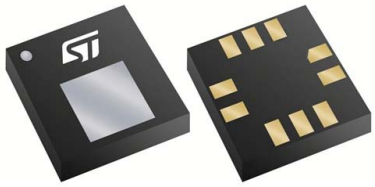
LPS22HH

High-performance MEMS nano pressure sensor: 260-1260 hPa absolute digital output barometer

Datasheet - production data



HLGA-10L
(2.0 x 2.0 x 0.73 mm)

Features

- 260 to 1260 hPa absolute pressure range
- Current consumption down to 4 µA
- Absolute pressure accuracy: 0.5 hPa
- Low pressure sensor noise: 0.65 Pa
- High-performance TCO: 0.65 Pa/°C
- Embedded temperature compensation
- 24-bit pressure data output
- ODR from 1 Hz to 200 Hz
- SPI, I²C or MIPI I3C^{SM} interfaces
- Embedded FIFO
- Interrupt functions: Data-Ready, FIFO flags, pressure thresholds
- Supply voltage: 1.7 to 3.6 V
- High shock survivability: 22,000 *g*
- Small and thin package
- ECOPACK® lead-free compliant

Applications

- Altimeters and barometers for portable devices
- GPS applications
- Weather station equipment
- Sport watches
- e-cigarettes
- Drones
- Gas metering

Description

The LPS22HH is an ultra-compact piezoresistive absolute pressure sensor which functions as a digital output barometer. The device comprises a sensing element and an IC interface which communicates through I²C, MIPI I3C^{SM} or SPI from the sensing element to the application.

The sensing element, which detects absolute pressure, consists of a suspended membrane manufactured using a dedicated process developed by ST.

The LPS22HH is available in a full-mold, holed LGA package (HLGA). It is guaranteed to operate over a temperature range extending from -40 °C to +85 °C. The package is holed to allow external pressure to reach the sensing element.

Table 1. Device summary

Order code	Temperature range [°C]	Package	Packing
LPS22HHTR	-40 to +85°C	HLGA-10L	Tape and reel

This is information on a product in full production. www.st.com

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1 Block diagrams

Figure 1. Device architecture block diagram

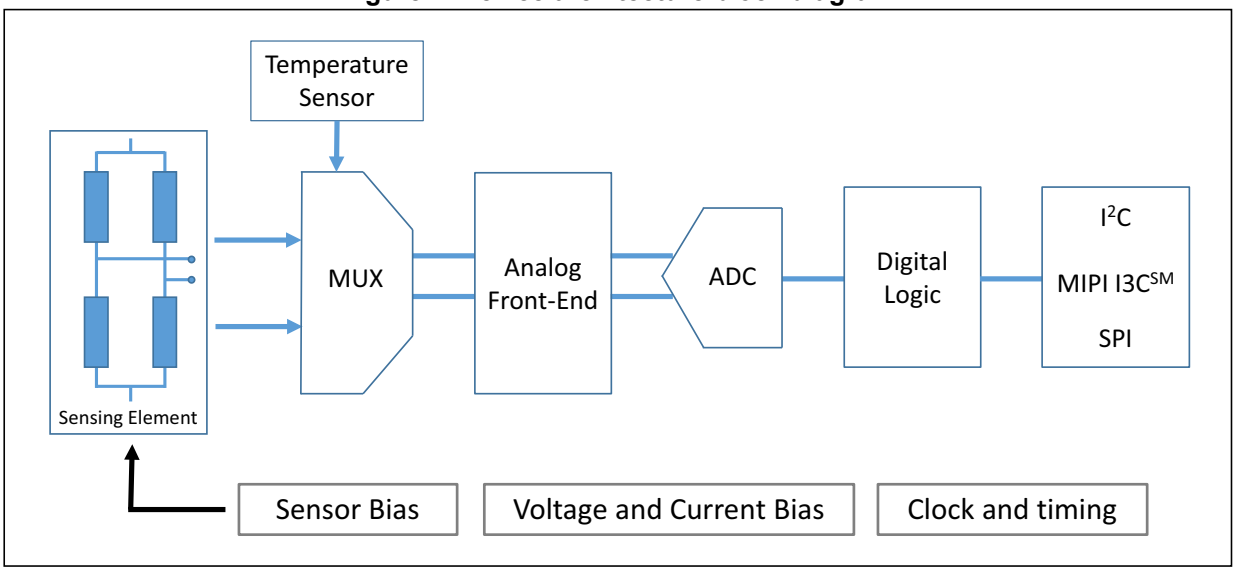
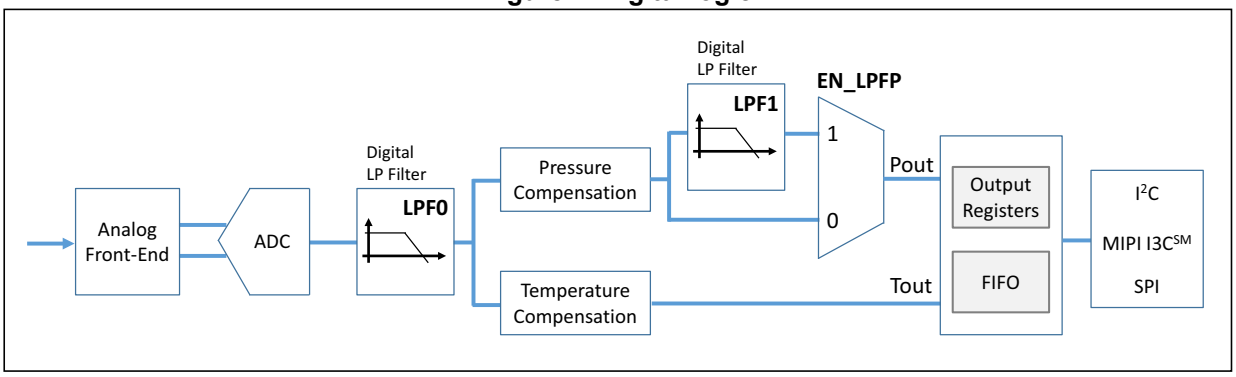


Figure 2. Digital logic



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2 Pin description

Figure 3. Pin connections (bottom view)

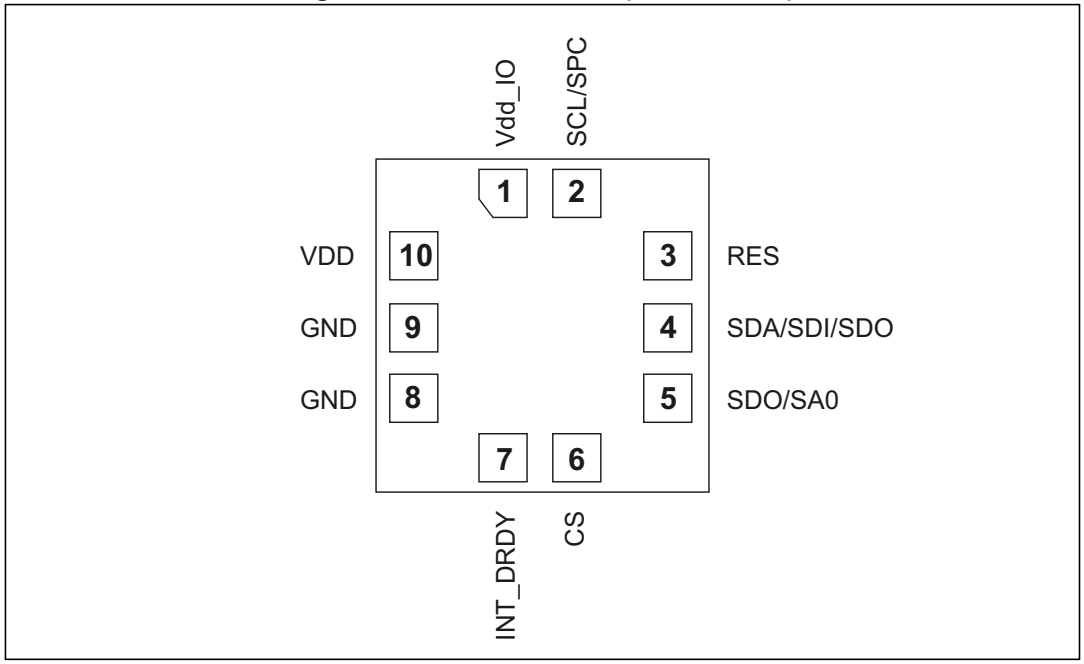


Table 2. Pin description

Pin number	Name	Function
1	Vdd_IO	Power supply for I/O pins
2	SCL SPC	I²C / MIPI I3C^{SM} serial clock (SCL) SPI serial port clock (SPC)
3	Reserved	Connect to GND
4	SDA SDI SDI/SDO	I²C / MIPI I3C^{SM} serial data (SDA) 4-wire SPI serial data input (SDI) 3-wire serial data input/output (SDI/SDO)
5	SDO SA0	4-wire SPI serial data output (SDO) I²C least significant bit of the device address (SA0) MIPI I3C^{SM} least significant bit of the static address (SA0)
6	CS	SPI enable I²C and MIPI I3C^{SM} / SPI mode selection (1: SPI idle mode / I²C and MIPI I3C^{SM} communication enabled; 0: SPI communication mode / I²C and MIPI I3C^{SM} disabled)
7	INT_DRDY	Interrupt or Data-Ready
8	GND	0 V supply
9	GND	0 V supply
10	VDD	Power supply

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3 Mechanical and electrical specifications

3.1 Mechanical characteristics

VDD = 1.8 V, T = 25 °C, unless otherwise noted.

Table 3. Pressure and temperature sensor characteristics

Symbol	Parameter	Test condition	Min.	Typ.(1)	Max.	Unit
Pressure sensor characteristics						
PT_{op}	Operating temperature range		-40		+85	°C
P_{op}	Operating pressure range		260		1260	hPa
P_{bits}	Pressure output data			24		bits
P_{sens}	Pressure sensitivity			4096		LSB/ hPa
P_{AccRel}	Relative accuracy over pressure(2)	P = 800 - 1100 hPa T = 25 °C		±0.025		hPa
P_{AccT}	Absolute accuracy over temperature	P_{op}, T = -20 to 80°C		±0.5		hPa
P_{noise}	RMS pressure sensing noise(3)	with embedded filter and at T = 25 °C		0.0065		hPa RMS
ODR_{Pres}	Pressure output data rate(4)			1 10 25 50 75 100 200		Hz
TCO	Temperature coefficient offset	P = 660 ~ 1160 hPa, T = -20 ~ +65 °C		±0.65		Pa/°C
P_longterm	Pressure accuracy, long-term stability(5)			±0.33		hPa/year
P_drift	Soldering drift			±0.5		hPa
Temperature sensor characteristics						
T_{op}	Operating temperature range		-40		+85	°C
T_{sens}	Temperature sensitivity			100		LSB/°C
T_{acc}	Temperature absolute accuracy	T = 0 to 80°C		±1.5		°C
ODR_T	Output temperature data rate(4)			1 10 25 50 75 100 200		Hz

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1. Typical specifications are not guaranteed.
2. By design, the typ. value is defined based characterization data with 10 hPa pressure interval.
3. Pressure noise RMS evaluated in a controlled environment, based on the average standard deviation of 50 measurements with LOW_NOISE_EN = 1, EN_LPFP = 1, LPFP_CFG = 1.
4. Output data rate is configured acting on ODR[2:0] in *CTRL_REG1 (10h)*.
5. Typ. value is defined considering a 5-year life cycle of the final application.

3.2 Electrical characteristics

VDD = 1.8 V, T = 25 °C, unless otherwise noted.

Table 4. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.(1)	Max.	Unit
VDD	Supply voltage		1.7		3.6	V
Vdd_IO	IO supply voltage		1.7		Vdd+0.1	V
Idd	Supply current	@ ODR 1 Hz LOW_NOISE_EN = 0		4		µA
		@ ODR 1 Hz LOW_NOISE_EN = 1		12		
IddPdn	Supply current in power-down mode			0.9		µA

1. Typical specifications are not guaranteed.

Table 5. DC characteristics

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
DC input characteristics						
Vil	Low-level input voltage (Schmitt buffer)	-	-	-	0.2 * Vdd_IO	V
Vih	High-level input voltage (Schmitt buffer)	-	0.8 * Vdd_IO	-	-	V
DC output characteristics						
Vol	Low-level output voltage		-	-	0.2	V
Voh	High-level output voltage		Vdd_IO - 0.2	-	-	V

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3.3 Communication interface characteristics

3.3.1 SPI - serial peripheral interface

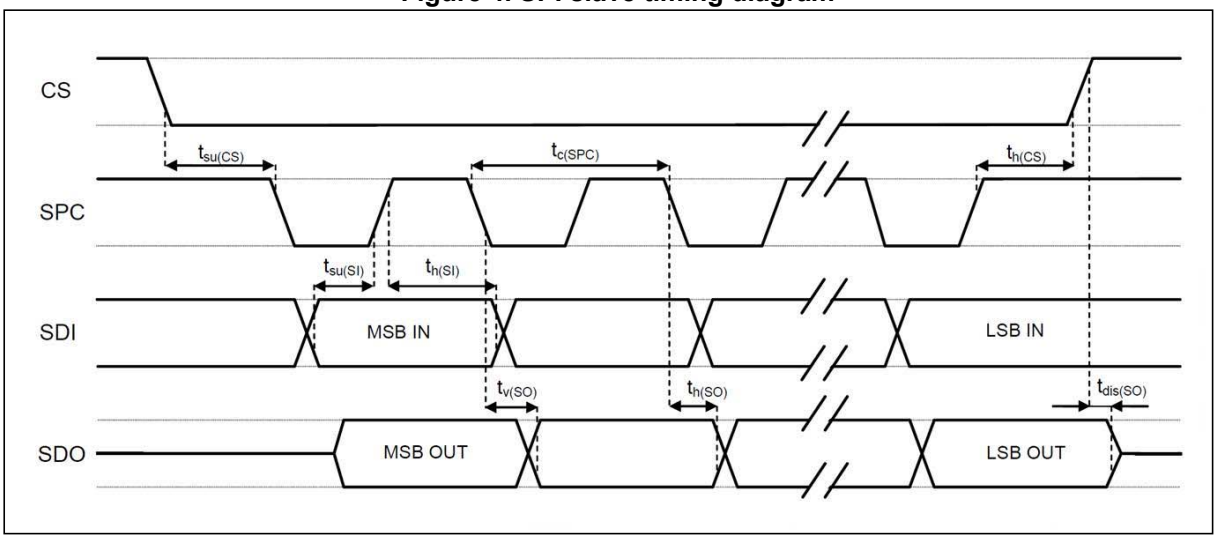
Subject to general operating conditions for Vdd and T_{OP}.

