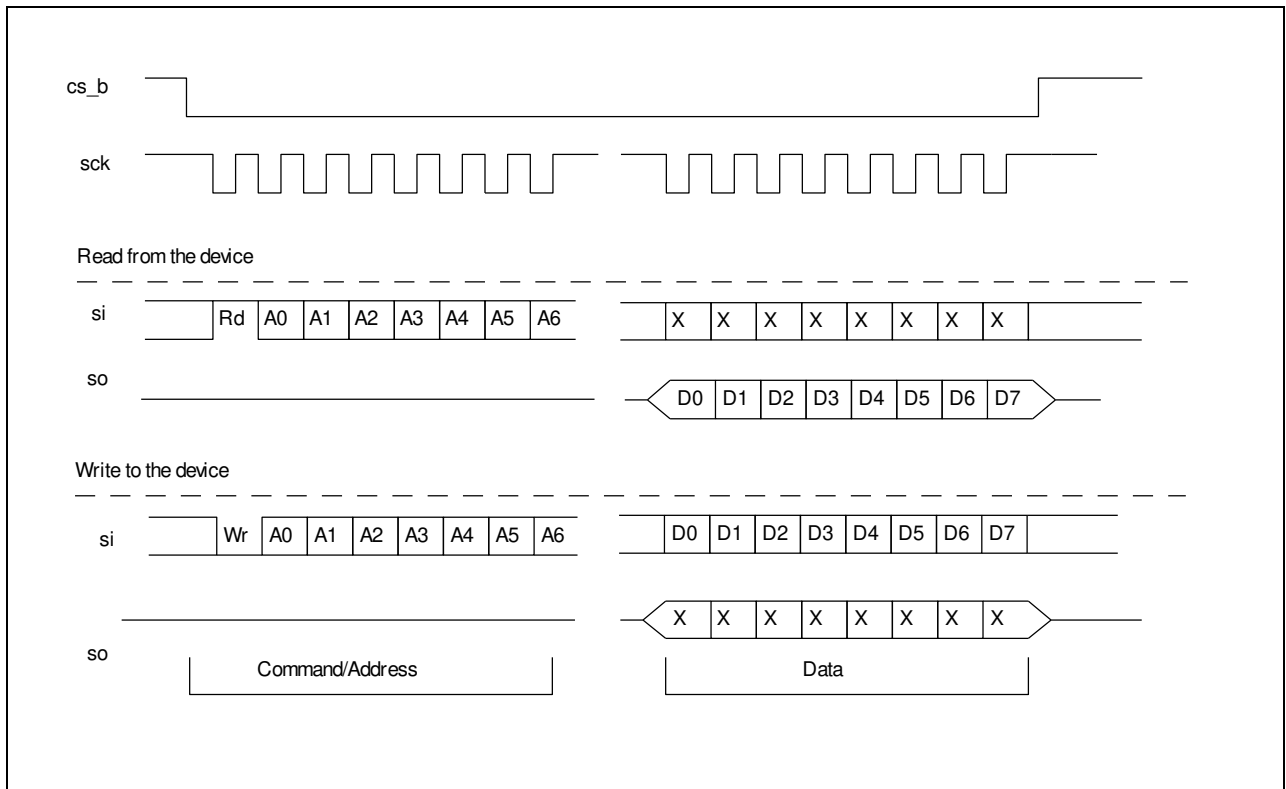
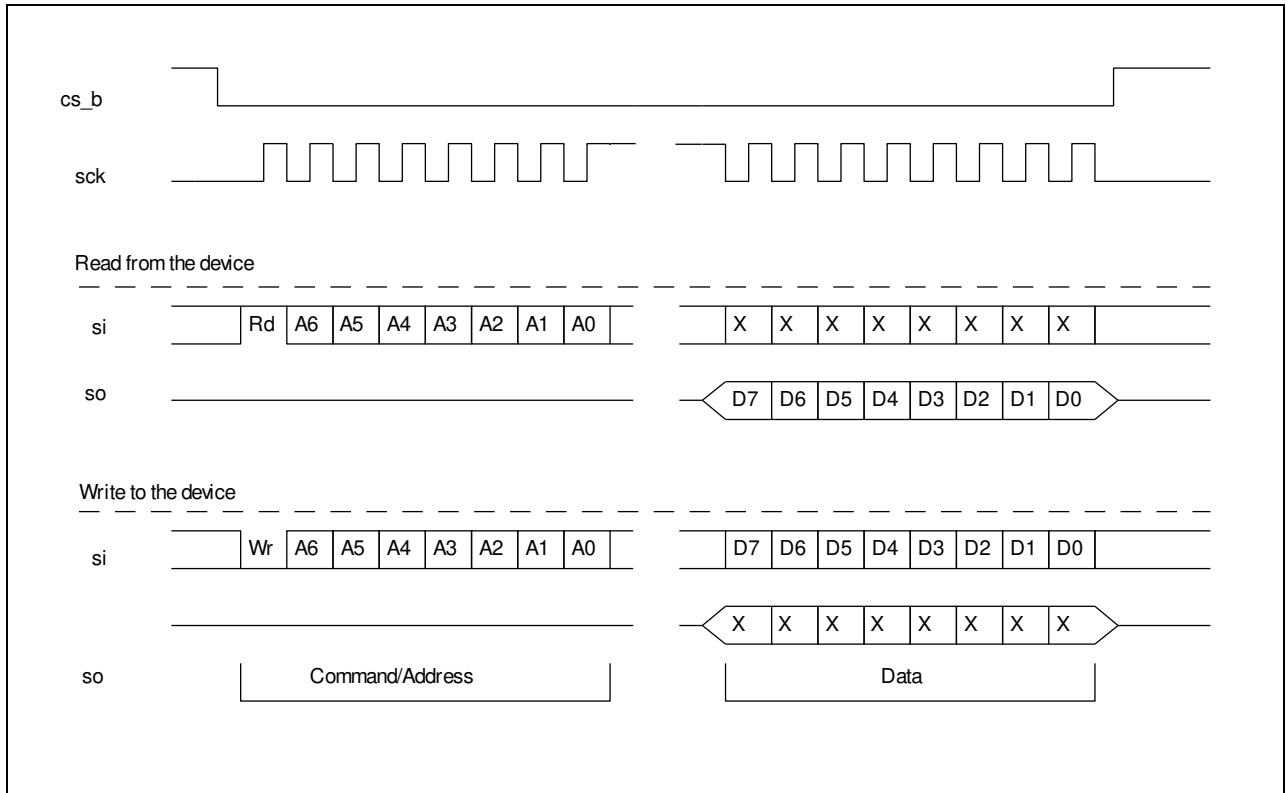

