MLX90308BB

Intelligent Sensor Interface

Features and Benefits

- Microprocessor-Controlled Signal Conditioning for Bridge-type Sensors
- Suited for low-cost Sensors: Reduction of non-linearity by Programmable Coefficients
- External or Internal Temperature Sensor for Compensating Temperature Errors
- Versatile Output Signal Ranges: 4V, 5V, 10V, 11V or 4-20mA loop
- Mass Calibration Easy with 2400 or 9600 Baud UART
- Power Supply from 5V to 35V

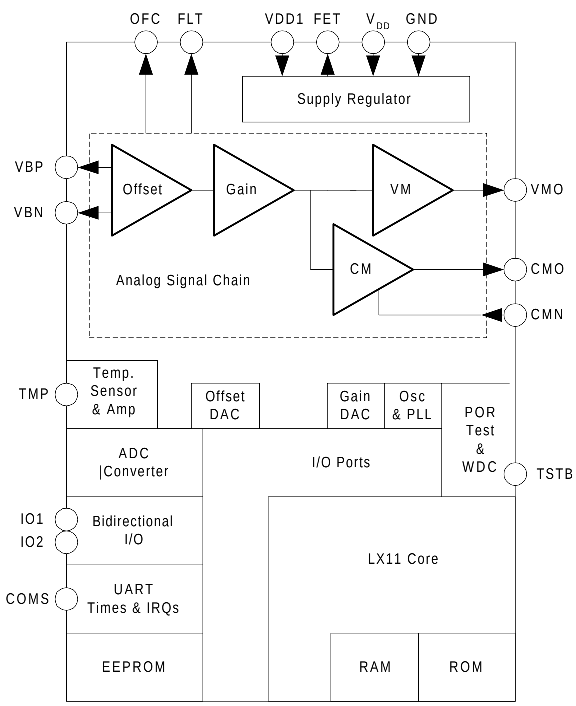
Applications

- Pressure Transducers
- Accelerometers
- Temperature Sensor Assemblies
- Linear Position Sensors

Ordering Information

Part No.	Temperature Suffix	Package	Temperature Range
MLX90308BB	N/A	LW-SO16W	-40°C to 140°C Automotive
Die Also Available			

Functional Diagram



Description

The MLX90308BB is a dedicated microcontroller which performs signal conditioning for sensors wired in a bridge or differential configuration. Sensors that can be used include thermistors, strain gauges, load cells, pressure sensors, acceleration, etc. The signal conditioning includes gain adjustment, offset control, high order temperature and linearity compensation. Compensation values are stored in EEPROM and are re-programmable. Programming is accomplished by using a PC, with an interface circuit (level shifting and glue logic), and provided software. The application circuits can provide an output of an absolute voltage, relative voltage, or current. The output can be range limited with defined outputs when the signal is beyond the programmed limits. Other features include alarm outputs and level steering. The robust electrical design allows the MLX90308BB to be used where most signal conditioning and sensor interface circuits cannot be used. Voltage regulation control is provided for absolute voltage and current modes, an external FET is required.

The standard package is a plastic SO16W.

Note:
Static sensitive device, please observe ESD precautions.

MLX90308 Electrical Specifications

DC Operating Parameters T_A = -40°C to 140°C, V_{DD} = 5V to 35V (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
		Regulator & Consumption				
Input Voltage Range	V_{IN}	V_{DD1} (Regulator connected)	6		35	V
Supply Current	I_{DD}	@ T_A= 100°C Current Mode			2.1	mA
Supply Current	I_{DD}	@ T_A= 100°C Voltage Mode			5.0	mA
Regulated Supply Voltage	V_{REG}		4.5	**4.75**	5.0	V
Regulated Voltage Temperature Coefficient				**-60**		µV/°C
Supply Rejection Ratio	PSRR	V_{DD1}>6V	90			dB
		Instrumentation Amplifier				
Differential Input Range	VBP-VBN	IINV=0	-12.0		34.0	mV/V
Differential Input Range	VBP-VBN	IINV=1	-34.0		12.0	mV/V
Common Mode Input Range	1/2 (VBP+VBN)		38.0		65.0	%VDD
Pin Leakage Current		Pins VBP & VBN to GND,V_{DD} = 5V			8.0	nA
Common Mode Rejection Ratio	CMRR		78			dB
Fixed Gain			19		20	V/V
Coarse Offset Control Range		CSOF[1:0]=00	-15.2		-14.2	mV/V
		CSOF[1:0]=01	-5.4		-4.4	mV/V
		CSOF[1:0]=10	4.4		5.4	mV/V
		CSOF[1:0]=11	14.2		15.2	mV/V
Fine Offset Control Range		* DARDIS=0	-3.0		4.4	mV/V
		* DARDIS=1	-5.3		7.7	mV/V
IA Chopper Frequency				300		kHz
		Gain Stage				
Course Gain		CSGN[1:0]=00	1.05		1.17	V/V
		CSGN[1:0]=01	1.71		1.89	V/V
		CSGN[1:0]=10	2.77		3.06	V/V
		CSGN[1:0]=11	4.48		4.95	V/V
Fine Gain Control Range			0.469		0.980	V/V

* Note: DARDIS is only accessible when writing custom firmware. For the MLX90308BB, DARDIS is fixed to 1.

MLX90308 Electrical Specifications

DC Operating Parameters T_A = -40°C to 140°C, V_{DD} = 5V to 35V (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Voltage Mode Output Stage (See Voltage Mode)						
Coarse Gain		CSGN[2:2]=0	2.74		3.03	V/V
		CSGN[2:2]=1	7.24		8.00	V/V
Output Voltage Span		CSGN[2:2]=0	5.0			V
		CSGN[2:2]=1	10.0			V
Minimum Output Voltage			0		1.0	V
Output Source Current			2.0		8.0	mA
Output Sink Current		@ 0V Output Voltage	20			µA
Output Resistance		Over Complete Output Range			25	Ω
Digital Mode Output Span		CSGN[2:2]=0	6.0			V
		CSGN[2:2]=1	11.0			V
Digital Mode Step Size		* Dardis=1,V_{DD}=5V,CSGN[2:2]=0		**6.0**		mV
		* Dardis=1,V_{DD}=5V,CSGN[2:2]=1		**11.0**		mV
Capacitive Load VMO pin				**10**		nF
Current Mode Output Stage						
Fixed Gain		R_{SENSE}=24Ω	8.4		9.3	mA/V
Output Current CMO pin		Current Mode		**50**		µA
Current Sense Resistor				**24**		Ω
Digital Mode Current Output Span		* DARDIS=1,V_{DD}=5V	23			mA
Digital Mode Current Step Size		* DARDIS=1,V_{DD}=5V,R_{SENSE}=24Ω		**30**		µA
Signal Path (General)						
Overall Gain		Voltage Mode	25		777	V/V
		Current Mode =24Ω	78		903	mA/V
Overall Non-linearity			-0.1		0.1	%
Bandwidth (-3dB)		39nF connected from FLT to GND		**3.5**		KHz
Temperature Sensor & - Amplifier						
Temperature Sensor Sensitivity				**390**		µV/°C
Temperature Sensor Output Voltage			70		380	mV

* Note: DARDIS is only accessible when writing custom firmware. For the MLX90308BB, DARDIS is fixed to 1.