Table 6. SPI slave timing values

Symbol	Parameter	Value(1)		Unit
		Min	Max	
$t_{c(SPC)}$	SPI clock cycle	100		ns
$f_{c(SPC)}$	SPI clock frequency		10(2)	MHz
$t_{su(CS)}$	CS setup time	6		ns
$t_{h(CS)}$	CS hold time	8		
$t_{su(SI)}$	SDI input setup time	5		
$t_{h(SI)}$	SDI input hold time	15		
$t_{v(SO)}$	SDO valid output time		50	
$t_{h(SO)}$	SDO output hold time	9		
$t_{dis(SO)}$	SDO output disable time		50	

1. Values are guaranteed at 10 MHz clock frequency for SPI with both 4 and 3 wires, based on characterization results, not tested in production.
2. Recommended to set max SPI clock 8 MHz to ≤50 Hz ODR.

Figure 4. SPI slave timing diagram



Note: Measurement points are done at 0.2·Vdd_IO and 0.8·Vdd_IO, for both ports.

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3.3.2 I²C - inter-IC control interface

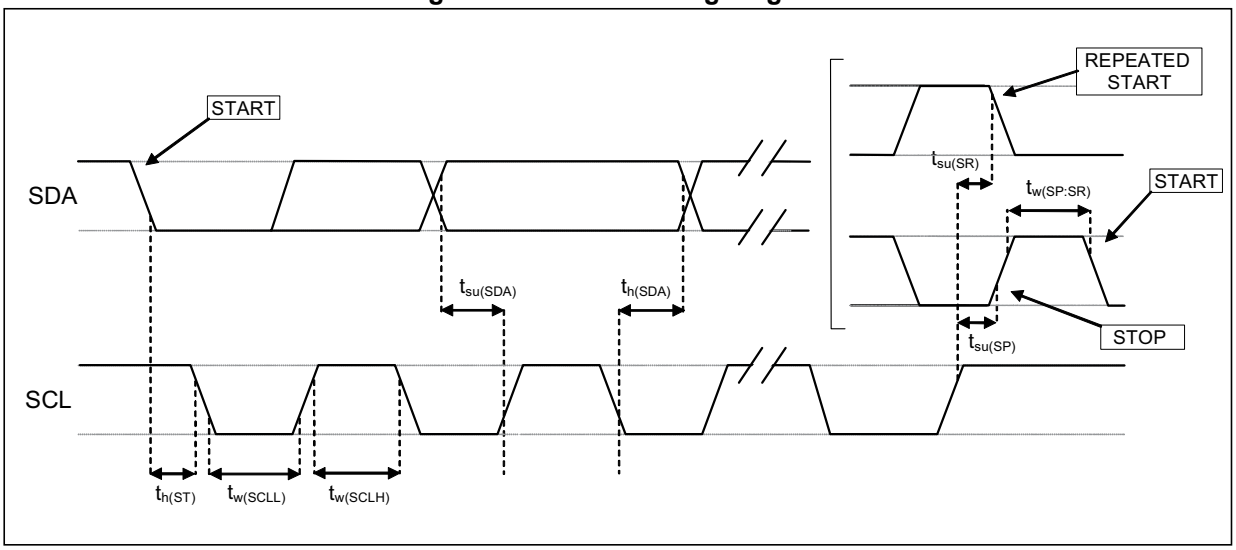
Subject to general operating conditions for Vdd and T_{OP}.

Table 7. I²C slave timing values

Symbol	Parameter (1)	I²C standard mode(1)		I²C fast mode(1)		Unit
		Min	Max	Min	Max	
$f_{(SCL)}$	SCL clock frequency	0	100	0	400	kHz
$t_{w(SCLL)}$	SCL clock low time	4.7		1.3		µs
$t_{w(SCLH)}$	SCL clock high time	4.0		0.6		
$t_{su(SDA)}$	SDA setup time	250		100		ns
$t_{h(SDA)}$	SDA data hold time	0	3.45	0	0.9	µs
$t_{h(ST)}$	START condition hold time	4		0.6		µs
$t_{su(SR)}$	Repeated START condition setup time	4.7		0.6		
$t_{su(SP)}$	STOP condition setup time	4		0.6		
$t_{w(SP:SR)}$	Bus free time between STOP and START condition	4.7		1.3		

1. Data based on standard I²C protocol requirement, not tested in production.

Figure 5. I²C slave timing diagram



Note: Measurement points are done at 0.2·Vdd_IO and 0.8·Vdd_IO, for both ports.

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3.4 Absolute maximum ratings

Stress above those listed as “Absolute maximum ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device under these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Table 8. Absolute maximum ratings

Symbol	Ratings	Maximum value	Unit
Vdd	Supply voltage	-0.3 to 4.8	V
Vdd_IO	I/O pins supply voltage	-0.3 to 4.8	V
Vin	Input voltage on any control pin	-0.3 to Vdd_IO +0.3	V
P	Overpressure	2	MPa
T_{STG}	Storage temperature range	-40 to +125	°C
ESD	Electrostatic discharge protection	2.5 (HBM)	kV

Note: Supply voltage on any pin should never exceed 4.8 V.



This device is sensitive to mechanical shock, improper handling can cause permanent damage to the part.



This device is sensitive to electrostatic discharge (ESD), improper handling can cause permanent damage to the part.

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4 Functionality

The LPS22HH is a high-resolution, digital output pressure sensor packaged in an HLGA full-mold package. The complete device includes a sensing element based on a piezoresistive Wheatstone bridge approach, and an IC interface which communicates a digital signal from the sensing element to the application.

4.1 Sensing element

An ST proprietary process is used to obtain a silicon membrane for MEMS pressure sensors. When pressure is applied, the membrane deflection induces an imbalance in the Wheatstone bridge piezoresistances whose output signal is converted by the IC interface.

4.2 IC interface

The complete measurement chain is composed of a low-noise amplifier which converts the resistance unbalance of the MEMS sensors (pressure and temperature) into an analog voltage using an analog-to-digital converter.

The pressure and temperature data may be accessed through an I²C/MIPI I3C^{SM}/SPI interface thus making the device particularly suitable for direct interfacing with a microcontroller.

The LPS22HH features a Data-Ready signal which indicates when a new set of measured pressure and temperature data are available, thus simplifying data synchronization in the digital system that uses the device.

4.3 Factory calibration

The trimming values are stored inside the device in a non-volatile structure. When the device is turned on, the trimming parameters are downloaded into the registers to be employed during the normal operation which allows the device to be used without requiring any further calibration.

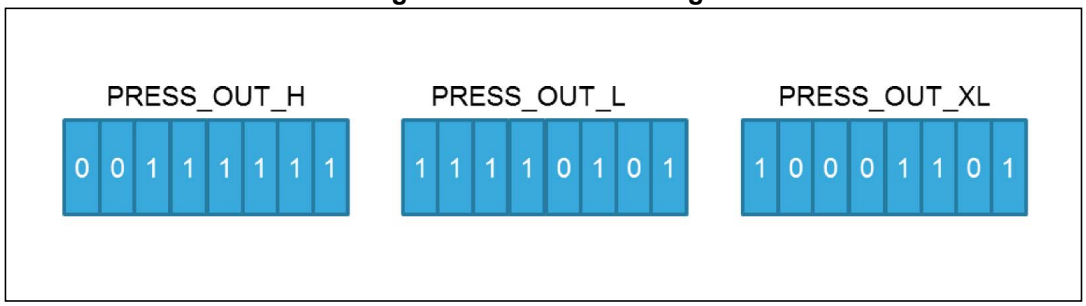
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4.4 Interpreting pressure readings

The pressure data are stored in 3 registers: *PRESS_OUT_H (2Ah)*, *PRESS_OUT_L (29h)*, and *PRESS_OUT_XL (28h)*. The value is expressed as a 24-bit signed number (in 2's complement).

To obtain the pressure in hPa, take the complete 24-bit word and then divide by the sensitivity 4096 LSB/hPa. This same interpretation is applied to pressure readings when FIFO is enabled and the pressure data are stored in 3 registers: *FIFO_DATA_OUT_PRESS_XL (78h)*, *FIFO_DATA_OUT_PRESS_L (79h)*, and *FIFO_DATA_OUT_PRESS_H (7Ah)*.

Figure 6. Pressure readings



Equation 1

$$\text{Pressure Value (LSB)} = \text{PRESS_OUT_H (2Ah) \& PRESS_OUT_L (29h) \& PRESS_OUT_XL (28h)}$$
$$= \text{3FF58Dh} = 4191629 \text{ LSB (signed decimal)}$$

Equation 2

$$\text{Pressure (hPa)} = \frac{\text{Pressure Value (LSB)}}{\text{Sensitivity}} = \frac{4191629 \text{ LSB}}{4096 \text{ LSB/hPa}} = 1023.3 \text{ hPA}$$

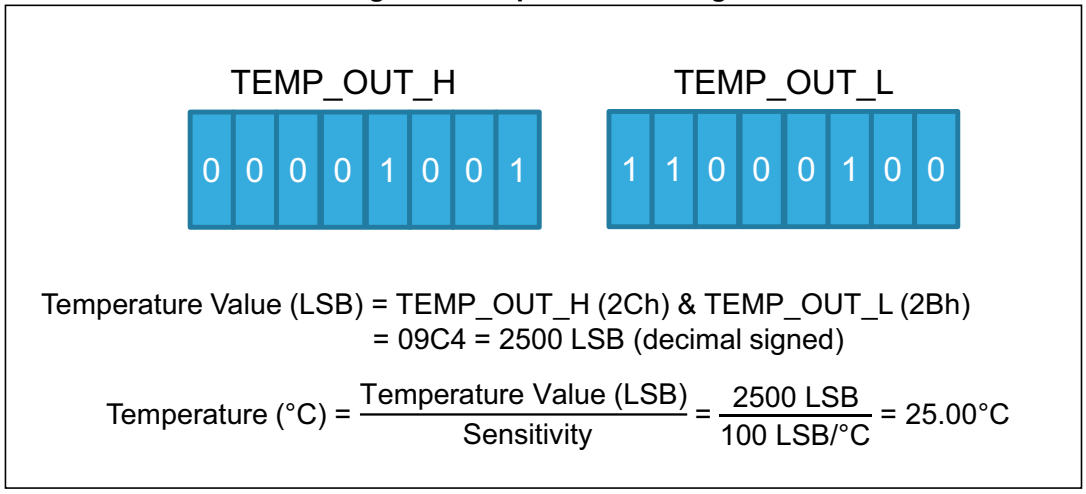
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4.5 Interpreting temperature readings

The temperature data are stored in 2 registers: *TEMP_OUT_H (2Ch)* and *TEMP_OUT_L (2Bh)*.

The value is expressed as 2's complement. To obtain the temperature in °C, take the two's complement of the complete 16-bit word and then divide by the sensitivity 100 LSB/°C. This same interpretation is applied to temperature readings when FIFO is enabled and the temperature data are stored in 2 registers: *FIFO_DATA_OUT_TEMP_H (7Ch)* and *FIFO_DATA_OUT_TEMP_L (7Bh)*.

Figure 7. Temperature readings



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5 FIFO

The LPS22HH embeds 128 slots of 40-bit data FIFO to store the pressure and temperature output values. This allows consistent power saving for the system, since the host processor does not need to continuously poll data from the sensor, but it can wake up only when needed and burst the significant data out from the FIFO. This buffer can work according to six different modes:

- Bypass mode
- FIFO mode
- Continuous (Dynamic-Stream) mode
- Continuous (Dynamic-Stream)-to-FIFO mode
- Bypass-to-Continuous (Dynamic-Stream)
- Bypass-to-FIFO mode

The FIFO buffer is enabled when a configuration different from all bits '0' are written in *FIFO_CTRL (13h)* and each mode is selected by the TRIG_MODES bit and F_MODE[1:0] bits in *FIFO_CTRL (13h)*. Programmable FIFO threshold status, FIFO overrun events and the number of unread samples stored are available in the *FIFO_STATUS1 (25h)* and *FIFO_STATUS2 (26h)* registers and can be set to generate dedicated interrupts on the INT_DRDY pad using the *CTRL_REG3 (12h)* register.

FIFO_STATUS2 (26h)(FIFO_WTM_IA) goes to '1' when the number of unread samples (*FIFO_STATUS1 (25h)*(FSS[7:0]) is greater than or equal to WTM[6:0] in *FIFO_WTM (14h)*. If *FIFO_WTM (14h)*(WTM[6:0]) is equal to 0, *FIFO_STATUS2 (26h)*(FIFO_WTM_IA) stays at '0'.

FIFO_STATUS2 (26h)(FIFO_OVR_IA) is equal to '1' if a FIFO slot is overwritten.

FIFO_STATUS1 (25h)(FSS[7:0]) contains stored data levels of unread samples; when FSS[7:0] is equal to ‘00000000’, FIFO is empty; when FSS[7:0] is equal to ‘10000000’, FIFO is full and the unread samples are 128.

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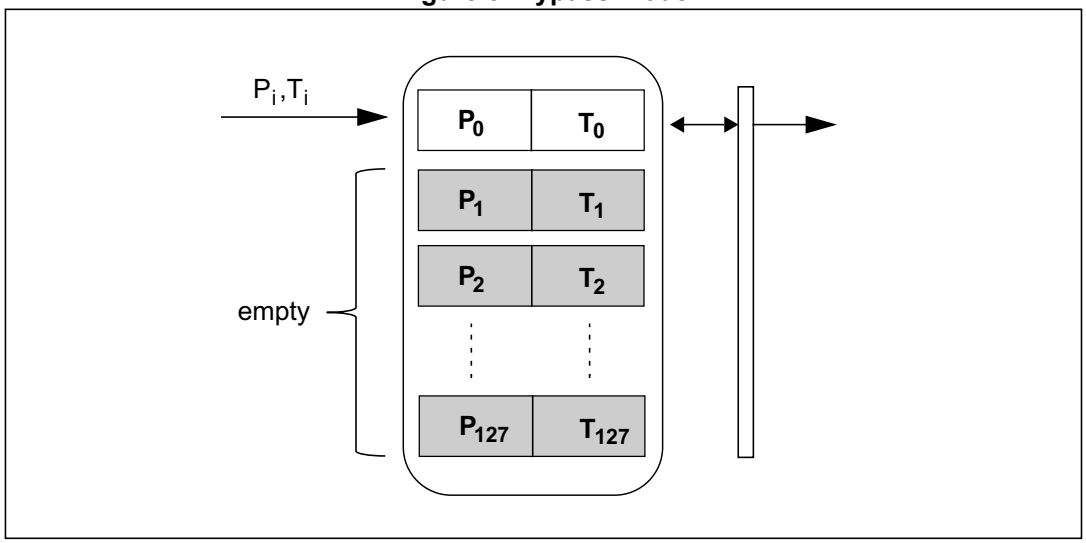
5.1 Bypass mode

In Bypass mode (*FIFO_CTRL (13h)*(TRIG_MODES and F_MODE[1:0] = ‘000’ or ‘100’), the FIFO is not operational and it remains empty.

Switching to Bypass mode is also used to reset the FIFO. Passing through Bypass mode is mandatory when switching between different FIFO buffer operating modes.

As described in the next figure, for each channel only the first address is used. When new data is available, the older data is overwritten.

