High Accuracy, Ultralow I_Q, 1 A, anyCAP® Low Dropout Regulator

ADP3338

FEATURES

High accuracy over line and load: ±0.8% @ 25°C, ±1.4% over temperature
Ultralow dropout voltage: 190 mV (typ) @ 1 A
Requires only C_O = 1.0 µF for stability
anyCAP is stable with any type of capacitor (including MLCC)
Current and thermal limiting
Low noise
2.7 V to 8 V supply range
−40°C to +85°C ambient temperature range
SOT-223 package

APPLICATIONS

Notebook, palmtop computers
SCSI terminators
Battery-powered systems
Bar code scanners
Camcorders, cameras
Home entertainment systems
Networking systems
DSP/ASIC supplies

FUNCTIONAL BLOCK DIAGRAM

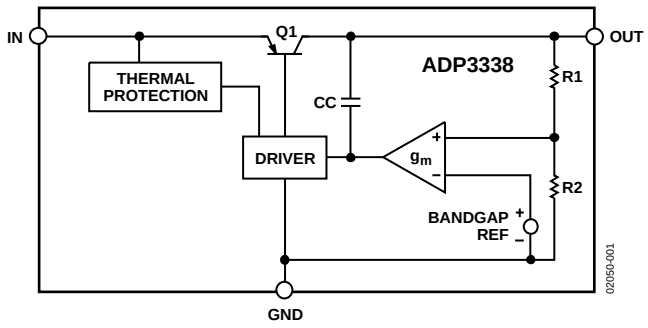

Figure 1.

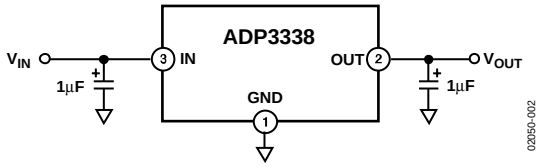

Figure 2. Typical Application Circuit

GENERAL DESCRIPTION

The ADP3338 is a member of the ADP33xx family of precision, low dropout (LDO), anyCAP voltage regulators. The ADP3338 operates with an input voltage range of 2.7 V to 8 V and delivers a load current up to 1 A. The ADP3338 stands out from conventional LDOs with a novel architecture and an enhanced process that offers performance advantages and higher output current than its competition. Its patented design requires only a 1 µF output capacitor for stability. This device is insensitive to output capacitor equivalent series resistance (ESR), and is stable with any good quality capacitor, including ceramic (MLCC) types for space-restricted applications. The ADP3338 achieves exceptional accuracy of ±0.8% at room temperature and ±1.4% over temperature, line, and load variations. The dropout voltage of the ADP3338 is only 190 mV (typical) at 1 A. The device also includes a safety current limit and thermal overload protection. The ADP3338 has ultralow quiescent current: 110 µA (typical) in light load situations.

Rev. B

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MS5837-30BA

Ultra-small, gel-filled, pressure sensor with stainless steel cap

The MS5837-30BA is a high-resolution pressure and temperature sensor from TE Connectivity (TE) with I^2C bus interface. This sensor is optimized for water depth measurement systems with a resolution of 0.2 cm. The sensor module includes a high linearity pressure sensor and an ultra-low power 24-bit ΔΣ ADC with internal factory calibrated coefficients. It provides a precise digital 24-bit pressure and temperature value and different operation modes that allow the user to optimize for conversion speed and current consumption. A high-resolution temperature output allows the implementation in depth measurement systems and thermometer function without any additional sensor. The MS5807-30BA can be interfaced to virtually any microcontroller. The communication protocol is simple, without the need of programming internal registers in the device. The gel protection and antimagnetic stainless-steel cap make the module water resistant.

Small dimensions of only 3.3 x 3.3 x 2.75 mm allow integration in mobile devices. Enhanced construction and design materials allow for enhanced chemical endurance in applications with harsh liquid media environments with limited exposure. This sensor module generation is based on leading MEMS technology from TE proven experience and know-how in high volume manufacturing of sensors modules.

APPLICATIONS

- Dive Computers
- Mobile Water Depth Measurement Systems
- Fitness Trackers
- Wearables
- Drug delivery
- Injection pumps
- Medical Portable Devices

FEATURES

- Ceramic and metal package: 3.3 x 3.3 x 2.75mm
- High resolution module: 0.2 cm (in water)
- Supply voltage: 1.5 to 3.6 V
- Low power: 0.6 µA (standby ≤ 0.1 µA at 25°C)
- Integrated digital pressure sensor (24-bit ΔΣ ADC)
- Operating range: 0 to 30 bar, -20 to +85 °C
- I^2C interface
- No external components (internal oscillator)
- Water resistant sealing with 1.8 x 0.8mm O-ring
- High chemical endurance
- Shielded metal lid

