GPS

locate, communicate, accelerate

NEO-6

u-blox 6 GPS Modules

Data Sheet

Abstract

Technical data sheet describing the cost effective, high-performance u-blox 6 based NEO-6 series of GPS modules, that brings the high performance of the u-blox 6 positioning engine to the miniature NEO form factor.
These receivers combine a high level of integration capability with flexible connectivity options in a small package. This makes them perfectly suited for mass-market end products with strict size and cost requirements.

16.0 x 12.2 x 2.4 mm

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Document status information	
Objective Specification	This document contains target values. Revised and supplementary data will be published later.
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Preliminary	This document contains data from product verification. Revised and supplementary data may be published later.
Released	This document contains the final product specification.

This document applies to the following products:

Name	Type number	ROM/FLASH version	PCN reference
NEO-6G	NEO-6G-0-001	ROM7.03	UBX-TN-11047-1
NEO-6Q	NEO-6Q-0-001	ROM7.03	UBX-TN-11047-1
NEO-6M	NEO-6M-0-001	ROM7.03	UBX-TN-11047-1
NEO-6P	NEO-6P-0-000	ROM6.02	N/A
NEO-6V	NEO-6V-0-000	ROM7.03	N/A
NEO-6T	NEO-6T-0-000	ROM7.03	N/A

Contents

1 Functional description

1.1 Overview

The NEO-6 module series is a family of stand-alone GPS receivers featuring the high performance u-blox 6 positioning engine. These flexible and cost effective receivers offer numerous connectivity options in a miniature 16 x 12.2 x 2.4 mm package. Their compact architecture and power and memory options make NEO-6 modules ideal for battery operated mobile devices with very strict cost and space constraints.

The 50-channel u-blox 6 positioning engine boasts a Time-To-First-Fix (TTFF) of under 1 second. The dedicated acquisition engine, with 2 million correlators, is capable of massive parallel time/frequency space searches, enabling it to find satellites instantly. Innovative design and technology suppresses jamming sources and mitigates multipath effects, giving NEO-6 GPS receivers excellent navigation performance even in the most challenging environments.

1.2 Product features

Model	Type					Supply		Interfaces				Features						
	GPS	PPP	Timing	Raw Data	Dead Reckoning	1.75 V - 2.0 V	2.7 V - 3.6 V	UART	USB	SPI	DDC (I^2C compliant)	Programmable (Flash) FW update	TCXO	RTC crystal	Antenna supply and supervisor	Configuration pins	Timepulse	External interrupt/ Wakeup
NEO-6G	•					•		•	•	•	•		•	•	O	3	1	•
NEO-6Q	•						•	•	•	•	•		•	•	O	3	1	•
NEO-6M	•						•	•	•	•	•			•	O	3	1	•
NEO-6P	•	•		•			•	•	•	•	•			•	O	3	1	•
NEO-6V	•				•		•	•	•	•	•			•	O	3	1	•
NEO-6T	•		•	•			•	•	•	•	•		•	•	O	3	1	•

O = Requires external components and integration on application processor

Table 1: Features of the NEO-6 Series

☞ All NEO-6 modules are based on GPS chips qualified according to AEC-Q100. See Chapter 5.1 for further information.

1.3 GPS performance

Parameter	Specification			
Receiver type	50 Channels GPS L1 frequency, C/A Code SBAS: WAAS, EGNOS, MSAS			
Time-To-First-Fix[1]		NEO-6G/Q/T	NEO-6M/V	NEO-6P
	Cold Start[2]	26 s	27 s	32 s
	Warm Start[2]	26 s	27 s	32 s
	Hot Start[2]	1 s	1 s	1 s
	Aided Starts[3]	1 s	<3 s	<3 s
Sensitivity[4]		NEO-6G/Q/T	NEO-6M/V	NEO-6P
	Tracking & Navigation	-162 dBm	-161 dBm	-160 dBm
	Reacquisition[5]	-160 dBm	-160 dBm	-160 dBm
	Cold Start (without aiding)	-148 dBm	-147 dBm	-146 dBm
	Hot Start	-157 dBm	-156 dBm	-155 dBm
Maximum Navigation update rate		NEO-6G/Q/M/T	NEO-6P/V	
		5Hz	1 Hz	
Horizontal position accuracy[6]	GPS	2.5 m		
	SBAS	2.0 m		
	SBAS + PPP[7]	< 1 m (2D, R50)[8]		
	SBAS + PPP[7]	< 2 m (3D, R50)[8]		
Configurable Timepulse frequency range		NEO-6G/Q/M/P/V	NEO-6T	
		0.25 Hz to 1 kHz	0.25 Hz to 10 MHz	
Accuracy for Timepulse signal	RMS	30 ns		
	99%	<60 ns		
	Granularity	21 ns		
	Compensated[9]	15 ns		
Velocity accuracy[6]		0.1m/s		
Heading accuracy[6]		0.5 degrees		
Operational Limits	Dynamics	≤ 4 g		
	Altitude[10]	50,000 m		
	Velocity[10]	500 m/s		

Table 2: NEO-6 GPS performance

1 All satellites at -130 dBm
2 Without aiding
3 Dependent on aiding data connection speed and latency
4 Demonstrated with a good active antenna
5 For an outage duration ≤10s
6 CEP, 50%, 24 hours static, -130dBm, SEP: <3.5m
7 NEO-6P only
8 Demonstrated under following conditions: 24 hours, stationary, first 600 seconds of data discarded. HDOP < 1.5 during measurement period, strong signals. Continuous availability of valid SBAS correction data during full test period.
9 Quantization error information can be used with NEO-6T to compensate the granularity related error of the timepulse signal
10 Assuming Airborne <4g platform

1.4 Block diagram

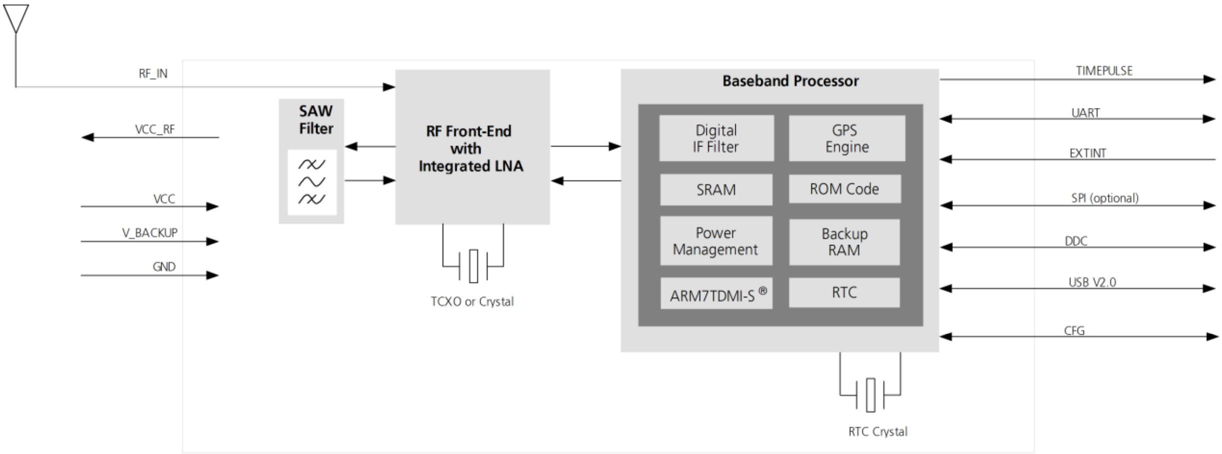


Figure 1: Block diagram (For available options refer to the product features table in section 1.2).

1.5 Assisted GPS (A-GPS)

Supply of aiding information like ephemeris, almanac, rough last position and time and satellite status and an optional time synchronization signal will reduce time to first fix significantly and improve the acquisition sensitivity. All NEO-6 modules support the u-blox AssistNow Online and AssistNow Offline A-GPS services[11] and are OMA SUPL compliant.

1.6 AssistNow Autonomous

AssistNow Autonomous provides functionality similar to Assisted-GPS without the need for a host or external network connection. Based on previously broadcast satellite ephemeris data downloaded to and stored by the GPS receiver, AssistNow Autonomous automatically generates accurate satellite orbital data ("AssistNow Autonomous data") that is usable for future GPS position fixes. AssistNow Autonomous data is reliable for up to 3 days after initial capture.

u-blox' AssistNow Autonomous benefits are:

- Faster position fix
- No connectivity required
- Complementary with AssistNow Online and Offline services
- No integration effort, calculations are done in the background

☞ For more details see the u-blox 6 Receiver Description including Protocol Specification [2].

[11] AssistNow Offline requires external memory.

1.7 Precision Timing

1.7.1 Time mode

NEO-6T provides a special Time Mode to provide higher timing accuracy. The NEO-6T is designed for use with stationary antenna setups. The Time Mode features three different settings described in Table 3: Disabled, Survey-In and Fixed Mode. For optimal performance entering the position of the antenna (when known) is recommended as potential source of errors will be reduced.

Time Mode Settings	Description
Disabled	Standard PVT operation
Survey-In	The GPS receiver computes the average position over an extended time period until a predefined maximum standard deviation has been reached. Afterwards the receiver will be automatically set to Fixed Mode and the timing features will be activated.
Fixed Mode	In this mode, a fixed 3D position and known standard deviation is assumed and the timing features are activated. Fixed Mode can either be activated directly by feeding pre-defined position coordinates (ECEF - Earth Center Earth Fixed format) or by performing a Survey-In. In Fixed mode, the timing errors in the TIMEPULSE signal which otherwise result from positioning errors are eliminated. Single-satellite operation is supported. For details, please refer to the u-blox 6 Receiver Description including Protocol Specification [2].

Table 3: Time mode settings

1.7.2 Timepulse and frequency reference

NEO-6T comes with a timepulse output which can be configured from 0.25 Hz up to 10 MHz. The timepulse can either be used for time synchronization (i.e. 1 pulse per second) or as a reference frequency in the MHz range. A timepulse in the MHz range provides excellent long-term frequency accuracy and stability.

1.7.3 Time mark

NEO-6T can be used for precise time measurements with sub-microsecond resolution using the external interrupt (EXTINT0). Rising and falling edges of these signals are time-stamped to the GPS or UTC time and counted. The Time Mark functionality can be enabled with the UBX-CFG-TM2 message

For details, please refer to the u-blox 6 Receiver Description including Protocol Specification [2].

1.8 Raw data

Raw data output is supported at an update rate of 5 Hz on the NEO-6T and NEO-6P. The UBX-RXM-RAW message includes carrier phase with half-cycle ambiguity resolved, code phase and Doppler measurements, which can be used in external applications that offer precision positioning, real-time kinematics (RTK) and attitude sensing.

1.9 Automotive Dead Reckoning

Automotive Dead Reckoning (ADR) is u-blox' industry proven off-the-shelf Dead Reckoning solution for tier-one automotive customers. u-blox' ADR solution combines GPS and sensor digital data using a tightly coupled Kalman filter. This improves position accuracy during periods of no or degraded GPS signal.

The NEO-6V provides ADR functionality over its software sensor interface. A variety of sensors (such as wheel ticks and gyroscope) are supported, with the sensor data received via UBX messages from the application processor. This allows for easy integration and a simple hardware interface, lowering costs. By using digital sensor data available on the vehicle bus, hardware costs are minimized since no extra sensors are required for Dead Reckoning functionality. ADR is designed for simple integration and easy configuration of different sensor options (e.g. with or without gyroscope) and vehicle variants, and is completely self-calibrating.

For more details contact the u-blox support representative nearest you to receive dedicated u-blox 6 Receiver Description Including Protocol Specification [3].

1.10 Precise Point Positioning

u-blox' industry proven PPP algorithm provides extremely high levels of position accuracy in static and slow moving applications, and makes the NEO-6P an ideal solution for a variety of high precision applications such as surveying, mapping, marine, agriculture or leisure activities.

Ionospheric corrections such as those received from local SBAS[12] geostationary satellites (WAAS, EGNOS, MSAS) or from GPS enable the highest positioning accuracy with the PPP algorithm. The maximum improvement of positioning accuracy is reached with PPP+SBAS and can only be expected in an environment with unobstructed sky view during a period in the order of minutes.

1.11 Oscillators

NEO-6 GPS modules are available in Crystal and TCXO versions. The TCXO allows accelerated weak signal acquisition, enabling faster start and reacquisition times.

1.12 Protocols and interfaces

Protocol	Type
NMEA	Input/output, ASCII, 0183, 2.3 (compatible to 3.0)
UBX	Input/output, binary, u-blox proprietary
RTCM	Input, 2.3

Table 4: Available protocols

All listed protocols are available on UART, USB, and DDC. For specification of the various protocols see the u-blox 6 Receiver Description including Protocol Specification [2].

1.12.1 UART

NEO-6 modules include one configurable UART interface for serial communication (for information about configuration see section 1.15).

1.12.2 USB

NEO-6 modules provide a USB version 2.0 FS (Full Speed, 12Mbit/s) interface as an alternative to the UART. The pull-up resistor on USB_DP is integrated to signal a full-speed device to the host. The VDDUSB pin supplies the USB interface. u-blox provides a Microsoft® certified USB driver for Windows XP, Windows Vista and Windows 7 operating systems.

1.12.3 Serial Peripheral Interface (SPI)

The SPI interface allows for the connection of external devices with a serial interface, e.g. serial flash to save configuration and AssistNow Offline A-GPS data or to interface to a host CPU. The interface can be operated in master or slave mode. In master mode, one chip select signal is available to select external slaves. In slave mode a single chip select signal enables communication with the host.

☞ The maximum bandwidth is 100kbit/s.

[12] Satellite Based Augmentation System

1.12.4 Display Data Channel (DDC)

The I^2C compatible DDC interface can be used either to access external devices with a serial interface EEPROM or to interface with a host CPU. It is capable of master and slave operation. The DDC interface is I^2C Standard Mode compliant. For timing parameters consult the I^2C standard.

☞ The DDC Interface supports serial communication with u-blox wireless modules. See the specification of the applicable wireless module to confirm compatibility.

☞ The maximum bandwidth is 100kbit/s.

1.12.4.1 External serial EEPROM

NEO-6 modules allow an optional external serial EEPROM to be connected to the DDC interface. This can be used to store Configurations permanently.

☞ For more information see the LEA-6/NEO-6/MAX-6 Hardware Integration Manual [1].

⚠ **Use caution when implementing since forward compatibility is not guaranteed.**

1.13 Antenna

NEO-6 modules are designed for use with passive and active[13] antennas.

Parameter	**Specification**	
Antenna Type		Passive and active antenna
Active Antenna Recommendations	Minimum gain Maximum gain Maximum noise figure	15 dB (to compensate signal loss in RF cable) 50 dB 1.5 dB

Table 5: Antenna Specifications for all NEO-6 modules

1.14 Power Management

u-blox receivers support different power modes. These modes represent strategies of how to control the acquisition and tracking engines in order to achieve either the best possible performance or good performance with reduced power consumption.

☞ For more information about power management strategies, see the u-blox 6 Receiver Description including Protocol Specification [2].

1.14.1 Maximum Performance Mode

During a Cold start, a receiver in Maximum Performance Mode continuously deploys the acquisition engine to search for all satellites. Once the receiver has a position fix (or if pre-positioning information is available), the acquisition engine continues to be used to search for all visible satellites that are not being tracked.

1.14.2 Eco Mode

During a Cold start, a receiver in Eco Mode works exactly as in Maximum Performance Mode. Once a position can be calculated and a sufficient number of satellites are being tracked, the acquisition engine is powered off resulting in significant power savings. The tracking engine continuously tracks acquired satellites and acquires other available or emerging satellites.

☞ Note that even if the acquisition engine is powered off, satellites continue to be acquired.

[13] For information on using active antennas with NEO-6 modules, see the LEA-6/NEO-6 Hardware Integration Manual [1].

1.14.3 Power Save Mode

Power Save Mode (PSM) allows a reduction in system power consumption by selectively switching parts of the receiver on and off.

Power Save mode is not available with NEO-6P, NEO-6T and NEO-6V.

1.15 Configuration

1.15.1 Boot-time configuration

NEO-6 modules provide configuration pins for boot-time configuration. These become effective immediately after start-up. Once the module has started, the configuration settings can be modified with UBX configuration messages. The modified settings remain effective until power-down or reset. If these settings have been stored in battery-backup RAM, then the modified configuration will be retained, as long as the backup battery supply is not interrupted.

NEO-6 modules include both **CFG_COM0** and **CFG_COM1** pins and can be configured as seen in Table 6. Default settings in bold.

CFG_COM1	CFG_COM0	Protocol	Messages	UARTBaud rate	USB power
1	**1**	**NMEA**	**GSV, RMC, GSA, GGA, GLL, VTG, TXT**	**9600**	**BUS Powered**
1	0	NMEA	GSV, RMC, GSA, GGA, GLL, VTG, TXT	38400	Self Powered
0	1	NMEA	GSV[14], RMC, GSA, GGA, VTG, TXT	4800	BUS Powered
0	0	UBX	NAV-SOL, NAV-STATUS, NAV-SVINFO, NAV-CLOCK, INF, MON-EXCEPT, AID-ALPSERV	57600	BUS Powered

Table 6: Supported COM settings

NEO-6 modules include a **CFG_GPS0** pin, which enables the boot-time configuration of the power mode. These settings are described in Table 7. Default settings in bold.