Figure 22. SPI slave interface

The serial peripheral interface supports half-duplex processor mode which means that during a write cycle to the device, output data from the **SO** pin must be ignored. Similarly, the input data on the **SI** pin is ignored by the device during a read cycle.

The SPI interface supports two modes of access: Most Significant bit (MSb) first transmission or Least Significant bit (LSb) first transmission. The mode is automatically selected based on the state of **SCK** pin when the **CS_b** pin is active. If the **SCK** pin is low during **CS_b** activation, then MSb first timing is selected. If the **SCK** pin is high during **CS_b** activation, then LSb first timing is assumed.

The SPI port expects 1-bit to differentiate between read and write operation followed by 7-bit addressing and 8-bit data transmission. During SPI access, the **CS_b** pin must be held low until the operation is complete. Burst read/write mode is also supported by leaving the chip select signal **CS_b** is low after a read or a write. The address will be automatically incremented after each data byte is read or written.

Functional waveforms for the LSb and MSb first mode, and burst mode are shown in Figure 23 and Figure 24 respectively. Figure 25 shows an example of burst mode operation which allows user to read or write consecutive location in the register map.


Figure 23. Serial Peripheral Interface Functional Waveform – LSB First Mode

Figure 24. Serial Peripheral Interface Functional Waveform – MSB First Mode

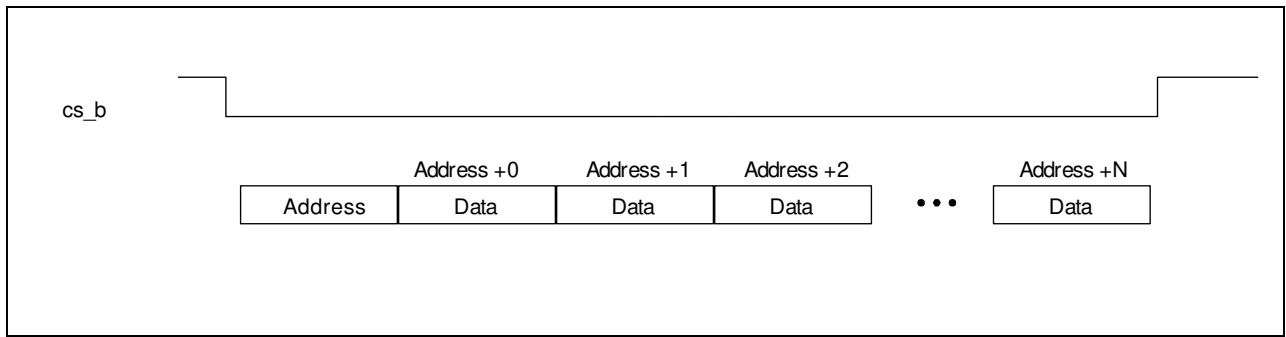


Figure 25. Example of the Burst Mode Operation

Register Map

The device is controlled by accessing registers through the serial interface. The following table provides a summary of the registers available for the configuration of the device.

Table 2 · Register Map

Address SPI A[6:0] Hex (0x)	Name	Data D[7:0]
00	XTALBG	xtal_buf_gain[7:0]
01	XTALDL	xtal_drive_level[7:0]
02	XTALLC	xtal_load_cap[7:0]
03	XTALNR	xtal_normal_run
04	-	Not used
05	INSEL	input_select[1:0]
06	OUTLOW	output_drive_low
07	OUTEN0	output_enable[4:0]
08	OUTEN1	output_enable[9:5]
09	DRVSTR0	driver_strength[4:0]
0A	DRVSTR1	driver_strength[9:5]
0B/0C/0D/0E	-	Not used
0F/10	Reserved	Leave as default
11	DEVID	Device ID
12 to 1F	Reserved	Leave as default

Address	0x00			Hex
XTALBG		XTAL Buffer Gain		
Bit	Name	Description	Type	Reset