PERFORMANCE SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Min.	Typ.	Max	Unit
Supply voltage	V_{DD}		-0.3		+4	V
Storage temperature	T_S		-40		+85	°C
Overpressure	P_{max}	ISO 6425 (1)			50	bar
Maximum Soldering Temperature (2)	T_{max}	40 sec max			250	°C
ESD rating		Human Body Model	-2		+2	kV
Latch up		JEDEC standard No 78	-100		+100	mA

(1): Pressure ramp up/down min 60s
(2): Refer to application note 808

ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Conditions		Min.	Typ.	Max	Unit
Operating Supply voltage	V_{DD}			1.5	3.0	3.6	V
Operating Temperature	T			-20	+25	+85	°C
Supply current (1 sample per sec.)	I_{DD}	OSR	8192 4096 2048 1024 512 256		20.09 10.05 5.02 2.51 1.26 0.63		µA
Peak supply current		during conversion			1.25		mA
Standby supply current		at 25°C (V_{DD} = 3.0V)			0.01	0.1	µA
Power supply hold off for internal reset (3)		VDD < 0.1V		200			ms
VDD Capacitor		From V_{DD} to GND		100	470		nF

(3): Supply voltage power up must be continuous from GND to VDD without any step

ANALOG DIGITAL CONVERTER (ADC)

Parameter	Symbol	Conditions		Min.	Typ.	Max	Unit
Output Word					24		bit
Conversion time (4)	t_c	OSR	8192 4096 2048 1024 512 256	14.80 7.40 3.72 1.88 0.95 0.48	16.44 8.22 4.13 2.08 1.06 0.54	18.08 9.04 4.54 2.28 1.17 0.60	ms

(4): Maximum values must be used to determine waiting times in I2C communication

PERFORMANCE SPECIFICATIONS (CONTINUED)

PRESSURE OUTPUT CHARACTERISTICS (V_{DD} = 3 V, T = 25°C UNLESS OTHERWISE NOTED)

Parameter	Conditions		Min.	Typ.	Max	Unit
Operating Pressure Range		P_{range}	0		30	bar
Absolute Accuracy (3), Temperature range: 0 … 45°C	Version -01	0 … 6 bar	-50		+50	mbar
	Version -28		-75		+75	mbar
Absolute Accuracy (3), Temperature range: 0 … 45°C	0 … 20 bar 0 … 30 bar		-100 -200		+100 +200	mbar
Absolute Accuracy (3), Temperature range: -20 … 85°C	Version -01	0 … 6 bar	-100		+100	mbar
	Version -28		-150		+150	mbar
Absolute Accuracy (3), Temperature range: -20 … 85°C	0 … 20 bar 0 … 30 bar		-200 -400		+200 +400	mbar
Maximum error with supply voltage (1)	Version -01	V_{DD} = 1.5 V … 3.6 V		±30		mbar
	Version -28			±50		mbar
Long-term stability				±30		mbar/yr
Reflow soldering impact IPC/JEDEC J-STD-020C	Version -01			±8		mbar
	Version -28			±30		mbar
Recovering time after reflow (2)				7		days
Resolution RMS	OSR 8192 4096 2048 1024 512 256			0.20 0.28 0.38 0.54 0.84 1.57		mbar

(1) With autozero at 3V point

(2) Time to recover at least 66% of the reflow impact.

(3) Wet/dry cycle: sensor must be dried typically once a day

TEMPERATURE OUTPUT CHARACTERISTICS (V_{DD} = 3 V, T = 25°C UNLESS OTHERWISE NOTED)

Parameter	Conditions	Min.	Typ.	Max	Unit
Absolute Accuracy	-20°C … +85°C	-4		+4	°C
Maximum error with supply voltage	V_{DD} = 1.5 V … 3.6 V		± 0.6		°C
Resolution RMS	OSR 8192 4096 2048 1024 512 256		0.0022 0.0026 0.0033 0.0041 0.0055 0.0086		°C

PERFORMANCE SPECIFICATIONS (CONTINUED)

DIGITAL INPUTS (SCL, SDA)

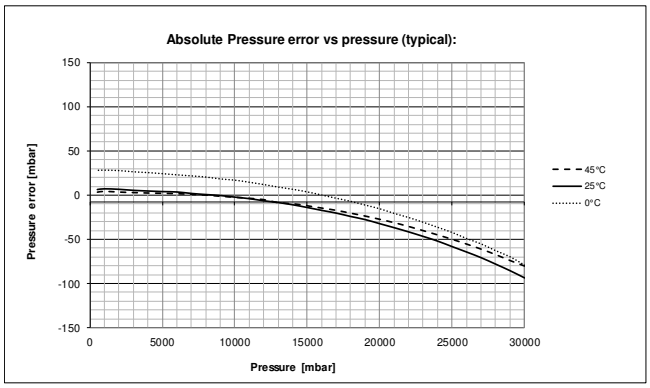
Parameter	Symbol	Conditions	Min.	Typ.	Max	Unit
Serial data clock	SCL				400	kHz
Input high voltage	V_{IH}		80% V_{DD}		100% V_{DD}	V
Input low voltage	V_{IL}		0% V_{DD}		20% V_{DD}	V
Input leakage current	$I_{leak25°C}$	at 25°c			0.1	µA