MLX90308 Electrical Specifications

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
		Temperature Sensor & -Amplifier Cont				
Input Voltage Range TMP pin		* DARDIS=0,GNTP[1,0]=00	325		490	mV
@ VDD = 5.0V		* DARDIS=0,GNTP[1,0]=01	230		345	mV
		* DARDIS=0,GNTP[1,0]=10	160		245	mV
		* DARDIS=0,GNTP[1,0]=11	113		170	mV
Input Voltage Range TMP pin		* DARDIS=1,GNTP[1,0]=00	205		490	mV
@ VDD = 5.0V		* DARDIS=1,GNTP[1,0]=01	140		345	mV
		* DARDIS=1,GNTP[1,0]=10	100		245	mV
		* DARDIS=1,GNTP[1,0]=11	70		170	mV
		DAC				
Resolution				**10**		Bit
Monotonicity			Guaranteed By Design			
Ratiometric Output Range		* DARDIS=0	29		71	% V_{DD}
		* DARDIS=1	1		71	% V_{DD}
Offset Error		* DARDIS=1		**10**		LSB
Differential Non-linearly					1	LSB
Integral Non-linearity					2	LSB
Storage Capacitors		OFC Buffer,Digital Mode Buffer	7		13	pF
Settling Time		MODSEL[1:0]= 1X	2		8	µs
		ADC				
Resolution				**10**		Bit
Monotonicity			Guaranteed By Design			
Ratiometric Input Range		* DARDIS=0	29		71	% V_{DD}
		* DARDIS=1	1		71	% V_{DD}
Offset Error		* DARDIS=1		**10**		LSB
Differential Non-linearly					1	LSB
Integral Non-linearity					2	LSB
Conversion Time		TURBO =0			110	µs
		TURBO=1			75	µs

* Note: DARDIS is only accessible when writing custom firmware. For the MLX90308BB, DARDIS is fixed to 1.

MLX90308 Electrical Specifications

DC Operating Parameters T_A = -40°C to 140°C, V_{DD} = 5V to 35V (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
EEPROM						
Size				**48X8**		Bit
Write / (Block)Erase Cycle		T_A<100°C			5	ms
Read Cycle				**2**		µs
On-Chip RC Oscillator and Clock						
Untrimmed RC Oscillator Frequency			40		250	KHz
Trimmed RC Oscillator Frequency			86.9	**87.8**	88.7	KHz
Frequency Temperature Coefficiency				**26**		Hz/°C
Ratio of f(Microcontroller Main Clock) and f(RC Oscillator)		TURBO=0		**7**		
		TURBO=1		**28**		
Timer Interrupts RC Oscillator						
TMI First Occurrence after ETMI			6.66		13.3	ms
TMI Timeout Period				**6.66**		ms
TPI First Occurrence after ETPI			850		1700	ms
TPI Timeout Period				**850**		ms
Watchdog Reset Timeout Period		TURBO=0		**106.7**		ms
		TURBO=1		**26.67**		ms
Input & Output Pins (I01 & I02)						
Analog Input Ranges		* DARDIS =0	1.5			V
		* DARDIS=1	0.05			V
Digital Input Levels		Low	0.5			V
		High			V_{DD}-0.5	
Output Levels		@ output current =5mA Low	V_{DD}-0.4		0.4	V
		@ Output current =5mA High		**V_{DD}**		
TSTB Pin						
Input Levels		Low	0.5			V
		High			V_{DD}-0.5	
Pull-up Resistor				**66**		KΩ

* Note: DARDIS is only accessible when writing custom firmware. For the MLX90308BB, DARDIS is fixed to 1.

MLX90308 Electrical Specifications

DC Operating Parameters T_A = -40°C to 140°C, V_{DD} = 5V to 35V (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
FLT Pin						
Output Resistance				**1.24**		KΩ
Output Voltage Range		VDD = 5V	0.05		3.6	V
OFC Pin						
Output Voltage Range		VDD = 5V	0.05		3.6	V
Load Capacitor					20	pf
UART & CMOS Pin						
UART Baud Rate		TURBO=0		**2400**		Baud
		TURBO=1		**9600**		Baud
COMS Pin Input Levels		Low	$0.3*V_{DD}$			V
		High			$0.7*V_{DD}$	V
COMS Pin Output Resistance		Low		**100**		Ω
		High		**100**		KΩ

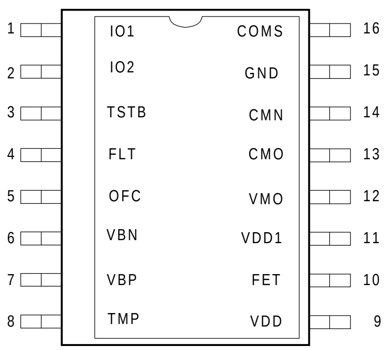
Pin Description

Pin	Signal Name	Description
1,2	I/O1, 2	Bi-directional I/O, can also be used as input to A/D converter. I/O can be controlled by the serial communications or by firmware as alarm inputs or level out.
3	TSTB	Test pin for Melexis production testing.
4	FLT	Filter Pin, allows for connection of a capacitor to the internal analog path.
5	OFC	Offset Control Output, Provides access to the internal programmed offset control voltage for use with external circuitry.
6,7	VBN,VBP	Bridge input – negative and positive
8	TMP	Temperature sensor input, an external temperature sensor can be used in conjunction with the internal one. The external sensor can provide a temperature reading at the location of the bridge sensor.
9	VDD	Regulated Supply Voltage, used for internal analog circuitry to ensure accurate and stable signal manipulation.
10	FET	Regulator FET Gate Control, for generating a stable supply for the bridge sensor and internal analog circuitry (generates regulated voltage for VDD).
11	VDD1	Unregulated Supply Voltage, used for digital circuitry and to generate FET output.
12	VMO	Voltage Mode Output, compensated sensor output voltage
13	CMO	Current Mode Output, compensated sensor output for current mode operation.
14	CMN	Current Mode Negative Rail, current mode return path.
15	GND	Power Supply Return.
16	COMS	Serial Communications Pin, bi-directional serial communication signal for reading and writing to the EEPROM.

Unique Features

Customization

Melexis can customize the MLX90308 in both hardware and firmware for unique requirements. Melexis can also provide all necessary development tools for the development of custom firmware to customize the MLX90308. The hardware design provides 64 bytes of RAM, 3 Kbytes of ROM, and 48 bytes of EEPROM for use by the firmware.



Pinout for
MLX90308BB, SO16W
(LW) Package

Special Information

The output of the sensor bridge is amplified via Offset and Gain amplifiers and then converted to the correct output signal form in one of the output stages.

The sensitivity and offset of the analog signal chain are defined by numbers passed to the DAC interfaces from the microcontroller core (GN[9:0] and OF[9:0]). The wide range of bridge offset and gain is accommodated by means of a 2-bit "coarse adjustment" DAC in the Offset adjustment (CSOF[1:0]), and a similar one in the Gain adjustment (CSGN[2:0]). The signal path can be directed through the processor for digital processing. Two I/O pins are available for analog inputs or digital outputs. These pins can be used for alarms on various points on the analog signal path and built in or external temperature value.

Programming and Setup

The MLX90308 needs to have the compensation coefficients programmed for a particular bridge sensor to create the sensor system. Programming the EEPROM involves some minimal communications interface circuitry, Melexis' setup software, and a PC. The communications interface circuitry is available in a development board. This circuitry communicates with the PC via a standard RS-232 serial communications port.

Cross Reference

There are no known devices which the MLX 90308BB can replace. However within it's application circuit it can replace the following devices:
Maxim: Max1457 or Max1458
Analog Devices: AD693, AD694. AD280
Burr Brown: XTR106,ADS1201,ADS1210,
and ADS1211.

ESD Precautions

Observe ESD standard control procedures for CMOS semiconductors.

Absolute Maximum Ratings

Supply Voltage (Regulator Disabled), V_{DD}	7V
Supply Voltage (Operating), VDD1	35V
Reverse Voltage Protection	-0.7V
Supply Current, I_{DD}	2.1mA
Supply Current, I_{DD}	5mA
Output Current, I_{OUT}	8mA
Output Current (Short to V_{DD}), I_{SC}	100mA
Output Current (Short to V_{SS}), I_{SC}	8mA
Output Voltage, V_{OUT}	+11V
Power Dissipation, P_D	71mW
Operating Temperature Range, T_A	-40° to +140°C
Storage Temperature Range, T_S	-55° to +150°C
Maximun Junction Temp, T_J	150°C
ESD Sensitivity	2KV

Analog Features

Supply Regulator

A bandgap-stabilized supply-regulator is on-chip, the pass-transistor is external. The bridge-type sensor is typically powered by the regulated supply (typ. 4.75V). For "ratiometric" operation, the supply-regulator can be disabled by shorting the unregulated and regulated supply-pins.