CFG_GPS0	Power Mode
0	Eco Mode
1	**Maximum Performance Mode**

Table 7: Supported CFG_GPS0 settings

Static activation of the **CFG_COM** and **CFG_GPS** pins is not compatible with use of the SPI interface.

1.16 Design-in

In order to obtain the necessary information to conduct a proper design-in, u-blox strongly recommends consulting the LEA-6/NEO-6/MAX-6 Hardware Integration Manual [1].

[14] Every 5th fix.

2 Pin Definition

2.1 Pin assignment

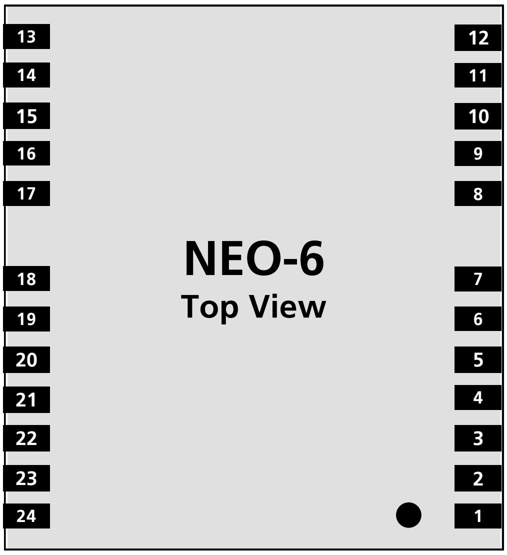


Figure 2 Pin Assignment

No	Module	Name	I/O	Description
1	All	Reserved	I	Reserved
2	All	SS_N	I	SPI Slave Select
3	All	TIMEPULSE	O	Timepulse (1PPS)
4	All	EXTINT0	I	External Interrupt Pin
5	All	USB_DM	I/O	USB Data
6	All	USB_DP	I/O	USB Data
7	All	VDDUSB	I	USB Supply
8	All	Reserved		See Hardware Integration Manual Pin 8 and 9 must be connected together.
9	All	VCC_RF	O	Output Voltage RF section Pin 8 and 9 must be connected together.
10	All	GND	I	Ground
11	All	RF_IN	I	GPS signal input
12	All	GND	I	Ground
13	All	GND	I	Ground
14	All	MOSI/CFG_COM0	O/I	SPI MOSI / Configuration Pin. Leave open if not used.
15	All	MISO/CFG_COM1	I	SPI MISO / Configuration Pin. Leave open if not used.
16	All	CFG_GPS0/SCK	I	Power Mode Configuration Pin / SPI Clock. Leave open if not used.
17	All	Reserved	I	Reserved
18	All	SDA2	I/O	DDC Data
19	All	SCL2	I/O	DDC Clock
20	All	TxD1	O	Serial Port 1
21	All	RxD1	I	Serial Port 1

No	Module	Name	I/O	Description
22	All	V_BCKP	I	Backup voltage supply
23	All	VCC	I	Supply voltage
24	All	GND	I	Ground

Table 8: Pinout

☞ Pins designated Reserved should not be used. For more information about Pinouts see the LEA-6/NEO-6/MAX-6 Hardware Integration Manual [1].

3 Electrical specifications

3.1 Absolute maximum ratings

Parameter	Symbol	Module	Min	Max	Units	Condition
Power supply voltage	VCC	NEO-6G	-0.5	2.0	V	
		NEO-6Q, 6M, 6P, 6V, 6T	-0.5	3.6	V	
Backup battery voltage	V_BCKP	All	-0.5	3.6	V	
USB supply voltage	VDDUSB	All	-0.5	3.6	V	
Input pin voltage	Vin	All	-0.5	3.6	V	
	Vin_usb	All	-0.5	VDDU SB	V	
DC current trough any digital I/O pin (except supplies)	Ipin			10	mA	
VCC_RF output current	ICC_RF	All		100	mA	
Input power at RF_IN	Prfin	NEO-6Q, 6M, 6G, 6V, 6T		15	dBm	source impedance = 50Ω, continuous wave
		NEO-6P		-5	dBm	
Storage temperature	Tstg	All	-40	85	°C	

Table 9: Absolute maximum ratings

GPS receivers are Electrostatic Sensitive Devices (ESD) and require special precautions when handling. For more information see chapter 6.4.

Stressing the device beyond the "Absolute Maximum Ratings" may cause permanent damage. These are stress ratings only. The product is not protected against overvoltage or reversed voltages. If necessary, voltage spikes exceeding the power supply voltage specification, given in table above, must be limited to values within the specified boundaries by using appropriate protection diodes. For more information see the *LEA-6/NEO-6/MAX-6 Hardware Integration Manual* [1].

3.2 Operating conditions

All specifications are at an ambient temperature of 25°C.

Parameter	Symbol	Module	Min	Typ	Max	Units	Condition
Power supply voltage	VCC	NEO-6G	1.75	1.8	1.95	V	
		NEO-6Q/M NEO-6P/V/T	2.7	3.0	3.6	V	
Supply voltage USB	VDDUSB	All	3.0	3.3	3.6	V	
Backup battery voltage	V_BCKP	All	1.4		3.6	V	
Backup battery current	I_BCKP	All		22		µA	V_BCKP = 1.8 V, VCC = 0V
Input pin voltage range	Vin	All	0		VCC	V	
Digital IO Pin Low level input voltage	Vil	All	0		0.2*VCC	V	
Digital IO Pin High level input voltage	Vih	All	0.7*VCC		VCC	V	
Digital IO Pin Low level output voltage	Vol	All			0.4	V	Iol=4mA
Digital IO Pin High level output voltage	Voh	All	VCC -0.4			V	Ioh=4mA
USB_DM, USB_DP	VinU	All	Compatible with USB with 22 Ohms series resistance				
VCC_RF voltage	VCC_RF	All		VCC-0.1		V	
VCC_RF output current	ICC_RF	All			50	mA	
Antenna gain	Gant	All			50	dB	
Receiver Chain Noise Figure	NFtot	All		3.0		dB	
Operating temperature	Topr	All	-40		85	°C	

Table 10: Operating conditions

Operation beyond the specified operating conditions can affect device reliability.

3.3 Indicative power requirements

Table 11 lists examples of the total system supply current for a possible application.

Parameter	Symbol	Module	Min	Typ	Max	Units	Condition
Max. supply current [15]	Iccp	All			67	mA	VCC = 3.6 V[16] / 1.95 V[17]
Average supply current[18]	Icc Acquisition	All		47[19]		mA	VCC = 3.0 V[16] / 1.8 V[17]
	Icc Tracking (Max Performance mode)	NEO-6G/Q/T		40[20]		mA	
		NEO-6M/P/V		39[20]		mA	
	Icc Tracking (Eco mode)	NEO-6G/Q/T		38[20]		mA	
		NEO-6M/P/V		37[20]		mA	
	Icc Tracking (Power Save mode / 1 Hz)	NEO-6G/Q		12[20]		mA	
		NEO-6M		11[20]		mA	

Table 11: Indicative power requirements

Values in Table 11 are provided for customer information only as an example of typical power requirements. Values are characterized on samples, actual power requirements can vary depending on FW version used, external circuitry, number of SVs tracked, signal strength, type of start as well as time, duration and conditions of test.

[15] Use this figure to dimension maximum current capability of power supply. Measurement of this parameter with 1 Hz bandwidth.
[16] NEO-6Q, NEO-6M, NEO-6P, NEO-6V, NEO-6T
[17] NEO-6G
[18] Use this figure to determine required battery capacity.
[19] >8 SVs in view, CNo >40 dBHz, current average of 30 sec after cold start.
[20] With strong signals, all orbits available. For Cold Starts typical 12 min after first fix. For Hot Starts typical 15 s after first fix.

3.4 SPI timing diagrams

In order to avoid a faulty usage of the SPI, the user needs to comply with certain timing conditions. The following signals need to be considered for timing constraints:

Symbol	Description
SS_N	Slave Select signal
SCK	Slave Clock signal

Table 12: Symbol description

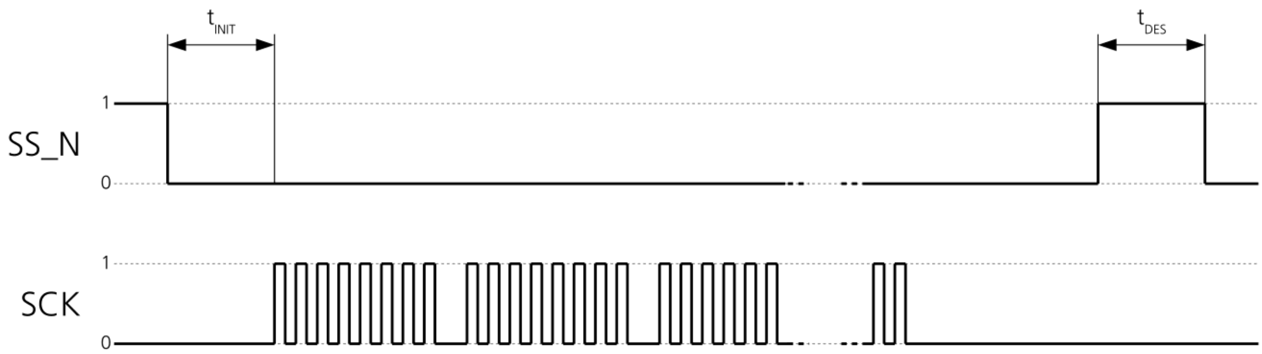


Figure 3: SPI timing diagram

3.4.1 Timing recommendations

Parameter	Description	Recommendation
t_{INIT}	Initialization Time	500 µs
t_{DES}	Deselect Time	1 ms
Bitrate		100 kbit/s

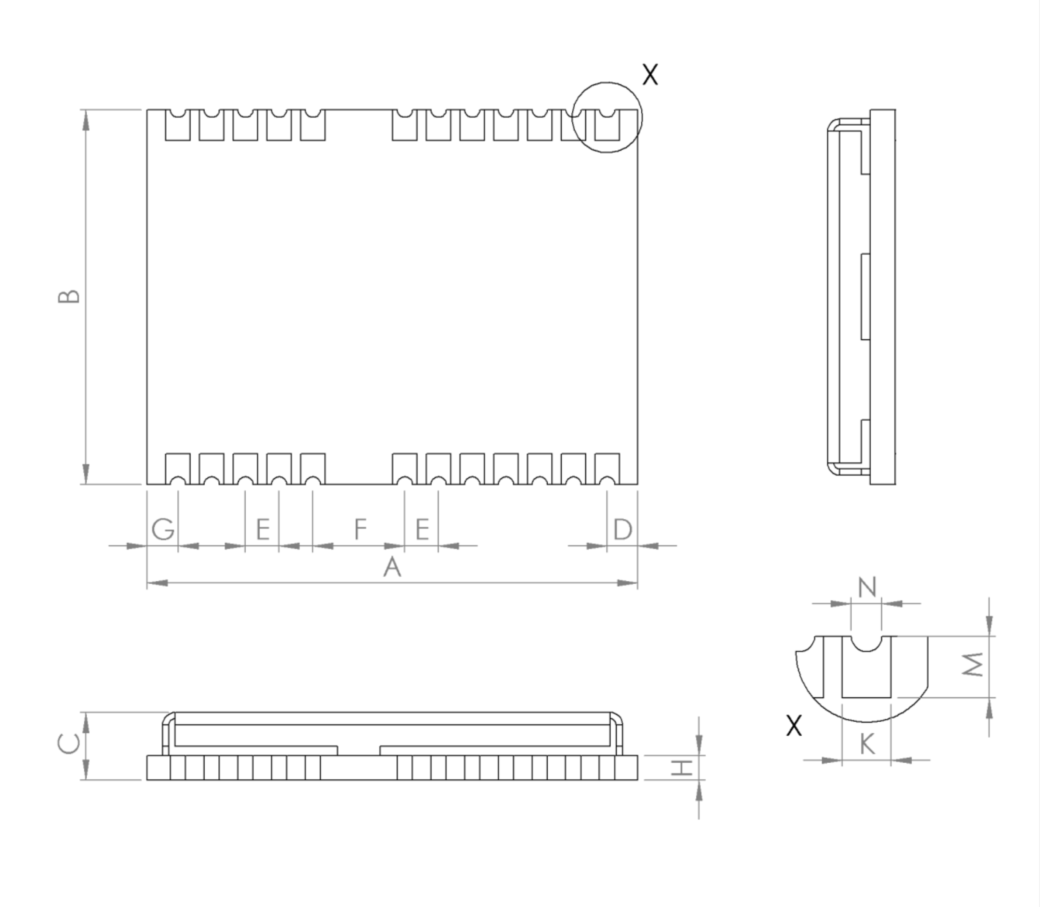
Table 13: SPI timing recommendations

☞ The values in the above table result from the requirement of an error-free transmission. By allowing just a few errors, the byte rate could be increased considerably. These timings – and therefore the byte rate – could also be improved by disabling other interfaces, e.g. the UART.

☞ The maximum bandwidth is 100 kbit/s[21].

[21] This is a theoretical maximum, the protocol overhead is not considered.

4 Mechanical specifications



Symbol	Min. (mm)	Typ. (mm)	Max. (mm)
A	15.9	16.0	16.6
B	12.1	12.2	12.3
C	2.2	2.4	2.6
D	0.9	1.0	1.3
E	1.0	1.1	1.2
F	2.9	3.0	3.1
G	0.9	1.0	1.3
H		0.82	
K	0.7	0.8	0.9
M	0.8	0.9	1.0
N	0.4	0.5	0.6
Weight		1.6g	

Figure 4: Dimensions

☞ For information regarding the Paste Mask and Footprint see the LEA-6/NEO-6/MAX-6 Hardware Integration Manual [1].

5 Qualification and certification

5.1 Reliability tests

☞ All NEO-6 modules are based on AEC-Q100 qualified GPS chips.

Tests for product family qualifications according to ISO 16750 "Road vehicles - Environmental conditions and testing for electrical and electronic equipment", and appropriate standards.

5.2 Approvals

Products marked with this lead-free symbol on the product label comply with the "Directive 2002/95/EC of the European Parliament and the Council on the Restriction of Use of certain Hazardous Substances in Electrical and Electronic Equipment" (RoHS).

All u-blox 6 GPS modules are RoHS compliant.

6 Product handling & soldering

6.1 Packaging

NEO-6 modules are delivered as hermetically sealed, reeled tapes in order to enable efficient production, production lot set-up and tear-down. For more information about packaging, see the u-blox Package Information Guide [4].

Figure 5: Reeled u-blox 6 modules

6.1.1 Reels

NEO-6 GPS modules are deliverable in quantities of 250pcs on a reel. NEO-6 modules are delivered using reel Type B as described in the u-blox Package Information Guide [4].

Parameter	Specification
Reel Type	B
Delivery Quantity	250

Table 14: Reel information for NEO-6 modules

6.1.1 Tapes

Figure 6 shows the position and orientation of NEO-6 modules as they are delivered on tape. The dimensions of the tapes are specified in Figure 7.

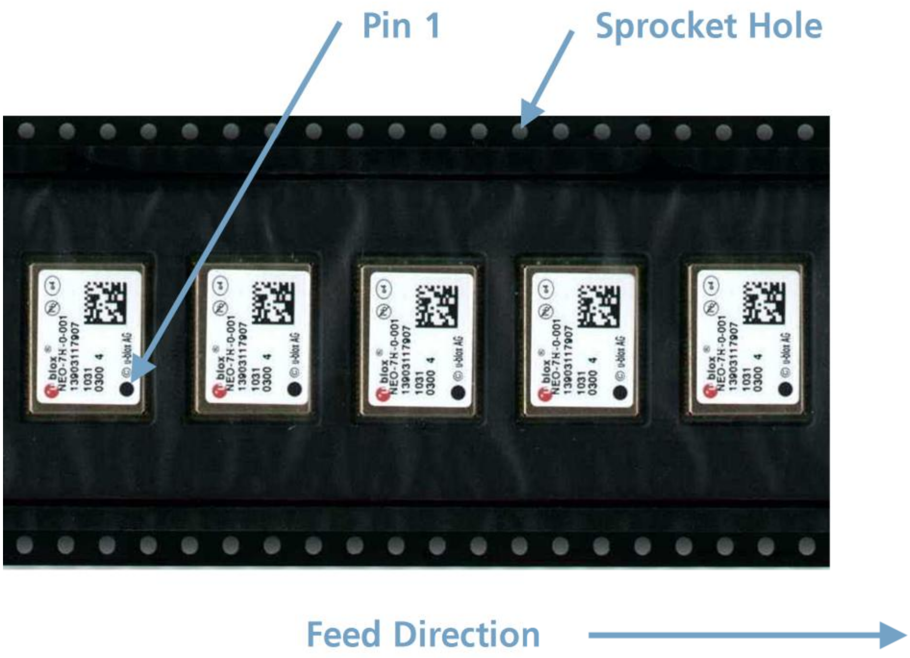


Figure 6: Orientation for NEO-6 modules on tape

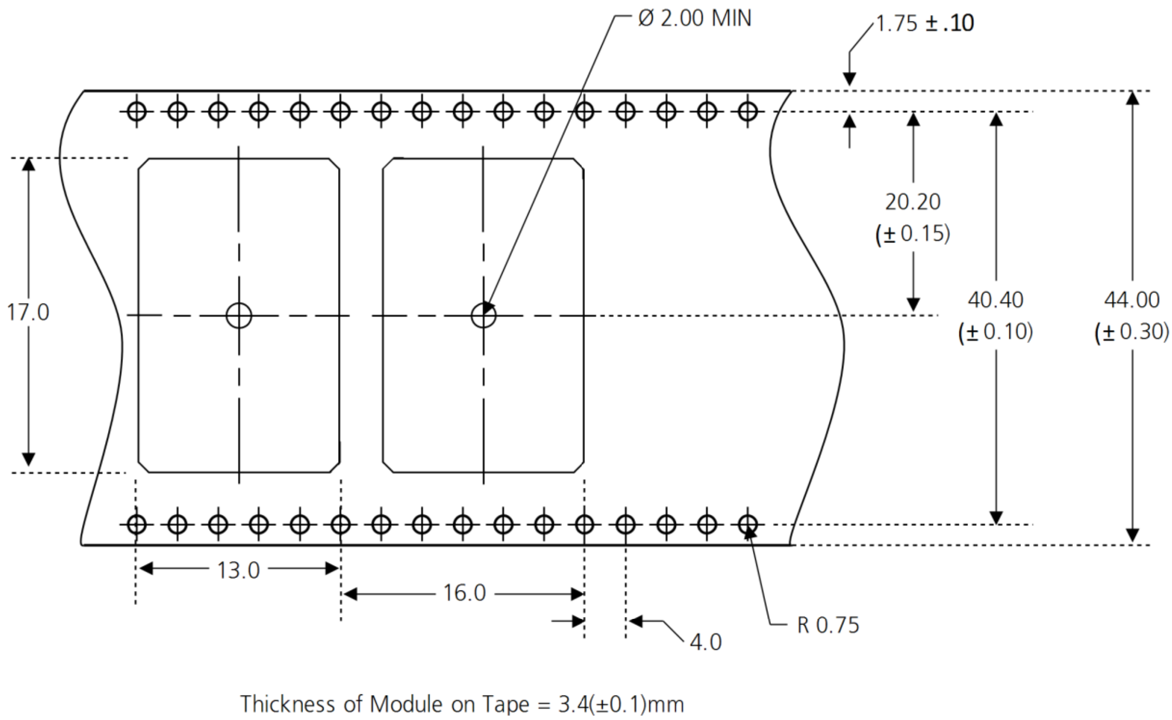


Figure 7: NEO tape dimensions (mm)

6.2 Moisture Sensitivity Levels

NEO-6 modules are Moisture Sensitive Devices (MSD) in accordance to the IPC/JEDEC specification.