Figure 8. Bypass mode



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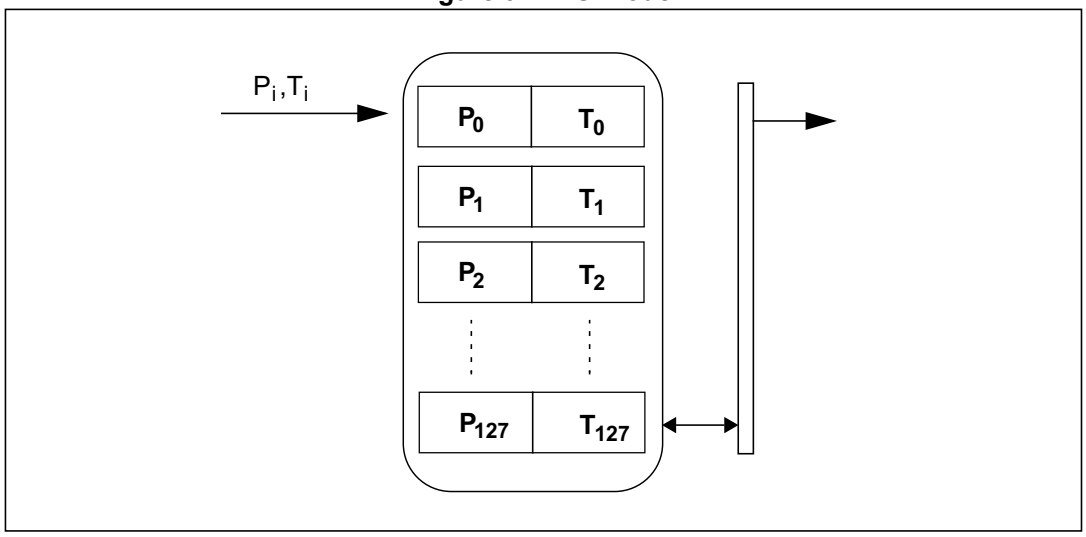
5.2 FIFO mode

In FIFO mode (*FIFO_CTRL (13h)*(TRIG_MODES and F_MODE[1:0] = ‘001’) data from the output *PRESS_OUT_XL (28h)*, *PRESS_OUT_L (29h)*, *PRESS_OUT_H (2Ah)*, *TEMP_OUT_L (2Bh)*, and *TEMP_OUT_H (2Ch)* are stored in the FIFO until it is full.

To reset FIFO content, in order to select Bypass mode the value '000' must be written in *FIFO_CTRL (13h)*(TRIG_MODE & F_MODE[1:0]). After this reset command it is possible to restart FIFO mode by writing the value '001' in *FIFO_CTRL (13h)*(TRIG_MODE & F_MODE[1:0]).

The FIFO buffer memorizes 128 levels of data, but the depth of the FIFO can be resized/reduced by setting the *FIFO_CTRL (13h)*(STOP_ON_WTM) bit. If the STOP_ON_WTM bit is set to '1', FIFO depth is limited to *FIFO_WTM (14h)*(WTM[6:0]) data.

Figure 9. FIFO mode



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5.3 Continuous (Dynamic-Stream) mode

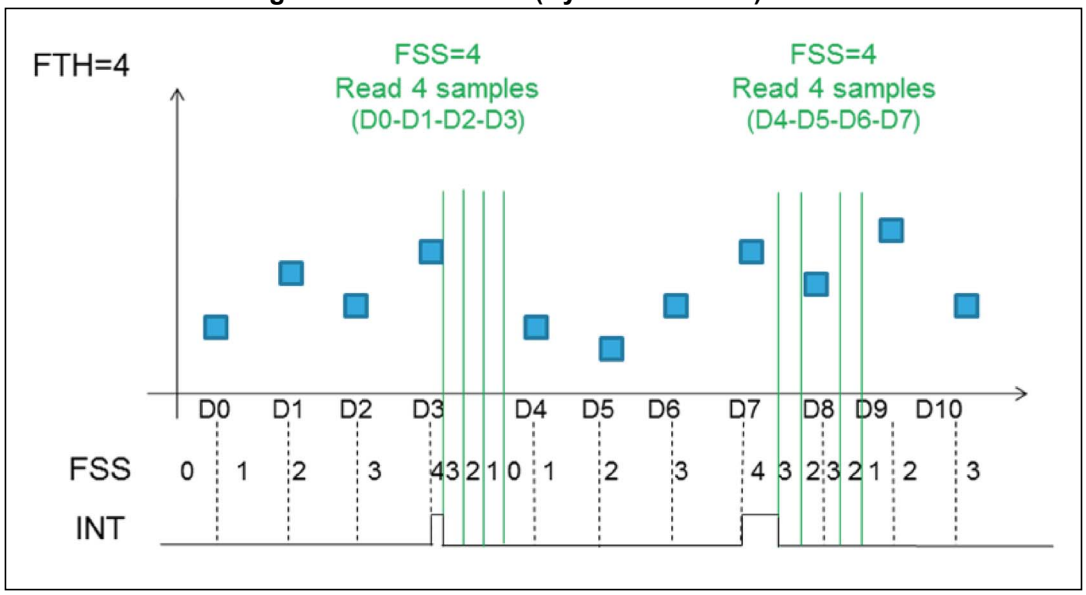
In Continuous (Dynamic-Stream) mode (*FIFO_CTRL (13h)*(TRIG_MODES and F_MODE[1:0] = ‘011’) after emptying the FIFO, the first new sample that arrives becomes the first to be read in a subsequent read burst. In this way, the number of new data available in FIFO does not depend on the previous read.

In Continuous (Dynamic-Stream) mode *FIFO_STATUS1 (25h)*(FSS[7:0]) is the number of new pressure and temperature samples available in the FIFO buffer.

Continuous (Dynamic-Stream) is intended to be used to read *FIFO_STATUS1 (25h)*(FSS[7:0]) samples when it is not possible to guarantee reading data within 1/ODR time period.

Also, a FIFO threshold interrupt on the INT_DRDY pad through *CTRL_REG3 (12h)*(INT_F_WTM) can be enabled in order to read data from the FIFO and leave free memory slots for incoming data.

Figure 10. Continuous (Dynamic-Stream) mode



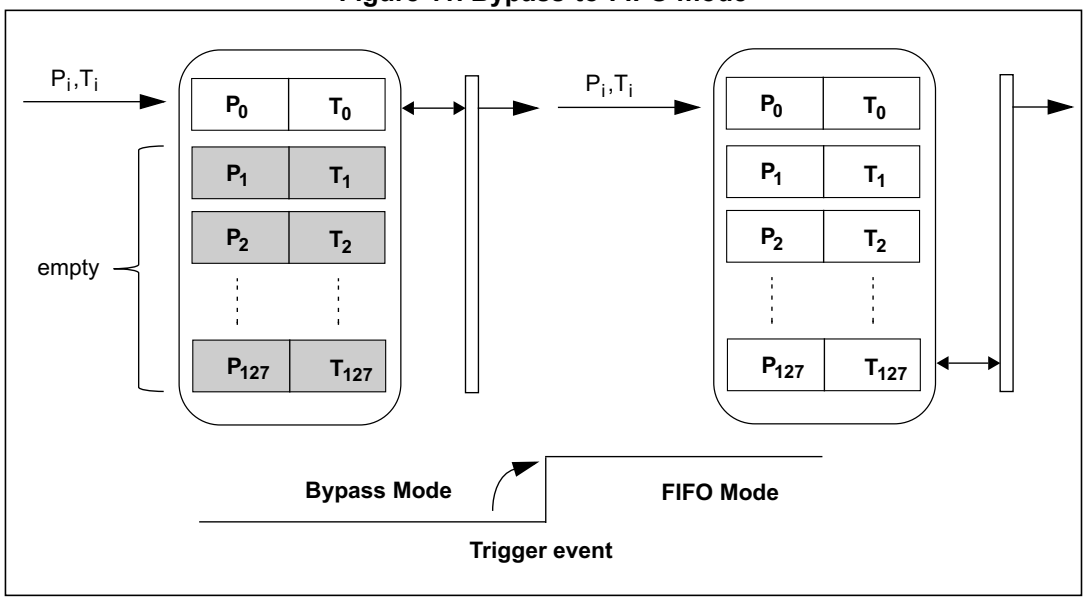
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5.4 Bypass-to-FIFO mode

In Bypass-to-FIFO mode (*FIFO_CTRL (13h)*(TRIG_MODES and F_MODE[1:0] = ‘101’), FIFO behavior switches when the *INT_SOURCE (24h)*(IA) bit rises for the first time. When the *INT_SOURCE (24h)*(IA) bit is equal to '0', FIFO behaves like in Bypass mode. Once the *INT_SOURCE (24h)*(IA) bit rises to '1', FIFO behavior switches and keeps behaving like in FIFO mode.

An interrupt generator has to be set to the desired configuration through *INTERRUPT_CFG (0Bh)*.

Figure 11. Bypass-to-FIFO mode



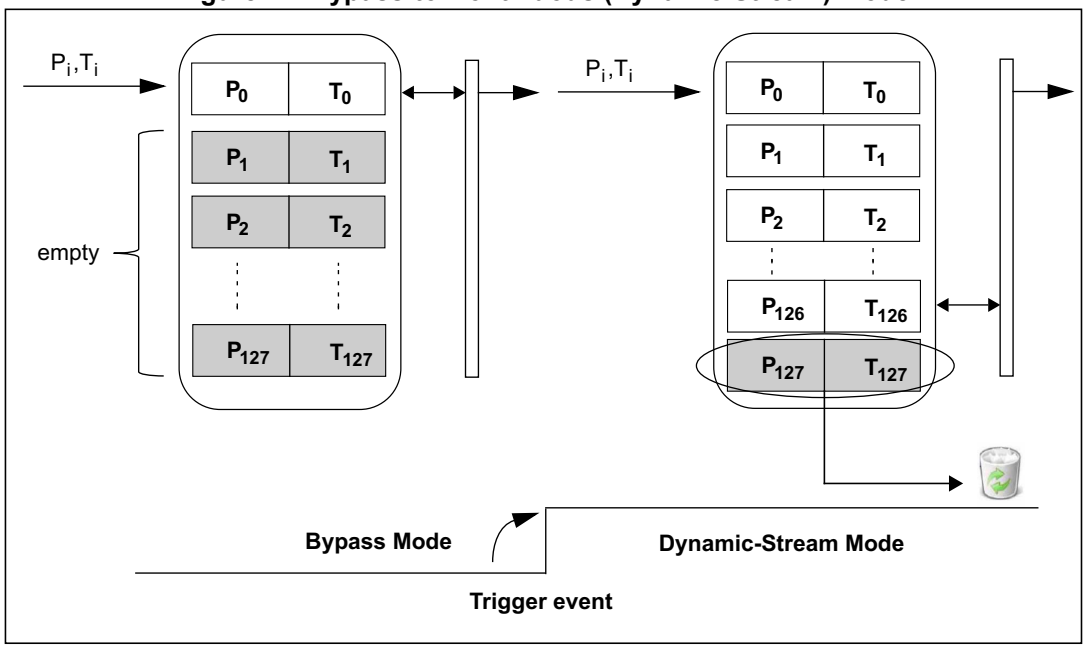
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5.5 Bypass-to-Continuous (Dynamic-Stream) mode

In Bypass-to-Continuous (Dynamic-Stream) mode (*FIFO_CTRL (13h)*(TRIG_MODES and F_MODE[1:0] = ‘110’), FIFO operates in Bypass mode until it switches to Continuous (Dynamic-Stream) mode behavior when *INT_SOURCE (24h)*(IA) rises to '1', then FIFO behavior keeps behaving like in Continuous (Dynamic-Stream) mode.

An interrupt generator has to be set to the desired configuration through *INTERRUPT_CFG (0Bh)*.

Figure 12. Bypass-to-Continuous (Dynamic-Stream) mode



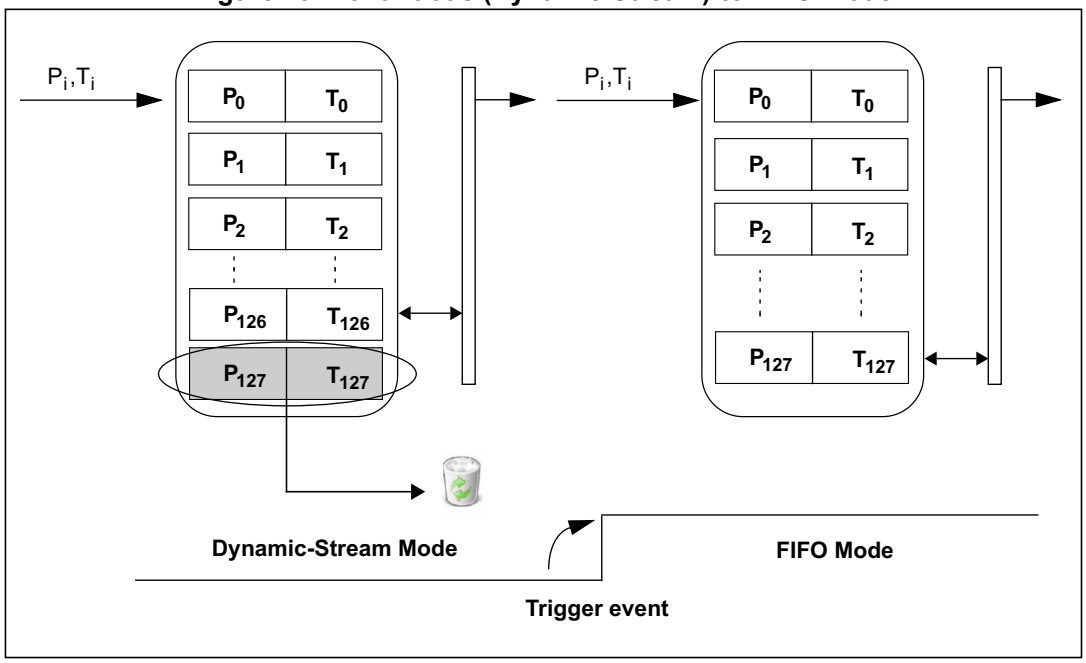
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5.6 Continuous (Dynamic-Stream)-to-FIFO mode

In Continuous (Dynamic-Stream)-to-FIFO mode (*FIFO_CTRL (13h)*(TRIG_MODES and F_MODE[1:0] = ‘111’), data are stored in FIFO and FIFO operates in Continuous (Dynamic-Stream) mode behavior until it switches to FIFO mode behavior when *INT_SOURCE (24h)*(IA) rises to '1'.

An interrupt generator has to be set to the desired configuration through *INTERRUPT_CFG (0Bh)*.

