SP40T

Tire Pressure Monitoring Sensor

Quality Requirement Category: Automotive

Features

- Patented Glass-Silicon-Glass MEMS pressure sensor with best-in-class media compatibility
- Calibrated pressure sensor for absolute air pressure measurement
- Z-axis accelerometer for motion detection and angular measurement
- Temperature and supply voltage sensors
- Industry-standard 8051 microcontroller with 14K of Flash memory
- System Controller with flexible wake-up and power management features
- RF Transmitter with fractional-N sigma-delta PLL
- Unique firmware functions for determination of angular wheel position, supporting tire localization (APS)
- LF Receiver allows carrier detection and modulated telegram reception

Variants

- SP40Truck (order code SP400-15-11, product code 0015_H) with pressure range up to 1400 kPa

Applications

- Valve based TPMS-Modules
- OEM
- Aftermarket
- Retrofit
- In Tire TPMS Modules

Description

The SP40T provides a very high level of integration, and is optimized to perform all of the functions necessary to implement a state-of-the-art Tire Pressure Monitoring System (TPMS) sensor module. With its integrated micro controller, sensors, and convenient peripherals, the SP40T needs the addition of only a few passive components and a battery to form a complete TPMS sensor assembly.

Figure 1 PG-DSOSP-14-82

1 Introduction

Measurements of pressure, acceleration, temperature, and battery voltage are performed under software control, allowing the application software to format and prepare the data for RF transmission. An intelligent system controller provides flexible wake-up capability in order to reduce energy usage. A calibrated Interval Timer is included to permit periodic wake-up of the CPU, which in turn can then perform measurements and transmit data to a receiver. The integrated Z-axis accelerometer may be used by the application software to detect motion and distinguish between parking and driving situation.

The integrated microcontroller is instruction set compatible to the standard 8051 processor and is supported by commercially available C compilers and IDE tool chains. The microcontroller core is supplemented with various peripherals (e.g. hardware Manchester/BiPhase Encoder/Decoder, CRC Generator/Checker, I2C- and UART-interface) that enable an easy implementation of TPMS application software.

For user specific application code the SP40T includes 12k of on-chip flash memory.

Another 2K of on-chip flash in a separated sector (extended code sector) is available, too. The main 12K code sector can be erased independently from the extended sector which allows for boot-loader functionality.

The RF Transmitter block covers both 315 and 434 MHz UHF bands and supports FSK and ASK modulation. The transmitter contains a fractional-N sigma-delta PLL synthesizer which allows for precise control of carrier frequency and accurate FSK frequency modulation. A flexible baseband encoder and advanced power management techniques are used to hold the peak current consumption during RF transmission to a minimum. An integrated autonomous LF Receiver allows the SP40T to receive diagnostic or operating state commands, supporting application features such as pressure-on-demand or tire position localization.

Finally, a comprehensive firmware library supports using all above mentioned hardware blocks effectively. Especially a unique set of Angular Position Sensing (APS) functions allows calculating the instantaneous angular position of the TPMS module relative to the car chassis which may be used for wheel localization on system level.