7:0	xtal_buf_gain[7:0]	<p>Programs crystal buffer (inverting amplifier) gain. Every bit pair (bits: 01, 23, 45, 67) of this register correspond to additional equal gain block which can be added (bits set) or removed (bits cleared). Minimum gain is 0x00 (default) and 0xFF is maximum gain When reference input mode is “bypass XTAL mode” or “differential input modes” with HIGH xtal_normal_run bit, the buffer is disabled and follows “Input Selection”. When xtal_normal_run bit is LOW, XTAL buffer is in the “xtal forced run” mode and keep running.</p> <p>8'b0000_0000: default crystal buffer strength. 8'b0000_0011: enable additional buffer strength 8'b0000_1100: enable additional buffer strength 8'b0011_0000: enable additional buffer strength 8'b1100_0000: enable additional buffer strength</p>	RW	FF

Address	0x01			Hex
XTALDL		XTAL Drive Level		
Bit	Name	Description	Type	Reset
7:0	xtal_drive_level[7:0]	<p>Internal damping resistance of crystal circuit to limit external crystal's drive level uW. The value of damping resistor is determined by crystal's motion resistance of crystal's equivalent circuit. Drive level should be lower than crystal manufacturer's specification. Crystal's equivalent values should be requested to the manufacturer, (motion resistance and shunt capacitance). The selected resistors are connected to XOUT. Multiple bit combinations available by 7-bit control. Resistors are connected in parallel. Hence, 0xFF is the smallest resistance and 0x01 is the highest resistance.</p> <p>8'b0000_0000: disable all resistors 8'b0000_0001: 312 Ohm resistor 8'b0000_0010: 161 Ohm resistor 8'b0000_0100: 84 Ohm resistor 8'b0000_1000: 42 Ohm resistor 8'b0001_0000: 21 Ohm resistor 8'b0010_0000: 10.5 Ohm resistor 8'b0100_0000: 0 Ohm connection 8'b1000_0000: not used</p>	RW	03

Address	0x02			Hex
XTALLC		XTAL Load Capacitance		
Bit	Name	Description	Type	Reset
7:0	xtal_load_cap[7:0]	Internal load capacitance of crystal circuit (0 pF to 21.75pF with the resolution of 0.25 pF). XIN and XOUT have each capacitor connected to GND. Multiple bit combinations available between 8 capacitors. 8'b0000_0000: disable all xtal load capacitors 8'b0000_0001: enable capacitor 0.25 pF 8'b0000_0010: enable capacitor 0.5 pF 8'b0000_0100: enable capacitor 1 pF 8'b0000_1000: enable capacitor 2 pF 8'b0001_0000: enable capacitor 2 pF 8'b0010_0000: enable capacitor 4 pF 8'b0100_0000: enable capacitor 4 pF 8'b1000_0000: enable capacitor 8 pF	RW	80 (8 pF)