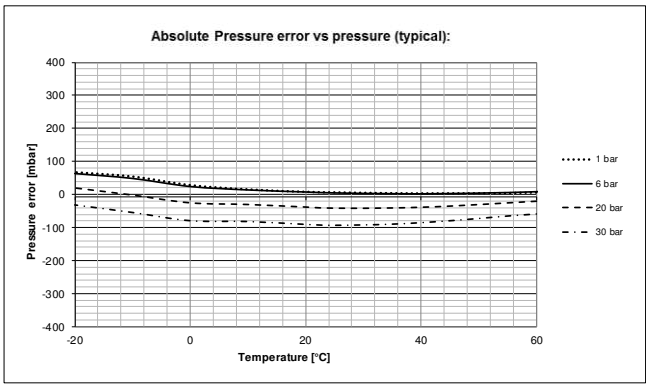
DIGITAL OUTPUTS (SDA)

Parameter	Symbol	Conditions	Min.	Typ.	Max	Unit
Output high voltage	V_{OH}	I_{source} = 0.6 mA	80% V_{DD}		100% V_{DD}	V
Output low voltage	V_{OL}	I_{sink} = 0.6 mA	0% V_{DD}		20% V_{DD}	V

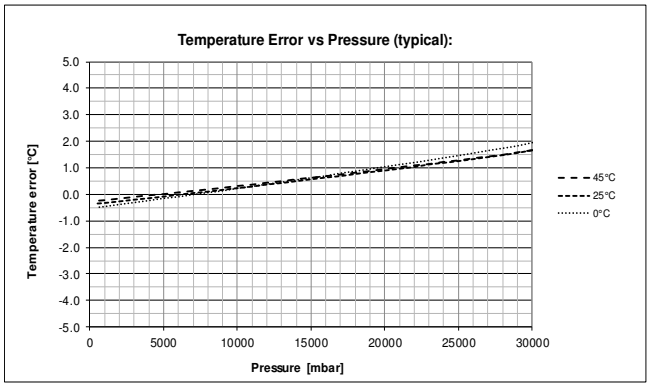
TYPICAL PERFORMANCE CHARACTERISTICS

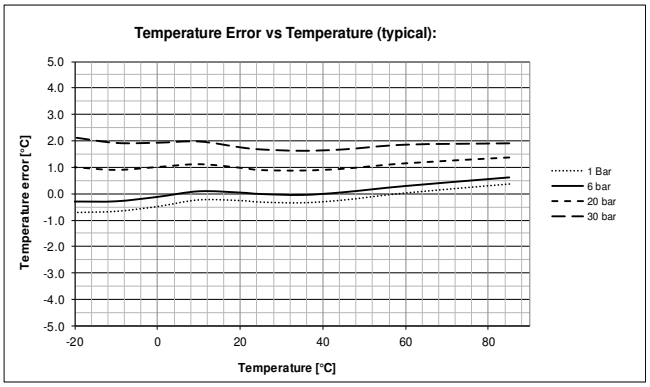
PRESSURE ERROR VS PRESSURE AND TEMPERATURE



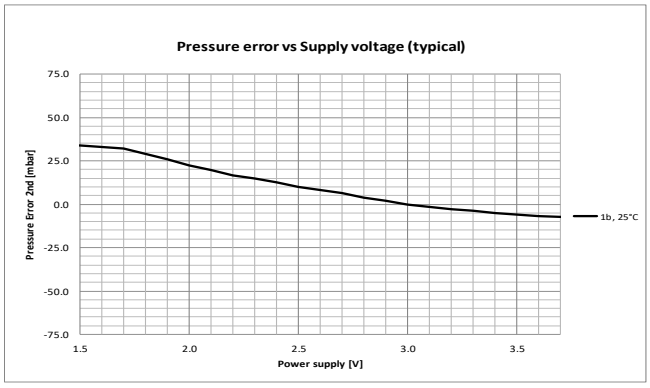


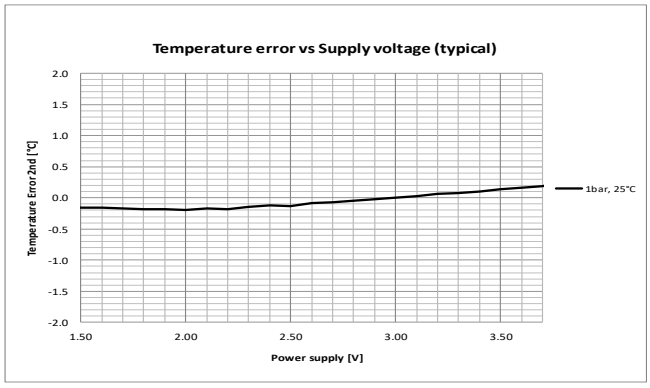
TEMPERATURE ERROR VS PRESSURE AND TEMPERATURE





PRESSURE AND TEMPERATURE VS SUPPLY VOLTAGE





FUNCTIONAL DESCRIPTION

GENERAL

The MS5837-30BA consists of a piezo-resistive sensor and a sensor interface IC. The main function of the MS5837-30BA is to convert the uncompensated analog output voltage from the piezo-resistive pressure sensor to a 24-bit digital value, as well as providing a 24-bit digital value for the temperature of the sensor