NEO-6 modules are rated at MSL level 4. For more information regarding moisture sensitivity levels, labeling, storage and drying see the u-blox Package Information Guide [4].

For MSL standard see IPC/JEDEC J-STD-020, which can be downloaded from www.jedec.org.

6.3 Reflow soldering

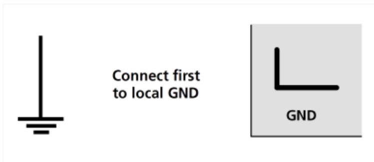
Reflow profiles are to be selected according to u-blox recommendations (see LEA-6/NEO-6/MAX-6 Hardware Integration Manual [1]).

6.4 ESD handling precautions

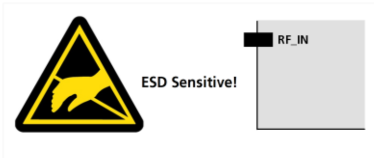
NEO-6 modules contain highly sensitive electronic circuitry and are Electrostatic Sensitive Devices (ESD). Observe precautions for handling! Failure to observe these precautions can result in severe damage to the GPS receiver!

GPS receivers are Electrostatic Sensitive Devices (ESD) and require special precautions when handling. Particular care must be exercised when handling patch antennas, due to the risk of electrostatic charges. In addition to standard ESD safety practices, the following measures should be taken into account whenever handling the receiver:

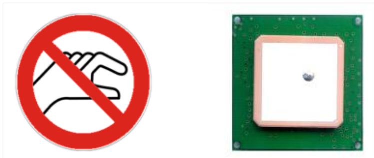
- Unless there is a galvanic coupling between the local GND (i.e. the work table) and the PCB GND, then the first point of contact when handling the PCB must always be between the local GND and PCB GND.
- Before mounting an antenna patch, connect ground of the device



- When handling the RF pin, do not come into contact with any charged capacitors and be careful when contacting materials that can develop charges (e.g. patch antenna ~10pF, coax cable ~50-80pF/m, soldering iron, …)



- To prevent electrostatic discharge through the RF input, do not touch any exposed antenna area. If there is any risk that such exposed antenna area is touched in non ESD protected work area, implement proper ESD protection measures in the design.



- When soldering RF connectors and patch antennas to the receiver's RF pin, make sure to use an ESD safe soldering iron (tip).

7 Default settings

Interface	Settings
Serial Port 1 Output	9600 Baud, 8 bits, no parity bit, 1 stop bit Configured to transmit both NMEA and UBX protocols, but only following NMEA and no UBX messages have been activated at start-up: **GGA, GLL, GSA, GSV, RMC, VTG, TXT** (In addition to the 6 standard NMEA messages the NEO-6T includes **ZDA**).
USB Output	Configured to transmit both NMEA and UBX protocols, but only following NMEA and no UBX messages have been activated at start-up: **GGA, GLL, GSA, GSV, RMC, VTG, TXT** (In addition to the 6 standard NMEA messages the NEO-6T includes **ZDA**). USB Power Mode: Bus-Powered
Serial Port 1 Input	9600 Baud, 8 bits, no parity bit, 1 stop bit Automatically accepts following protocols without need of explicit configuration: **UBX, NMEA** The GPS receiver supports interleaved UBX and NMEA messages.
USB Input	Automatically accepts following protocols without need of explicit configuration: **UBX, NMEA** The GPS receiver supports interleaved UBX and NMEA messages. USB Power Mode: Bus-Powered
TIMEPULSE (1Hz Nav)	1 pulse per second, synchronized at rising edge, pulse length 100ms
Power Mode	Maximum Performance mode
AssistNow Autonomous	Disabled.

Table 15: Default settings

Refer to the u-blox 6 Receiver Description including Protocol Specification [2] for information about further settings.

8 Labeling and ordering information

8.1 Product labeling

The labeling of u-blox 6 GPS modules includes important product information. The location of the product type number is shown in Figure 8.

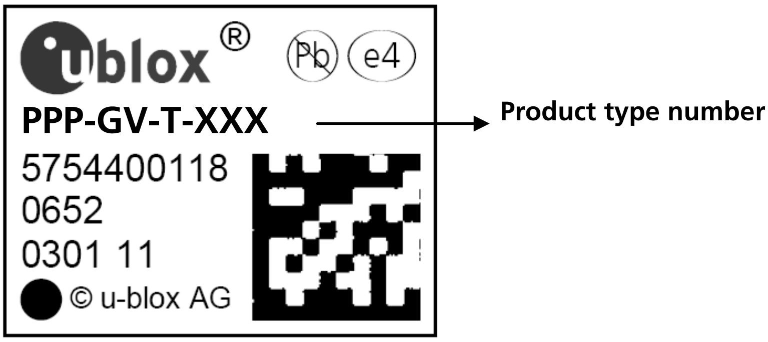


Figure 8: Location of product type number on u-blox 6 module label

8.2 Explanation of codes

3 different product code formats are used. The **Product Name** is used in documentation such as this data sheet and identifies all u-blox 6 products, independent of packaging and quality grade. The **Ordering Code** includes options and quality, while the **Type Number** includes the hardware and firmware versions. Table 16 below details these 3 different formats:

Format	Structure
Product Name	PPP-GV
Ordering Code	PPP-GV-T
Type Number	PPP-GV-T-XXX

Table 16: Product Code Formats

The parts of the product code are explained in Table 17.

Code	Meaning	Example
PPP	Product Family	NEO
G	Product Generation	6 = u-blox6
V	Variant	T = Timing, R = DR, etc.
T	Option / Quality Grade	Describes standardized functional element or quality grade such as Flash size, automotive grade etc.
XXX	Product Detail	Describes product details or options such as hard- and software revision, cable length, etc.

Table 17: part identification code

8.3 Ordering information

Ordering No.	Product
NEO-6G-0	u-blox 6 GPS Module, 1.8V, TCXO, 12x16mm, 250 pcs/reel
NEO-6M-0	u-blox 6 GPS Module, 12x16mm, 250 pcs/reel
NEO-6Q-0	u-blox 6 GPS Module, TCXO, 12x16mm, 250 pcs/reel
NEO-6P-0	u-blox 6 GPS Module, PPP, 12x16mm, 250 pcs/reel
NEO-6V-0	u-blox 6 GPS Module, Dead Reckoning SW sensor, 12x16mm, 250 pcs/reel
NEO-6T-0	u-blox 6 GPS Module, Precision Timing, TCXO, 12x16mm, 250 pcs/reel

Table 18: Product Ordering Codes

☞ Product changes affecting form, fit or function are documented by u-blox. For a list of Product Change Notifications (PCNs) see our website at: http://www.u-blox.com/en/notifications.html

Related documents

[1] LEA-6/NEO-6/MAX-6 Hardware Integration Manual, Docu. GPS.G6-HW-09007

[2] u-blox 6 Receiver Description Including Protocol Specification (Public version), Docu. No. GPS.G6-SW-10018

[3] u-blox 6 Receiver Description Including Protocol Specification (Confidential version), Docu. No. GPS.G6-SW-10019

[4] u-blox Package Information Guide, Docu. No GPS-X-11004

☞ For regular updates to u-blox documentation and to receive product change notifications please register on our homepage.

Revision history

Revision	Date	Name	Status / Comments
	31/08/2009	tgri	Initial Version
1	21/09/2009	tgri	update of section 1.3 GPS performance, section 1.4 block diagram, section 3.2 peak supply current
A	25/02/2010	tgri	Change of status to Advance Information. Addition of NEO-6G. Update of section 1.8.2, removed reference to Vddio – added USB driver certification. Update of section 3.2 table 11: average supply current, Added section 3.3-3.4: SPI & DDC timing, section 5.1: addition of table 12.
B	24/06/2010	dhur	Change of status to Preliminary. Update of section 1.2, 1.8.4, 1.10.4, 3.1, 3.2 and chapter 2 and 4. General clean-up and consistency check.
B1	11/08/2010	dhur	Replaced graphic in figure 2.
C	18/07/2011	dhur	Added chapter 1.6, update to FW7.03.
D	19/10/2011	dhur	Added NEO-6P and NEO-6V. Added chapter 1.7 and 1.8. Revised Chapter 6.
E	05/12/2011	dhur	Added NEO-6T. Added chapter 1.7 and 1.8. Added Accuracy for Timepulse signal in Table 2. Corrected Maximum Input power at RF_IN for NEO-6P in Table 9.

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3DRobotics

3DR RADIO V2
QUICK START GUIDE

GETTING STARTED

3DR Radios provide an air-to-ground data link between the autopilot and your ground station laptop or tablet. Follow this guide to install the radios on your plane, copter, or rover. 3DR Radios arrive ready to use. Just mount and connect to view real-time data from your drone.

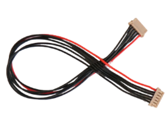
PARTS

Two 3DR Radios in 915 or 433 mHz

Attach the antennas, and use either radio as an air or ground module.

Android adapter cable

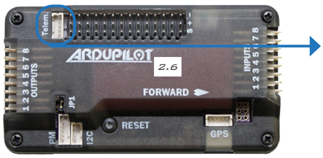
Micro-USB cable



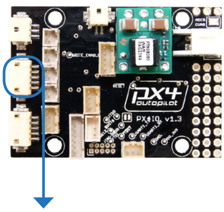
6-wire Pixhawk connector cable

6-to-5-position APM and PX4 connector cable

CONNECT TO AUTOPILOT



Connect to the APM 2.5 or 2.6 telemetry port using the 6-to-5-position cable.



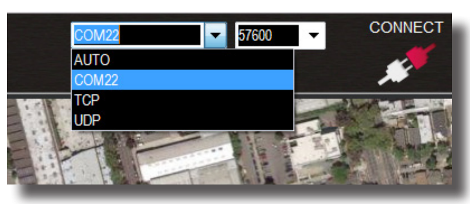
Connect to the PX4 I/O telemetry port using the 6-to-5-position cable.

Connect to the Pixhawk telemetry port using the 6-wire cable.

MOUNT

Mount the air module securely to your vehicle keeping the antenna clear of any propellers or moving components. Ensure that the antenna is oriented vertically for maximum range.

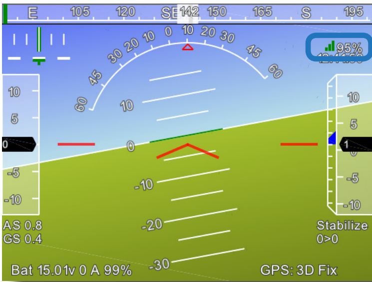
CONNECT TO MISSION PLANNER



Mission Planner

Use the micro-USB cable to connect the ground module to your laptop. In Mission Planner and APM Planner ground station applications, select the communication option that shows COM, set the rate to 57600, and select Connect. The radio will not connect unless the vehicle is powered. Use the Flight Data screen to view your vehicle's status and control missions in flight.

LEARN MORE
about installing a mission planner application for your laptop or tablet and interacting with the autopilot using 3DR Radios (including retrieving flight data logs) at planner.ardupilot.com.

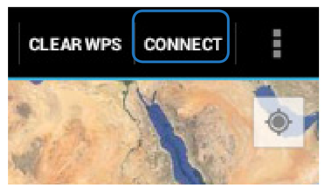


View the strength of the radio signal in the mission planner's flight data screen.

> **TIPS**
> Orient the ground radio antenna vertically for maximum range.

CONNECT TO TABLET

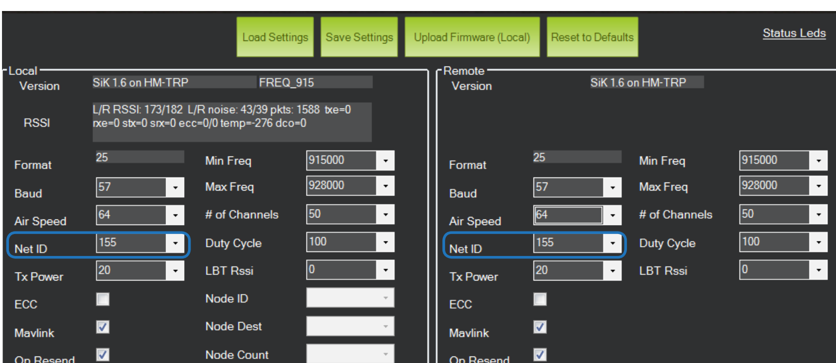
Connect the ground module to your tablet using the Android adapter cable. Connect the colored end to the tablet and the black end to the radio. In DroidPlanner or Andropilot, select Connect.



DroidPlanner Flight Data screen

SETTINGS

To change the radio settings in the mission planner, connect the radio to your computer, but do not select Connect. Radios can only be configured while unconnected to MAVLink. Select Initial Setup, 3DR Radio, and Load Settings to configure the radios.



All settings should be the same for both modules. Ensure that the Net ID setting is identical on each radio to enable pairing. Select Save Settings to apply settings. For flying with friends, make sure your Net IDs do not conflict.

Use the configuration options on this screen to apply the correct airspace regulation requirements for your area. You are responsible for complying with all airspace regulations in your area, including frequency restrictions, power levels, and licenses. For more information on configuring 3DR Radios to comply with local regulations, visit the online documentation at goo.gl/Tsrksf.

LED MEANINGS

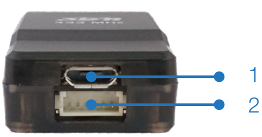
Blinking green
Searching for paired radio

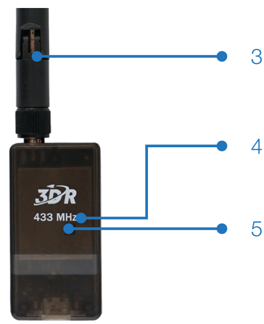
Solid green
Link established with paired radio

Blinking red
Transmitting data

Solid red
Firmware update mode

RADIO DESCRIPTION





1 Micro-USB port
2 6-wire cable connector
3 Antenna
4 Frequency
5 LED indicator

SPECIFICATIONS

Processing
100 mW maximum output power (adjustable)
-117 dBm receive sensitivity
Based on HopeRF's HM-TRP module
RP-SMA connector
2-way full-duplex communication through adaptive TDM
UART interface
Transparent serial link
MAVLink protocol framing
Frequency Hopping Spread Spectrum (FHSS)
Configurable duty cycle
Error correction corrects up to 25% of bit errors
Open-source SIK firmware
Configurable through Mission Planner & APM Planner

Features
Interchangeable air and ground modules
915 or 433 mHz
Micro-USB port
6-position DF13 connector

Dimensions
26.7 cm x 55.5 cm x 13.3 cm
(without antenna)

Power
Supply voltage: 3.7-6 VDC (from USB or DF13)
Transmit current: 100 mA at 30 dBm
Receive current: 25 mA
Serial interface: 3.3 V UART

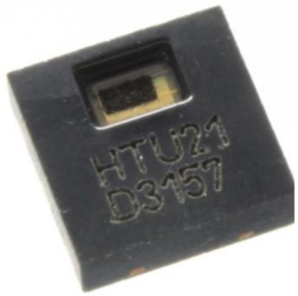
SUPPORT

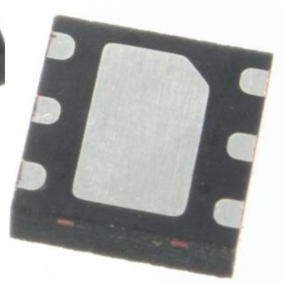
For more information about mission planner applications and APM firmware, visit ardupilot.com. For online documentation of 3DR Radios, visit goo.gl/Tsrksf.