Figure 13. Continuous (Dynamic-Stream)-to-FIFO mode



5.7 Retrieving data from FIFO

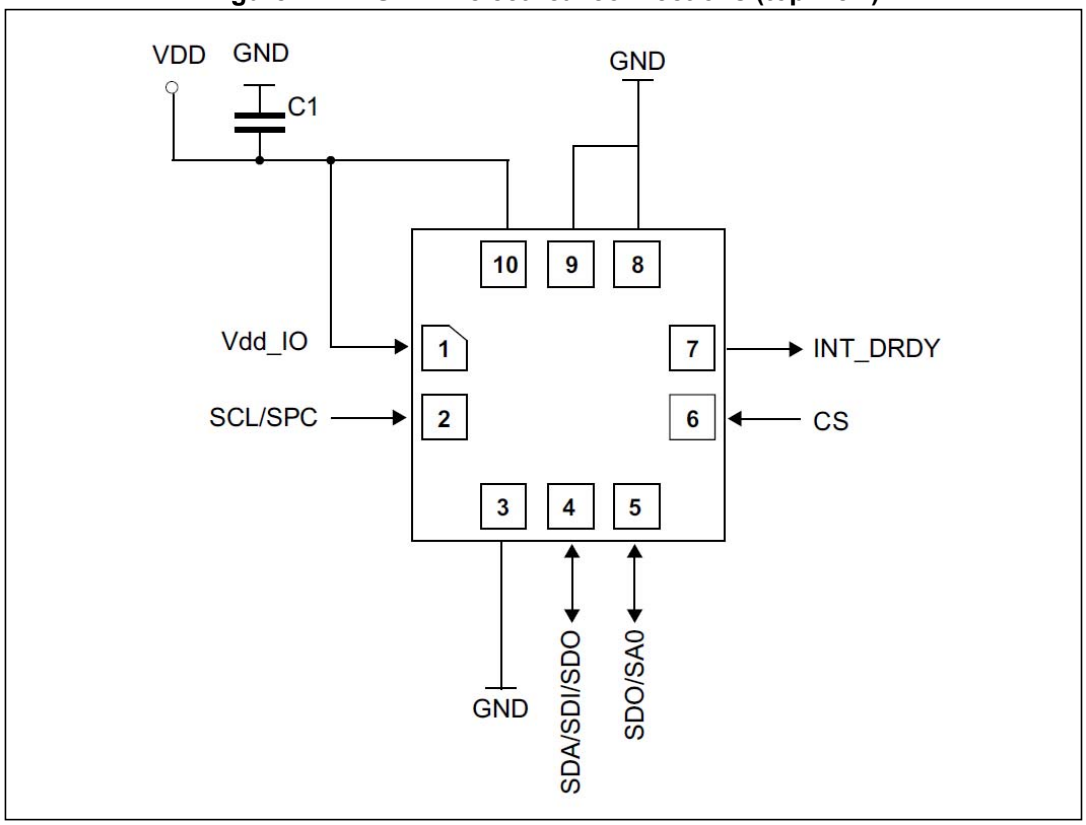
FIFO data is read through FIFO_DATA_OUT_PRESS (78h, 79h and 7Ah) and FIFO_DATA_OUT_TEMP (7Bh, 7Ch).

The read address is automatically updated by the device and it rolls back to 78h when register 7Ch is reached. In order to read all FIFO levels in a multiple byte read, 640 bytes (5 output registers by 128 levels) must be read.

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6 Application hints

Figure 14. LPS22HH electrical connections (top view)



The device power supply must be provided through the VDD line; a power supply decoupling capacitor C1 (100 nF) must be placed as near as possible to the supply pads of the device. The C1 capacitor can be tied to VDD and VDDIO, but it is recommended to use 2 capacitors, one on each VDD and VDDIO line, in case VDD are VDDIO are separate. Depending on the application, an additional capacitor of 4.7 µF could be placed on VDD line.

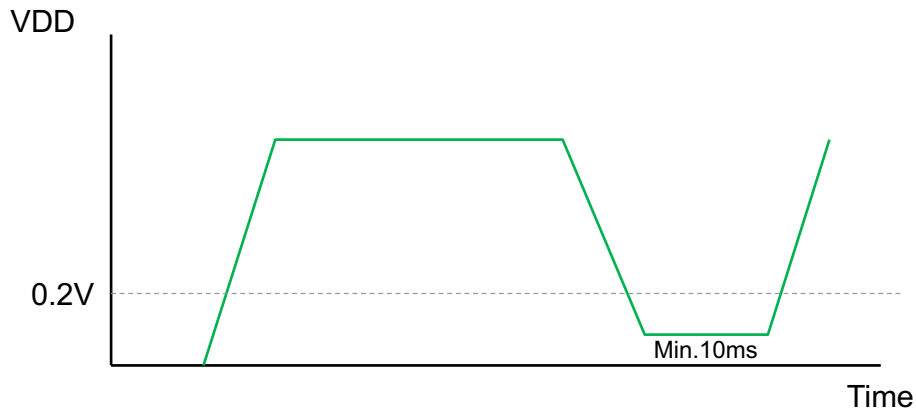
The functionality of the device and the measured data outputs are selectable and accessible through the I²C, MIPI I3C^{SM}, SPI interface. When using the I²C and MIPI I3C^{SM}, CS must be tied to Vdd_IO.

All the voltage and ground supplies must be present at the same time to have proper behavior of the IC (refer to *Figure 14*). It is possible to remove VDD while maintaining Vdd_IO without blocking the communication bus, in this condition the measurement chain is powered off.

Note: To guarantee proper power-off of the device, it is recommended to maintain the duration of the VDD line to GND for at least 10 ms.

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Figure 15. LPS22HH power-off sequence



- VDD Rising / Falling time : 10 µs ~ 100 ms
- VDD must be lower than 0.2 V for at least 10 ms during power-off sequence for correct POR

6.1 Soldering information

The HLGA package is compliant with the ECOPACK® standard and it is qualified for soldering heat resistance according to JEDEC J-STD-020.

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7 Digital interfaces

7.1 Serial interfaces

The registers embedded in the LPS22HH may be accessed through either the I²C, MIPI I3C^{SM} or SPI serial interfaces. The latter may be SW configured to operate either in 3-wire or 4-wire interface mode.

The serial interfaces are mapped onto the same pads. To select/exploit the I²C interface, the CS line must be tied high (i.e. connected to Vdd_IO).

Table 9. Serial interface pin description

Pin name	Pin description
CS	SPI enable I²C/SPI mode selection (1: SPI idle mode / I²C communication enabled; 0: SPI communication mode / I²C disabled)
SCL/SPC	I²C serial clock (SCL) SPI serial port clock (SPC)
SDA SDI SDI/SDO	I²C serial data (SDA) 4-wire SPI serial data input (SDI) 3-wire serial data input /output (SDI/SDO)
SDO SAO	4-wire SPI serial data output (SDO) I²C less significant bit of the device address (SA0)

7.2 I²C serial interface (CS = high)

The LPS22HH I²C is a bus slave. The I²C is employed to write data into registers whose content can also be read back.

The relevant I²C terminology is given in *Table 10.*

Table 10. I²C terminology

Term	Description
Transmitter	The device which sends data to the bus
Receiver	The device which receives data from the bus
Master	The device which initiates a transfer, generates clock signals and terminates a transfer
Slave	The device addressed by the master

There are two signals associated with the I²C bus: the serial clock line (SCL) and the serial data line (SDA). The latter is a bidirectional line used for sending and receiving the data to/from the interface. Both lines have to be connected to Vdd_IO through pull-up resistors.

The I²C interface is compliant with fast mode (400 kHz) I²C standards as well as with the normal mode.

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7.2.1 I²C operation

The transaction on the bus is started through a START (ST) signal. A start condition is defined as a HIGH-to-LOW transition on the data line while the SCL line is held HIGH. After the master has transmitted this, the bus is considered busy. The next data byte transmitted after the start condition contains the address of the slave in the first 7 bits and the eighth bit tells whether the master is receiving data from the slave or transmitting data to the slave. When an address is sent, each device in the system compares the first seven bits after a start condition with its address. If they match, the device considers itself addressed by the master.

The 7-bit slave address (SAD) associated to the LPS22HH is 101110xb. The **SDO**/**SA0** pad can be used to modify the less significant bit of the device address. If the SA0 pad is connected to voltage supply, LSb is ‘1’ (7-bit address 1011101b=5Dh), otherwise if the SA0 pad is connected to ground, the LSb value is ‘0’ (7-bit address 1011100b=5Ch). This solution permits connecting and addressing two different LPS22HH devices to the same I²C lines.

Data transfer with acknowledge is mandatory. The transmitter must release the SDA line during the acknowledge pulse. The receiver must then pull the data line LOW so that it remains stable low during the HIGH period of the acknowledge clock pulse. A receiver which has been addressed is obliged to generate an acknowledge after each byte of data received.

The I²C embedded inside the ASIC behaves like a slave device and the following protocol must be adhered to. After the start condition (ST) a slave address is sent, once a slave acknowledge has been returned (SAK), an 8-bit sub-address will be transmitted (SUB): the 7 LSB represent the actual register address while the MSB has no meaning. The IF_ADD_INC bit in *CTRL_REG2 (11h)* enables sub-address auto increment (IF_ADD_INC is '1' by default), so if IF_ADD_INC = '1' the SUB (sub-address) will be automatically increased to allow multiple data read/write.

The slave address is completed with a Read/Write bit. If the bit is ‘1’ (Read), a repeated START (SR) condition must be issued after the two sub-address bytes; if the bit is ‘0’ (Write) the master will transmit to the slave with direction unchanged. *Table 11* explains how the SAD+read/write bit pattern is composed, listing all the possible configurations.

Table 11. SAD+Read/Write patterns

Command	SAD[6:1]	SAD[0] = SA0	R/W	SAD+R/W
Read	101110	0	1	10111001 (B9h)
Write	101110	0	0	10111000 (B8h)
Read	101110	1	1	10111011 (BBh)
Write	101110	1	0	10111010 (BAh)

Table 12. Transfer when master is writing one byte to slave

Master	ST	SAD + W		SUB		DATA		SP
Slave			SAK		SAK		SAK	

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Table 13. Transfer when master is writing multiple bytes to slave

Master	ST	SAD + W		SUB		DATA		DATA		SP
Slave			SAK		SAK		SAK		SAK	

Table 14. Transfer when master is receiving (reading) one byte of data from slave

Master	ST	SAD + W		SUB		SR	SAD + R			NMAK	SP
Slave			SAK		SAK			SAK	DATA		

Table 15. Transfer when master is receiving (reading) multiple bytes of data from slave

Master	ST	SAD+W		SUB		SR	SAD+R			MAK		MAK		NMAK	SP
Slave			SAK		SAK			SAK	DATA		DATA		DATA		

Data are transmitted in byte format (DATA). Each data transfer contains 8 bits. The number of bytes transferred per transfer is unlimited. Data is transferred with the most significant bit (MSb) first. If a receiver cannot receive another complete byte of data until it has performed some other functions, it can hold the clock line, SCL LOW to force the transmitter into a wait state. Data transfer only continues when the receiver is ready for another byte and releases the data line. If a slave receiver does not acknowledge the slave address (i.e. it is not able to receive because it is performing some real-time function), the data line must be kept HIGH by the slave. The master can then abort the transfer. A LOW-to-HIGH transition on the SDA line while the SCL line is HIGH is defined as a STOP condition. Each data transfer must be terminated by the generation of a STOP (SP) condition.

In the presented communication format MAK is Master acknowledge and NMAK is no master acknowledge.

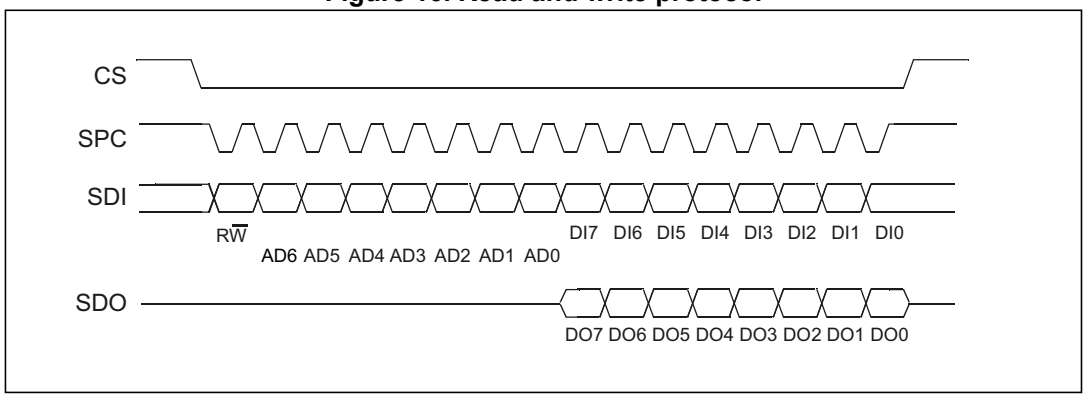
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7.3 SPI bus interface (CS = low)

The LPS22HH SPI is a bus slave. The SPI allows writing to and reading from the registers of the device.

The serial interface interacts with the application using 4 wires: **CS**, **SPC**, **SDI** and **SDO**.

Figure 16. Read and write protocol



CS is the serial port enable and it is controlled by the SPI master. It goes low at the start of the transmission and returns to high at the end. **SPC** is the serial port clock and it is controlled by the SPI master. It is stopped high when **CS** is high (no transmission). **SDI** and **SDO** are respectively the serial port data input and output. Those lines are driven at the falling edge of **SPC** and should be captured at the rising edge of **SPC**.

Both the read register and write register commands are completed in 16 clock pulses or multiples of 8 in the case of multiple read/write bytes. Bit duration is the time between two falling edges of **SPC**. The first bit (bit 0) starts at the first falling edge of **SPC** after the falling edge of **CS** while the last bit (bit 15, bit 23,...) starts at the last falling edge of SPC just before the rising edge of **CS**.

bit 0: R$\overline{W}$ bit. When 0, the data DI(7:0) is written into the device. When 1, the data DO(7:0) from the device is read. In the latter case, the chip will drive **SDO** at the start of bit 8.

bit 1-7: address AD(6:0). This is the address field of the indexed register.

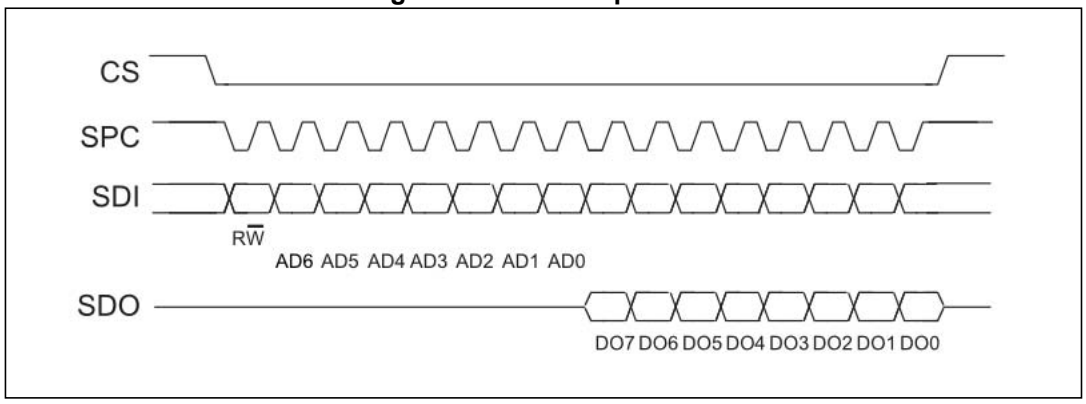
bit 8-15: data DI(7:0) (write mode). This is the data that is written into the device (MSb first).
bit 8-15: data DO(7:0) (read mode). This is the data that is read from the device (MSb first).
In multiple read/write commands further blocks of 8 clock periods are added. When the IF_ADD_INC bit is 0, the address used to read/write data remains the same for every block. When the IF_ADD_INC bit is 1, the address used to read/write data is incremented at every block.