FACTORY CALIBRATION

Every module is individually factory calibrated at two temperatures and two pressures. As a result, 6 coefficients necessary to compensate for process variations and temperature variations are calculated and stored in the 112-bit PROM of each module. These bits (partitioned into 6 coefficients W1 to W6) must be read by the microcontroller software and used in the program converting D1 and D2 into compensated pressure and temperature values.
The coefficients W0 is for factory configuration and CRC.

SERIAL I^2C INTERFACE

The external microcontroller clocks in the data through the input SCL (Serial CLock) and SDA (Serial DAta). The sensor responds on the same pin SDA which is bidirectional for the I^2C bus interface. So this interface type uses only 2 signal lines and does not require a chip select.

Module ref	Mode	Pins used	Address (7 bits)
MS5837-30BA	I^2C	SDA, SCL	0x76 (1110110 b)

COMMANDS

The MS5837-30BA has only five basic commands:

1. Reset
2. Read PROM (128 bit of calibration words)
3. D1 conversion
4. D2 conversion
5. Read ADC result (24 bit pressure / temperature)

Size of each command is 1 byte (8 bits) as described in the table below. After ADC read commands the device will return 24 bit result and after the PROM read 16bit result. The address of the PROM is embedded inside of the PROM read command using the a2, a1 and a0 bits.

	Command byte								**hex value**
Bit number	0	1	2	3	4	5	6	7	
Bit name	PRM	COV	-	Typ	Ad2/ Os2	Ad1/ Os1	Ad0/ Os0	Stop	
Command									
Reset	0	0	0	1	1	1	1	0	0x1E
Convert D1 (OSR=256)	0	1	0	0	0	0	0	0	0x40
Convert D1 (OSR=512)	0	1	0	0	0	0	1	0	0x42
Convert D1 (OSR=1024)	0	1	0	0	0	1	0	0	0x44
Convert D1 (OSR=2048)	0	1	0	0	0	1	1	0	0x46
Convert D1 (OSR=4096)	0	1	0	0	1	0	0	0	0x48
Convert D2 (OSR=256)	0	1	0	1	0	0	0	0	0x50
Convert D2 (OSR=512)	0	1	0	1	0	0	1	0	0x52
Convert D2 (OSR=1024)	0	1	0	1	0	1	0	0	0x54
Convert D2 (OSR=2048)	0	1	0	1	0	1	1	0	0x56
Convert D2 (OSR=4096)	0	1	0	1	1	0	0	0	0x58
ADC Read	0	0	0	0	0	0	0	0	0x00
PROM Read	1	0	1	0	Ad2	Ad1	Ad0	0	0xA0 to 0xAC

Figure 1: Command Structure

I²C INTERFACE

RESET SEQUENCE

The Reset sequence shall be sent once after power-on to make sure that the calibration PROM gets loaded into the internal register. It can be also used to reset the device PROM from an unknown condition.
The reset can be sent at any time. In the event that there is not a successful power on reset this may be caused by the SDA being blocked by the module in the acknowledge state. The only way to get the MS5837-30BA to function is to send several SCLs followed by a reset sequence or to repeat power on reset.

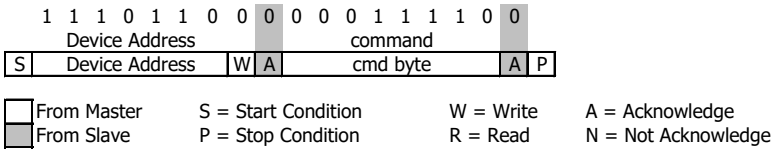


Figure 2: I²C Reset Command

PROM READ SEQUENCE

The read command for PROM shall be executed once after reset by the user to read the content of the calibration PROM and to calculate the calibration coefficients. There are in total 7 addresses resulting in a total memory of 112 bit. Addresses contain factory data and the setup, calibration coefficients, the serial code and CRC. The command sequence is 8 bits long with a 16 bit result which is clocked with the MSB first. The PROM Read command consists of two parts. First command sets up the system into PROM read mode. The second part gets the data from the system.