For customer support, contact us at help@3drobotics.com or call our support line at +1 (858) 225-1414.

HTU21D(F) Sensor

Digital Relative Humidity sensor with Temperature output





- **DFN type package**
- **Relative Humidity and Temperature Digital Output, I²C interface**
- **Fully calibrated**
- **Lead free sensor, reflow solderable**
- **Low power consumption**
- **Fast response time**

DESCRIPTION

The HTU21D(F) is a new digital humidity sensor with temperature output by MEAS. Setting new standards in terms of size and intelligence, it is embedded in a reflow solderable Dual Flat No leads (DFN) package with a small 3 x 3 x 0.9 mm footprint. This sensor provides calibrated, linearized signals in digital, I²C format.

HTU21D(F) digital humidity sensors are dedicated humidity and temperature plug and play transducers for OEM applications where reliable and accurate measurements are needed. Direct interface with a micro-controller is made possible with the module for humidity and temperature digital outputs. These low power sensors are designed for high volume and cost sensitive applications with tight space constraints.

Every sensor is individually calibrated and tested. Lot identification is printed on the sensor and an electronic identification code is stored on the chip – which can be read out by command. Low battery can be detected and a checksum improves communication reliability. The resolution of these digital humidity sensors can be changed by command (8/12bit up to 12/14bit for RH/T).

With MEAS' improvements and miniaturization of this sensor, the performance-to-price ratio has been improved – and eventually, any device should benefit from its cutting edge energy saving operation mode.

Optional PTFE filter/membrane (F) protects HTU21D digital humidity sensors against dust and water immersion, as well as against contamination by particles. PTFE filter/membranes preserve a high response time. The white PTFE filter/membrane is directly stuck on the sensor housing.

FEATURES

- Full interchangeability with no calibration required in standard conditions
- Instantaneous desaturation after long periods in saturation phase
- Compatible with automatized assembly processes, including Pb free and reflow processes
- Individual marking for compliance to stringent traceability requirements

APPLICATIONS

- Automotive: defogging, HVAC
- Home Appliance
- Medical
- Printers
- Humidifier

Digital Relative Humidity sensor with Temperature output

NOMENCLATURE

HTU2XY(F)

With embedded PTFE filter: HTU2XYF

Output Sensor:
Y = D for Digital, I2C protocol
= P for PWM interface, analog output
= S for SDM interface convertible to analog output

Humidity accuracy :
X = 0: +/-5%RH tolerance @55%RH
= 1: +/-3%RH tolerance @55%RH

HTU2XY Modules

HTU2XYF Modules

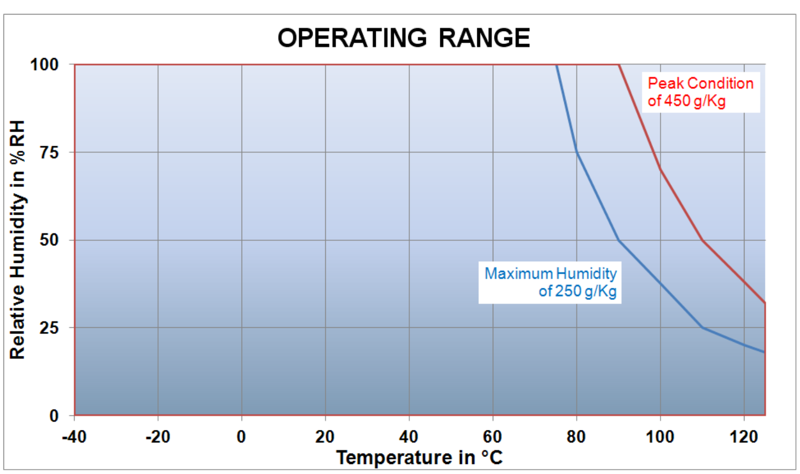
PERFORMANCE SPECS

MAXIMUM RATINGS

Ratings	Symbol	Value	Unit
Storage Temperature	T_{stg}	-40 to 125	°C
Supply Voltage (Peak)	V_{cc}	3.8V	V_{dc}
Humidity Operating Range	RH	0 to 100	%RH
Temperature Operating Range	T_a	-40 to +125	°C
VDD to GND		-0.3 to 3.6V	V
Digital I/O pins (DATA/SCK) to VDD		-0.3 to VDD+0.3	V
Input current on any pin		-10 to +10	mA

Peak conditions: less than 10% of the operating time

Exposure to absolute maximum rating conditions for extended periods may affect the sensor reliability.



Digital Relative Humidity sensor with Temperature output

ELECTRICAL AND GENERAL ITEMS

(@T = 25°C, @Vdd = 3V)

Characteristics		Symbol	Min	Typ	Max	Unit
Voltage Supply		VDD	1.5	3.0	3.6	V
Current consumption [1]	Sleep mode	idd		0.02	0.14	µA
	Measuring		300	450	500	µA
Power Dissipation	Sleep mode			0.06	0.5	µW
	Average 8bit [2]			2.7		µW
Communication		digital 2-wire interface, I²C protocol				
Heater	VDD=3V	5.5mW/ΔT=+0.5-1.5°C				
Storage		-40°C/125°C				

[1] Conditions: V_{dd} = 3V, SCK= 400kHz at 25°C
[2] Conditions: V_{dd} = 3V, SCK= 400kHz, Temp<60°C, duty cycle <10%

SENSOR PERFORMANCE

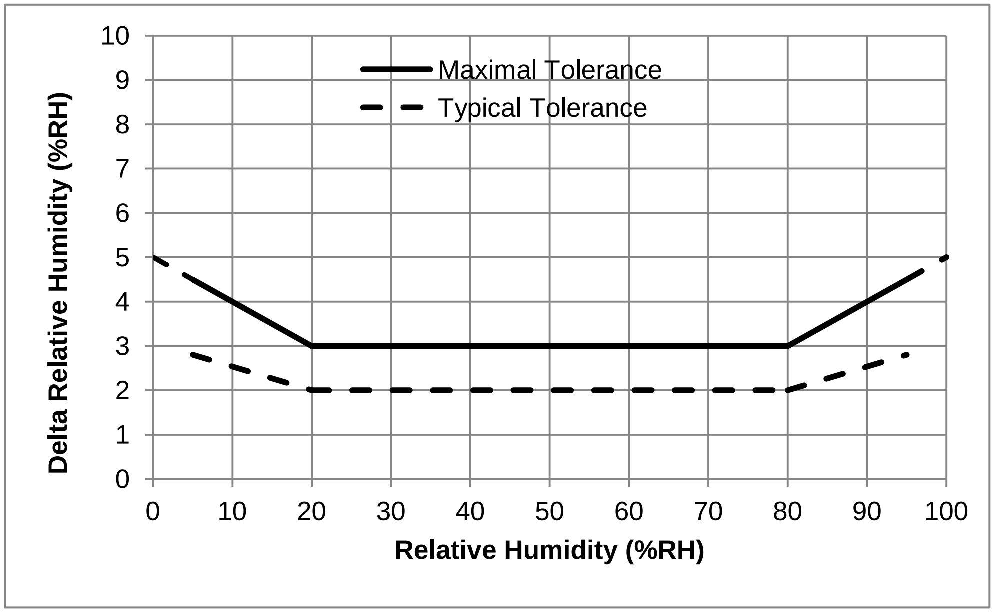
RELATIVE HUMIDITY

(@T = 25°C, @Vdd = 3V)

Characteristics		Symbol	Min	Typ	Max	Unit
Resolution	12 bits			0.04		%RH
	8 bits			0.7		%RH
Humidity Operating Range		RH	0		100	%RH
Relative Humidity Accuracy @25°C (20%RH to 80%RH)	typ			±2		%RH
	max		See graph 1			%RH
Replacement		fully interchangeable				
Temperature coefficient (from 0°C to 80°C)		T_{cc}			-0.15	%RH/°C
Humidity Hysteresis				±1		%RH
Measuring Time [1]	12 bits			14	16	ms
	11 bits			7	8	ms
	10 bits			4	5	ms
	8 bits			2	3	ms
PSRR					±10	LSB
Recovery time after 150 hours of condensation		t		10		s
Long term drift				0.5		%RH/yr
Response Time (at 63% of signal) from 33 to 75%RH [2]		τ_{RH}		5	10	s

[1] Typical values are recommended for calculating energy consumption while maximum values shall be applied for calculating waiting times in communication.
[2] At 1m/s air flow

GRAPH 1 : RELATIVE HUMIDITY ERROR BUDGET CONDITIONS AT 25°C



- HTU21D(F) sensors are specified for optimum accuracy measurements within 5 to 95%RH.
- Operation out of this range (< 5% or > 95% RH, including condensation) is however possible.

TEMPERATURE COEFFICIENT COMPENSATION EQUATION

Using the following temperature coefficient compensation equation will guarantee Relative Humidity accuracy given p.3, from 0°C to 80°C:

$$RH_{compensatedT} = RH_{actualT} + (25 - T_{actual}) \times CoeffTemp$$

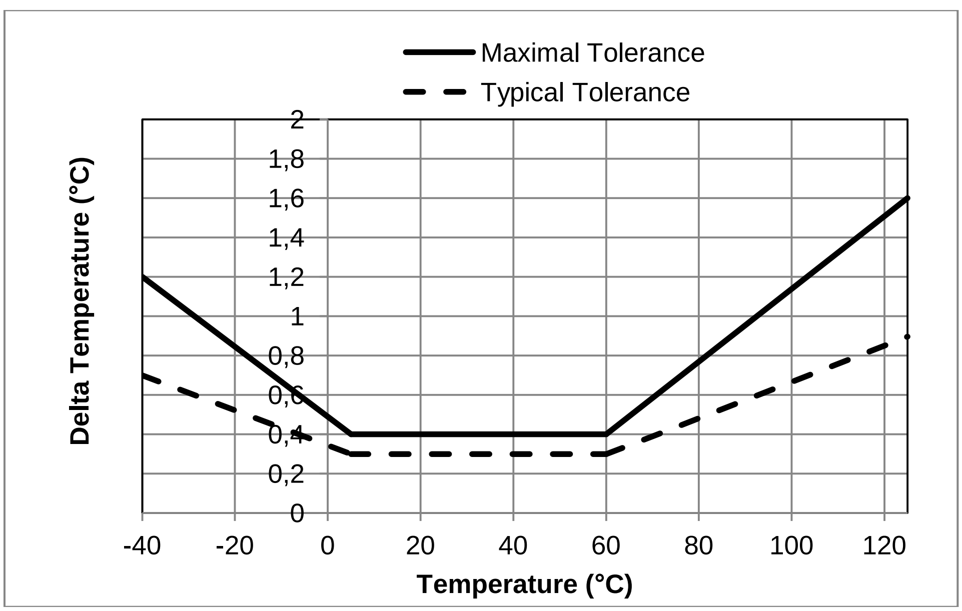
RHactualT	Ambient humidity in %RH, computed from HTU21D(F) sensor
Tactual	Humidity cell temperature in °C, computed from HTU21D(F) sensor
CoeffTemp	Temperature coefficient of the HTU21D(F) in %RH/°C

TEMPERATURE

Characteristics		Symbol	Min	Typ	Max	Unit
Resolution	14 bit			0.01		°C
	12 bit			0.04		°C
Temperature Operating Range		T	-40		+125	°C
Temperature Accuracy @25°C	typ			±0.3		°C
	max		See graph 2			°C
Replacement			fully interchangeable			
Measuring time [(1)]	14 bit			44	50	ms
	13 bit			22	25	ms
	12 bit			11	13	ms
	11 bit			6	7	ms
PSSR					±25	LSB
Long term drift				0.04		°C/yr
Response Time (at 63% of signal) from 15°C to 45°C [(2)]		τ_T		10		s

(1) Typical values are recommended for calculating energy consumption while maximum values shall be applied for calculating waiting times in communication.
(2) At 1m/s air flow

GRAPH 2 : TEMPERATURE ERROR BUDGET



USER GUIDE HTU21D(F)

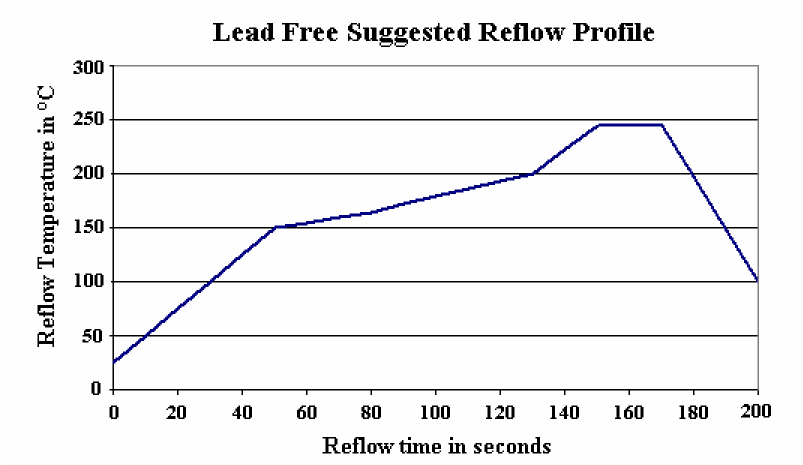
APPLICATION INFORMATION

- **Soldering instructions: Lead free reflow soldering recommended process**

For soldering HTU21D(F) sensor standard reflow soldering ovens may be used.

HTU21D(F) sensor as a humidity sensitive component (as classified by IPC/JEDEC J-STD-020 or equivalent documented procedure with peak temperature at 260°C during up to 30 seconds for Pb-free assembly in IR/convection reflow ovens) must be handled in a manner consistent with IPC/JEDEC J-STD-033 or an equivalent documented procedure. IPC-1601 provides humidity control, handling and packing of PCBs.

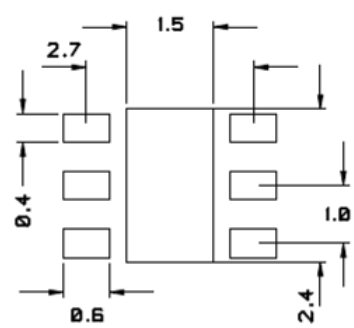
The HTU21D(F) sensor is qualified to withstand one lead free reflow soldering recommended process profile below according to JEDEC standard.



Mount parts within 24 hours after printing solder paste to avoid potential dry up.

For manual soldering, contact time must be limited to 5 seconds at up to 350°C.

For the design of the HTU21D(F) sensor footprint, it is recommended to use dimensions according to figure below.



Recommended footprint for HTU21D(F) sensors. Values in mm.

No specific conditioning of devices is necessary after soldering process, either manual or reflow soldering. Optimized performance in case of metrological measurements can be reached with stabilization of devices (24 hours at 25°C / 55%RH). Similar process is advised after exposure of the devices to extreme relative humidity conditions.

In no case, neither after manual nor reflow soldering, a board wash shall be applied. Therefore, it is strongly recommended to use a “no-clean” solder paste. In case of applications with exposure of the sensor to corrosive gases or condensed water (i.e. environments with high relative humidity) the soldering pads shall be sealed (e.g. conformal coating) to prevent loose contacts or short cuts.

- **Storage Conditions and Handling Instructions**

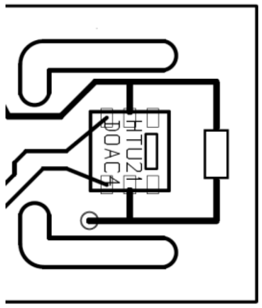
It is recommended to store HTU21D(F) sensor in its original packaging at following conditions: Temperature shall be in the range of -40°C – 125°C.

- **Temperature Effects**

Relative humidity reading strongly depends on temperature. Therefore, it is essential to keep humidity sensors at the same temperature as the air of which the relative humidity is to be measured.

In case of testing or qualification the reference sensor and test sensor must show equal temperature to allow for comparing humidity readings.

The HTU21D(F) sensor should be mounted in a way that prevents heat transfer from electronic sensor or that keeps it as low as possible. Advice can be ventilation, reduction of copper layers between the HTU21D(F) sensor and the rest of the PCB or milling a slit into the PCB around the sensor (1mm minimum width).



Example of HTU21D(F) sensor mounting with slits mills to minimize heat transfer

- **Materials Used for Sealing / Mounting**

For sealing and gluing (use sparingly), use high filled epoxy for electronic packaging and silicone. For any specific material please request to humidity.application@meas-spec.com.
Window must remain uncovered.

- **Wiring Considerations and Signal Integrity**

Carrying the SCK and DATA signal parallel and in close proximity (e.g. in wires) for more than 10 cm may result in cross talk and loss of communication.
This may be resolved by routing VDD and/or GND between the two data signals and/or using shielded cables. Furthermore, slowing down SCK frequency will possibly improve signal integrity.

Power supply pins (VDD, GND) must be bypassed with a 100nF capacitor if wires are used. Capacitor should be placed as close as possible to the sensor.