2 Specification

2.1 Absolute Maximum Ratings

Table 2-1 Absolute Maximum Ratings

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Max. Supply Voltage	V_{DDmax}	-0.3		+3.8	V		1.1
ESD robustness HBM	V_{ESD_HBM}	-2000		2000	V	All pins according to EIA/JESD22-A114-B	1.2
		-4000		4000	V	PAOUT pin according to EIA/JESD22-A114-B	1.3
ESD robustness CDM	V_{ESD_CDM}	-500		500	V	All pins (According to ESDA STM 5.3.1)	1.4
		-750		750	V	Corner pins (According to ESDA STM 5.3.1)	1.5
Latch up	I_{LU}	-100		+100	mA	AEC-Q100 (transient current)	1.6
Input voltage	V_{In}	-0.3		V_{DD} + 0.3	V	PP0, PP1, PP2, PP3	1.7
		-0.3		+1.8	V	LFP, LFN, XIN	1.8
	V_{In_LF}	-0.3		+0.3	V	Differential input at LFP and LFN	1.9
Peak voltage at PAOUT pin	V_{PAOUT_peak}			8	V	The matching network must be designed such that the peak-voltage at PA does not exceed this value	1.10
Output short-circuit capability[1)]	V_{SC}	0		3.8	V	Short to VDD, GND or neighbor pin for max. 10min at VDD=3.8V. **Note: VDDREG and XOUT must not be shorted to VDD**	1.11
DC current	I_{DC}	-10		10	mA	all pins	1.13
Over pressure	p_{max}			2000	kPa	static load	1.14
Burst pressure	p_{burst}	2000			kPa	10 times 1 sec	1.15
Static acceleration	a_{static}			3000	g	Device unpowered. Tested in z-direction.	1.16

Table 2-1 Absolute Maximum Ratings

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Mechanical shock	a_{shock}			6000	g	0.3 ms half sine pulses. 5 shocks in +/- x,y,z-direction, respectively. Device unpowered.	1.17
Storage temperature	$T_{storage}$	-50		+150	°C	Maximal 1000 hours accumulated over lifetime between 125°C and 150°C. Device not powered. Temperature cycling only allowed between -40°C and 125°C.	1.18

1) Refers to following pins: PP0 to PP3 if configured as output, XOUT, VDDREG, PAOUT and VDDPA. For input pins see parameter input voltage.

Note: ***Absolute maximum ratings are values beyond recommended operating conditions. They describe those conditions which the device can withstand for some limited time. After exposure to maximum ratings the device will remain functional, but the reliability is no longer ensured.***

2.2 Operating Range

The operating range defines the ambient conditions where the device operates as specified. Certain specified parameters in this data sheet may depend on additional operating conditions. These additional conditions are indicated in the corresponding sections.

Table 2-2 Operating Range

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Supply Voltage[1)]	V_{DD}	VUVRA	–	3.6	V	Device not in power down state	3.1
		VUVRPD	–	3.6	V	Device in power down state	3.2
Ambient Temperature	$T_{Operating}$	-40	–	125	°C	Normal Operation	3.3
	T_{Flash}	-20	–	90	°C	FLASH programming/erasing	3.4
Extended Temperature Range	T_{EXT}	-50		150	°C	Thermal shutdown functional. $V_{DD} = V_{UVRA}$ to 3.6 V. Exposure to 125°C...150°C maximal 24h over lifetime	3.5
z-axis Acceleration	$a_{Operating}$	-1600	–	1600	g	Exceeding this acceleration will result in a higher pressure error as specified.	3.6

1) Supply voltage must be connected to VDDBAT pin.

2.3 Characteristics

2.3.1 Pressure Sensor

Table 2-3 Pressure Sensor 1400kPa Range[1)2)]

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Input Pressure Range	p_{in}	100		1400	kPa		5.1
Random Error	p_{random}	-1.37		1.37	kPa	95% of all measurements	5.2
ADC resolution	p_{ADC_res}			1	kPa/ LSB	1 LSB of a raw measurement corresponds to 1 kPa or less	5.3
Measurement Error[3)]	$p_{Error\ 100\text{-}1100}$	-19		19	kPa	0°C to +60°C	5.4
		-25		25	kPa	-20°C to 0°C +60°C to +100°C	5.5
		-30		30	kPa	-40°C to -20°C +100°C to +125°C	5.6
	$p_{Error\ 1100\text{-}1400}$	-25		25	kPa	0°C to +60°C	5.10
		-30		30	kPa	-20°C to 0°C +60°C to +100°C	5.11
		-35		35	kPa	-40°C to -20°C +100°C to 125°C	5.12

1) Based on averaging two raw values for each measurement
2) Exceeding the maximum z-axis acceleration (parameter 3.6) as defined in the operating range will result in a higher pressure measurement error than specified
3) The measurement error is understood as total error, including random error (noise)