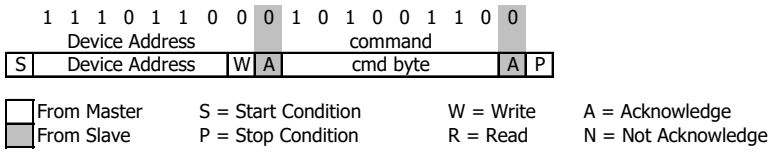


Figure 3: I²C Command to read memory address= 011

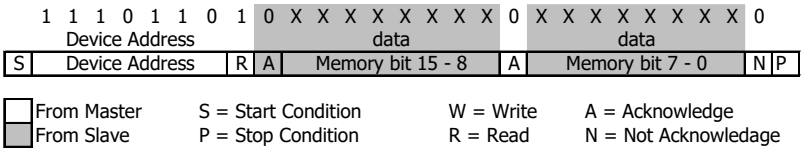


Figure 4: I²C answer from MS5837-30BA

CONVERSION SEQUENCE

The conversion command is used to initiate uncompensated pressure (D1) or uncompensated temperature (D2) conversion. After the conversion, using ADC read command the result is clocked out with the MSB first. If the conversion is not executed before the ADC read command, or the ADC read command is repeated, it will give 0 as the output result. If the ADC read command is sent during conversion the result will be 0, the conversion will not stop and the final result will be wrong. Conversion sequence sent during the already started conversion process will yield incorrect result as well. A conversion can be started by sending the command to MS5837-30BA. When command is sent to the system it stays busy until conversion is done. When conversion is finished the data can be accessed by sending a Read command, when acknowledge is sent from the MS5837-30BA, 24 SCL cycles may be sent to receive all result bits. Every 8 bits the system waits for an acknowledge signal.

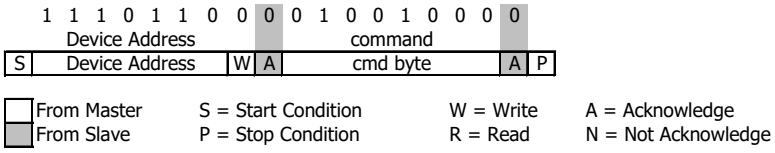


Figure 5: I²C command to initiate a pressure conversion (OSR=4096, typ=D1)

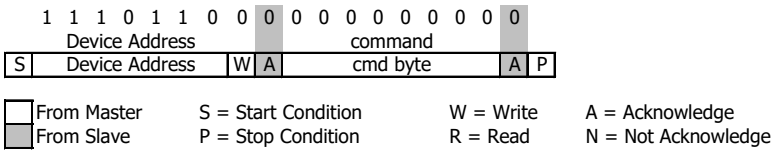


Figure 6: I²C ADC read sequence

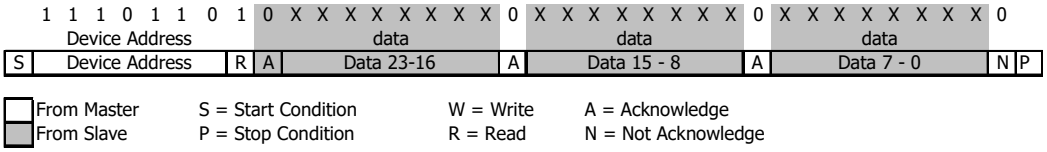


Figure 7: I2C answer from MS5837-30BA

Version PROM Word 0 programming

For product type, the bits [11:5] of memory address 0 must be programmed with the following fixed values:

MS5837-30BA26

Address	*15*	*14*	*13*	*12*	11	10	9	8	7	6	5	*4*	*3*	*2*	*1*	*0*
0	*crc*				**0**	**0**	**1**	**1**	**0**	**1**	**0**	*factory settings*				

CYCLIC REDUNDANCY CHECK (CRC)

MS5837-30BA contains a PROM memory with 112-Bit. A 4-bit CRC has been implemented to check the data validity in memory. The besides C code describes in detail CRC-4 calculation.

	DB15	DB14	DB13	DB12	DB11	DB10	DB9	DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	CRC				Factory defined											
1	C1															
2	C2															
3	C3															
4	C4															
5	C5															
6	C6															

Figure 8: Memory PROM mapping

C Code example for CRC-4 calculation:

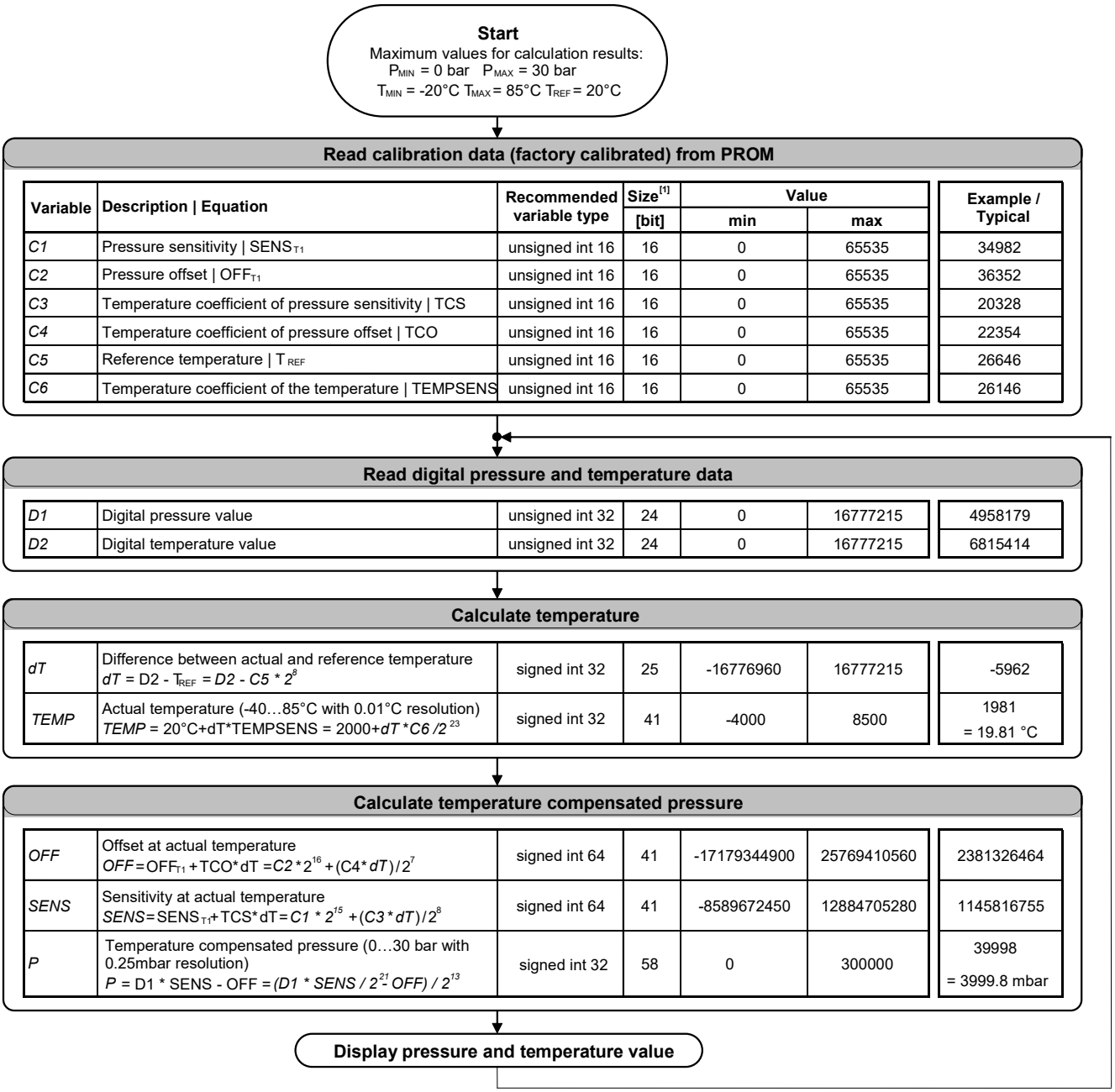
```
unsigned char crc4(unsigned int n_prom[])                    // n_prom defined as 8x unsigned int (n_prom[8])
{
int cnt;                                                     // simple counter
unsigned int n_rem=0;                                        // crc remainder
unsigned char n_bit;

        n_prom[0]=((n_prom[0]) & 0x0FFF);                    // CRC byte is replaced by 0
        n_prom[7]=0;                                         // Subsidiary value, set to 0
        for (cnt = 0; cnt < 16; cnt++)                       // operation is performed on bytes
                {                                            // choose LSB or MSB

                if (cnt%2==1)       n_rem ^= (unsigned short) ((n_prom[cnt>>1]) & 0x00FF);
                else                n_rem ^= (unsigned short) (n_prom[cnt>>1]>>8);
                for (n_bit = 8; n_bit > 0; n_bit--)
                        {
                        if (n_rem & (0x8000))       n_rem = (n_rem << 1) ^ 0x3000;
                        else                        n_rem = (n_rem << 1);
                        }

                }
        n_rem= ((n_rem >> 12) & 0x000F);                     // final 4-bit remainder is CRC code
        return (n_rem ^ 0x00);
}
```

PRESSURE AND TEMPERATURE CALCULATION



Read calibration data (factory calibrated) from PROM

Variable	Description | Equation	Recommended variable type	Size[1] [bit]	Value min	Value max	Example / Typical
C1	Pressure sensitivity | $SENS_{T1}$	unsigned int 16	16	0	65535	34982
C2	Pressure offset | OFF_{T1}	unsigned int 16	16	0	65535	36352
C3	Temperature coefficient of pressure sensitivity | TCS	unsigned int 16	16	0	65535	20328
C4	Temperature coefficient of pressure offset | TCO	unsigned int 16	16	0	65535	22354
C5	Reference temperature | T_{REF}	unsigned int 16	16	0	65535	26646
C6	Temperature coefficient of the temperature | TEMPSENS	unsigned int 16	16	0	65535	26146