Address	0x03			Bin
XTALNR		XTAL Normal Run		
Bit	Name	Description	Type	Reset
7:1	Unused	Unused	R	1111111
0	xtal_normal_run	When this bit is set high crystal oscillator circuit is running only if input_select[1:0] register at address 0x05 selects crystal mode (2'b10). This value is recommended because it provides best jitter performance--XO circuit is running only when it is needed. When this bit is set low the crystal oscillator will keep running even if crystal oscillator is not selected in input_select[1:0] register at address 0x05. This mode should only be used when fast switching between input references and crystal oscillator is required.	RW	1

Address	0x05			Bin
INSEL		Input Select Register		
Bit	Name	Description	Type	Reset
7:2	Unused	Unused	R	11111
1:0	input_select[1:0]	Input reference clock selection. Proper external coupling and termination are required. 2'b00: differential input from IN0_p and IN0_n 2'b01: differential input from IN1_p and IN1_n 2'b10: 1) fundamental XTAL mode with XIN and XOUT (Use internal crystal oscillator circuits) OR 2) XTAL overdrive mode (single-ended clock signal with XIN) 2'b11: XTAL bypass mode (single-ended clock signal with XIN and disabled internal crystal buffer circuit in the analog block)	RW	10

Address	0x06			Bin
OUTLOW		Output Drive Low		
Bit	Name	Description	Type	Reset
7:1	Unused	Unused	R	1111111
0	output_drive_low	After disabling outputs, output state is known state in logic LOW. (This bit is used for only disabled outputs. Otherwise, enabled outputs are not impacted by this bit.) 1'b0: All LVCMOS outputs will be in high-impedance state. 1'b1: All LVCMOS outputs will drive logic LOW.	RW	0

Address	0x07			Bin
OUTEN0		Output Enable 0		
Bit	Name	Description	Type	Reset
7:5	Unused	Unused	R	111
4:0	output_enable[4:0]	Output enable for OUT0/1/2/3/4. Disabled state is dependent on "out_drive_low" control bit. Each bit controls one output. 5'b0_0000: disable outputs 5'b0_0001: enable OUT0 5'b0_0010: enable OUT1 5'b0_0100: enable OUT2 5'b0_1000: enable OUT3 5'b1_0000: enable OUT4	RW	11111

Address	0x08			Hex
OUTEN1		Output Enable 1		
Bit	Name	Description	Type	Reset
7:5	Unused	Unused	R	111
4:0	output_enable[9:5]	Output enable for OUT5/6/7/8/9. Disabled state is dependent on "out_drive_low" control bit. Each bit controls one output. 5'b0_0000: disable outputs 5'b0_0001: enable OUT5 5'b0_0010: enable OUT6 5'b0_0100: enable OUT7 5'b0_1000: enable OUT8 5'b1_0000: enable OUT9	RW	11111

Address	0x09			Hex
DRVSTR0		Driver Strength 0		
Bit	Name	Description	Type	Reset
7:5	Unused	Unused	R	111
4:0	driver_strength[4:0]	Output driver strength for OUT0/1/2/3/4. Each bit controls one output. Low driver strength and high driver strength. 5'b0_0000: low driver strength outputs 5'b0_0001: high driver strength for OUT0 5'b0_0010: high driver strength for OUT1 5'b0_0100: high driver strength for OUT2 5'b0_1000: high driver strength for OUT3 5'b1_0000: high driver strength for OUT4	RW	11111

Address	0x0A			Hex
DRVSTR1		Driver Strength 1		
Bit	Name	Description	Type	Reset
7:5	Unused	Unused	R	111
4:0	driver_strength[9:5]	Output driver strength for OUT5/6/7/8/9. Each bit controls one output. Low driver strength and high driver strength. 5'b0_0000: low driver strength outputs 5'b0_0001: high driver strength for OUT5 5'b0_0010: high driver strength for OUT6 5'b0_0100: high driver strength for OUT7 5'b0_1000: high driver strength for OUT8 5'b1_0000: high driver strength for OUT9	RW	11111

Address	0x11			Hex
DEVID		Device Identification		
Bit	Name	Description	Type	Reset
7:5	Unused	Unused	R	0
4:0	dev_id	Device ID. 5'h01: ZL40240	RO	01