Oscillator

The MLX90308 contains a programmable on-chip RC-oscillator. No external components are needed to set the frequency (87.8 kHz +/- 1%). The MCU-clock is generated by a PLL (614kHz or 2.46Mhz) that locks on the basic oscillator.

A/D and D/A

Conversions using only one DAC

For saving chip-area, the "Offset DAC" is multiplexed in various ways. Both "fine offset" and "digital mode" signals are stored on a capacitor. An ADC-loop is available by using a comparator and SAR.

D/A

Before changing to another capacitor, the DAC output should be settled to the new value. Therefore, i.e. MODSEL moves the analog multiplexer to the so-called "open state 0". At the same time, the 10 bit mux selects OF[9:0] for the offset-DAC. After the DAC settling-time, the analog multiplexer is moved to it's final state and the DAC-output is stored on a capacitor.

A/D

The S/W-Signal MODSEL connects the SAR-output to the DAC and the DAC-output to the comparator. The SARegister is initialized by a rising edge of STC (S/W signal). At the end of the A/D conversion, the EOC flag is set to 1 and the controller can read the ADC values.

Power-On Reset

The Power-On Reset (POR) initializes the state of the digital part after power up. The reset circuitry is completely internal. The chip is completely reset and fully operational 3.5 ms from the time the supply crosses 3.5 Volts. The POR circuitry will issue another POR if the supply voltage goes below this threshold for 1.0 us.

Test Mode

For 100% testability, a "TEST"-pin is provided. If the pin is pulled low, then the "monitor" program is entered and the chip changes its functionality. In all applications, this pin should be pulled high or left floating (internal pull-up).

Temperature Sense

The temperature measurement, TPO, is generated from the external or internal temperature sensor. This is converted to a 10-bit number for use in calculating the signal compensation factors. A 2-bit "coarse adjustment" GNTP [1:0] is used for the temperature signal gain & offset adjustment.

Digital Features

Microprocessor, LX11 Core,

Interrupt Controller and Memories

The LX11 microcontroller core is described in its own datasheet. As an overview, this implementation of the LX11 RISC core has following resources:

- -2 accumulators, 1 index and 2 interrupt accumulators
- -15 - 8 bit I/O ports to internal resources
- -64 byte RAM
- -4 Kbytes ROM : 3 Kbytes is available for the customer's application firmware, 1k is reserved, for test.
- -48 x 8 bit EEPROM.
- -4 interrupt sources, 2 UART interrupts and 2 timers.

UART

The serial link is a potentially full-duplex UART. It is receive-buffered. This means it can receive a second byte before a previously received byte has been read from the receiving register. However, if the first byte is not read by the time the reception of the second byte is completed, the first byte will be lost. The UART's Baud rate depends on the RC-oscillator's frequency and the "TURBO"-bit (see output port). The transmitted & received data has following structure : "start bit = 0, 8 bits of data, stop bit = 1".

Sending Data

-Writing a byte to port 1 automatically starts a transmission sequence.

-The TX Interrupt is set when the STOP-bit of the byte is latched on the serial line.

Receiving Data

-Reception is initialized by a 1 to 0 transition on the serial line (i.e. a START-bit).

-The Baud rate period (i.e. the duration of one bit) is divided in 16 phases.

The first 6 and last 7 phases of a bit are of no use. The decision on the bit-value is then the result of a majority vote of phase 7, 8 and 9 (i.e. the center of the bit).

Spike-synchronization is avoided by de-bouncing on the incoming data and a verification of the START-bit value.

The RX Interrupt is set when the STOP-bit is latched in the UART.

Timer

The clock of the timers TMI and TPI is taken directly from the main oscillator. The timers are never reloaded, so the next interrupt will take place 2x oscillator pulses after the first interrupt.

Watch Dog

An internal watch dog will reset the whole circuit in case of a software crash. If the watch dog counter is not reset at least once every 26ms (@2.46MHz main clock), the microcontroller and all the peripherals will be reset.

Firmware

The MLX90308 firmware performs the signal conditioning by one of two means, analog or digitial. The analog signal conditioning allows separate offset and gain temperature coefficients for up to four temperature ranges. Digital mode allows for all of the analog capabilities plus up to five different gain values based on the input signal level. Also available in both modes is the capability of range limiting and level steering

Temperature Processing

In both analog and digital modes, the temperature reading controls the temperature compensation. This temperature reading is filtered with the amount of filtering controlled by the user. The filter adjusts the temperature reading by factoring in a portion of the previous value. This helps to minimize the effect of noise and other anomalies. The filter equation is:

Temp_f(n+1) =

[Temp_f(n)*(65535–N_factor)+(Temp*n_Factor)] / [65536]

Where: N_factor is set by the user and stored in EEPROM.
Temp_f(n) is the previous filtered tempera ture value.
Temp is the raw digital temperature reading.
Temp_f(n+1) is the new filtered temperature value.

If N_factor is set to 65535, no filtering will be done, Temp_f(n+1) = Temp. If N_factor is set to 0, the user can fix the value of the temperature. N_factor has a range of 0 to 65535.

Analog Mode

The parameters OF and GN represent offset correction and span control respectively, while OFTCi and GNTCi represent their temperature coefficients (thermal zero shift and thermal span shift). After reset, the firmware continuously calculates the offset- and gain-DAC settings as follows: The EEPROM holds parameters GN, OF, OFTCi and GNTCi. Where i is the gap number and can be $1 \leq i \leq 4$. The transister function is as described below.

Vout=DAC_GAIN*[(FG*Vin)+DAC_OFFSET]

where:

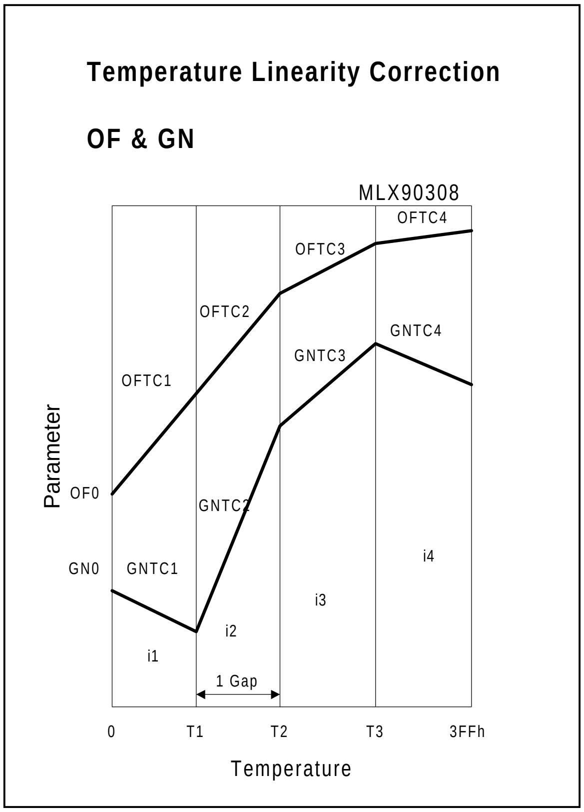
FG = Fixed Gain (~20V/V), is part of the hardware design, and not changeable.
DAC_GAIN = (Tempf - Ti) * GNTCi+GN

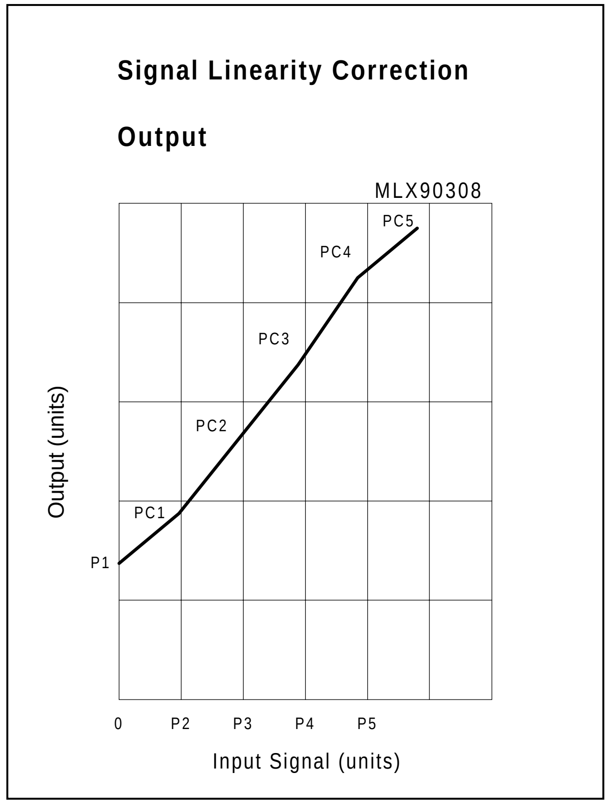
Tempf = Filtered Temperature (previously described)
Ti= Temperature segment point, TRiL&H in EEPROM table
GNTCi = Gain TC for a given temperature segment i, GNTCiL and GNTCiH in EEPROM table
GN = Overall Gain CSGN*GN[9:0]