The function and the behavior of **SDI** and **SDO** remain unchanged.

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7.3.1 SPI read

Figure 17. SPI read protocol



The SPI read command is performed with 16 clock pulses. The multiple byte read command is performed by adding blocks of 8 clock pulses to the previous one.

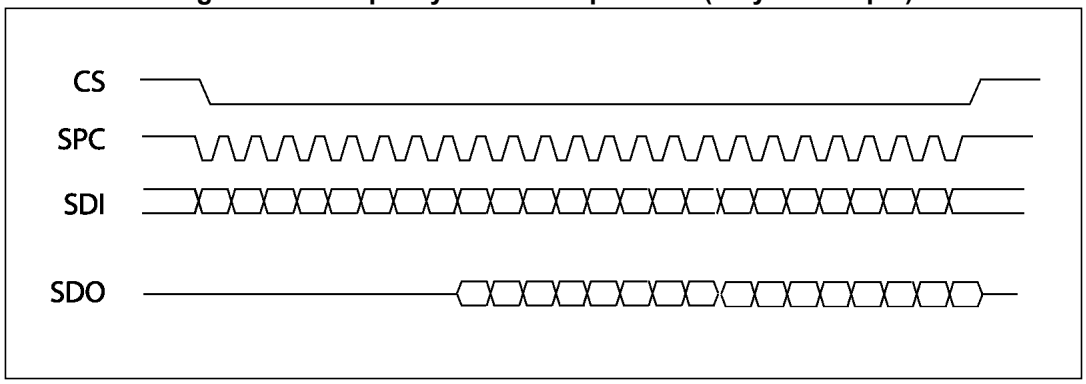
bit 0: READ bit. The value is 1.

bit 1-7: address AD(6:0). This is the address field of the indexed register.

bit 8-15: data DO(7:0) (read mode). This is the data that is read from the device (MSb first).

bit 16-...: data DO(...-8). Further data in multiple byte reads.

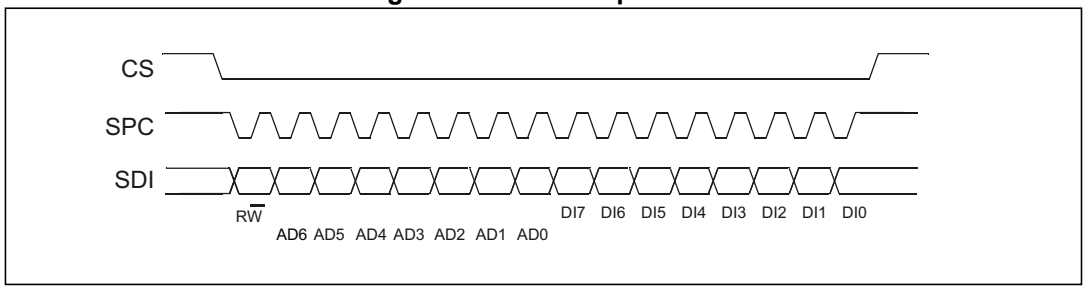
Figure 18. Multiple byte SPI read protocol (2-byte example)



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7.3.2 SPI write

Figure 19. SPI write protocol



The SPI write command is performed with 16 clock pulses. The multiple byte write command is performed by adding blocks of 8 clock pulses to the previous one.

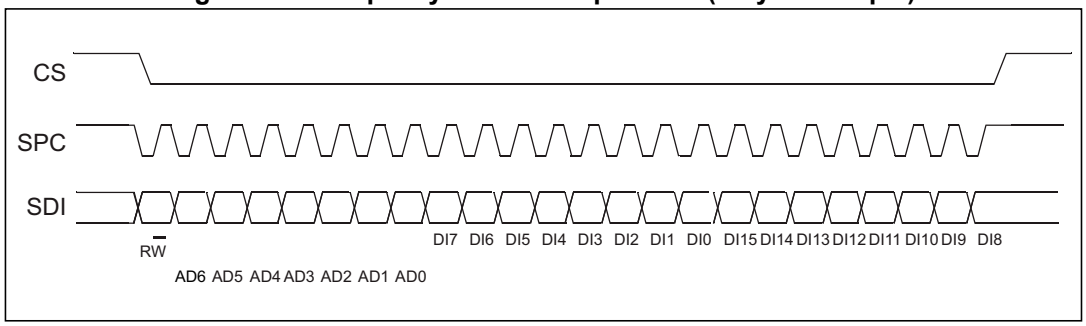
bit 0: WRITE bit. The value is 0.

bit 1-7: address AD(6:0). This is the address field of the indexed register.

bit 8-15: data DI(7:0) (write mode). This is the data that is written in the device (MSb first).

bit 16-...: data DI(...-8). Further data in multiple byte writes.

Figure 20. Multiple byte SPI write protocol (2-byte example)

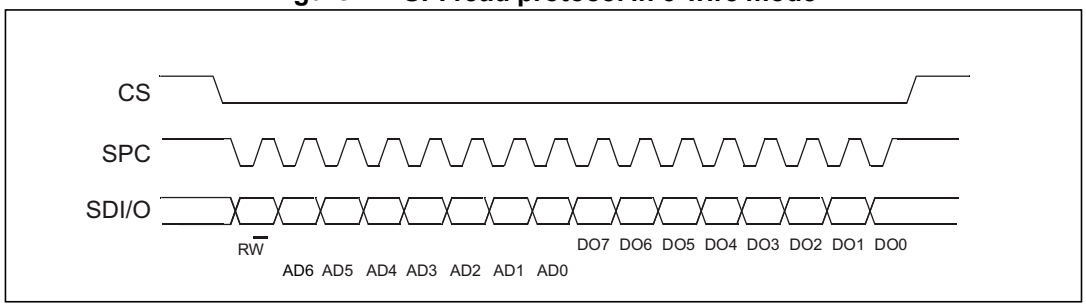


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7.3.3 SPI read in 3-wire mode

A 3-wire mode is entered by setting bit SIM to ‘1’ (SPI serial interface mode selection) in *CTRL_REG1 (10h)*.

Figure 21. SPI read protocol in 3-wire mode



The SPI read command is performed with 16 clock pulses:

bit 0: READ bit. The value is 1.

bit 1-7: address AD(6:0). This is the address field of the indexed register.

bit 8-15: data DO(7:0) (read mode). This is the data that is read from the device (MSb first).
A multiple read command is also available in 3-wire mode.

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7.4 MIPI I3C^{SM} slave interface

The LPS22HH interface includes a MIPI I3C^{SM} SDR only slave interface with MIPI I3C^{SM} SDR embedded features:

- CCC command
- Direct CCC communication (SET and GET)
- Broadcast CCC communication
- Private communications
- Private read and write for single byte
- Multiple read and write
- In-band interrupt and hot-join requests

7.4.1 MIPI I3C^{SM} CCC supported commands

The list of MIPI I3C^{SM} CCC commands supported by the device is detailed in the following table.

Table 16. MIPI I3C^{SM} CCC commands

Command	Command code	Default	Description
ENEC	0x80 / 0x00		Slave activity control (direct and broadcast)
RSTDAA	0x86 / 0x06		Reset the assigned dynamic address (direct and broadcast)
DISEC	0x81 / 0x01		Slave activity control (direct and broadcast)
ENTAS0	0x82 / 0x02		Enter activity state (direct and broadcast)
ENTAS1	0x83 / 0x03		Enter activity state (direct and broadcast)
ENTAS2	0x84 / 0x04		Enter activity state (direct and broadcast)
ENTAS3	0x85 / 0x05		Enter activity state (direct and broadcast)
SETMWL	0x89 / 0x08	0x00 0x08	Define maximum write length during private write (direct and broadcast)
SETMRL	0x8A / 0x09	0x00 0x10 0x04	Define maximum read length during private read (direct and broadcast)
SETDASA	0x87		Assign dynamic address using static address (0x5C / 0x5D depending on the SDO level)
SETNEWDA	0x88		Change dynamic address
GETMWL	0x8B	0x00 0x08	Get maximum write length during private write
GETMRL	0x8C	0x00 0x10 0x04	Get maximum read length during private read

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Table 16. MIPI I3C^{SM} CCC commands (continued)

Command	Command code	Default	Description
GETPID	0x8D	0x02 0x08 0x00 0xB3 0x00 0x00	Device ID register
GETBCR	0x8E	0x07	Bus characteristics register
GETDCR	0x8F	0x62	DCR
GETSTATUS	0x90		Status register
GETMXDS	0x94	0x00 0x20	Return max data speed
GETXTIME	0x99	0x07 0x04 0x0A 0x64	Get exchange time information

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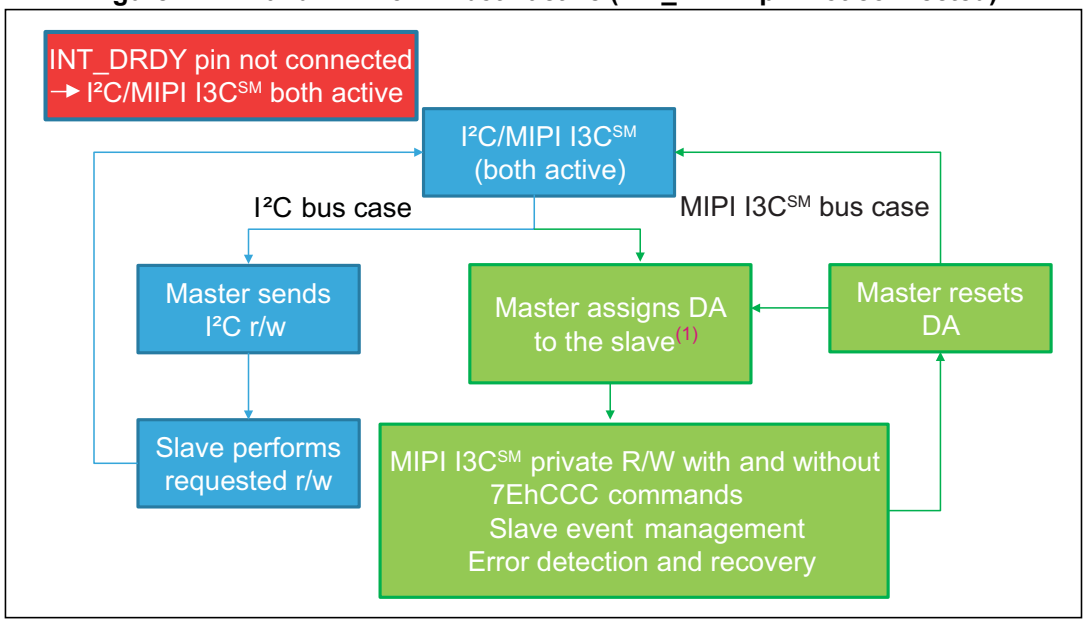
7.5 I²C/MIPI I3C^{SM} coexistence in LPS22HH

In the LPS22HH, the SDA and SCL lines are common to both I²C and MIPI I3C^{SM}. The I²C bus requires anti-spike filters on the SDA and SCL pins that are not compatible with MIPI I3C^{SM} timing.

The device can be connected to both I²C and MIPI I3C^{SM} or only to the MIPI I3C^{SM} bus depending on the connection of the INT1 pin when the device is powered up:

- INT_DRDY pin floating (internal pull-down): I²C/MIPI I3C^{SM} both active, see *Figure 22*
  - I²C case: INT_DRDY pin is by default an input with pull-down. If I²C is used, INT_DRDY must be left unconnected or eventually pulled down during device initialization. After power-on, during device configuration, the INT_DRDY pin can be programmed as an interrupt output pin and it is recommended to set bit I3C_disable to '1'.
  - I3C case: INT_DRDY pin is by default an input with pull-down. If I3C is used and the INT_DRDY pin is unconnected, dynamic address assignment must be performed using I²C Fast Mode Plus Timing (max 1 MHz clock). After dynamic address assignment, I3C can be used in full speed mode.
- INT_DRDY pin connected to VDD_IO: only MIPI I3C^{SM} active, see *Figure 23*
  - Only I3C: INT_DRDY pin is by default an input with pull-down. If INT_DRDY is set to Vdd_IO, I3C slave is selected and device can be initialized at full speed through the SETDASA command. If the I3C bus is available for more than 10 msec and the device is not yet addressed, a hot join request is performed (SDA line kept to ground from slave) and the master must manage the request. After device address assignment, a private write can be performed to disconnect the INT_DRDY pull-down.

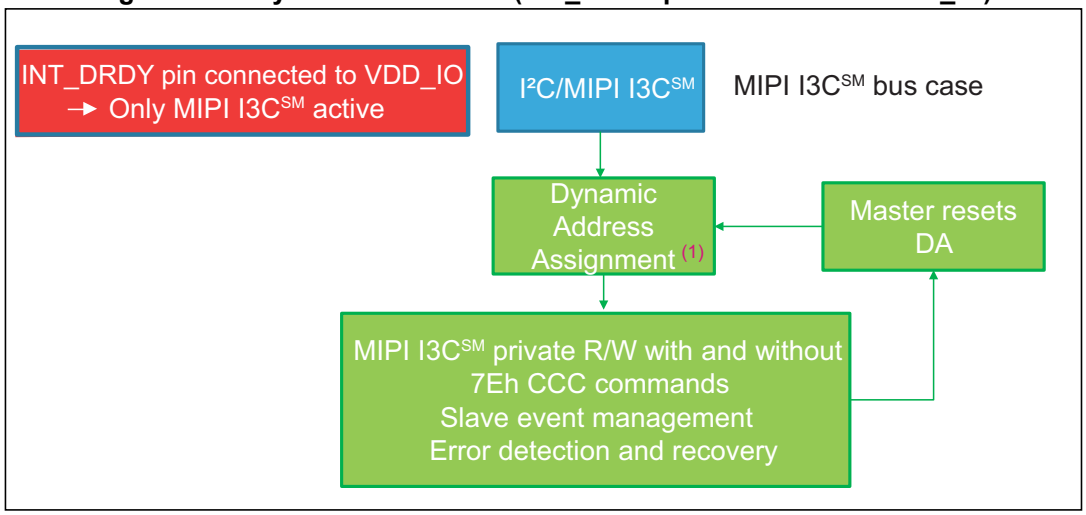
Figure 22. I²C and MIPI I3C^{SM} both active (INT_DRDY pin not connected)



1. Address assignment (SETDASA) must be performed with I²C Fast Mode Plus Timing. When the slave is addressed, the I²C slave is disabled and the timing is compatible with MIPI I3C^{SM} specifications.