- **ESD (ElectroStatic Discharge)**

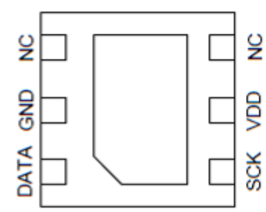
ESD immunity is qualified according to:

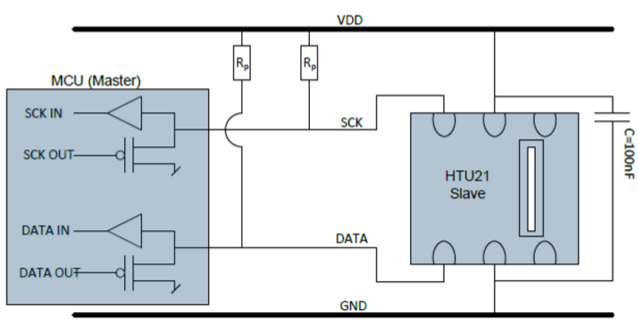
- JEDEC JESD22-A114 method (Human Body Model at ±4kV) for pads & open window
- JEDEC JESD22-A115 method (Machine Model ±200V)
- ESDA ESD-STM5.3.1-1999 and AEC-Q100-011 (charged device model, 750V corner pins, 500V other pins)

Latch-up immunity is provided at a force current of ±100mA with Tamb=25°C according to JEDEC JESD78. For exposure beyond named limits the sensor need additional protection circuit.

INTERFACE SPECIFICATION

N°	Function	Comment
1	DATA	Data bit-stream
2	GND	Ground
3	NC	Must be left unconnected
4	NC	Must be left unconnected
5	VDD	Supply Voltage
6	SCK	Selector for RH or Temp
PAD		Ground or unconnected





Typical application circuit, including pull-up resistor Rp and decoupling of VDD and GND by a capacitor.

- **Power Pins (VDD, GND)**

The supply voltage of HTU21D(F) sensors must be in the range of 1.5VDC - 3.6VDC. Recommended supply voltage is 3VDC (regulated).

However the typical application circuit includes a pull-up resistor R on data wire and a 100nF decoupling capacitor between VDD and GND, placed as close as possible to the sensor.

- **Serial clock input (SCK)**

SCK is used to synchronize the communication between microcontroller and HTU21D(F) sensor. Since the interface consists of fully static logic there is no minimum SCK frequency.

- **Serial data (DATA)**

The DATA pin is used to transfer data in and out of the device. For sending a command to the HTU21D(F) sensor, DATA is valid on the rising edge of SCK and must remain stable while SCK is high. After the falling edge of SCK, the DATA value may be changed. For safe communication DATA shall be valid t_{SU} and t_{HD} before the rising and after the falling edge of SCK, respectively. For reading data from the HTU21D(F) sensor, DATA is valid t_{VD} after SCK has gone low and remains valid until the next falling edge of SCK.
An external pull-up resistor (e.g. 10kΩ) on SCK is required to pull the signal high only for open collector or open drain technology microcontrollers. In most of the cases, pull-up resistors are internally included in I/O circuits of microcontrollers.

ELECTRICAL CHARACTERISTICS

- **Input/output DC characteristics**

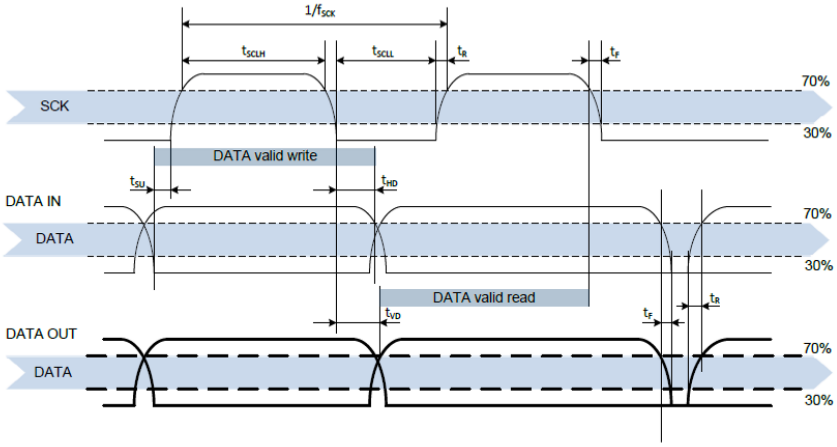
(VDD=3V, Temperature=25°C unless otherwise noted)

Characteristics		Symbol	Min	Typ	Max	Unit
Low level output voltage	VDD=3V -4mA<IOL<0mA	VOL	0	-	0.4	V
High level output voltage		VOH	70%VDD	-	VDD	V
Low level input voltage		VIL	0	-	30%VDD	V
High level input voltage		VIH	70%VDD	-	VDD	V

- **Timing specifications of digital input/output pads for I²C fast mode**

Characteristics	Symbol	Min	Typ	Max	Unit
SCK frequency	f_{SCK}	0	-	0.4	MHz
SCK high time	t_{SCKLH}	0.6	-	-	µs
SCK low time	t_{SCLL}	1.3	-	-	µs
DATA set-up time	t_{SU}	100	-	-	ns
DATA hold-time	t_{HD}	0	-	900	ns
DATA valid-tile	t_{VD}	0	-	400	ns
SCK/DATA fall time	t_F	0	-	100	ns
SCK/DATA rise time	t_R	0	-	300	ns
Capacitive load on bus line	C_B	0	-	500	pF

- **Timing diagram for digital input/output pads**



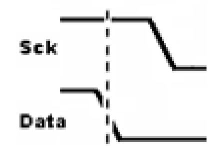
DATA directions are seen from the HTU21D(F) sensor. DATA line in bold is controlled by the sensor. DATA valid read time is triggered by falling edge of anterior toggle.

COMMUNICATION PROTOCOL WITH HTU21D(F) SENSOR

- **Start-up sensor**

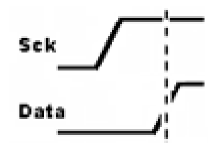
The HTU21D(F) sensor requires a voltage supply between 1.5V and 3.6V. After power up, the device needs at most 15ms while SCK is high for reaching idle state (sleep mode), i.e to be ready accepting commands from the MCU. No command should be sent before that time. Soft reset is recommended at start, refer p.11.

- **Start sequence (S)**



To initiate transmission, a start bit has to be issued. It consists of a lowering of the DATA line while SCK is high followed by lowering SCK.

- **Stop sequence (P)**



To stop transmission, a stop bit has to be issued. It consists of a heightening of the DATA line while SCK is high preceded by a heightening of the SCK.

HTU21D(F) SENSOR LIST OF COMMANDS AND REGISTER ADRESSES

For sample source code, please request to humidity.application@meas-spec.com.

- **Sending a command**

After sending the start condition, the subsequent I²C header consist of a 7-bit I²C device address 0x40 and a DATA direction bit ('0' for Write access : 0x80). The HTU21D(F) sensor indicates the proper reception of a byte by pulling the DATA pin low (ACK bit) after the falling edge of the 8^{th} SCK clock. After the issue of a measurement command (0xE3 for temperature, 0xE5 for relative humidity), the MCU must wait for the measurement to complete. The basic commands are given in the table below:

Command	Code	Comment
Trigger Temperature Measurement	0xE3	Hold master
Trigger Humidity Measurement	0xE5	Hold master
Trigger Temperature Measurement	0xF3	No Hold master
Trigger Humidity Measurement	0xF5	No Hold master
Write user register	0xE6	
Read user register	0xE7	
Soft Reset	0xFE	

- **Hold/No Hold master modes**

There are two different operation modes to communicate with the HTU21D(F) sensor: Hold Master mode and No Hold Master mode.

In the first case, the SCK line is blocked (controlled by HTU21D(F) sensor) during measurement process while in the second case the SCK line remain open for other communication while the sensor is processing the measurement.

No Hold Master mode allows for processing other I²C communication tasks on a bus while the HTU21D(F) sensor is measuring. A communication sequence of the two modes is available below.
In the Hold Master mode, the HTU21D(F) pulls down the SCK line while measuring to force the master into a wait state. By releasing the SCK line, the HTU21D(F) sensor indicates that internal processing is completed and that transmission may be continued.

In the No Hold Master mode, the MCU has to poll for the termination of the internal processing of the HTU21D(F) sensor. This is done by sending a start condition followed by the I²C header ('1' for Read access: 0x81) as shown below. If the internal processing is finished, the HTU21D(F) sensor acknowledges the poll of the MCU and data can be read by the MCU. If the measurement processing is not finished, the HTU21D(F) sensor answers no ACK bit and start condition must be issued once more.

For both modes, since the maximum resolution of the measurement is 14 bits, the two last least significant bits (LSBs, bits 43 and 44) are used for transmitting status information. Bit 1 of the two LSBs indicates the measurement type ('0': temperature, '1': humidity). Bit 0 is currently not assigned.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S	1	0	0	0	0	0	0	0	ACK	1	1	1	0	0	1	0	1	ACK
	I²C address + write									Command (see table p.9)								

	19	20	21	22	23	24	25	26	27	
S	1	0	0	0	0	0	0	1	ACK	Measurement
	I²C address + read									Hold during measurement

28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
0	1	1	1	1	1	0	0	ACK	1	0	0	0	0	0	1	0	ACK
Data (MSB)									Data (LSB)						Status		

46	47	48	49	50	51	52	53	54	
1	0	0	1	0	1	1	1	NACK	P
Checksum									

Hold Master communication sequence

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S	1	0	0	0	0	0	0	0	ACK	1	1	1	1	0	1	0	1	ACK
	I²C address + write									Command (see table p.9)								
										19	20	21	22	23	24	25	26	27
	Measurement								S	1	0	0	0	0	0	0	1	NACK
	measuring									I²C address + read								
										19	20	21	22	23	24	25	26	27
	Measurement								S	1	0	0	0	0	0	0	1	ACK
	continue measuring									I²C address + read								
	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
	0	1	1	1	1	1	0	0	ACK	1	0	0	0	0	0	1	0	ACK
	Data (MSB)									Data (LSB)						Status		
	46	47	48	49	50	51	52	53	54									
	1	0	0	1	0	1	1	1	NACK	P								
	Checksum																	

No Hold Master communication sequence

Grey blocks are controlled by HTU21D(F) sensor.
For Hold Master sequence, bit 45 may be changed to NACK followed by a stop condition to omit checksum transmission.

For No Hold Master sequence, if measurement is not completed upon “read” command, sensor does not provide ACK on bit 27 (more of these iterations are possible). If bit 45 is changed to NACK followed by stop condition, checksum transmission is omitted.

In those examples, the HTU21D(F) sensor output is S_{RH} = ‘0111’1100’1000’0000 (0x7C80). For the calculation of physical values status bits must be set to ‘0’. Refer to “Conversion of signal outputs” section p.14.

The maximum duration for measurement depends on the type of measurement and resolution chosen. Maximum values shall be chosen for the communication planning of the MCU. Refer to the table p.3 and p.4 regarding measuring time specifications.

I²C communication allows for repeated start conditions without closing prior sequence with stop condition.

- **Soft reset**

This command is used for rebooting the HTU21D(F) sensor switching the power off and on again. Upon reception of this command, the HTU21D(F) sensor system reinitializes and starts operation according to the default settings with the exception of the heater bit in the user register. The soft reset takes less than 15ms.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
S	1	0	0	0	0	0	0	0	ACK	1	1	1	1	1	1	1	0	ACK	P
	I²C address + write									Soft Reset Command									

Grey blocks are controlled by HTU21D(F) sensor.

- **User register**

The content of user register is described in the table below. Reserved bits must not be changed and default values of respective reserved bits may change over time without prior notice. Therefore, for any writing to user register, default values of reserved bits must be read first.

The "End of Battery" alert/status is activated when the battery power falls below 2.25V.

The heater is intended to be used for functionality diagnosis: relative humidity drops upon rising temperature. The heater consumes about 5.5mW and provides a temperature increase of about 0.5-1.5°C.

OTP reload is a safety feature and load the entire OTP settings to the register, with the exception of the heater bit, before every measurement. This feature is disabled per default and it is not recommended for use. Please use soft reset instead as it contains OTP reload.

<table>
<tr><th>Bit</th><th>#Bits</th><th>Description/Coding</th><th>Default</th></tr>
<tr><td>7,0</td><td>2</td><td>Measurement resolution
<table>
<tr><td>Bit 7</td><td>Bit 0</td><td>RH</td><td>Temp</td></tr>
<tr><td>0</td><td>0</td><td>12 bits</td><td>14 bits</td></tr>
<tr><td>0</td><td>1</td><td>8 bits</td><td>12 bits</td></tr>
<tr><td>1</td><td>0</td><td>10 bits</td><td>13 bits</td></tr>
<tr><td>1</td><td>1</td><td>11 bits</td><td>11 bits</td></tr>
</table></td><td>'00'</td></tr>
<tr><td>6</td><td>1</td><td>Status: End of Battery(1)
'0': VDD>2.25V
'1': VDD<2.25V</td><td>'0'</td></tr>
<tr><td>3, 4, 5</td><td>3</td><td>Reserved</td><td>'0'</td></tr>
<tr><td>2</td><td>1</td><td>Enable on-chip heater</td><td>'0'</td></tr>
<tr><td>1</td><td>1</td><td>Disable OTP reload</td><td>'1'</td></tr>
</table>

(1) This status bit is updated after each measurement

Cut-off value for "End of Battery" signal may vary by ±0.1V.
Reserved bits must not be changed.
OTP reload active loads default settings after each time a measurement command is issued.

- **I²C communication reading and writing the user register example**

In this example, the resolution is set to 8 bits / 12 bits (for RH/Temp) from default configuration.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
S	1	0	0	0	0	0	0	0	ACK	1	1	1	0	0	1	1	1	ACK
	I²C address + write									Read Register Command								

	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
S	1	0	0	0	0	0	0	1	ACK	0	0	0	0	0	0	1	0	NACK
	I²C address + read									Register content								

	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
S	1	0	0	0	0	0	0	0	ACK	1	1	1	0	0	1	1	0	ACK
	I²C address + write									Write Register Command								

55	56	57	58	59	60	61	62	63	
0	0	0	0	0	0	1	1	ACK	P
Register Content to be written									

Grey blocks are controlled by HTU21D(F) sensor.

- **CRC Checksum**

HTU21D(F) sensor provides a CRC-8 checksum for error detection. The polynomial used is $X^8 + X^5 + X^4 + 1$.

Basic Considerations

CRC stands for Cyclic Redundancy Check. It is one of the most effective error detection schemes and requires a minimal amount of resources.

The types of errors that are detectable with CRC that is implemented in HTU21D(F) sensors are:
- Any odd number of errors anywhere within the data transmission
- All double-bit errors anywhere within the transmission
- Any cluster of errors that can be contained within an 8-bit window (1-8 bits incorrect)
- Most larger clusters of errors

A CRC is an error-detecting code commonly used in digital networks and storage devices to detect accidental changes to raw data.

Blocks of data entering these systems get a short check value attached, based on the remainder of a polynomial division of their contents; on retrieval the calculation is repeated, and corrective action can be taken against presumed data corruption if the check values do not match.

CRCs are so called because the check (data verification) value is a redundancy (it expands the message without adding information) and the algorithm is based on cyclic codes. CRCs are popular because they are simple to implement in binary hardware, easy to analyze mathematically, and particularly good at detecting common errors caused by noise in transmission channels. Because the check value has a fixed length, the function that generates it is occasionally used as a hash function.

CRC for HTU21D(F) sensors using I²C Protocol

When HTU21D(F) sensors are run by communicating with the standard I²C protocol, an 8-bit CRC can be used to detect transmission errors. The CRC covers all read data transmitted by the sensor. CRC properties for HTU21D(F) sensors communicating with I²C protocol are listed in the table below.

CRC with I²C protocol	
Generator polynomial	$X^8 + X^5 + X^4 + 1$
Initialization	0x00
Protected data	Read data
Final Operation	none

CRC calculation

To compute an n-bit binary CRC, line the bits representing the input in a row, and position the (n+1)-bit pattern representing the CRC's divisor (called a "polynomial") underneath the left-hand end of the row.

This is first padded with zeroes corresponding to the bit length n of the CRC.

If the input bit above the leftmost divisor bit is 0, do nothing. If the input bit above the leftmost divisor bit is 1, the divisor is XORed into the input (in other words, the input bit above each 1-bit in the divisor is toggled). The divisor is then shifted one bit to the right, and the process is repeated until the divisor reaches the right-hand end of the input row.

Since the left most divisor bit zeroed every input bit it touched, when this process ends the only bits in the input row that can be nonzero are the n bits at the right-hand end of the row. These n bits are the remainder of the division step, and will also be the value of the CRC function.

The validity of a received message can easily be verified by performing the above calculation again, this time with the check value added instead of zeroes. The remainder should equal zero if there are no detectable errors.

CRC examples

The input message 11011100 (0xDC) will have as result 01111001 (0x79).

The input message 01101000 00111010 (0x683A: 24.7°C) will have as result 01111100 (0x7C).

The input message 01001110 10000101 (0x4E85: 32.3%RH) will have as result 01101011 (0x6B).

CONVERSION OF SIGNAL OUTPUTS

Default resolution is set to 12-bit relative humidity and 14-bit temperature readings. Measured data are transferred in two byte packages, i.e. in frames of 8-bit length where the most significant bit (MSB) is transferred first (left aligned). Each byte is followed by an acknowledge bit. The two status bits, the last bits of LSB, must be set to '0' before calculating physical values.