CSGN = Course Gain, part of byte 2 in EEPROM
GN[9:0] = Fine Gain(called fixed gain in the EEPROM table)Bytes 2 and 17 in EEPROM

DAC_OFFSET = OF + OFTCi * (Temp_f – Ti)

OF = Overall Offset, CSOF + OF[9:0]
CSOF = Coarse Offset, part of byte 2 in EEPROM
OF[9:0] = Fine offset (called fixed Offset in the EEPROM table) Bytes 4 and 17 in EEPROM
OFTCi = Offset TC for a given temperature segment i, Up to four segments or Gaps, OFTCiL&H in EEPROM table
(Temp_f-Ti) = Same as above





Digital Mode

The MLX90308 firmware provides the capability of digitally processing the sensor signal in addition to the analog processing. This capability allows for digital filtering and signal correction.

Signal Correction

While in digital mode the firmware can perform signal correction. This is an adjustment to the output level based on the input signal level. Adjustment coefficients can be set for five different signal ranges. The output is obtained by the following formula:

Output = (Signal – Pi)*Pci + Pi

Signal: Input signal measurement
Pi: Programmed signal point (i=2,3,4,5)
Tempo1: Pressure ordinate
Pci: Programmed coefficient

Notes:
The PCi are coded on 12 bits: 1 bit for the sign, 1 bit for the unity, and the rest for the decimals.
The Pi are coded on 10 bits (0-3FFh) in high low order.
PNB_TNB: codes the last address of the signal point (Figure I.5.b). The address is coded only on the 4MSB. (The 4LSB are reserved for temperature point).
The PNB_TNB byte must be stored as followed:

PNB_TNB Bit Definition

Number of gap Pressure	4MSB of PNB_TNB Value
Fixed	15
1	14
2	12
3	10
4	8
5	6

PNB_TNB Bit Definition

Number of Temperature Gaps	4 LSB of PNB_TNB
Fixed (1)	0
2 Gaps	5
3 Gaps	8
4 Gaps	11

Compensation Trade-Offs

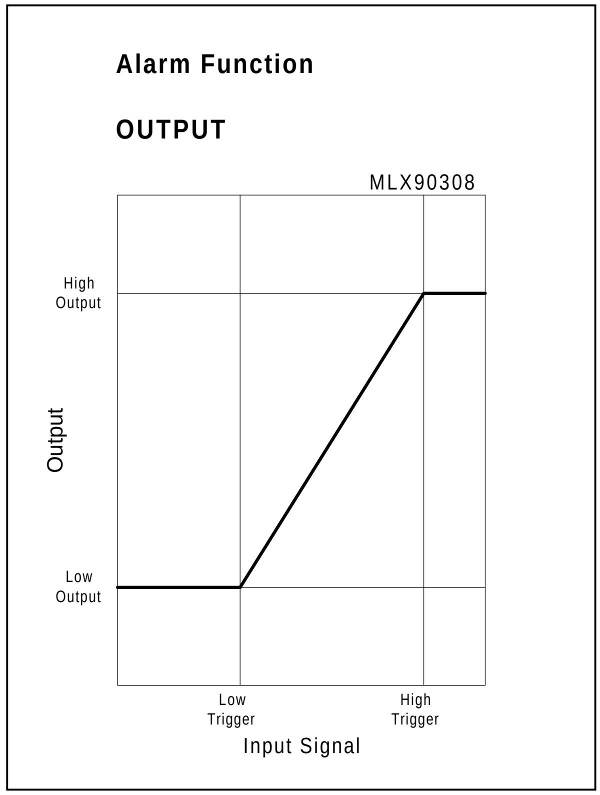
Compromise between temperature compensation and pressure correction.
The EEPROM space where the signal coefficients are stored is shared with the temperature coefficients. This means that an EEPROM byte can be used for a temperature coefficient or for a signal coefficient, not both. Therefore, the following table gives the possibilities between the maximum number of temperature gaps and the maximum number of signal

Temp & Signal Limitations

Maximum number of temperature gaps	Maximum number of signal gaps
Fixed Gain and fixed Offset	5 Gaps
2 Gaps	3 Gaps
3 Gaps	2 Gaps
4 Gaps	Fixed signal

I.8- Alarm option

This option allows controlling the limit (low and high limit) of the output. The output level is set when the output tries to exceed the programmed limits. Five bytes are reserved for this option. The two first bytes are dedicated to the low limit: the first one is the low trigger limit and the second one is the low output. The two following are for the high limit and the last one is the alarm control byte to select the alarm input.



The different levels are programmed as eight bit numbers. These correspond to the 8 upper bits of the 10 bit signal measurement. When the alarm mode is not used, all of the data is 0. The control code is coded as shown in the table below. The six possible signals are listed below and are encoded on the 4 MSBs of byte 31 of the EEPROM.

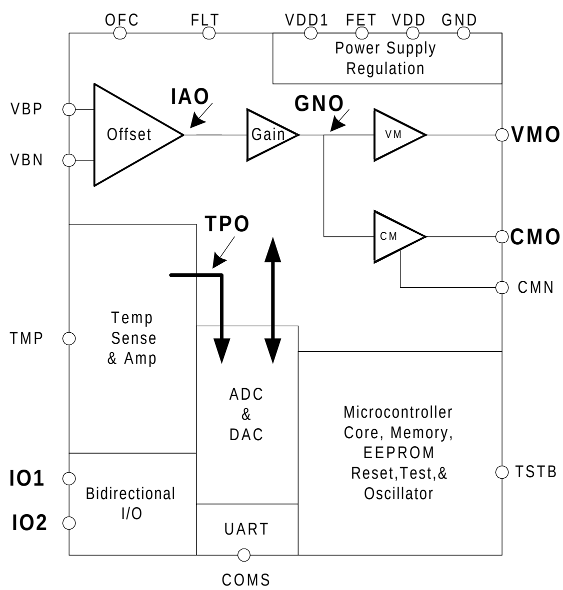
Alarm Source Bit Definition

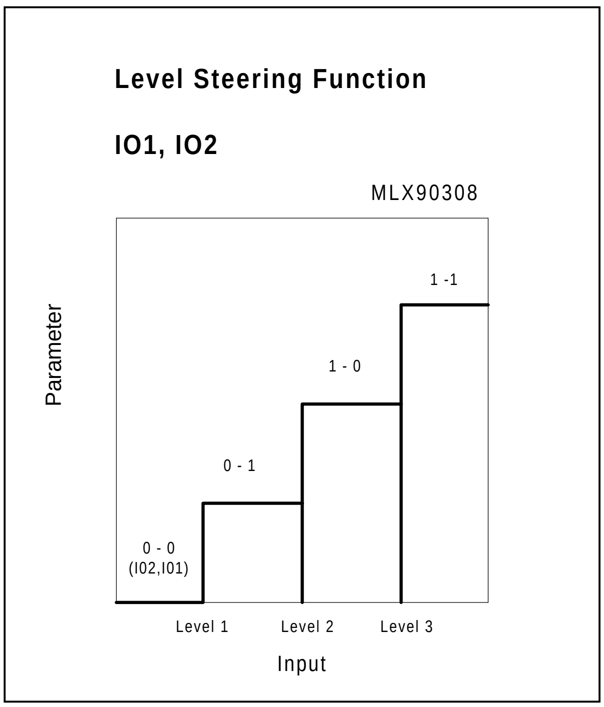
Selected input	MUX Value
TPO	0010
IAO	0110
GNO	0000
VMO	0011
IO1	0100
IO2	0101

IO1 & IO2

The MLX90308BB has two spare I/O Signals (IO1 and IO2) which can be configured to be a digital input/output, or an analog input. These pins are readable as analog or digital inputs or digital outputs via the serial communications. These pins can also be used for the level steering function.