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Figure 23. Only MIPI I3C^{SM} active (INT_DRDY pin connected to VDD_IO)



1. When the slave is MIPI I3C^{SM} only, the I²C slave is always disabled. The address can be assigned using MIPI I3C^{SM} SDR timing.

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8 Register mapping

Table 17 provides a quick overview of the 8-bit registers embedded in the device.

Table 17. Registers address map

Name	Type	Register address	Default	Function and comment
		Hex	Binary	
Reserved		00 – 0A	-	Reserved
INTERRUPT_CFG	R/W	0B	00000000	Interrupt register
THS_P_L	R/W	0C	00000000	Pressure threshold registers
THS_P_H	R/W	0D	00000000	
IF_CTRL	R/W	0E	00000000	Interface control register
WHO_AM_I	R	0F	10110011	Who am I
CTRL_REG1	R/W	10	00000000	Control registers
CTRL_REG2	R/W	11	00010000	
CTRL_REG3	R/W	12	00000000	
FIFO_CTRL	R/W	13	00000000	FIFO configuration register
FIFO_WTM	R/W	14	00000000	
REF_P_L	R	15	00000000	Reference pressure registers
REF_P_H	R	16	00000000	
Reserved		17	-	Reserved
RPDS_L	R/W	18	00000000	Pressure offset registers
RPDS_H	R/W	19	00000000	
Reserved		1A-23	-	Reserved
INT_SOURCE	R	24	Output	Interrupt register
FIFO_STATUS1	R	25	Output	FIFO status registers
FIFO_STATUS2	R	26	Output	
STATUS	R	27	Output	Status register
PRESSURE_OUT_XL	R	28	Output	Pressure output registers
PRESSURE_OUT_L	R	29	Output	
PRESSURE_OUT_H	R	2A	Output	
TEMP_OUT_L	R	2B	Output	Temperature output registers
TEMP_OUT_H	R	2C	Output	
Reserved		2D - 77	-	Reserved
FIFO_DATA_OUT_PRESS_XL	R	78	Output	FIFO pressure output registers
FIFO_DATA_OUT_PRESS_L	R	79	Output	
FIFO_DATA_OUT_PRESS_H	R	7A	Output	

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Table 17. Registers address map (continued)

Name	Type	Register address	Default	Function and comment
		Hex	Binary	
FIFO_DATA_OUT_TEMP_L	R	7B	Output	FIFO temperature output registers
FIFO_DATA_OUT_TEMP_H	R	7C	Output	

Registers marked as Reserved must not be changed. Writing to those registers may cause permanent damage to the device.

To guarantee the proper behavior of the device, all register addresses not listed in the above table must not be accessed and the content stored in those registers must not be changed.

The content of the registers that are loaded at boot should not be changed. They contain the factory calibration values. Their content is automatically restored when the device is powered up.

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9 Register description

The device contains a set of registers which are used to control its behavior and to retrieve pressure and temperature data. The register address, made up of 7 bits, is used to identify them and to read/write the data through the serial interface.

9.1 INTERRUPT_CFG (0Bh)

Interrupt mode for pressure acquisition configuration (R/W)

7	6	5	4	3	2	1	0
AUTOREFP	RESET_ARP	AUTOZERO	RESET_AZ	DIFF_EN	LIR	PLE	PHE

AUTOREFP	Enable AUTOREFP function. Default value: 0 (0: normal mode; 1: AUTOREFP enabled)
RESET_ARP	Reset AUTOREFP function. Default value: 0 (0: normal mode; 1: reset AUTOREFP function)
AUTOZERO	Enable AUTOZERO function. Default value: 0 (0: normal mode; 1: AUTOZERO enabled)
RESET_AZ	Reset AUTOZERO function. Default value: 0 (0: normal mode; 1: reset AUTOZERO function)
DIFF_EN	Enable interrupt generation. Default value: 0 (0: interrupt generation disabled; 1: interrupt generation enabled)
LIR	Latch interrupt request to the *INT_SOURCE (24h)* register. Default value: 0 (0: interrupt request not latched; 1: interrupt request latched)
PLE	Enable interrupt generation on pressure low event. Default value: 0 (0: disable interrupt request; 1: enable interrupt request on pressure value lower than preset threshold)
PHE	Enable interrupt generation on pressure high event. Default value: 0 (0: disable interrupt request; 1: enable interrupt request on pressure value higher than preset threshold)

Referring to *Figure 24: "Threshold-based" interrupt event*, the LPS22HH can be set by the user to support the interrupt function when P_DIFF_IN (defined below) is higher or lower than the threshold value stored in *THS_P_L (0Ch)* and *THS_P_H (0Dh)*.

It is enabled when the DIFF_EN bit in *INTERRUPT_CFG (0Bh)* register is set to '1' and either PHE bit or PLE bit (or both bits) = '1'. Then, the differential pressure can be compared to a user-defined threshold stored in the 15-bit THS_P (0Ch and 0Dh) registers.

The threshold pressure value defined by the user is a 15-bit unsigned value in a 16-bit register composed of *THS_P_L (0Ch)* and *THS_P_H (0Dh)* The value is:

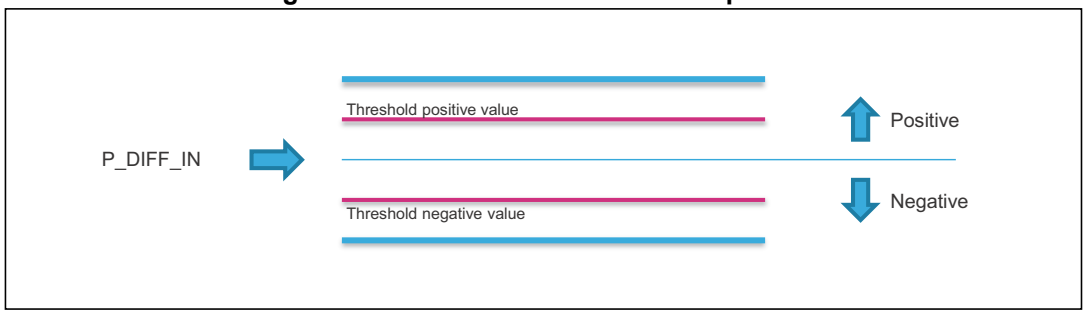
THS_P (15-bit unsigned) = Desired Interrupt threshold (hPa) x 16

The PHE and PLE bits in *INTERRUPT_CFG (0Bh)* enable the differential pressure interrupt generation on the positive or negative event respectively.

The differential interrupt must be used with AUTOREFP or AUTOZERO mode. Please refer to the application note (AN5209: Section 8. Interrupt modes) for further details.

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Figure 24. “Threshold-based” interrupt event



To enable the **AUTOZERO** mode, the AUTOZERO bit must be set to '1' and then the measured pressure value is used as the reference and stored in the register REF_P (*REF_P_L (15h)*, *REF_P_H (16h)*). From this point on, the output pressure value (*PRESS_OUT_XL (28h)*, *PRESS_OUT_L (29h)*, *PRESS_OUT_H (2Ah)*) is updated with the difference between the measured pressure and REF_P.

– P_DIFF_IN = measured pressure - REF_P
– PRESS_OUT = measured pressure - REF_P

After the first conversion, the AUTOZERO bit is automatically set back to '0'. In order to return back to normal mode, the RESET_AZ bit in the *INTERRUPT_CFG (0Bh)* register has to be set to '1'. This also resets the content of the REF_P registers to 0.

AUTOREFP mode allows using the pressure differential for the generation of the interrupt keeping the output pressure registers PRESS_OUT (*PRESS_OUT_XL (28h)*, *PRESS_OUT_L (29h)*, *PRESS_OUT_H (2Ah)*) without comparing REF_P. If the AUTOREFP bit is set to '1', the measured output pressure is used as the reference in the register REF_P (*REF_P_L (15h)*, *REF_P_H (16h)*) for interrupt generation with following:

– P_DIFF_IN = measured pressure - REF_P

The output registers PRESS_OUT (28h, 29h and 2Ah) are not changed by REF_P and shows as follows.

– PRESS_OUT = measured pressure

After the first conversion, the AUTOREFP bit is automatically set to '0'. In order to return back to normal mode, the RESET_ARP bit has to be set to '1'

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9.2 THS_P_L (0Ch)

User-defined threshold value for pressure interrupt event (Least significant bits) (R/W)

7	6	5	4	3	2	1	0
THS7	THS6	THS5	THS4	THS3	THS2	THS1	THS0

THS[7:0]	This register contains the low part of threshold value for pressure interrupt generation. Default value: 00h

The threshold value for pressure interrupt generation is a 15-bit unsigned right-justified value composed of *THS_P_H (0Dh)* and *THS_P_L (0Ch)*.The value is expressed as:

THS_P (15-bit unsigned) = Desired interrupt threshold (hPa) x 16

To enable the interrupt event based on this user-defined threshold, the DIFF_EN bit in *INTERRUPT_CFG (0Bh)* must be set to '1', the PHE bit or PLE bit (or both bits) in *INTERRUPT_CFG (0Bh)* has to be enabled.

9.3 THS_P_H (0Dh)

User-defined threshold value for pressure interrupt event (Most significant bits) (R/W)

7	6	5	4	3	2	1	0
-	THS14	THS13	THS12	THS11	THS10	THS9	THS8

THS[14:8]	This register contains the high part of threshold value for pressure interrupt generation. Refer to *THS_P_L (0Ch)*. Default value: 00h

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9.4 IF_CTRL (0Eh)

Interface control register (R/W)

7	6	5	4	3	2	1	0
INT_EN_I3C	0	0	SDA_PU_EN	SDO_PU_EN	PD_DIS_INT1	I3C_DISABLE	I2C_DISABLE

INT_EN_I3C	Enable INT1 pad with MIPI I3C^{SM}. If the INT_EN_I3C bit is set, the INT1 pad is polarized as OUT. Default value: 0 (0: INT1 disabled with MIPI I3C^{SM}; 1: INT1 enabled with MIPI I3C^{SM})
SDA_PU_EN	Enable pull-up on the SDA pin. Default value: 0 (0: SDA pin pull-up disconnected; 1: SDA pin with pull-up)
SDO_PU_EN	Enable pull-up on the SDO pin. Default value: 0 (0: SDO pin pull-up disconnected; 1: SDO pin with pull-up)
PD_DIS_INT1	Disable pull down on the INT1 pin. Default value: 0 (0: INT1 pin with pull-down; 1: INT1 pin pull-down disconnected)
I3C_DISABLE(1)	Disable MIPI I3C^{SM} interface. Default value: 0 (0: MIPI I3C^{SM} enabled; 1: MIPI I3C^{SM} disabled)
I2C_DISABLE(2)	Disable I²C interface. Default value: 0 (0: I²C enabled; 1: I²C disabled)

1. I3C_DISABLE bit disables the MIPI I3C^{SM} communication protocol.
2. I2C_DISABLE bit disables the I²C interface, by default both SPI and I²C interfaces are enabled.

9.5 WHO_AM_I (0Fh)

Device Who am I

7	6	5	4	3	2	1	0
1	0	1	1	0	0	1	1

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9.6 CTRL_REG1 (10h)

Control register 1 (R/W)

7	6	5	4	3	2	1	0
0	ODR2	ODR1	ODR0	EN_LPFP	LPFP_CFG	BDU	SIM

ODR[2:0]	Output data rate selection. Default value: 000 Refer to *Table 18*.
EN_LPFP	Enable low-pass filter on pressure data when Continuous mode is used. Default value: 0 (0: Low-pass filter disabled; 1: Low-pass filter enabled)
LPFP_CFG	LPFP_CFG: Low-pass configuration register. Default value: 0 Refer to *Table 19*.
BDU(1)	Block data update. Default value: 0 (0: continuous update; 1: output registers not updated until MSB and LSB have been read)
SIM	SPI Serial Interface Mode selection. Default value: 0 (0: 4-wire interface; 1: 3-wire interface)

1. To guarantee the correct behavior of BDU feature, *PRESS_OUT_H (2Ah)* must be the last address read.

Table 18. Output data rate bit configurations

ODR[2:0]	Temperature, Pressure
000	One-shot
001	1 Hz
010	10 Hz
011	25 Hz
100	50 Hz
101	75 Hz
110(1)	100 Hz
111(1)	200 Hz

1. This option disables the low-noise mode automatically.

When the ODR bits are set to '000', the device is in **Power-down mode**. When the device is in power-down mode, almost all internal blocks of the device are switched off to minimize power consumption. The I²C interface is still active to allow communication with the device. The content of the configuration registers is preserved and output data registers are not updated, therefore keeping the last data sampled in memory before going into power-down mode.

If the ONE_SHOT bit in *CTRL_REG2 (11h)* is set to '1', **One-shot mode** is triggered and a new acquisition starts when it is required. Enabling this mode is possible only if the device was previously in power-down mode (ODR bits set to '000'). Once the acquisition is completed and the output registers updated, the device automatically enters in power-down mode. ONE_SHOT bit self-clears itself.

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When the ODR bits are set to a value different than '000', the device is in **Continuous mode** and automatically acquires a set of data (pressure and temperature) at the frequency selected through the ODR[2:0] bits.

Once the additional low-pass filter has been enabled through the EN_LPFP bit, it is possible to configure the device bandwidth acting on the LPFP_CFG bit. See *Table 19* for low-pass filter configurations.

Table 19. Low-pass filter configurations

EN_LPFP	LPFP_CFG	Additional low-pass filter status	Device bandwidth
0	x	Disabled	ODR/2
1	0	Enabled	ODR/9
1	1	Enabled	ODR/20

The BDU bit is used to inhibit the update of the output registers until both upper and lower (and XLOW) register parts are read. In default mode (BDU = ‘0’) the output register values are updated continuously. If for any reason it is not sure to read faster than the output data rate, it is recommended to set the BDU bit to ‘1’. In this way, the content of the output registers is not updated until MSB, LSB and XLSB have been read which avoids reading values related to different sample times.