Read digital pressure and temperature data

D1	Digital pressure value	unsigned int 32	24	0	16777215	4958179
D2	Digital temperature value	unsigned int 32	24	0	16777215	6815414

Calculate temperature

dT	Difference between actual and reference temperature $dT = D2 - T_{REF} = D2 - C5 * 2^8$	signed int 32	25	-16776960	16777215	-5962
TEMP	Actual temperature (-40…85°C with 0.01°C resolution) $TEMP = 20°C + dT * TEMPSENS = 2000 + dT * C6 / 2^{23}$	signed int 32	41	-4000	8500	1981 = 19.81 °C

Calculate temperature compensated pressure

OFF	Offset at actual temperature $OFF = OFF_{T1} + TCO * dT = C2 * 2^{16} + (C4 * dT) / 2^7$	signed int 64	41	-17179344900	25769410560	2381326464
SENS	Sensitivity at actual temperature $SENS = SENS_{T1} + TCS * dT = C1 * 2^{15} + (C3 * dT) / 2^8$	signed int 64	41	-8589672450	12884705280	1145816755
P	Temperature compensated pressure (0…30 bar with 0.25mbar resolution) $P = D1 * SENS - OFF = (D1 * SENS / 2^{21} - OFF) / 2^{13}$	signed int 32	58	0	300000	39998 = 3999.8 mbar

Notes
[1] Maximal size of intermediate result during evaluation of variable

Figure 9: Flow chart for pressure and temperature reading and software compensation.

SECOND ORDER TEMPERATURE COMPENSATION

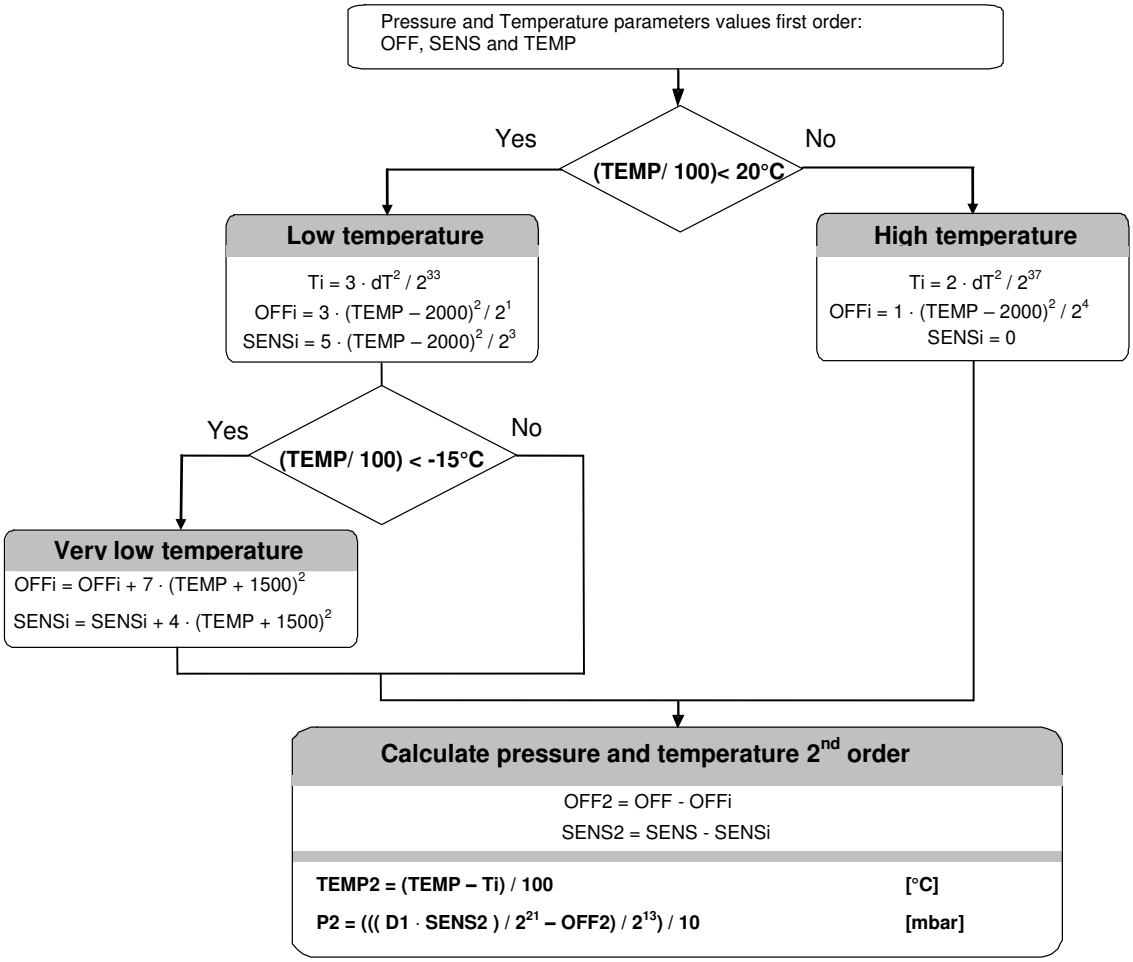


Figure 10: Flow chart for pressure and temperature to the optimum accuracy.