Alarm & Steering Source Points





Level Steering

The level steering option allows commanding the IO pins, as outputs to indicate the relative signal level of a selected signal. The levels at which the two outputs transition are programmed by the user. The programmed levels are set as 8 bit numbers and compared to the upper 8 bits of the digitized signal. This function utilizes the same resources as the alarm function. The two functions can not be used at the same time. Four bytes in the EEPROM commands this options. This first one is used to select the input. The remaining three are the transition levels.
The control byte for the level steering is the same as for the alarm. The 4MSB holds the code for the selected input. The control byte has several possibilities, according the MUX settings:

Level Steering Bit Definitions

Selected input	MUX Value
TPO	0010
IAO	0110
GNO	0000
VMO	0011

Communications

The MLX90308BB firmware transfers a complete block of data into and from the memory based on a simple command structure. The commands allow data to be read and written to and from the EEPROM and read from the RAM. RAM data that can be read includes the current digitized temperature, digitized GNO. The commands are described below. Melexis provides setup software for programming the MLX90308BB.

UART Commands

The commands can be divided into three parts: one for the downloading of data from the ASIC, one for the uploading of data to the ASIC and the reset command. All the commands have the same identification bits. The two MSB of the sent byte code the command.

AAXX XXXX:

A codes the command

X codes the wanted address

The commands are coded as followed:

11 to read a RAM byte

10 to read an EEPROM byte

01 to write in the EEPROM

00 to write in the RAM

The addresses can be between:

0-63 for the RAM

0-47 for the EEPROM

63 EEPROM, RESET Command (read)

Downloading Command

With one byte, you can download data from the ASIC. The ASIC will send automatically the value of the wanted byte.

Uploading Command

To write in the RAM or in the EEPROM, two bytes are needed. The first one codes the command and the address. The second one codes the value, which has to be stored.

To synchronize the transmission of the second byte, the ASIC sends back the first byte. Then it's ready to receive the data byte. After the firmware has received the data byte, it sends back a received receipt: 188dh. That means that the ASIC has stored the value. If there is no receipt, the byte is not stored because of bad transmission or over range address.

When writing a value in the EEPROM the Hamming correcting code algorithm has to be active before the data is sent. Without doing this, the firmware won't calculate the hamming code bits and after the reset, it will correct with irrelevant code bits

Reset Command

Reading the 63rd address of the EEPROM resets the ASIC. There is a received receipt for this command. Just before the reset, the ASIC sends #BCh value to the UART, saying that the reset is taken into account. EEPROM's data. This resets the software only.

EEPROM Data

The Modes are controlled by means of the mode-register :

Mode Byte Bit Definition

Bit	Function	Remarks
7	1= Hamming Code active 0= Hamming Code not active	Correcting code mode for the certification of the EEPROM data
6	0 = Analog Mode 1 = Digital Mode	Digital mode must be acti-vated when VMO and CMO both active.

5	0 = Alarm function not active
	1 = Alarm function active
		Alarm functions are like "limiting functions" :
		If (defined ADC INPUT) is below (low alarm trigger), then DIGMOD becomes active with (alarm low output)
		If (defined ADC INPUT) is above (high alarm trigger), then DIGMOD becomes active with (alarm high output)
		Note: Disactivated if the level-steering mode is active

4	0 = IO1/IO2 are no active outputs 1 = levelsteering : IO1/IO2 are active outputs	Depending on the sampled input, IO1/IO2 will be a 2 bit digital output. If IO1/IO2 are no active out-puts, then they will be analog inputs.
3	0 = Turbo not active	
2	0 = VMO not active	
1	0 = Internal tempera-ture sensor active 1 = External tem-perature sensor ac-	
0	0 = CMO not active 1 = CMO active	CMO has fixed digital value (EEPROM byte see below) if both VMO and CMO are ac-tive. To activate this value, digital

The EEPROM is 48 bytes long, divided in two parts: address 0 until address 31 are reserved for the data (mode byte, compensation coefficients...); address 32 until address 47 are reserved for the correcting codes. The certification of the data reduces the available part of the EEPROM. To avoid reducing the number of compensation coefficients, the coefficients are com-pacted. A 12 bits coefficient is stored on 1.5 bytes. The 8LSBs are stored in one byte. The 4MSBs are stored on another byte shared with the 4MSBs of another co-efficient.

EEPROM Byte Definitions

0	MODE byte	Contents is described above
1	Cadj	Mirror for input Port 7, 8 Bit 1's Complement
2	Coarse Control	Mirror for input Port 13
3	GN1L	Fixed gain number (8LSB)
4	OF1L	Fixed offset number (8LSB)
5	GNTC1L	First gain TC (8LSB)
6	OFTC1L	First offset TC (8LSB)
7	TR1L / PC5L	First Temperature point / Pressure (input signal) coefficient 5 (8LSB)
8	GNTC2L / P5L	Second gain TC / Pressure (input signal) point 5 (8LSB)
9	OFTC2L / PC4L	Second offset TC / Pressure coefficient 4 (8LSB)
10	TR2L / P4L	Second Temp. point / Pressure point 4 (or Signature) (8LSB)
11	GNTC3L / PC3L	Third gain TC / Pressure coefficient 3 (or Signature) (8LSB)
12	OFTC3L / P3L	Third offset TC / Pressure point 2 (or Signature) (8LSB)
13	TR3L / PC2L	Third Temperature point/ Pressure coefficient 2 (8LSB)
14	GNTC4L / P2L	Fourth gain TC / Pressure point 2 (8LSB)
15	OFTC4L / PC1L	Fourth offset TC/ Pressure coefficient 1 (8LSB)
16	P1L	Pressure (output signal) point 1 (8LSB)
17	GN1H_OF1H	Fixed Gain and Fixed offset (4MSB-4LSB)
18	GNTC1H_OFTC1H	First Gain TC and Offset TC (4MSB-4LSB)
19	TR1H/PC5H_GNTC2H/P5H	First Temperature point / Pressure coefficient 5 (4MSB-4LSB) Second Gain TC/ Pressure Point 5 (4MSB-4LSB)
20	OFTC2H/PC4H_TR2H/P4H	Second Offset TC / Pressure coefficient 4 (4MSB-4LSB) Second Temperature point/ Pressure Point 4 (4MSB-4LSB)
21	GNTC3H/PC3H_OFTC3H/P3H	Third Gain TC / Pressure coefficient 3 (4MSB-4LSB) Third Offset TC/ Pressure Point 3 (4MSB-4LSB)
22	TR3H/PC2H_GNTC4H/P2H	Third Temperature point / Pressure coefficient 2 (4MSB-4LSB) Fourth Gain TC/ Pressure Point 2 (4MSB-4LSB)
23	OFTC4H/PC1H_P1H	Fourth Offset TC / Pressure coefficient 1 (4MSB-4LSB) Fixed pressure number
24	PNB_TNB	Address of the last temperature point and pressure point
25-26	n_factor	Temperature Filter Coefficient
27	ALARM low trigger /Level1 IO2/ IO1	Value below which ALARM will go on Value of first level ([IO2,IO1]=00-01)
28	ALARM low output /Level2 IO2/ IO1	Value of DIGMO during "ALARM low" condition Value of second level ([IO2,IO1]=01-10)
29	ALARM high trigger /Level3 IO2/ IO1	Value above which ALARM will go on Value of third level ([IO2,IO1]=10-11)
30	ALARM high out. level	Value of DIGMO during "ALARM high" condition
31	ALARM control byte IO1/IO2 control byte 4 LSBs are unused	3 bits needed for choice of input for ALARM detection (TPO, IAO, GNO, VMO, IO1 or IO2) or the value of the output during an EEPROM failure 2 bits needed for choice of input for LEVEL-steering (TPO, IAO, GNO or VMO) These bits are multiplexed according the mode. If both CMO and VMO are active, then alarm is not active.
32-47	HAMMING CODES	Codes for the certification of the data

Notes: See next page

Notes:

-Not all the temperature and pressure coefficients must be used. When a coefficient is unused, the 8LSB and the 4MSB are replaced by 0.

