ISL29501 Firmware Routines

This document describes the coding of five commonly used functions in ISL29501 applications. Register reads and writes for each function are listed in a pseudo code fashion that can be applied to any microprocessor. Each method has a code block followed by a high-level description or comments. A short explanation of the reasoning behind the calibration is included, but further details are available in the evaluation manual and register definitions in the *ISL29501 Datasheet*. The contents of the initialization and distance measurement code overlaps and could reside in either function. Conceptually they are different but they could be combined in a single function.

Contents

1. Chip Initialization

Important: The sample time and period as well as the emitter current are set in the Chip Initialization step. These registers must be set with the application settings before any of the calibration routines are executed. Failure to do this results in invalid calibration values. At the end of each calibration, registers between 0x24 and 0x30 are written. These values are subtracted inside the chip correcting each measurement.

Table 1. Chip Initialization

Steps[1]	Operation	Reg	Data	Comment
1	Write	0x10	0x04	Optional - Set integration time, increase over default is normal
2	Write	0x11	0x6E	Optional - Set measurement period, default normally OK
3	Write	0x13	0x71	Setup single shot mode
4	Write	0x60	0x01	Setup ISL29501 to interrupt when data ready
5	Write	0x18	0x1B	Optimize AGC
6	Write	0x19	0x23	Optimize VGA
7	Write	0x90		Set emitter scale multiplier
8	Write	0x91		Set emitter current, register value determined by the LED or laser

1. These are the steps that are often performed during an initialization routine. In most applications, these settings remain fixed during operation, however, they could be changed at any time. Registers 0x90 and 0x91 are multiplied and that value sets the emitter current.

2. Distance Measurements

Before making a distance measurement, registers 0x24 to 0x30 need to be written with calibration values. This can be done by executing the calibrations that are described in the following sections or the registers can be loaded from a table or file.

Table 2. Making a Distance Measurement

Steps[1]	Operation	Reg	Data	Comment
1	Write	0x13	0x71	Setup single shot mode
2	Write	0x60	0x01	Setup ISL29501 to interrupt when data ready
3	Read	0x69	Unused	Read clears interrupts
4	SS = 0	-	-	Initiates a distance measurement
5	Wait for IRQ	-	-	Micro waits for external interrupt (data is ready)
6	Read	0xD1		Read Distance MSB
7	Read	0xD2		Read Distance LSB
8	Calculate		From 6 and 7	Distance = (MSB * 256 + LSB) / 65536 * 33.31

1. These are the steps required to make a distance measurement. Steps 1 and 2 can be done during the initialization step rather than in a measurement routine. The emitter current, sample period, and integration time must be set in advance.

3. Calibration Procedures

The three calibration routines should be run in order: Magnitude →Crosstalk → Distance.

3.1 Magnitude Calibration Procedures

Magnitude calibration does not require any user setup other than Chip Initialization. This is a chip internal calibration that does not emit any light from the emitter and takes less than 1s to execute.

Table 3. Magnitude Calibration Procedure[1]

Steps	Operation	Reg	Data	Comment
1	Write	0x13	0x61	Setup single shot mode
2	Write	0x60	0x01	Setup ISL29501 to interrupt when data ready
3	Read	0x69	Unused	Read clears interrupts
4	SS = 0	-	-	Initiates calibration measurement
5	Wait for IRQ	-	-	Micro waits for external interrupt (data is ready)
6	Read	0xF6		Read magnitude exponent
7	Write	0x2C	From #6	Write calibration magnitude exponent
8	Read	0xF7		Read magnitude MSB
9	Write	0x2D	From #8	Write calibration magnitude MSB
10	Read	0xF8		Read magnitude LSB
11	Write	0x2E	From #10	Write calibration magnitude LSB
12	Write	0x13	0x7C	Return 0x13 to default
13	Write	0x60	0x00	Return 0x60 to default

1. The magnitude calibration compensates for changes in the chip because of the programmed emitter settings. This is an internal calibration so external conditions are not relevant. The emitter current, sample period, and integration time must be set in advance.

3.2 Crosstalk Calibration Procedures

The crosstalk calibration goal is to cancel unwanted electrical signal coupling from the emitter to the PD block. This crosstalk can come from the emitter and photodiodes, the circuit board, or inside the chip itself. This calibration averages a series of distance measurements with all the light from the emitter blocked from reaching the detector. For this calibration to be accurate, it is critical that all this light is blocked. With all the light blocked, only the electrical signals coupled through parasitics reach the PD circuits. The calibration averages 100 measurements, so depending on the sample time, could take up to 15s to run.