To accommodate/adapt any process variation (nominal capacitance value of the humidity die), tolerances of the sensor above 100%RH and below 0%RH must be considered. As a consequence:

- 118%RH corresponds to 0xFF which is the maximum RH digital output that can be sent out from the ASIC. RH output can reach 118%RH and above this value, there will have a clamp of the RH output to this value.
- -6%RH corresponds to 0x00 which is the minimum RH digital output that can be sent out from the ASIC. RH output can reach -6%RH and below this value, there will have a clamp of the RH output to this value.

• Relative Humidity conversion

With the relative humidity signal output S_{RH}, the relative humidity is obtained by the following formula (result in %RH), no matter which resolution is chosen:

$$RH = -6 + 125 \times \frac{S_{RH}}{2^{16}}$$

In the example given p.10, the transferred 16-bit relative humidity data is 0x7C80: 31872. The relative humidity results to be 54.8%RH.

• Temperature conversion

The temperature T is calculated by inserting temperature signal output S_{Temp} into the following formula (result in °C), no matter which resolution is chosen:

$$Temp = -46.85 + 175.72 \times \frac{S_{Temp}}{2^{16}}$$

APPLICATION: DEW POINT TEMPERATURE MEASUREMENT

The dew point is the temperature at which the water vapor in the air becomes saturated and condensation begins.

The dew point is associated with relative humidity. A high relative humidity indicates that the dew point is closer to the current air temperature. Relative humidity of 100% indicates that the dew point is equal to the current temperature (and the air is maximally saturated with water). When the dew point stays constant and temperature increases, relative humidity will decrease.

Dew point temperature of the air is calculated using Ambient Relative Humidity and Temperature measurements from HTU21D(F) sensor with following formulas given below:

Partial Pressure (PP_{Tamb}) formula from Ambient Temperature:

$$PP_{Tamb} = 10^{\left[A - \frac{B}{(Tamb + C)}\right]}$$

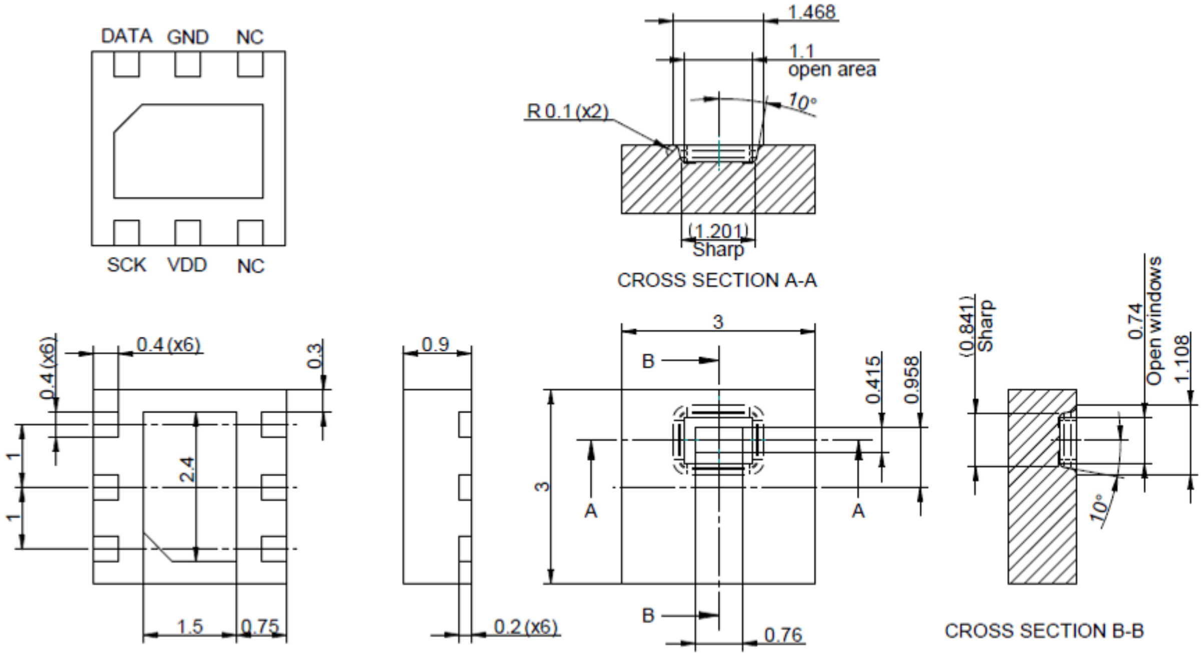
Dew point Temperature (T_d) formula from Partial Pressure (PP_{Tamb}):

$$T_d = -\left[\frac{B}{\log_{10}\left(RH_{amb} \times \frac{PP_{Tamb}}{100}\right) - A} + C\right]$$

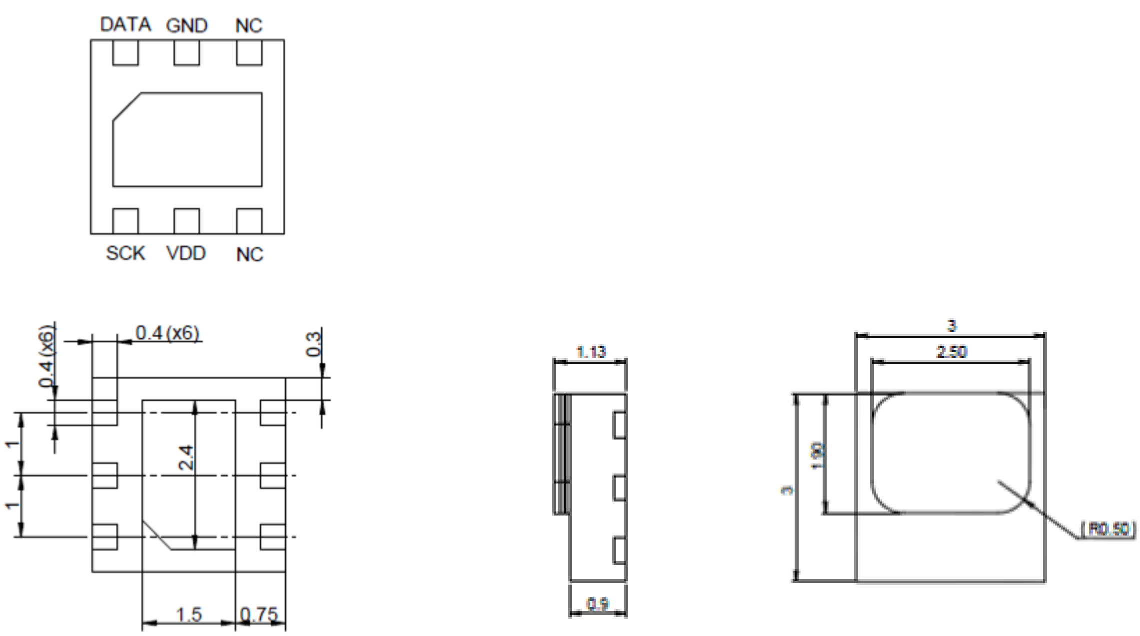
PP_{Tamb}	Partial Pressure in mmHg at ambient temperature (T_{amb})
RH_{amb}	Ambient humidity in %RH, computed from HTU21D(F) sensor
T_{amb}	Humidity cell temperature in °C, computed from HTU21D(F) sensor
T_d	Calculated Dew Point in °C
A, B, C	Constants: A=8.1332; B=1762.39; C=235.66

PACKAGE OUTLINE

- **HTU21D Sensor Dimensions**



- **HTU21DF Sensor Dimensions**



Dimensions are given in mm, tolerances are ±0.1mm. The die pad (thermal center pad) is internally connected to GND.

- **Packaging Type**

HTU21D(F) sensors are provided in DFN packaging. DFN stands for Dual Flat No leads.

The HTU21D(F) sensor chip is mounted to a lead frame made of Cu and plated with Ni/Pd/Au. Chip and lead frame are over molded by green epoxy-based mold compound. Please note that side walls of sensors are diced and hence lead frame at diced edge is not covered with respective protective coating.

The total weight of the sensor is 0.025g.

- **Traceability Information**

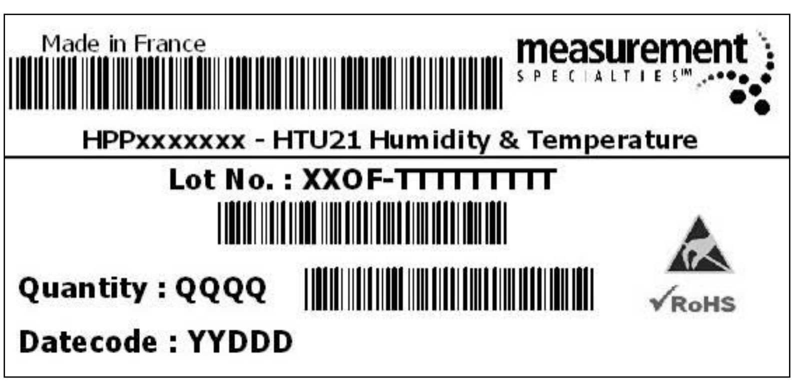
All HTU21D(F) sensors are laser marked with an alphanumeric, five-digit code on the sensor as pictured below.

The marking on the HTU21D(F) sensor consists of two lines with five digits each:

- The first line denotes the sensor type: HTU21.
- The second line denotes several information as:
  - The first digit of the second line defines the output mode:
    - D = digital and I²C
    - P = PWM
    - S = SDM
  - The second digit defines the manufacturing year: 2 = 2012, 3 = 2013, etc.
  - The last three digits represent an alphanumeric tracking code. That code can be decoded by MEAS only and allows for tracking on batch level through production, calibration and testing and will be provided upon justified request.

Laser marking on HTU21D(F) sensor

Reels are also labeled, as displayed below and give additional traceability information.



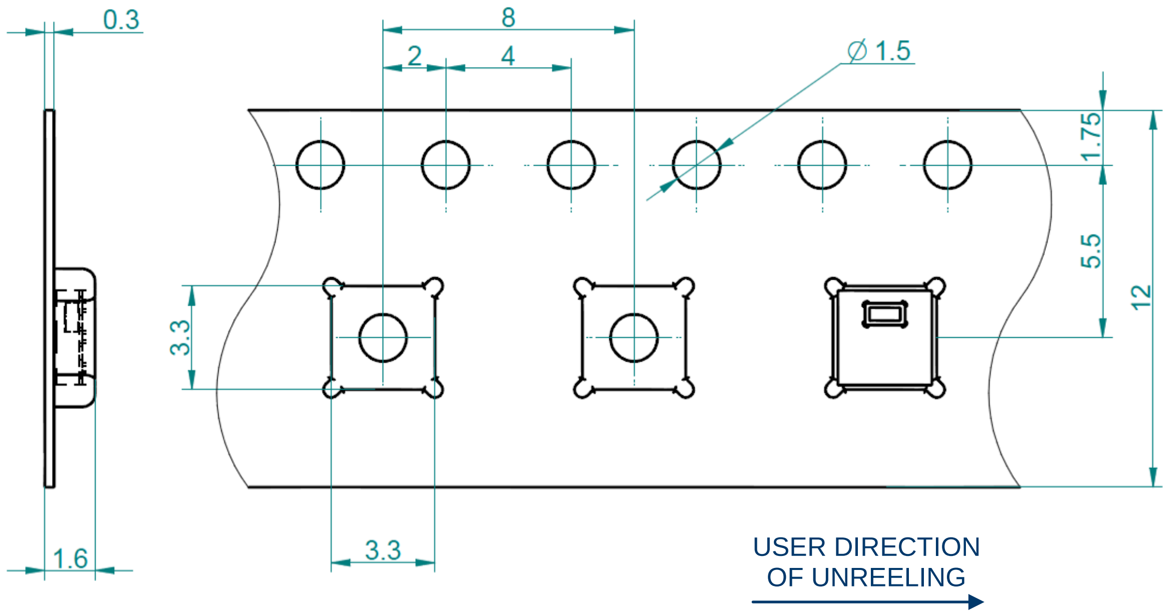
With:

XX:	Sensor Type (21 for HTU21D(F))
O:	Output mode (D = Digital, P = PWM, S = SDM)
(F):	Sensor with PTFE membrane (only for HTU21DF)
NN:	Product revision number
TTTTTTTTT:	MEAS Traceability Code
YY:	Two last digits of the year
DDD:	Day of the year
QQQQ:	Quantity per real (400, 1500 or 5000 units)

- **Tape and Reel Packaging**

HTU21D(F) sensors are shipped in tape & reel packaging, sealed into antistatic ESD bags.

Standard packaging sizes are 400, 1500 and 5000 units per reel. Each reel contains 440mm (55 pockets) header tape and 200mm (25 pockets) trailer tape. The drawing of the packaging tapes with sensor orientation is shown in the picture below.



- **Packaging reels**

For 400 and 1500 units: outside diameter of 7” (178mm) and a 1/2” (13mm) diameter arbor hole.

For 5000 units: outside diameter of 13” (330mm) and a 1/2” (13mm) diameter arbor hole.

ORDERING INFORMATION

**** HTU21D – DIGITAL TEMPERATURE AND RELATIVE HUMIDITY MODULE ****

PACKAGE: TAPE AND REEL M.P.Q OF 400 PIECES, 1500 PIECES OR 5000 PIECES

- **HPP828E031R4 - HTU21D in tape and reel of 400 pieces**
- **HPP828E031R1 - HTU21D in tape and reel of 1500 pieces**
- **HPP828E031R5 - HTU21D in tape and reel of 5000 pieces**

**** HTU21DF – DIGITAL TEMPERATURE AND RELATIVE HUMIDITY MODULE WITH PTFE MEMBRANE ****

PACKAGE: TAPE AND REEL M.P.Q OF 400 PIECES, 1500 PIECES OR 5000 PIECES

- **HPP828E131R4 - HTU21DF in tape and reel of 400 pieces**
- **HPP828E131R1 - HTU21DF in tape and reel of 1500 pieces**
- **HPP828E131R5 - HTU21DF in tape and reel of 5000 pieces**

**** HTU21D DEMOKIT – HPP828KIT ****

This is a USB device for MEAS Model HTU21D Digital Relative Humidity & Temperature sensor demonstration. Supporting up to 4 sensor acquisitions at the same time, it shows the consistency of different sensors and test sensor functions conveniently.
For detailed information, please request to humidity.application@meas-spec.com.

Customer Service contact details

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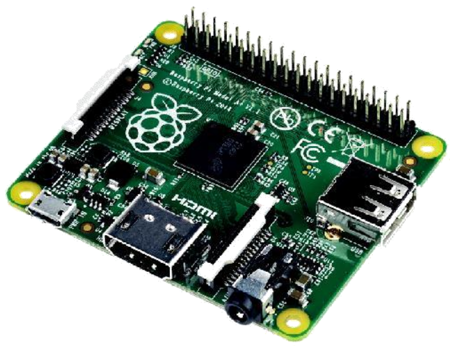
MEAS Website: http://www.meas-spec.com/humidity-sensors.aspx

Revision	Comments	Who	Date
0	Document creation	D. LE GALL	April 12
A	General update	D. LE GALL-ZIRILLI	February 13
2	HTU21DF product with embedded PTFE membrane reference added, Storage conditions after soldering process updated (typing error), ESD performances updated, complementary information on RH output signal in "Conversion of signal outputs" paragraph, information on tape and reel packaging added, HTU21D demokit availability information added.	D. LE GALL-ZIRILLI	July 13
3	Correction of I^2C communication reading and writing, correction of soldering peak temperature	M.ROBERT	October 2013

Raspberry Pi



MODEL A+

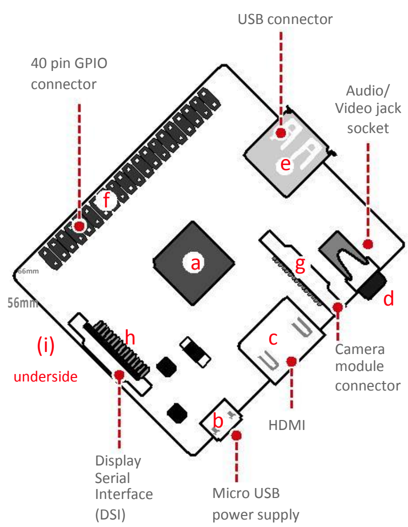
Product Name	Raspberry Pi Model A+
Product Description	The Raspberry Pi model A+ features lower power consumption, better audio performance and a 40-pin GPIO connector in an even smaller package.