-The levelsteering and the alarm mode can't be both active because the levels bytes are shared with the two modes.

-If the alarm mode and the level steering are both active, the level steering mode is dominant: the firmware will run with the level steering mode, by default.

-If the DIGMO mode (VMO and CMO both active) is active, the alarm will be automatically disabled by the firmware.

-At PNB_TNB address, the 4MSBs correspond to the address of the last pressure point and the 4LSB to the address of the last temperature point.

-In the alarm_control variable, the selected input is stored on the 3MSB.

-Pi and OFi are 10 bit values, right justified in 12 bits fields.

Bit Definitions Coarse Control , Byte 2

Bit	Symbol	Function
7	IINV	Invert Signal Sign
6	GNTP1	Gain & Offset of Temperature
5	GNTP0	GNTP = 0-3
4	CSOF 1	Coarse Offset of Signal Amplifier
3	CSOF 0	CSOF = 0-3
2	CSGN2	Coarse Gain of Signal Amplifierer
1	CSGN1	CSGN = 0-7
0	CSGN0	If CSGN> 3 Output range = 0-10v If CSGN< 3 Output range = 0-5v

RAM Byte Definitions

Byte	Functions	Remarks
0	MODE byte	Contents is described above
1	GN1L	Fixed gain number (8LSB)
2	OF1L	Fixed offset number (8LSB)
3	GNTC1L	First gain TC (8LSB)
4	OFTC1L	First offset TC (8LSB)
5	TR1L / PC5L	First Temperature point / Pressure coefficient 5 (8LSB)
6	GNTC2L / P5L	Second gain TC / Pressure point 5 (8LSB)
7	OFTC2L / PC4L	Second offset TC / Pressure coefficient 4 (8LSB)
8	TR2L / P4L	Second Temp. point / Pressure point 4 (or Signature) (8LSB)
9	GNTC3L / PC3L	Third gain TC / Pressure coefficient 3 (or Signature) (8LSB)
10	OFTC3L / P3L	Third offset TC / Pressure point 2 (or Signature) (8LSB)
11	TR3L / PC2L	Third Temperature point/ Pressure coefficient 2 (8LSB)
12	GNTC4L / P2L	Fourth gain TC / Pressure point 1 (8LSB)
13	OFTC4L / PC1L	Fourth offset TC/ Pressure coefficient 1 (8LSB)
14	DIGMOP1L	Fixed Pressure (8LSB)
15	GN1H_OF1H	Fixed Gain and Fixed offset (4MSB-4LSB)
16	GNTC1H_OFTC1H	First Gain TC and Offset TC (4MSB-4LSB)
17	TR1H/PC5H_GNTC2H/P5H	First Temperature point / Pressure coefficient 5 (4MSB-4LSB) Second Gain TC/ Pressure Point 5 (4MSB-4LSB)
18	OFTC2H/PC4H_TR2H/P4H	Second Offset TC / Pressure coefficient 4 (4MSB-4LSB) Second Temperature point/ Pressure Point 4 (4MSB-4LSB)
19	GNTC3H/PC3H_OFTC3H/ P3H	Third Gain TC / Pressure coefficient 3 (4MSB-4LSB) Third Offset TC/ Pressure Point 3 (4MSB-4LSB)
20	TR3H/PC2H_GNTC4H/P2H	Third Temperature point / Pressure coefficient 2 (4MSB-4LSB) Fourth Gain TC/ Pressure Point 2 (4MSB-4LSB)
21	OFTC4H/ PC1H_DIGMOP1H	Fourth Offset TC / Pressure coefficient 1 (4MSB-4LSB) Fixed pressure (4MSB)
22	PNB_TNB	Address of the last pressure point and temperature point
23-24	Filter	Filter Coefficient
25-26	GN	Offset Ordinate of the current gap
27-28	OF	Gain Ordinate of the current gap
29	Taddress	4 bits for the max. temperature address of the current gap 4 bits for the min. Temperature address of the current gap
30	ALARM control byte IO1/IO2 control byte	3 bits needed for choice of input for ALARM detection (TPO, IAO, GNO, VMO, IO1 or IO2) 2 bits needed for choice of input for LEVEL-steering (TPO, IAO, GNO or VMO) These bits are multiplexed according the mode. Note: if both CMO and VMO are active, then alarm is not active.
31	ALARM low trigger level IO1/IO2 level 1	Value below which ALARM will go on value of first level ([IO2,IO1]=00-01)
32	ALARM low output level IO1/IO2 level 2	Value of DIGMO during “ALARM low” condition value of second level ([IO2,IO1] =01-10)
33	ALARM high trig. Level IO1/ IO2 level 3	Value above which ALARM will go on value of third level ([IO2,IO1]=10-11)

RAM Byte Definitions (cont.)

Byte	Functions	Remarks
34	ALARM high output level	Value of DIGMO during "ALARM high" condition
35-36	A_16	16 bits A Register
37-38	B_16	16 bits B Register
39-42	RESULT_32	32 bits result (for 16 bits multiplication)
43-44	Tempo1	Measured Temperature (int. or ext.) & Temporary variable 1
45	Tempo2	Temporary variable 2
46	Tempo3	Temporary variable 3
47-48	Rx_char	Received character on the serial port
49	P3_copy	Port 3 settings' copy
50	Adsav1	Address saved when interrupt
51-52	Aaccsav	A-Accumulators saved when interrupt
53	Baccsav	B-Accumulators saved when interrupt
54-55	DAC_gain	DAC gain (GN)
56-57	DAC_offset	DAC offset (OF)
58-59	F_Temp	Final Temperature
60-61	Pressure	Pressure
62-63	Adsav2	Address saved when call

Note: Because of space trouble, the measured temperature can't be kept in the RAM, all the time. If the user wants to see the measured temperature, he must set 65535 in the Filter Factor variable.

RAM's Data

All the coefficients (pressure, temperature) are compacted, similar to the EEPROM. They are stored on 12 bits instead of keeping 16 bits for each coefficient. All the measurements are stored on 16 bits.
In any case, the user must have an access to the RAM and the EEPROM, meanwhile interrupt reading of the serial port. Therefore, we must keep bytes for the return address, the A-accu and the B-accu, when an interrupt occurs.
Anyway, the RAM keeps the same structure in the both modes.

Data Range

The different data has the range followed:
Temperature points: 10 bits, 0-03FF in high-low order
Pressure points: 10 bits, 0-03FF in high-low order
GN1: 10 bits, 0-03FF in high-low order
OF1: 10 bits, 0-03FF in high-low order
GNTCi: signed 12 bits (with MSB for the sign), [-1.9990234, +1.9990234]
OFTCi: signed 12 bits (with MSB for the sign), [-1.9990234, +1.9990234]
Pci: signed 12 bits (with MSB for the sign), [-1.9990234, +1.9990234]
DIGMO: 10 bits, 0-03FF in high-low order.

The representation of all values are discussed below :

Temp Measurement

- unsigned 10-bit value
- Measured in firmware, visible from RAM (low byte 58, high byte 59) if filter is set to 65535.

Range :
RAM[59]=00, RAM[58]=00 -> Text = 0
RAM[59]=03, RAM[58]=FF -> Text = 1023

Temp Points

- unsigned 10-bit value
- Set in EEPROM by calibration program.