APPLICATION CIRCUIT

The MS5837 is a circuit that can be used in conjunction with a microcontroller in mobile altimeter applications.

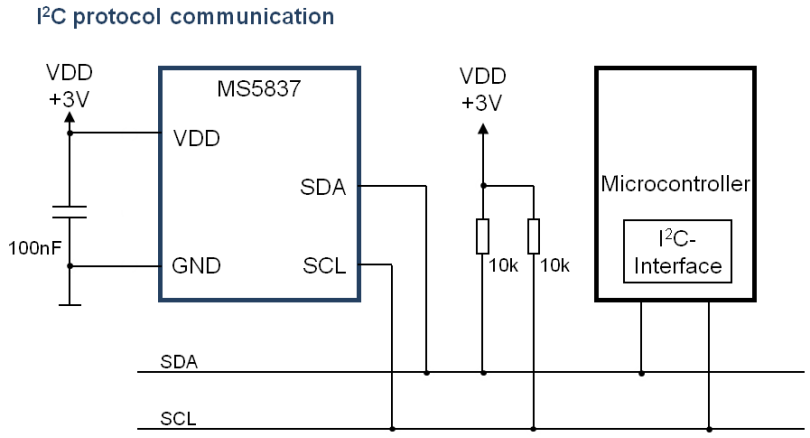
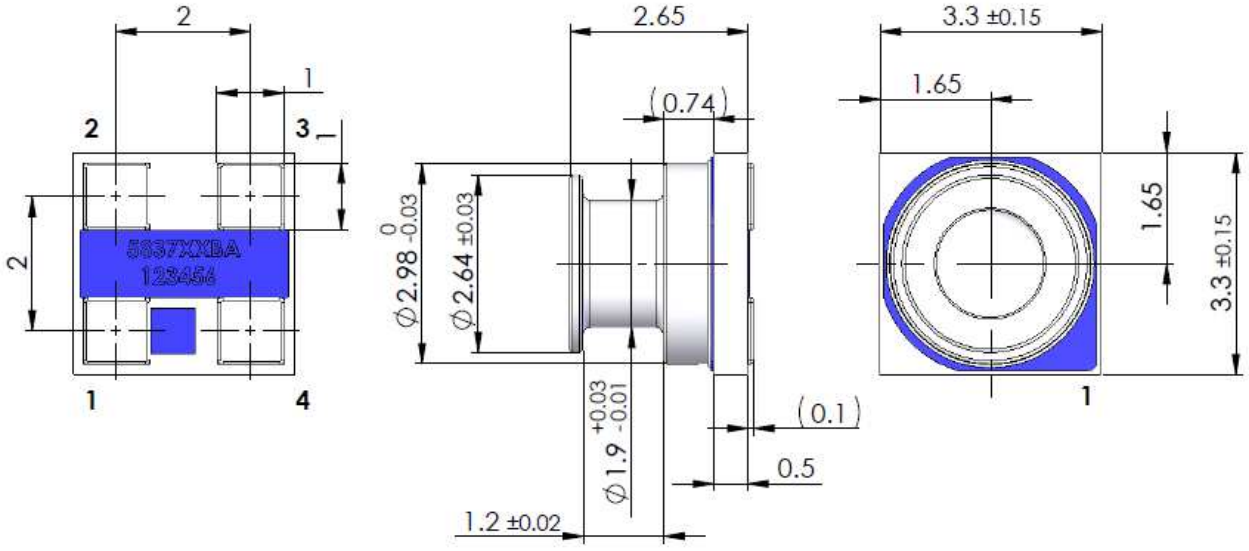


Figure 11: Typical application circuit

PIN CONFIGURATION AND DEVICE PACKAGE OUTLINE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS. GENERAL TOLERANCE ± 0.1



1	GND	GROUND
2	VDD	POSITIVE SUPPLY
3	SCL	I2C CLOCK
4	SDA	I2C DATA

Figure 12: Package outlines and Pin configuration

Water Pressure vs. Depth Table:

Depth (meters):	Pressure (millibars)
0	1013
5	1519
10	2026
20	3039
30	4052
40	5065
50	6078

Water pressure increases predictably with depth due to the weight of the water above. This table will help you implement the code converting pressure to depth.