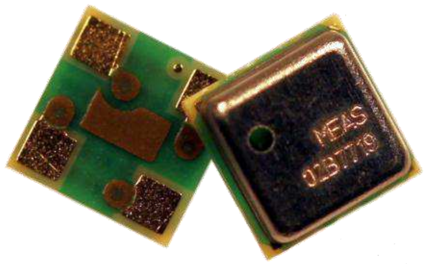
Specifications

Chip	Broadcom BCM2835 (a)
Core architecture	ARM11
CPU	700 MHz Low Power ARM1176JZFS Applications Processor
GPU	Dual Core VideoCore IV® Multimedia Co-Processor Provides Open GL ES 2.0, hardware-accelerated OpenVG, and 1080p30 H.264 high-profile decode Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure
Memory	512MB SDRAM
Operating System	Boots from micro SD card, running a version of the Linux operating system
Dimensions	66 x 56 x 14mm
Power	Micro USB socket 5V, 2A (b)

Connectors:

Digital AV Output	HDMI (rev 1.3 & 1.4) (c)
Analogue AV Output	3.5mm jack (d), Stereo audio, Composite video (PAL, NTSC)
USB	USB 2.0 Connector (e)
GPIO Connector	40-pin 0.1in header compatible with Model A/B 26-pin add-on boards (f)
Camera Connector	15-pin MIPI Camera Serial Interface (CSI-2) (g)
Display Connector	15-pin Display Serial Interface (DSI) (h)
Memory Card Slot	Micro SD (i)





✓RoHS

MS5637-02BA03

Low Voltage Barometric Pressure Sensor

SPECIFICATIONS

- **QFN package 3 x 3 x 0.9 mm^3**
- **High-resolution module, 13 cm**
- **Supply voltage: 1.5 to 3.6 V**
- **Fast conversion down to 0.5 ms**
- **Low power, 0.6 µA (standby ≤ 0.1 µA at 25°C)**
- **Integrated digital pressure sensor (24 bit ΔΣ ADC)**
- **Operating range: 300 to 1200 mbar, -40 to +85 °C**
- **I^{2}C interface**
- **No external components (internal oscillator)**

The MS5637 is an ultra-compact micro altimeter. It is optimized for altimeter and barometer applications in Smart-phones and Tablet PCs. The altitude resolution at sea level is 13 cm of air. 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 of an altimeter/thermometer function without any additional sensor. The MS5637 can be interfaced to any microcontroller with I^{2}C-bus interface. The communication protocol is simple, without the need of programming internal registers in the device. Small dimensions of 3 x 3 x 0.9 mm^3 allow the integration in mobile devices. This new sensor module generation is based on leading MEMS technology and latest benefits from MEAS Switzerland proven experience and know-how in high volume manufacturing of altimeter modules, which has been widely used for over a decade. The sensing principle employed leads to very low hysteresis and high stability of both pressure and temperature signal.

FEATURES

FIELD OF APPLICATION

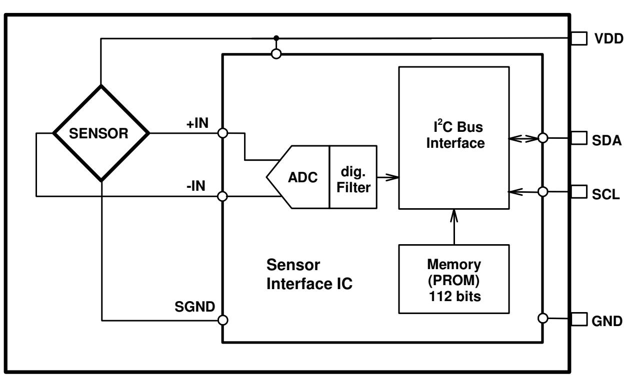
Smart-phones
Tablet PCs
Personal navigation devices

TECHNICAL DATA

Sensor Performances (V_{DD} = 3 V)				
Pressure	**Min**	**Typ**	**Max**	**Unit**
Maximum Range	10		2000	mbar
ADC	24			bit
Resolution (1)	0.11 / 0.062/ 0.039 / 0.028 / 0.021 / 0.016			mbar
Error band at 25°C, 300 to 1200 mbar	-2		+2	mbar
Error band, -20°C to + 85°C 300 to 1200 mbar (2)	-4		+4	mbar
Response time (1)	0.5 / 1.1 / 2.1 / 4.1 / 8.22 / 16.44			ms
Long term stability		±1		mbar/yr
Temperature	**Min**	**Typ**	**Max**	**Unit**
Range	-40		+85	°C
Resolution		<0.01		°C
Accuracy at 25°C	-1		+1	°C

Notes: (1) Oversampling Ratio: 256 / 512 / 1024 / 2048 / 4096 / 8192
(2) With auto-zero at one pressure point

FUNCTIONAL BLOCK DIAGRAM



PERFORMANCE SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply voltage	V_{DD}		-0.3		+3.6	V
Storage temperature	T_S		-20		+85	°C
Overpressure	P_{max}			6		bar
Maximum Soldering Temperature	T_{max}	40 sec max			250	°C
ESD rating		Human Body Model	-2		+2	kV
Latch up		JEDEC standard No 78	-100		+100	mA

ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Operating Supply voltage	V_{DD}		1.5	3.0	3.6	V
Operating Temperature	T		-40	+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} = 3.0 V)		0.01	0.1	µA
VDD Capacitor		from VDD to GND	100	470		nF

ANALOG DIGITAL CONVERTER (ADC)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Output Word				24		bit
Conversion time	t_c	OSR 8192 4096 2048 1024 512 256		16.44 8.22 4.13 2.08 1.06 0.54		ms

PERFORMANCE SPECIFICATIONS (CONTINUED)

PRESSURE OUTPUT CHARACTERISTICS (V_{DD} = 3.0 V, T = 25 °C UNLESS OTHERWISE NOTED)

Parameter	Conditions		Min.	Typ.	Max.	Unit
Operating Pressure Range	P_{range}		300		1200	mbar
Extended Pressure Range	P_{ext}	Linear Range of ADC	10		2000	mbar
Relative Accuracy, autozero at one pressure point (1)	700…1000 mbar at 25°C			±0.1		mbar
Absolute Accuracy, no autozero	300..1200 mbar at 25°C 300..1200mbar, -20..85°C		-2 -4		+2 +4	mbar
Resolution RMS	OSR	8192 4096 2048 1024 512 256		0.016 0.021 0.028 0.039 0.062 0.11		mbar
Maximum error with supply voltage	V_{DD} = 1.5 V … 3.6 V			±0.5		mbar
Long-term stability				±1		mbar/yr
Reflow soldering impact	IPC/JEDEC J-STD-020C (See application note AN808 on http://meas-spec.com)			-1		mbar
Recovering time after reflow (2)				3		days

(1) Characterized value performed on qualification devices
(2) Recovering time at least 66% of the reflow impact

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

Parameter	Conditions		Min.	Typ.	Max.	Unit
Absolute Accuracy	at 25°C -20..85°C		-1 -2		+1 +2	°C
Maximum error with supply voltage	V_{DD} = 1.5 V … 3.6 V			±0.3		°C
Resolution RMS	OSR	8192 4096 2048 1024 512 256		0.002 0.003 0.004 0.006 0.009 0.012		°C

PERFORMANCE SPECIFICATIONS (CONTINUED)

DIGITAL INPUTS (SDA, SCL)

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_{leak}	T = 25 °C			0.1	µA
Input capacitance	C_{IN}			6		pF

DIGITAL OUTPUTS (SDA)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Output high voltage	V_{OH}	I_{source} = 1 mA	80% V_{DD}		100% V_{DD}	V
Output low voltage	V_{OL}	I_{sink} = 1 mA	0% V_{DD}		20% V_{DD}	V
Load capacitance	C_{LOAD}			16		pF

FUNCTIONAL DESCRIPTION

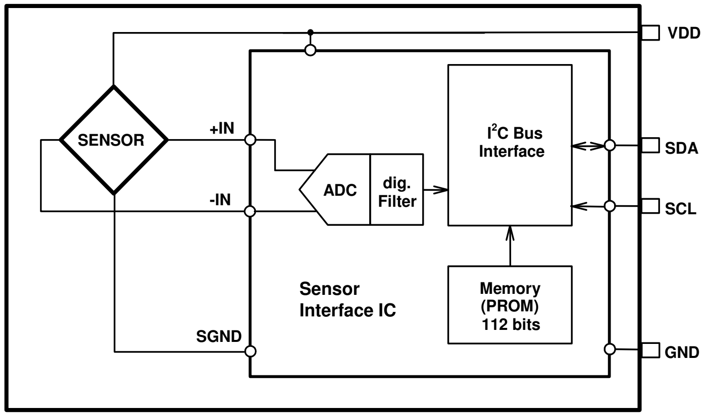


Figure 1: Block diagram

GENERAL

The MS5637 consists of a piezo-resistive sensor and a sensor interface integrated circuit. The main function of the MS5637 is to convert the uncompensated analogue 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) must be read by the microcontroller software and used in the program converting D1 and D2 into compensated pressure and temperature values.

SERIAL I2C 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 I²C bus interface. So this interface type uses only 2 signal lines and does not require a chip select.

Module reference	Mode	Pins used
MS563702BA03	I²C	SDA, SCL

PRESSURE AND TEMPERATURE CALCULATION

Start
Maximum values for calculation results:
P_{MIN} = 10mbar P_{MAX} = 2000mbar
T_{MIN} = -40°C T_{MAX} = 85°C T_{REF} = 20°C

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	46372
C2	Pressure offset | OFF_{T1}	unsigned int 16	16	0	65535	43981
C3	Temperature coefficient of pressure sensitivity | TCS	unsigned int 16	16	0	65535	29059
C4	Temperature coefficient of pressure offset | TCO	unsigned int 16	16	0	65535	27842
C5	Reference temperature | T_{REF}	unsigned int 16	16	0	65535	31553
C6	Temperature coefficient of the temperature | TEMPSENS	unsigned int 16	16	0	65535	28165

Read digital pressure and temperature data

D1	Digital pressure value	unsigned int 32	24	0	16777216	6465444
D2	Digital temperature value	unsigned int 32	24	0	16777216	8077636

Calculate temperature

dT	Difference between actual and reference temperature [2] $dT = D2 - T_{REF} = D2 - C5 * 2^8$	signed int 32	25	-16776960	16777216	68
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	2000 = 20.00 °C

Calculate temperature compensated pressure

OFF	Offset at actual temperature [3] $OFF = OFF_{T1} + TCO * dT = C2 * 2^{17} + (C4 * dT) / 2^6$	signed int 64	41	-17179344900	25769410560	5764707214
SENS	Sensitivity at actual temperature [4] $SENS = SENS_{T1} + TCS * dT = C1 * 2^{16} + (C3 * dT) / 2^7$	signed int 64	41	-8589672450	12884705280	3039050829
P	Temperature compensated pressure (10…1200mbar with 0.01mbar resolution) $P = D1 * SENS - OFF = (D1 * SENS / 2^{21} - OFF) / 2^{15}$	signed int 32	58	1000	120000	110002 = 1100.02 mbar

Display pressure and temperature value

Notes
[1] Maximal size of intermediate result during evaluation of variable
[2] min and max have to be defined
[3] min and max have to be defined
[4] min and max have to be defined

Figure 2: Flow chart for pressure and temperature reading and software compensation.

SECOND ORDER TEMPERATURE COMPENSATION

In order to obtain best accuracy over temperature range, particularly at low temperature, it is recommended to compensate the non-linearity over the temperature. This can be achieved by correcting the calculated temperature, offset and sensitivity by a second-order correction factor. The second-order factors are calculated as follows:

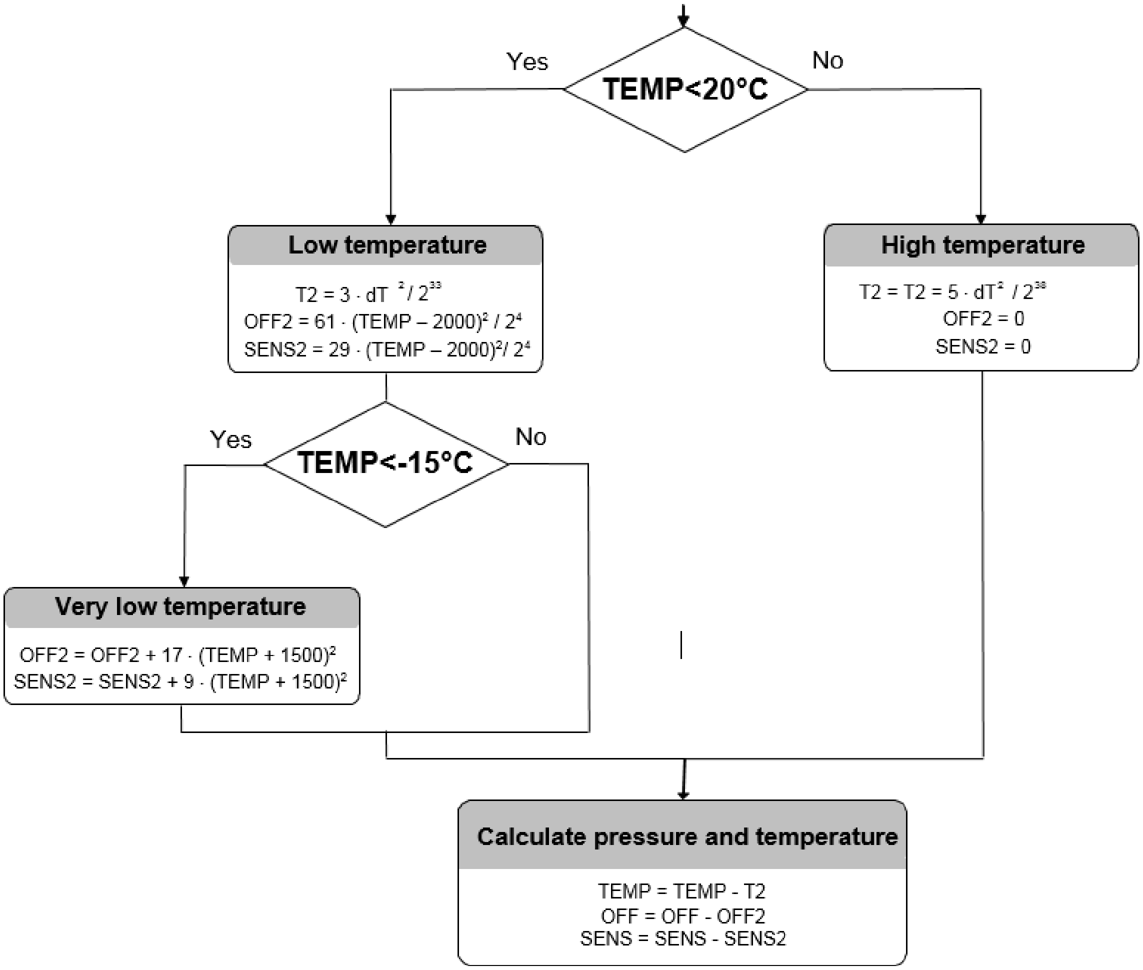


Figure 3: Flow chart for pressure and temperature to the optimum accuracy.

I²C INTERFACE

COMMANDS

The MS5637 has only five basic commands:

1. Reset
2. Read PROM (112 bit of calibration words)
3. D1 conversion
4. D2 conversion
5. Read ADC result (24 bit pressure / temperature)

Each I²C communication message starts with the start condition and it is ended with the stop condition. The MS5637 address is 1110110x (write : x=0, read : x=1).

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 16 bit results. 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	PROM	CONV	-	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 D1 (OSR=8192)	0	1	0	0	1	0	1	0	0x4A
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
Convert D2 (OSR=8192)	0	1	0	1	1	0	1	0	0x5A
ADC Read	0	0	0	0	0	0	0	0	0x00
PROM Read	1	0	1	0	Ad2	Ad1	Ad0	0	0xA0 to 0xAE

Figure 4: Command structure

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 MS5637 to function is to send several SCLs followed by a reset sequence or to repeat power on reset.

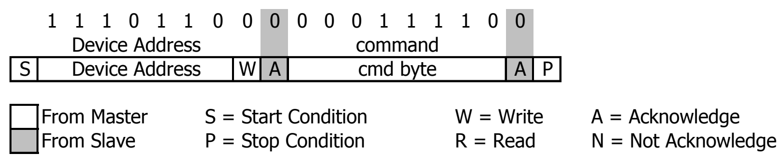


Figure 5: I²C Reset Command

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 contains 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.

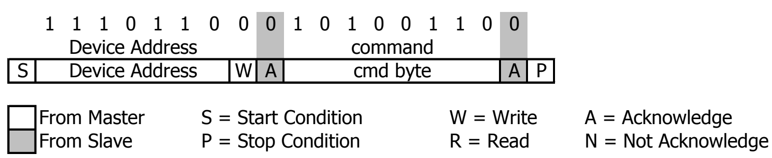


Figure 6: I²C Command to read memory address= 011

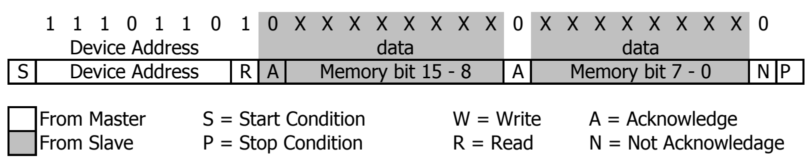


Figure 7: I²C answer from MS5637

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 MS5637. 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 an acknowledge is sent from the MS5637, 24 SCL cycles may be sent to receive all result bits. Every 8 bits the system waits for an acknowledge signal.