2.3.2 z-axis Acceleration Sensor

Table 2-4 z-axis Acceleration Sensor

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Input acceleration Range	a_{in}	-20		355	g	Selectable by firmware function	12.1
		-355		20	g		12.2
Total Acceleration Error[1)]	a_{err_tot}	-6.5 (-3.0)		+6.5 (+3.0)	g	$\|a_{in}\|$=0g ... 20g T = -40°C...90°C	12.3
		-8.5 (-5.0)		+8.5 (+5.0)	g	$\|a_{in}\|$=0g ... 20g T = 90°C...125°C	12.4
		-8.5 (-5.0)		+8.5 (+5.0)	g	$\|a_{in}\|$>20g ... 100g T = -40°C...90°C	12.5
		-10.5 (-7.0)		+10.5 (+7.0)	g	$\|a_{in}\|$>20g ... 100g T = 90°C...125°C	12.6
		-12.5 (-9.0)		+12.5 (+9.0)	g	$\|a_{in}\|$>100g ... 200g T = -40°C...90°C	12.7
		-14.5 (-11.0)		+14.5 (+11.0)	g	$\|a_{in}\|$>100g ... 200g T = 90°C...125°C	12.8
		-22.5 (-19.0)		+22.5 (+19.0)	g	$\|a_{in}\|$>200g ... 355g T = -40°C...90°C	12.9
		-24 (-20.5)		+24 (+20.5)	g	$\|a_{in}\|$>200g ... 355g T = 90°C...125°C	12.10
Random error of acceleration compensated values	$a_{rnd\_comp\_16}$	-0.35		+0.35	g	99.7% of all measurements. Averaging of 16 ADC-samples. No external noise sources present.	12.11
ADC resolution	a_{ADC_res}	0.057		0.175	g/ LSB	1 LSB of a raw measurement corresponds to minimal 0.057g and maximal 0.175g	12.14
Random error of acceleration raw values	$a_{rnd\_raw\_16}$	-4		+4	LSB	99.7% of all measurements. Averaging of 16 ADC-samples. No external noise sources present.	12.16
Accelerometer resonance frequency	f_{res_acc}	5.1	6	6.9	kHz	Mechanical excitation of the SP40T in this frequency range must be avoided (e.g. PCB sawing process)	12.17

1) Total error specifications are based on averaging 16 raw values for each measurement and they include random error (noise). The total error may be reduced by 3.5g by periodically, at least every 3 months, using the automatic acceleration offset compensation function Lib_Comp_Auto_Acc_Offset(). The reduced errors are put into brackets.

2.3.3 Temperature Sensor

Table 2-5 Temperature Sensor

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Measurement range	T_{range}	-40		+125	°C		14.1
Measurement error[1)]	T_{Error}	-3		+3	°C		14.2
Random error	T_{random}	-1		+1	°C	95% of all measurements	14.4

1) The measurement error is understood as total error, including random error (noise)

2.3.4 Battery Sensor

Table 2-6 Battery Sensor

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Measurement range	V_{range}	VUVRA		3.6	V	see **Table 2-10** for V_{UVRA}	15.1
Measurement error[1)]	V_{Error}	-3	–	+3	%	percentage of measurement value	15.2

1) The measurement error is understood as total error, including random error (noise)

2.3.5 Thermal Shutdown

Table 2-7 Thermal Shutdown

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Thermal Shutdown HOT threshold	$T_{HOT\ TH}$	119	122	125	°C		16.1
Thermal Shutdown HOT release	$T_{HOT\ RE}$	115	120	123.5	°C		16.2
Hysteresis	T_{HYST}	1.5		4	°C		16.3
Thermal Shutdown COLD threshold	$T_{COLD\ TH}$	-40	-37	-34	°C		16.4
Thermal Shutdown COLD release	$T_{COLD\ RE}$	-38.5	-35	-30	°C		16.5