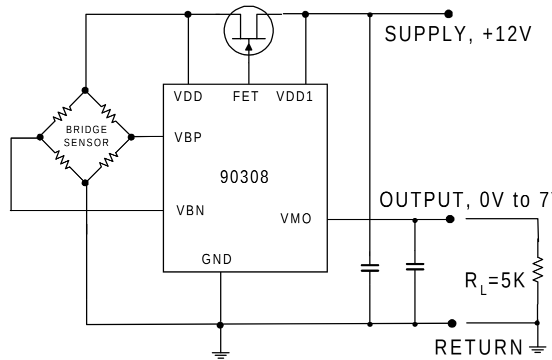
Prototyping

Melexis has available a MLX90308 evaluation kit which contains an evaluation circuit board, serial interface cable, and software diskette. The circuit board provides the neccessary circuitry for all three applications circuits shown in the MLX90308 datasheet (section 4 of this book). Also contained on the board is level shifting and glue logic necessary for RS-232 communicatios.

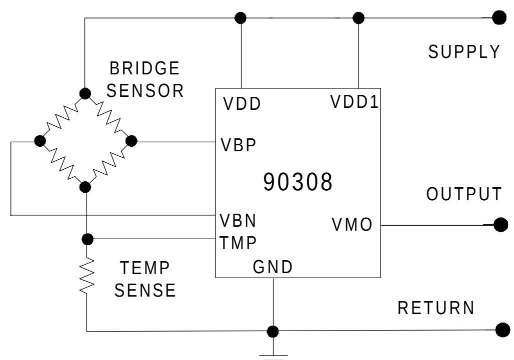
The board has a socket with a single MLX90308 installed, and direct access to the pins of the IC. The user can easily attach bridge sensor to the board for in-system evaluation. The serial interface cable connects the evaluation board directly to a PC's serial port for in-system calibration.

The software runs in the familiar Windows platform and allows for programming and evalution of all compensation parameters within the EEPROM.

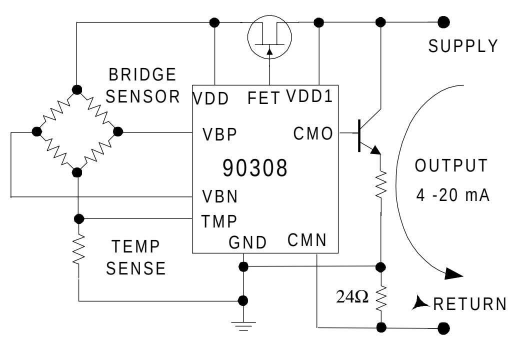
Application Schematics



Absolute Voltage Mode

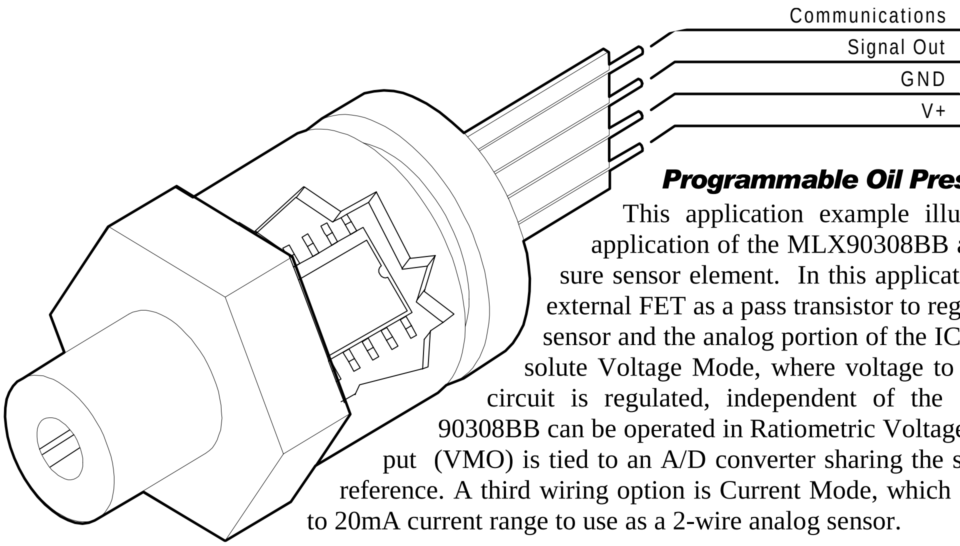


Ratiometric Voltage Mode



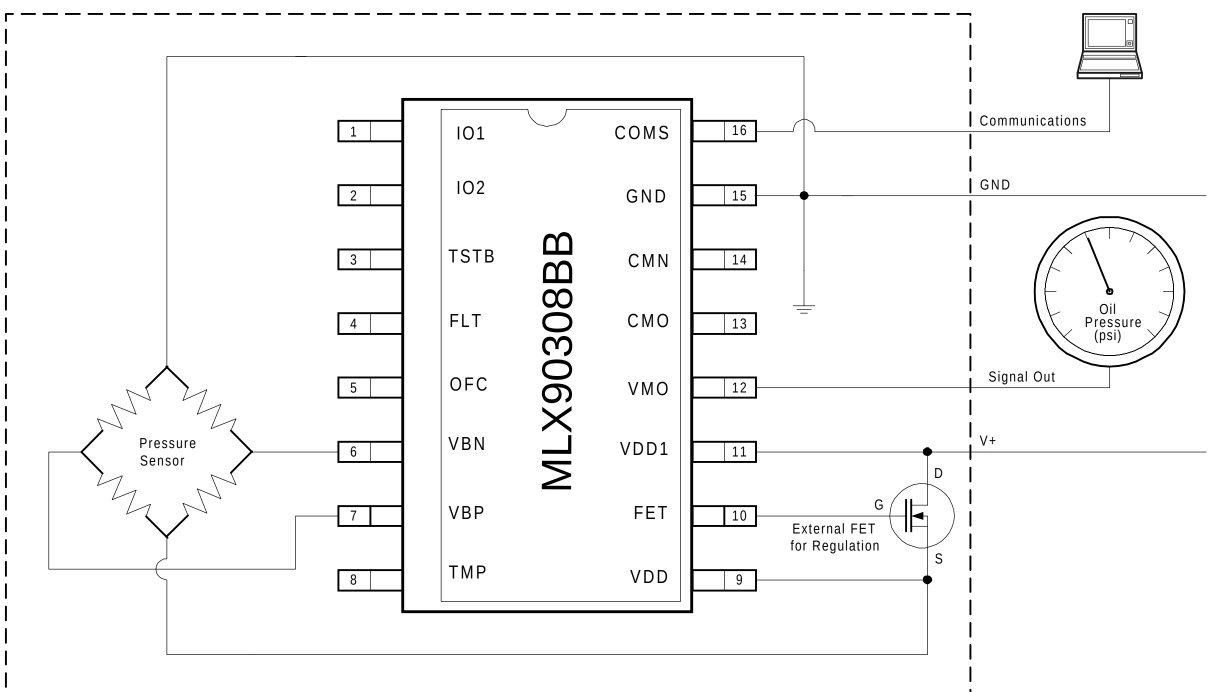
Current Mode

Application Example



Programmable Oil Pressure Gauge

This application example illustrates a fundamental application of the MLX90308BB and a bridge type pressure sensor element. In this application, the 90308 uses an external FET as a pass transistor to regulate the voltage to the sensor and the analog portion of the IC. This is known as Absolute Voltage Mode, where voltage to the sensor and analog circuit is regulated, independent of the supply voltage. The 90308BB can be operated in Ratiometric Voltage Mode, where the output (VMO) is tied to an A/D converter sharing the same Supply and GND reference. A third wiring option is Current Mode, which allows the user a 4mA to 20mA current range to use as a 2-wire analog sensor.