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9.7 CTRL_REG2 (11h)

Control register 2 (R/W)

7	6	5	4	3	2	1	0
BOOT	INT_H_L	PP_OD	IF_ADD_INC	0	SWRESET	LOW_NOISE_EN	ONE_SHOT

BOOT	Reboots memory content. Default value: 0 (0: normal mode; 1: reboot memory content)
INT_H_L	Interrupt active-high, active-low. Default value: 0 (0: active high; 1: active low)
PP_OD	Push-pull/open-drain selection on interrupt pad. Default value: 0 (0: push-pull; 1: open-drain)
IF_ADD_INC	Register address automatically incremented during a multiple byte access with a serial interface (I²C or SPI). Default value: 1 (0: disable; 1: enable)
SWRESET	Software reset. Default value: 0 (0: normal mode; 1: software reset). The bit is self-cleared when the reset is completed.
LOW_NOISE_EN	Enables low noise (used only if ODR is lower than 100 Hz). Default value: 0 (0: low-current mode; 1: low-noise mode)
ONE_SHOT	Enables one-shot. Default value: 0 (0: idle mode; 1: a new dataset is acquired)

The BOOT bit is used to refresh the content of the internal registers stored in the Flash memory block. At device power-up, the content of the Flash memory block is transferred to the internal registers related to the trimming functions to allow correct behavior of the device itself. If for any reason the content of the trimming registers is modified, it is sufficient to use this bit to restore the correct values. When the BOOT bit is set to '1', the content of the internal Flash is copied into the corresponding internal registers and is used to calibrate the device. These values are factory trimmed and they are different for every device. They allow the correct behavior of the device and normally they should not be changed. At the end of the boot process, the BOOT bit is set again to '0' by hardware. The BOOT bit takes effect immediately after it is set to 1.

INT_H_L selects an interrupt active-high/low value.

PP_OD selects push-pull/open-drain on the interrupt pad.

The IF_ADD_INC bit enables the address to be automatically incremented during a multiple byte access with a serial interface (SPI or I²C).

The SWRESET bit resets the volatile registers to default value ‘0’. It returns to ‘0’ by hardware.

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LOW_NOISE_EN is disabled by default and must be changed when the device is in power-down mode. It enables low-noise mode but can be used when the ODR is lower than 100 Hz. If ODR = 100 Hz or ODR = 200 Hz, this option is automatically switched off and the value of the low-noise enable bit is ignored.

LOW_NOISE_EN mode is enabled to have less RMS noise and the best performance is achieved with LOW_NOISE_EN set to 1 and filter at ODR/20. Depending on the application, the LOW_NOISE_EN bit can be enabled (low-noise mode) or disabled (low-current mode) to have less RMS noise or less power consumption (refer to the following table).

Table 20. RMS noise and power consumption

Mode	Additional low-pass filter status	Device bandwidth	RMS noise [Pa]	Supply current @ ODR = 1 Hz [µA]
Low noise	Disabled		1.7	12
	Enabled	ODR/9	0.9	12
	Enabled	ODR/20	0.65	12
Low current	Disabled		4.5	4
	Enabled	ODR/9	2.6	4
	Enabled	ODR/20	1.7	4

The ONE_SHOT bit is used to start a new conversion when the ODR[2:0] bits in *CTRL_REG1 (10h)* are set to '000'. Writing a '1' in ONE_SHOT triggers a single measurement of pressure and temperature. Once the measurement is done, the ONE_SHOT bit will self-clear, the new data are available in the output registers, and the *STATUS (27h)* bits are updated.

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9.8 CTRL_REG3 (12h)

Control register 3 - INT_DRDY pin control register (R/W)

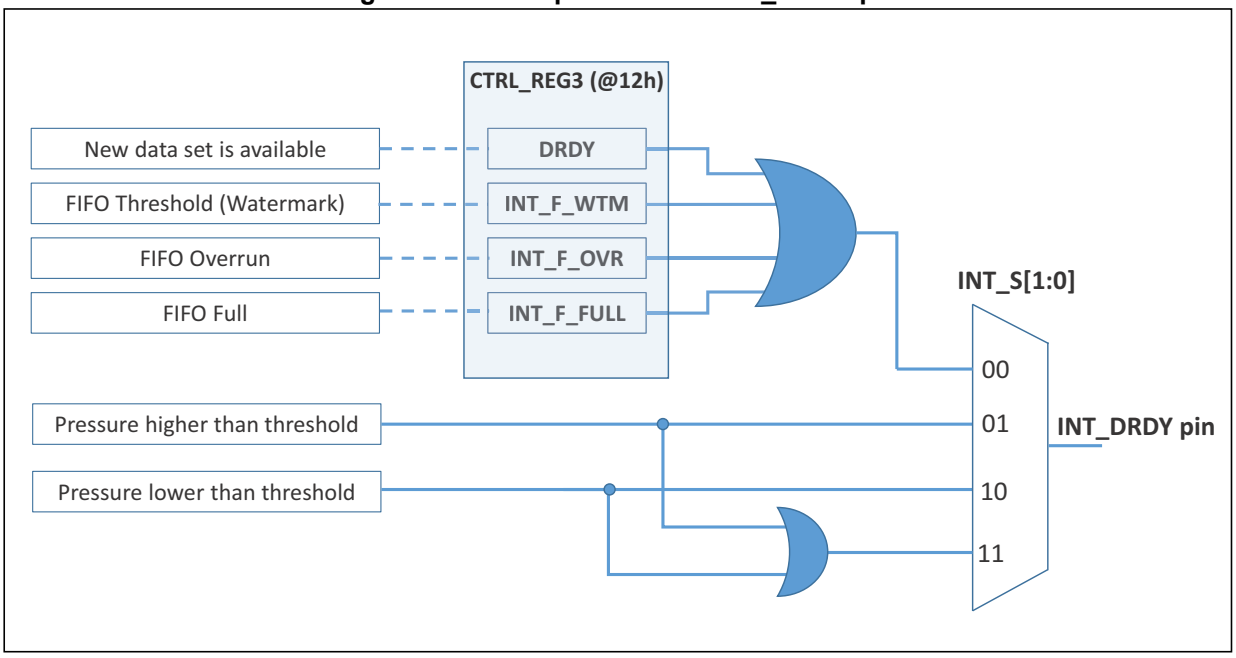
7	6	5	4	3	2	1	0
0	0	INT_F_FULL	INT_F_WTM	INT_F_OVR	DRDY	INT_S1	INT_S0

INT_F_FULL	FIFO full flag on INT_DRDY pin. Default value: 0 (0: FIFO empty; 1: FIFO full - 128 unread samples)
INT_F_WTM	FIFO threshold (watermark) status on INT_DRDY pin. Default value: 0 (0: FIFO is lower than FTH level; 1: FIFO is equal to or higher than FTH level)
INT_F_OVR	FIFO overrun status on INT_DRDY pin. Default value: 0 (0: not overwritten; 1: at least one sample in the FIFO has been overwritten)
DRDY	Data-ready signal on INT_DRDY pin. Default value: 0 (0: disable; 1: enable)
INT_S[1:0]	Data signal on INT_DRDY pin control bits. Default value: 00 Refer to *Table 21*.

Table 21. Interrupt configurations

INT_S1	INT_S0	INT_DRDY pin configuration
0	0	Data signal (in order of priority: DRDY or INT_F_WTM or INT_F_OVR or INT_F_FULL)
0	1	Pressure high (P_high)
1	0	Pressure low (P_low)
1	1	Pressure low OR high

Figure 25. Interrupt events on INT_DRDY pin



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9.9 FIFO_CTRL (13h)

FIFO control register (R/W)

7	6	5	4	3	2	1	0
0	0	0	0	STOP_ON_WTM	TRIG_MODES	F_MODE1	F_MODE0

STOP_ON_WTM	Stop-on-FIFO watermark. Enables FIFO watermark level use. Default value: 0 (0: disable; 1: enable)
TRIG_MODES	Enables triggered FIFO modes. Default value: 0
F_MODE[1:0]	Selects triggered FIFO modes. Default value: 00 Refer to *Table 22*.

Table 22. FIFO mode selection

TRIG_MODES	F_MODE[1:]	Mode
x	00	Bypass
0	01	FIFO mode
0	1x	Continuous (Dynamic-Stream)
1	01	Bypass-to-FIFO
1	10	Bypass-to-Continuous (Dynamic-Stream)
1	11	Continuous (Dynamic-Stream)-to-FIFO

The STOP_ON_WTM bit enables the use of the FIFO watermark level: when the number of samples in FIFO is equal to the watermark level (set using the WTM[4:0] bits in *FIFO_WTM (14h)*) then FIFO is full.

The TRIG_MODES bit enables the triggered FIFO modes.

The F_MODE[1:0] bits select one of the FIFO modes, as described in *Table 22*.

Output data (pressure and temperature) are read through *FIFO_DATA_OUT_PRESS_XL (78h)*, *FIFO_DATA_OUT_PRESS_L (79h)*, *FIFO_DATA_OUT_PRESS_H (7Ah)*, *FIFO_DATA_OUT_TEMP_L (7Bh)* and *FIFO_DATA_OUT_TEMP_H (7Ch)*; both single read and multiple read operations can be used.

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9.10 FIFO_WTM (14h)

FIFO threshold setting register (R/W)

7	6	5	4	3	2	1	0
0	WTM6	WTM5	WTM4	WTM3	WTM2	WTM1	WTM0

WTM[6:0]	FIFO threshold. Watermark level setting. Default value: 0000000

9.11 REF_P_L (15h)

Reference pressure LSB data (R)

7	6	5	4	3	2	1	0
REFL7	REFL6	REFL5	REFL4	REFL3	REFL2	REFL1	REFL0

REFL[7:0]	This register contains the low part of the reference pressure value. Default value: 00000000

The Reference pressure value is 16-bit data and it is composed of *REF_P_H (16h)* and *REF_P_L (15h)*. The value is expressed as 2's complement.

The reference pressure value is stored and used when the AUTOZERO or AUTOREFP function is enabled. Please refer to the *INTERRUPT_CFG (0Bh)* register description.

9.12 REF_P_H (16h)

Reference pressure MSB data (R)

7	6	5	4	3	2	1	0
REFL15	REFL14	REFL13	REFL12	REFL11	REFL10	REFL9	REFL8

REFL[15:8]	This register contains the high part of the reference pressure value. Default value: 00000000

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9.13 RPDS_L (18h)

Pressure offset (LSB data)

7	6	5	4	3	2	1	0
RPDS7	RPDS6	RPDS5	RPDS4	RPDS3	RPDS2	RPDS1	RPDS0

RPDS[7:0]	This register contains the low part of the pressure offset value. Default value: 00000000

The pressure offset value is 16-bit data that can be used to implement one-point calibration (OPC) after soldering. This value is composed of *RPDS_H (19h)* and *RPDS_L (18h)*. The value is expressed as 2's complement.

9.14 RPDS_H (19h)

Pressure offset (MSB data)

7	6	5	4	3	2	1	0
RPDS15	RPDS14	RPDS13	RPDS12	RPDS11	RPDS10	RPDS9	RPDS8

RPDS[15:8]	This register contains the high part of the pressure offset value. Refer to *RPDS_L (18h)*. Default value: 00000000

9.15 INT_SOURCE (24h)

Interrupt source (read only)

7	6	5	4	3	2	1	0
BOOT_ON	0	0	0	0	IA	PL	PH

BOOT_ON	Indication of Boot phase. (0: Boot phase has ended; 1: Boot phase is running).
IA	Interrupt active. (0: no interrupt has been generated; 1: one or more interrupt events have been generated).
PL	Differential pressure Low. (0: no interrupt has been generated; 1: low differential pressure event has occurred).
PH	Differential pressure High. (0: no interrupt has been generated; 1: high differential pressure event has occurred).

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9.16 FIFO_STATUS1 (25h)

FIFO status register (read only)

7	6	5	4	3	2	1	0
FSS7	FSS6	FSS5	FSS4	FSS3	FSS2	FSS1	FSS0

FSS[7:0]	FIFO stored data level, number of unread samples stored in FIFO. (00000000: FIFO empty; 10000000: FIFO full, 128 unread samples)

9.17 FIFO_STATUS2 (26h)

FIFO status register (read only)

7	6	5	4	3	2	1	0
FIFO_WTM_IA	FIFO_OVR_IA	FIFO_FULL_IA	-	-	-	-	-

FIFO_WTM_IA	FIFO threshold (watermark) status. Default value: 0 (0: FIFO filling is lower than treshold level; 1: FIFO filling is equal or higher than treshold level).
FIFO_OVR_IA	FIFO overrun status. Default value: 0 (0: FIFO is not completely full; 1: FIFO is full and at least one sample in the FIFO has been overwritten).
FIFO_FULL_IA	FIFO full status. Default value: 0 (0: FIFO is not completely filled; 1: FIFO is completely filled, no samples overwritten)

9.18 STATUS (27h)

Status register (read only)

7	6	5	4	3	2	1	0
--	--	T_OR	P_OR	--	--	T_DA	P_DA

T_OR	Temperature data overrun. (0: no overrun has occurred; 1: a new data for temperature has overwritten the previous data)
P_OR	Pressure data overrun. (0: no overrun has occurred; 1: new data for pressure has overwritten the previous data)
T_DA	Temperature data available. (0: new data for temperature is not yet available; 1: a new temperature data is generated)
P_DA	Pressure data available. (0: new data for pressure is not yet available; 1: a new pressure data is generated)

This register is updated every ODR cycle.

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9.19 PRESS_OUT_XL (28h)

Pressure output value LSB data (read only)

7	6	5	4	3	2	1	0
POUT7	POUT6	POUT5	POUT4	POUT3	POUT2	POUT1	POUT0

POUT[7:0]	This register contains the low part of the pressure output value.

The pressure output value is a 24-bit data that contains the measured pressure. It is composed of *PRESS_OUT_H (2Ah)*, *PRESS_OUT_L (29h)* and *PRESS_OUT_XL (28h)*. The value is expressed as 2's complement.

The output pressure register **PRESS_OUT** is provided as the difference between the measured pressure and the content of the register RPDS (18h, 19h)*.

Please refer to *Section 4.4: Interpreting pressure readings* for additional info.

*DIFF_EN = '0', AUTOZERO = '0', AUTOREFP = '0'

9.20 PRESS_OUT_L (29h)

Pressure output value middle data (read only)

7	6	5	4	3	2	1	0
POUT15	POUT14	POUT13	POUT12	POUT11	POUT10	POUT9	POUT8

POUT[15:8]	This register contains the mid part of the pressure output value. Refer to *PRESS_OUT_XL (28h)*

9.21 PRESS_OUT_H (2Ah)

Pressure output value MSB data (read only)

7	6	5	4	3	2	1	0
POUT23	POUT22	POUT21	POUT20	POUT19	POUT18	POUT17	POUT16

POUT[23:16]	This register contains the high part of the pressure output value. Refer to *PRESS_OUT_XL (28h)*

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9.22 TEMP_OUT_L (2Bh)

Temperature output value LSB data (read only)

7	6	5	4	3	2	1	0
TOUT7	TOUT6	TOUT5	TOUT4	TOUT3	TOUT2	TOUT1	TOUT0

TOUT[7:0]	This register contains the low part of the temperature output value.

The temperature output value is 16-bit data that contains the measured temperature. It is composed of *TEMP_OUT_H (2Ch)*, and *TEMP_OUT_L (2Bh)*. The value is expressed as 2's complement.

9.23 TEMP_OUT_H (2Ch)

Temperature output value MSB data (read only)

7	6	5	4	3	2	1	0
TOUT15	TOUT14	TOUT13	TOUT12	TOUT11	TOUT10	TOUT9	TOUT8

TOUT[15:8]	This register contains the high part of the temperature output value.