Table 4. Crosstalk Calibration Procedures[1]

Steps	Operation	Reg	Data	Comment
1	Write	0x13	0x7D	Setup single shot mode
2	Write	0x60	0x01	Setup ISL29501 to interrupt when data ready
3	Read	0x69	Unused	Read clears interrupts
Begin	Repeat Steps 4 through 19 N times			N = 100, the loop will sum numbers for averaging
4	SS = 0	-	-	Initiates calibration measurement
5	Wait for IRQ	-	-	Micro waits for external interrupt (data is ready)
6	Read	0xDA		Read I raw exponent

Table 4. Crosstalk Calibration Procedures[1] (Cont.)

Steps	Operation	Reg	Data	Comment
7	Read	0xDB		Read I raw MSB
8	Read	0xDC		Read I raw LSB
9	Convert	0xDA-0xDC		Convert I (EXP/MSB/LSB) to double
10	Sum		I double	Add new double to I sum
11	Read	0xDD		Read Q raw exponent
12	Read	0xDE		Read Q raw MSB
13	Read	0xDF		Read Q raw LSB
14	Convert	0xDD-0xDF		Convert Q (EXP/MSB/LSB) to double
15	Sum		Q double	Add new double to Q sum
16	Read	0xE6		Read Gain MSB
17	Read	0xE7		Read Gain LSB
18	Convert	0xE6-0xE7		Convert Gain (EXP/MSB/LSB) to double
19	Sum		G double	Add new double to Gain sum
End	End of measurement loop			
20	Calculate		I sum	Divide by N to get I average
21	Calculate		Q sum	Divide by N to get Q average
22	Calculate		Gain sum	Divide by N to get G average
23	Convert		I avg	Convert to 3-byte format, EXP/MSB/LSB
24	Convert		Q avg	Convert to 3-byte format, EXP/MSB/LSB
25	Convert		Gain avg	Convert to 2-byte format, MSB/LSB
26	Write	0x24	I EXP	Write crosstalk I exponent to calibration register
27	Write	0x25	I MSB	Write crosstalk I MSB to calibration register
28	Write	0x26	I LSB	Write raw crosstalk I LSB to calibration register
29	Write	0x27	Q EXP	Write crosstalk Q exponent to calibration register
30	Write	0x28	Q MSB	Write crosstalk Q MSB to calibration register
31	Write	0x29	Q LSB	Write crosstalk Q LSB to calibration register
32	Write	0x2A	Q MSB	Write crosstalk Gain MSB to calibration register
33	Write	0x2B	Q LSB	Write crosstalk Gain LSB to calibration register

1. The crosstalk calibration compensates for the electrical signal that is coupled by parasitics in the chip and on the circuit board to the receiver circuit. The photo diode must be shielded from all light so that only electrical energy is measured. After averaging a number of measurements (100), a coefficient is written into an offset register. The emitter current, sample period, and integration time must be set in advance.

3.3 Distance Calibration Procedures

Distance calibration averages a series of distance measurements at a known reference distance. The emitter and detector are not covered. This calibration compensates for phase delays introduced in the emitter and photodiodes. The calibration averages 100 measurements, so depending on the sample time, could take up to 15s to run.

Table 5. Distance Calibration Procedures[1]

Steps	Operation	Reg	Data	Comment
1	Write	0x13	0x7D	Setup single shot mode
2	Write	0x60	0x01	Setup ISL29501 to interrupt when data ready
3	Read	0x69	Unused	Read clears interrupts
Begin	Repeat steps 4 through 19 N times			N = 100, the loop will sum numbers for averaging
4	SS = 0	-	-	Initiates calibration measurement
5	Wait for IRQ	-	-	Micro waits for external interrupt (data is ready)
6	Read	0xD8		Read Phase MSB
7	Read	0xD9		Read Phase LSB
8	Convert	0xD8-0xD9		Convert Phase (MSB/LSB) to double
9	Sum		Double phase	Add new double to Phase sum
End	End of measurement loop			
10	Calculate		Phase sum	Divide by N to get Phase average
11	Convert		Phase avg	Convert and subtract ref distance, Dist_cal = phase avg - (dist actual/33.31 * 65536)
12	Convert		Distance Calibration Offset	Convert to 2-byte format, unsigned int MSB/LSB
13	Write	0x2F	Distance Calibration Offset	Write distance calibration offset MSB to calibration register
14	Write	0x30	Distance Calibration Offset	Write distance calibration offset LSB to calibration register

1. The distance calibration sets a reference point for all chip distance measurements. The board should be mounted a known distance from a target. This known actual distance is passed into this routine, which then takes the average of a number of (100) distance measurements and subtracts it from that value. The calculated value is then written into a distance offset register. The emitter current, sample period, and integration time must be set in advance.

4. Revision History

Revision	Date	Description
2.00	Apr 6, 2022	Updated to the latest template. Added Revision History section.

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Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Contact Information

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