Typical Application

Error Compensation

Figure A

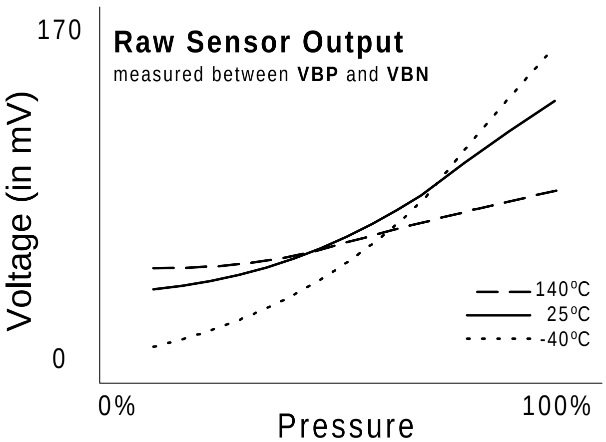
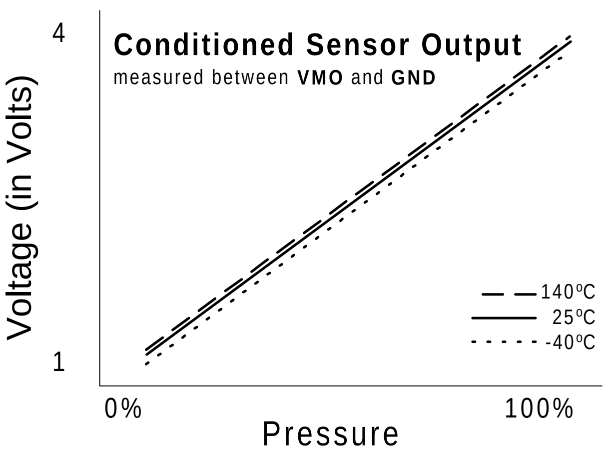


Figure B

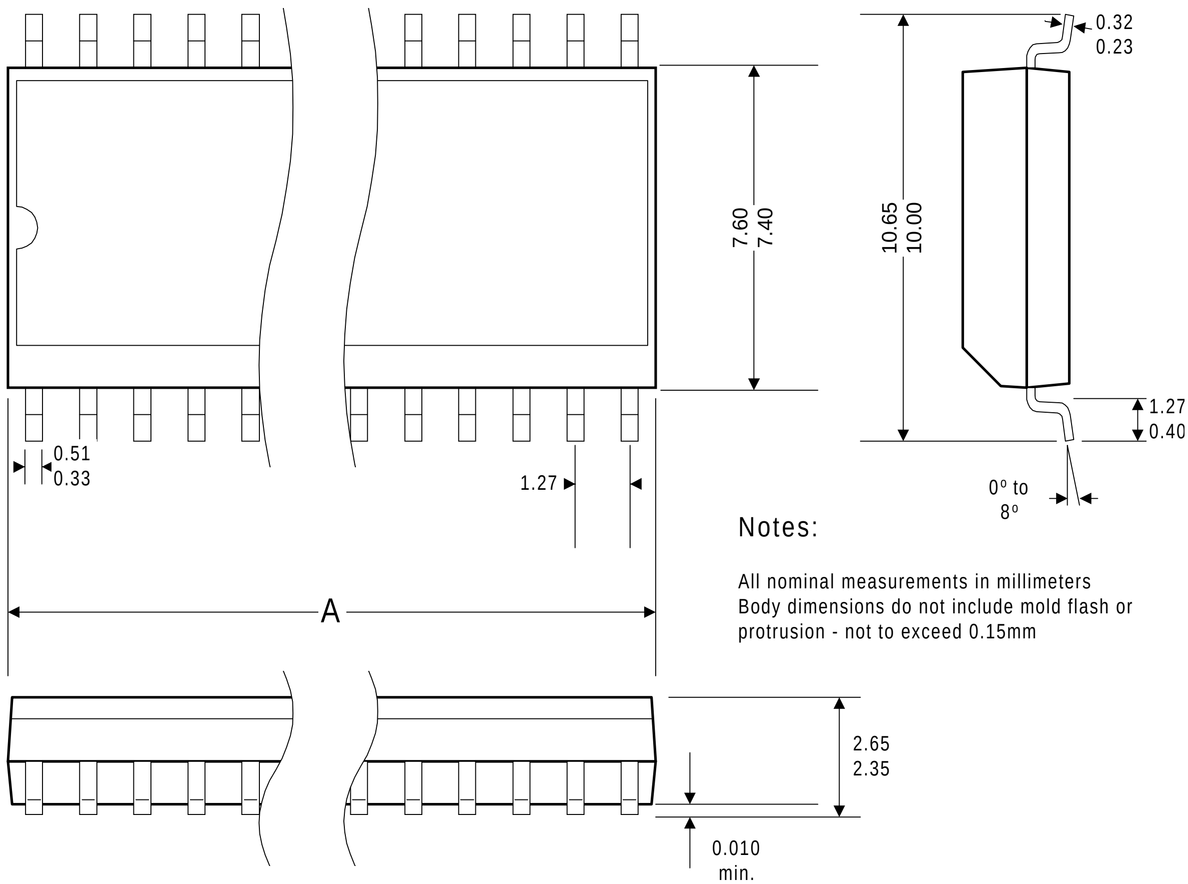


The figures above illustrate the performance of an unconditioned sensor output and a conditioned sensor output versus stimulus (pressure) and temperature. Notice that figure A has a range of only 170mV(Max range with a 5V supply) and has a non-linear response over a 0-100psi range. The sensitivity of the unconditioned output will also drift over temperature, as illustrated by the three slopes. The MLX90308 corrects these errors and also amplifies the output to a more usable voltage range as shown in figure B.

Glossary of Terms

A/D	Analog to digital conversion
ADC	Analog to digital converter
ASCII	American Standard Code for Information Interchange
ASIC	Application Specific Integrated Circuit
CM	Current Mode
CMN	Current Mode Negative (supply connection)
CMO	Current Mode Output
COMS	Communication, Serial
CR	Carrage Return
CSGN	Coarse Gain
CSOF	Coarse Offset
CV	Current/Voltage Mode select bit
DAC	Digital to analog converter
DACFnew	Filtered DAC value, new
DACFold	Filtered DAC value, old
DARDIS	DAC Resistor Disable
dB	Decibel
DOGMO	Digital Mode
EEPROM	Electrically Erasable Programmable Read Only Memory
EOC	End Of Conversion flag bit
ESD	Electro-Static Discharge
ETMI	Timer Interrupt Enable
ETPI	Enable Temperature Interrupt
FET	Field Effect Transistor
FG	Fixed Gain
FLT	Filter pin
GNO	Gain and Offset adjusted digitized signal
GNOF	Gain, Offset
GNTP	Temperature gain/offest coarse adjustment
HS	Hardware/Software limit
I/O	Input/Output
IFIX	Fixed current output value
IINV	Input signal invert command bit
ILIM	Current Limit
KHz	Kilo Hertz, 1000 Hz
LSB	Least Significant Bit
mA	mili Amps, 0.001 Amps
MODSEL	Mode Select
ms	mili Second, 0.001 second
MUX	Multiplexer
mV	mili Volts, 0.001 Volts
nF	nano Farads, 1 X 10^{-9} Farads
OFC	Offset Control
PC	Personal Computer, IBM clone
pF	pico Farad, 1 X 10^{-12} Farad
PLL	Phase Locked Loop
POR	Power On Reset
RAM	Random Access Memory
RISC	Reduced Instruction Set Computer
ROM	Read Only Memory
RS-232	Insustry standard serial communications protocol
RX	Receive
SAR	Successive Approximation Register
STC	Start A/D conversion
Tdiff	Temperature difference
Text	Temperature External
TMI	Timer Interrupt
TMP	Temperature Signal
TPI	Temperature Interrupt
Tref	Temperature Reference
TSTB	Test mode pin
TX	Transmit
UART	Universal Asynchronous Receiver/ Transmitter
VBN	Bridge, positive, input
VBP	Bridge, negative, input
Vdd	Supply voltage
VM	Voltage Mode
VMGN	Voltage Mode Gain
VMO	Voltage Mode Output
WCB	Warn/Cold Boot
WDC	Watch Dog Counter

Physical Characteristics



Notes:

All nominal measurements in millimeters
Body dimensions do not include mold flash or protrusion - not to exceed 0.15mm

Dimension		16 Leads
A	Max Min	10.50 10.10

For more information, please contact:
Melexis, Inc.
41 Locke Road
Concord, NH 03301
Phone: (603) 223-2362 Fax: (603)223-9614
E-mail: sales@melexis.com
Web: www.melexis.com

CERTIFIED
ISO 9002