9.24 FIFO_DATA_OUT_PRESS_XL (78h)

FIFO pressure output LSB data (read only)

7	6	5	4	3	2	1	0
FIFO_P7	FIFO_P6	FIFO_P5	FIFO_P4	FIFO_P3	FIFO_P2	FIFO_P1	FIFO_P0

FIFO_P[7:0]	Pressure LSB data in FIFO buffer

9.25 FIFO_DATA_OUT_PRESS_L (79h)

FIFO pressure output middle data (read only)

7	6	5	4	3	2	1	0
FIFO_P15	FIFO_P14	FIFO_P13	FIFO_P12	FIFO_P11	FIFO_P10	FIFO_P9	FIFO_P8

FIFO_P[15:8]	Pressure middle data in FIFO buffer

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9.26 FIFO_DATA_OUT_PRESS_H (7Ah)

FIFO pressure output MSB data (read only)

7	6	5	4	3	2	1	0
FIFO_P23	FIFO_P22	FIFO_P21	FIFO_P20	FIFO_P19	FIFO_P18	FIFO_P17	FIFO_P16

FIFO_P[23:16]	Pressure middle data in FIFO buffer

9.27 FIFO_DATA_OUT_TEMP_L (7Bh)

FIFO temperature output LSB data (read only)

7	6	5	4	3	2	1	0
FIFO_T7	FIFO_T6	FIFO_T5	FIFO_T4	FIFO_T3	FIFO_T2	FIFO_T1	FIFO_T0

FIFO_T[7:0]	Temperature LSB data in FIFO buffer

9.28 FIFO_DATA_OUT_TEMP_H (7Ch)

FIFO temperature output MSB data (read only)

7	6	5	4	3	2	1	0
FIFO_T15	FIFO_T14	FIFO_T13	FIFO_T12	FIFO_T11	FIFO_T10	FIFO_T9	FIFO_T8

FIFO_T[15:8]	Temperature MSB data in FIFO buffer

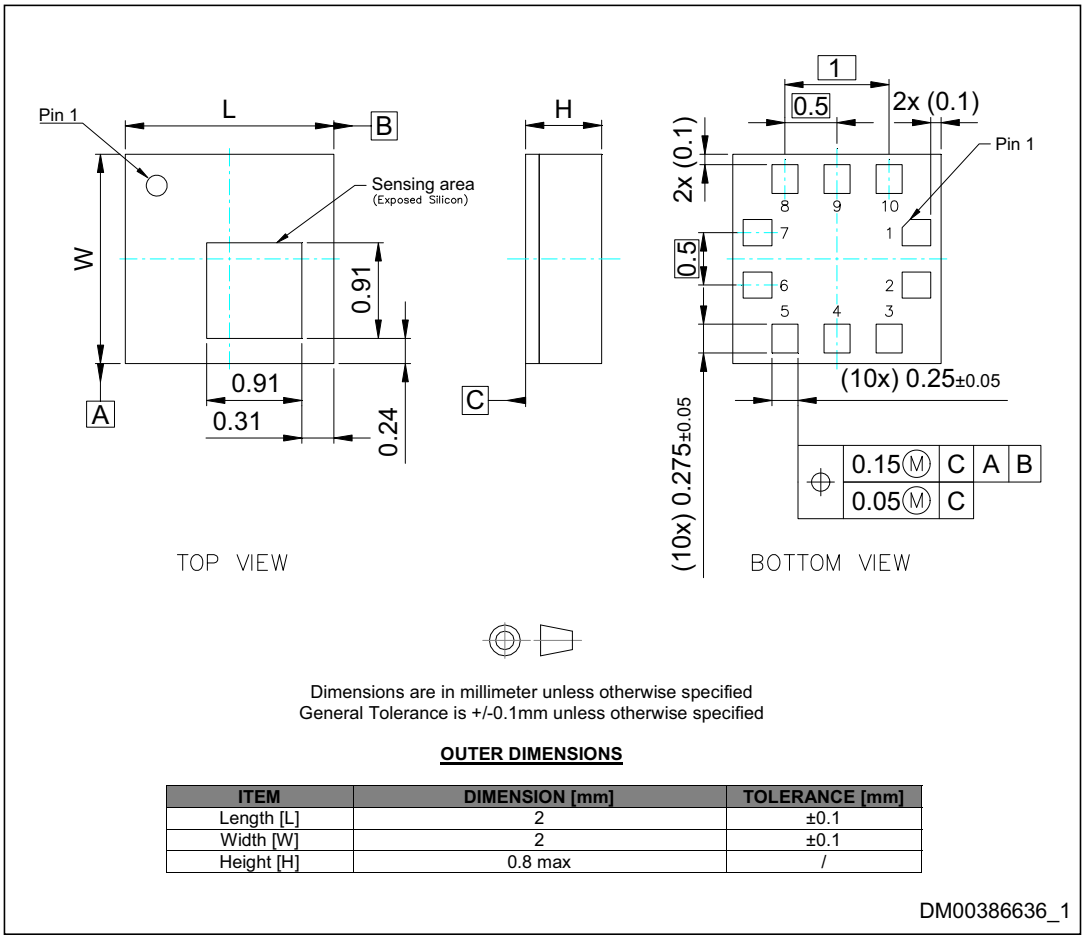
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10 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*. ECOPACK® is an ST trademark.

10.1 HLGA-10L package information

Figure 26. HLGA-10L (2.0 x 2.0 x 0.73 mm typ.) package outline and mechanical dimensions



Dimensions are in millimeter unless otherwise specified
General Tolerance is +/-0.1mm unless otherwise specified

OUTER DIMENSIONS

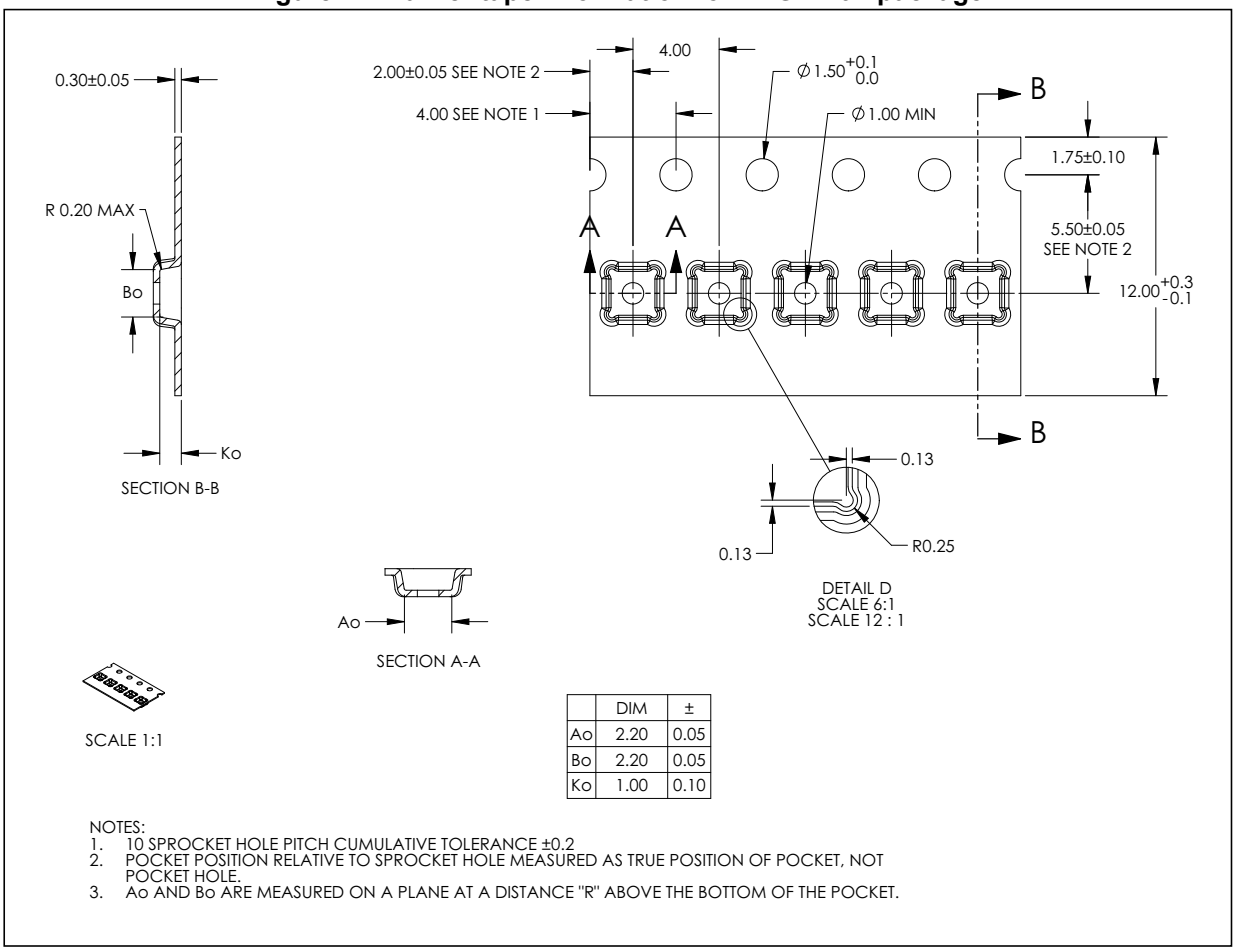
ITEM	DIMENSION [mm]	TOLERANCE [mm]
Length [L]	2	±0.1
Width [W]	2	±0.1
Height [H]	0.8 max	/

DM00386636_1

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10.2 HLGA-10L packing information

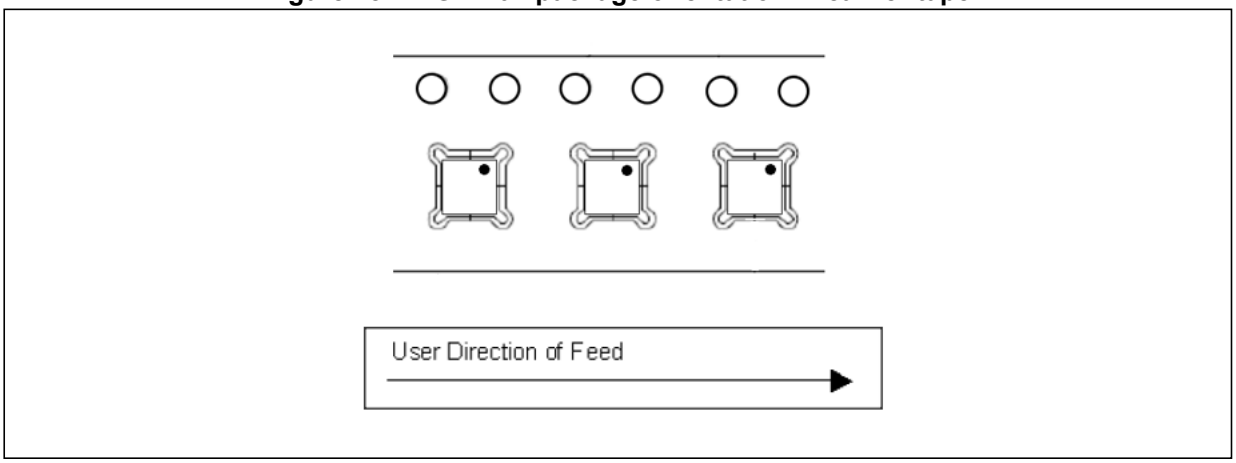
Figure 27. Carrier tape information for HLGA-10L package



	DIM	±
Ao	2.20	0.05
Bo	2.20	0.05
Ko	1.00	0.10

NOTES:
1. 10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE ±0.2
2. POCKET POSITION RELATIVE TO SPROCKET HOLE MEASURED AS TRUE POSITION OF POCKET, NOT POCKET HOLE.
3. Ao AND Bo ARE MEASURED ON A PLANE AT A DISTANCE "R" ABOVE THE BOTTOM OF THE POCKET.

Figure 28. HLGA-10L package orientation in carrier tape



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Figure 29. Reel information for carrier tape of HLGA-10L package

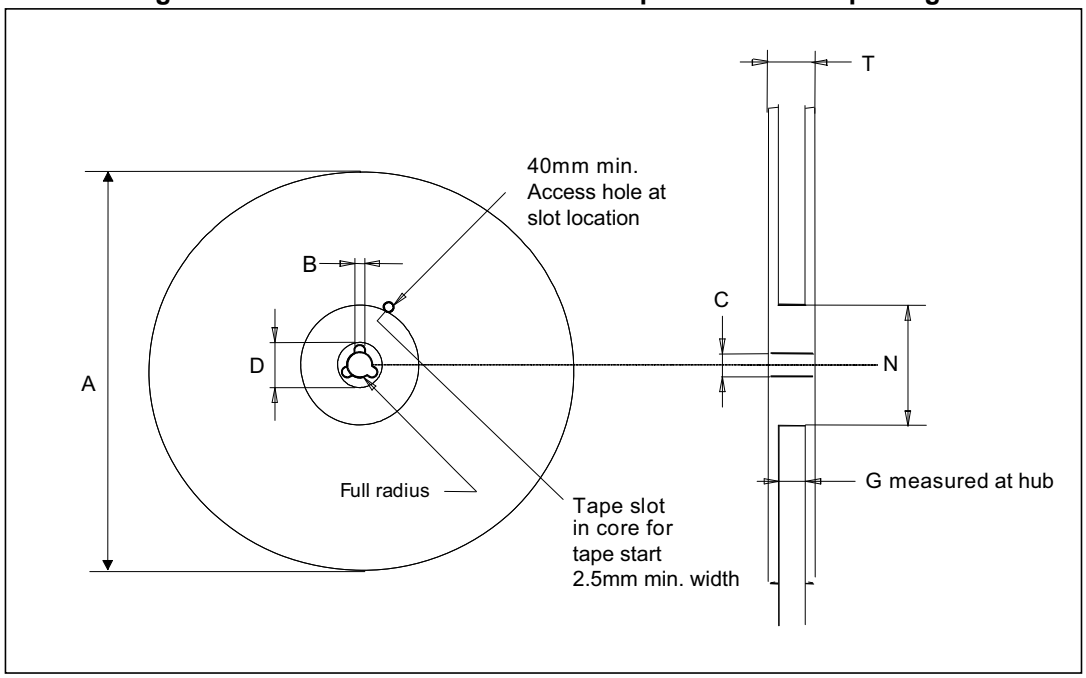


Table 23. Reel dimensions for carrier tape of HLGA-10L package

Reel dimensions (mm)	
A (max)	330
B (min)	1.5
C	13 ±0.25
D (min)	20.2
N (min)	60
G	12.4 +2/-0
T (max)	18.4

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11 Revision history

Table 24. Document revision history

Date	Revision	Changes
22-Aug-2018	1	Initial release
04-Feb-2019	2	Updated description of SETDASA in *Table 16: MIPI I3C^{SM} CCC commands* Updated text concerning BOOT bit in *CTRL_REG2 (11h)* Updated bit 7 in *INT_SOURCE (24h)* Updated *Figure 27: Carrier tape information for HLGA-10L package*

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