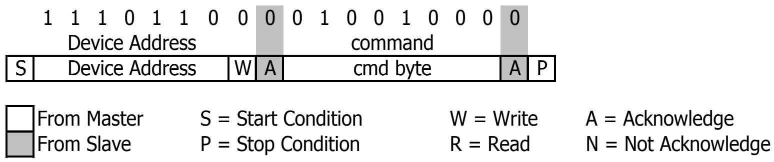


Figure 8: I²C command to initiate a pressure conversion (OSR=4096, typ=D1)

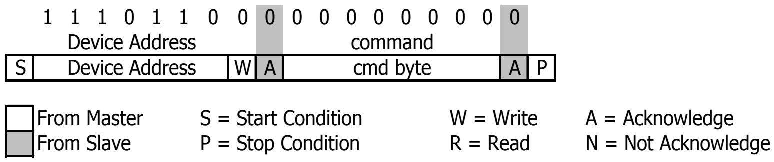


Figure 9: I²C ADC read sequence

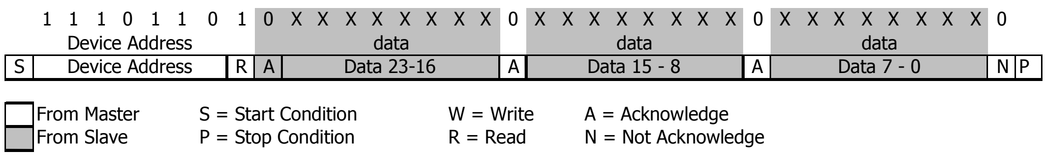


Figure 10: I²C answer from MS5637

CYCLIC REDUNDANCY CHECK (CRC)

MS5637 contains a PROM memory with 112-Bit. A 4-bit CRC has been implemented to check the data validity in memory. The C code example below describes the CRC calculation which is stored on DB12 to DB15 in the first PROM word.

Add	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 11: 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 reminder
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 reminder is CRC code
        return (n_rem ^ 0x00);
}
```

APPLICATION CIRCUIT

The MS5637 is a circuit that can be used in conjunction with a microcontroller in mobile altimeter applications.

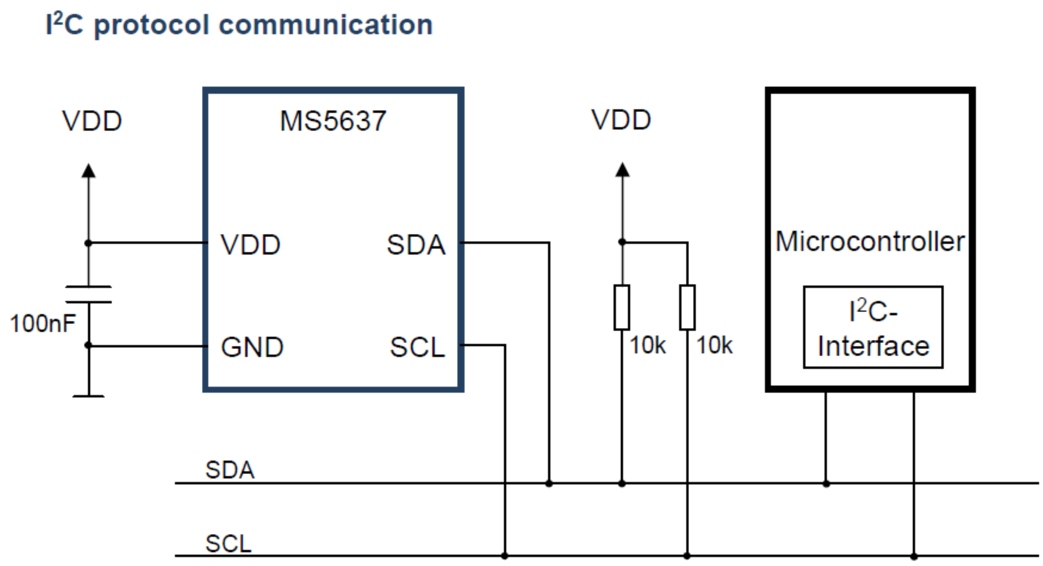
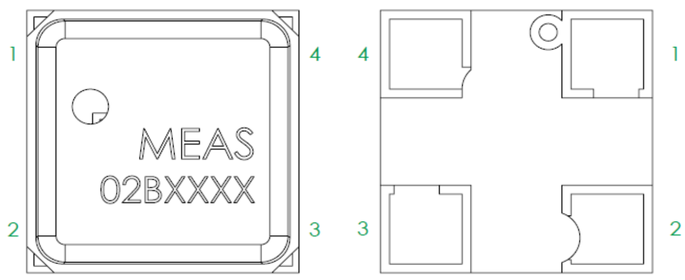


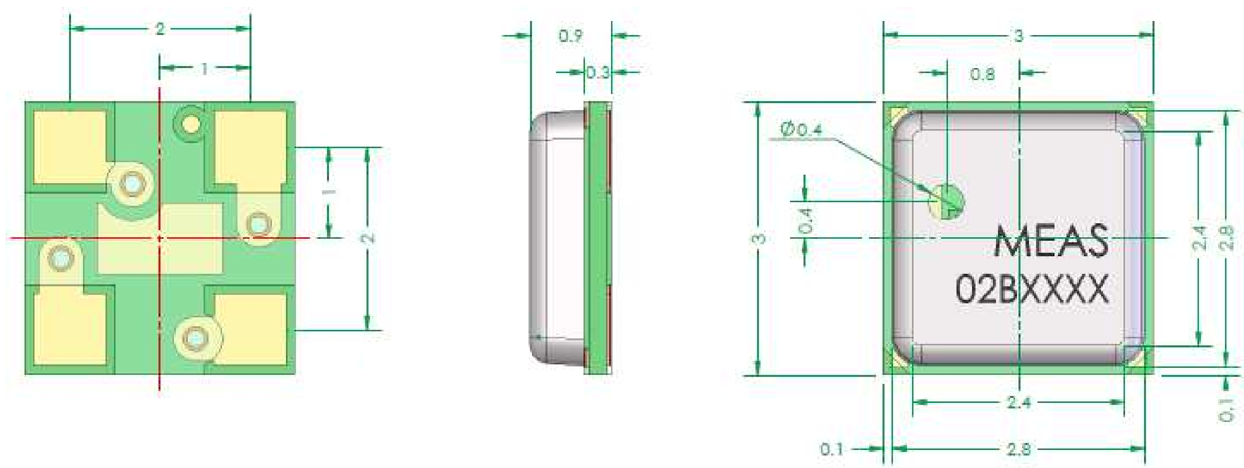
Figure 12: Typical application circuit

PIN CONFIGURATION

Pin	Name	Type	Function
1	VDD	P	Positive supply voltage
2	SDA	I/O	I^2C data
3	SCL	I	I^2C clock
4	GND	I	Ground



DEVICE PACKAGE OUTLINE



Notes: (1) Dimensions in mm
(2) General tolerance: ±0.1

Figure 13: MS5637 package outline

RECOMMENDED PAD LAYOUT

Pad layout for bottom side of the MS5637 soldered onto printed circuit board.

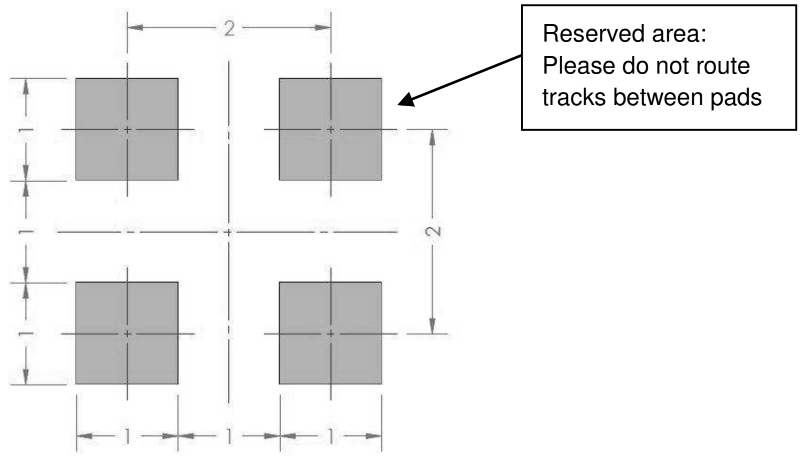
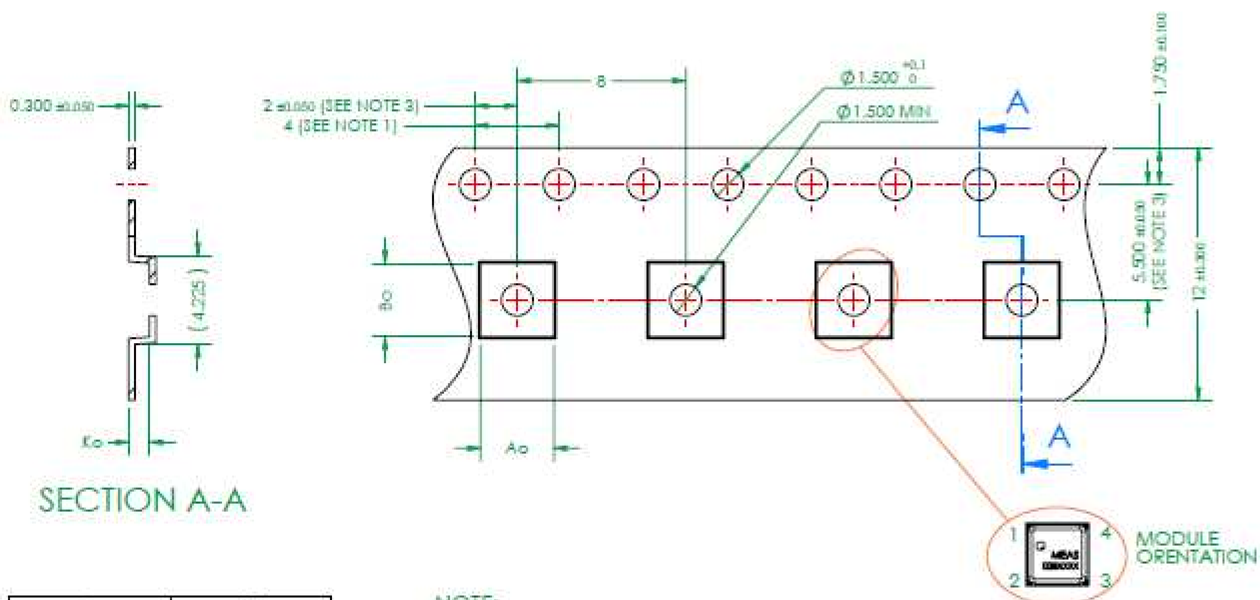


Figure 14: MS5637 pad layout

SHIPPING PACKAGE



Ao	3.5
Bo	3.5
Ko	1.4

NOTE:

1: 10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE ±0.2
2: CAMBER IN COMPLIANCE WITH EIA 481
3: POCKET POSITION RELATIVE TO SPROCKET HOLE MEASURED AS TRUE POSITIONOF POCKET, NOT POCKET HOLE
4: IN CASE OF DOUBT REFER TO EIA-481-C

MOUNTING AND ASSEMBLY CONSIDERATIONS

SOLDERING

Please refer to the application note AN808 available on our website for all soldering issues.

MOUNTING

The MS5637 can be placed with automatic Pick & Place equipment using vacuum nozzles. It will not be damaged by the vacuum. Due to the low stress assembly the sensor does not show pressure hysteresis effects. It is important to solder all contact pads.

CONNECTION TO PCB

The package outline of the module allows the use of a flexible PCB for interconnection. This can be important for applications in watches and other special devices.

CLEANING

The MS5637 has been manufactured under clean-room conditions. It is therefore recommended to assemble the sensor under class 10'000 or better conditions. Should this not be possible, it is recommended to protect the sensor opening during assembly from entering particles and dust. To avoid cleaning of the PCB, solder paste of type "no-clean" shall be used. Cleaning might damage the sensor!

ESD PRECAUTIONS

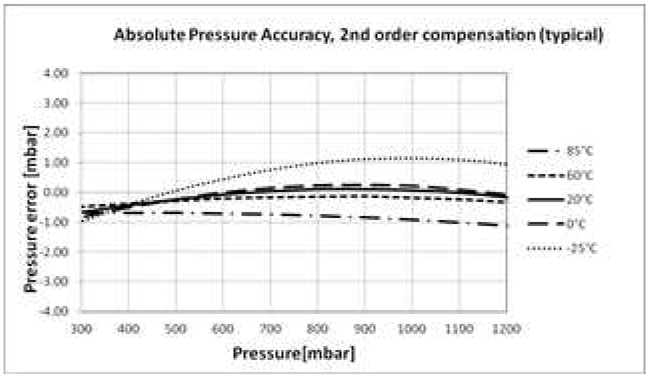
The electrical contact pads are protected against ESD up to 2 kV HBM (human body model). It is therefore essential to ground machines and personnel properly during assembly and handling of the device.
The MS5637 is shipped in antistatic transport boxes. Any test adapters or production transport boxes used during the assembly of the sensor shall be of an equivalent antistatic material.

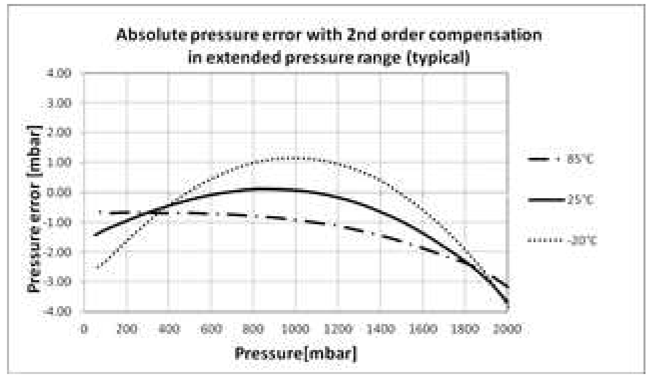
DECOUPLING CAPACITOR

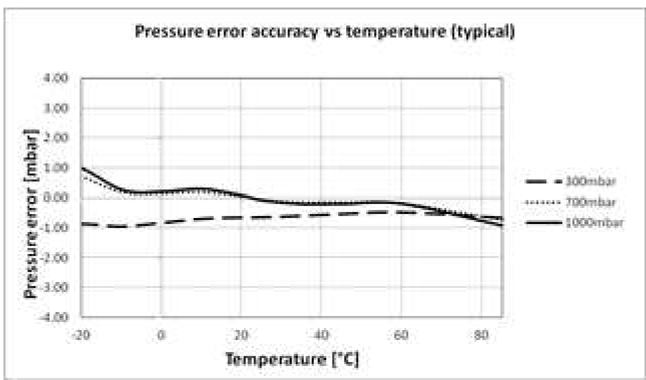
Particular care must be taken when connecting the device to the power supply. A 100nF minimum ceramic capacitor must be placed as close as possible to the MS5637 VDD pin. This capacitor will stabilize the power supply during data conversion and thus, provide the highest possible accuracy.

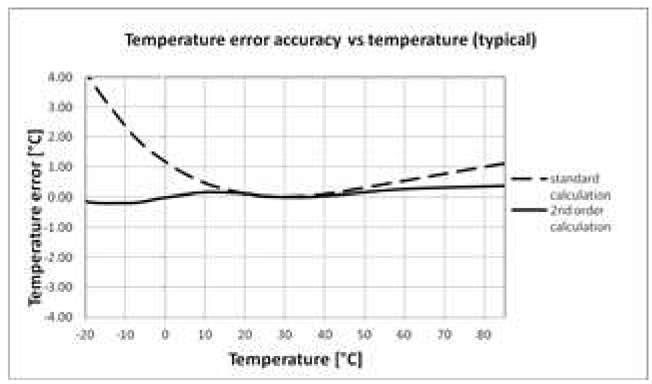
TYPICAL PERFORMANCE CHARACTERISTICS

PRESSURE AND TEMPERATURE ERROR VERSUS PRESSURE AND TEMPERATURE (TYPICAL VALUES)

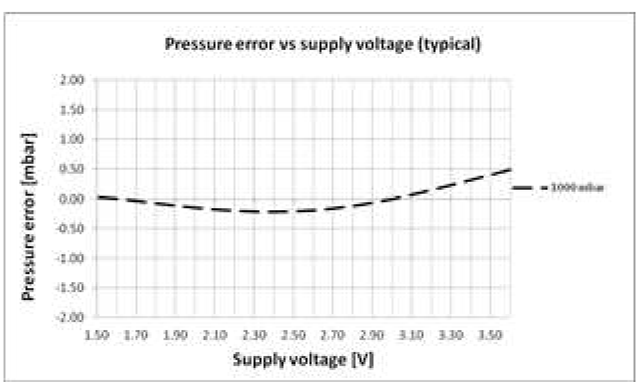


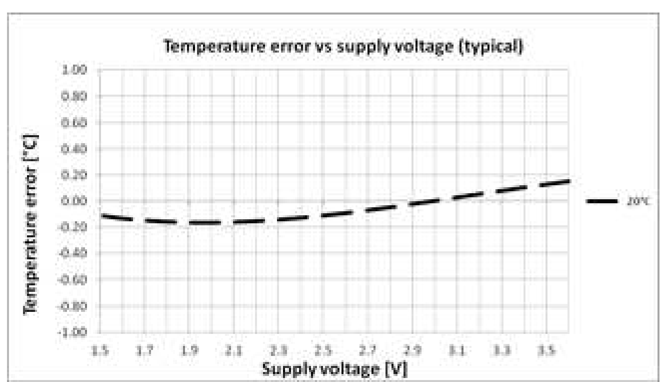






PRESSURE AND TEMPERATURE ERROR VERSUS POWER SUPPLY (TYPICAL VALUES)





ORDERING INFORMATION

Part Number / Art. Number	Product	Delivery Form
MS563702BA03-50	Micro Altimeter Module 3x3mm	Tape & Reel

NORTH AMERICA
Measurement Specialties, Inc.,
a TE Connectivity Company
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Website: www.meas-spec.com

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e-mail: sales.ch@meas-spec.com
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