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## MDS-02-0010F

## COMPASS ALTIMETER MODULE

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- Pressure range: 300 – 1100 mbar.
- 2D Compass interface.
- Integrated pressure sensor.
- Integrated 16 bits ADC.
- Integrated low power 8 bits MCU.
- 3-wire synchronous serial interface.
- Integrated software for pressure calculation and compass.
- Internal EEPROM for calibration data storage
- Low power, low voltage.
- Two Magnetic Sensors MF1\_B or Honeywell HMC1022.

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### Description

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The MDS-02-0010F is a SMD module including a piezoresistive pressure sensor, an 8 bits MCU with integrated 16 bits ADC with interface for 2 high sensitivity compass magnetoresistive sensors. With its integrated firmware and calibrated pressure sensor, this device supplies to designer all processed information like temperature, atmospheric pressure, altitude, electronic compass heading and battery level. This high integration level allows an easy access to sensor technology without any background in it.

MDS-02-0010F is a low power, low voltage device that could be interfaced through its 3 wires synchronous interface to a low cost 4 bits MCU. An interface to a 2D MR sensors and its flipping circuit is also implemented.

Asynchronous interface is available on request.

The small size of this module (10 x 10 x 6 mm) eases its integration in all watch applications.

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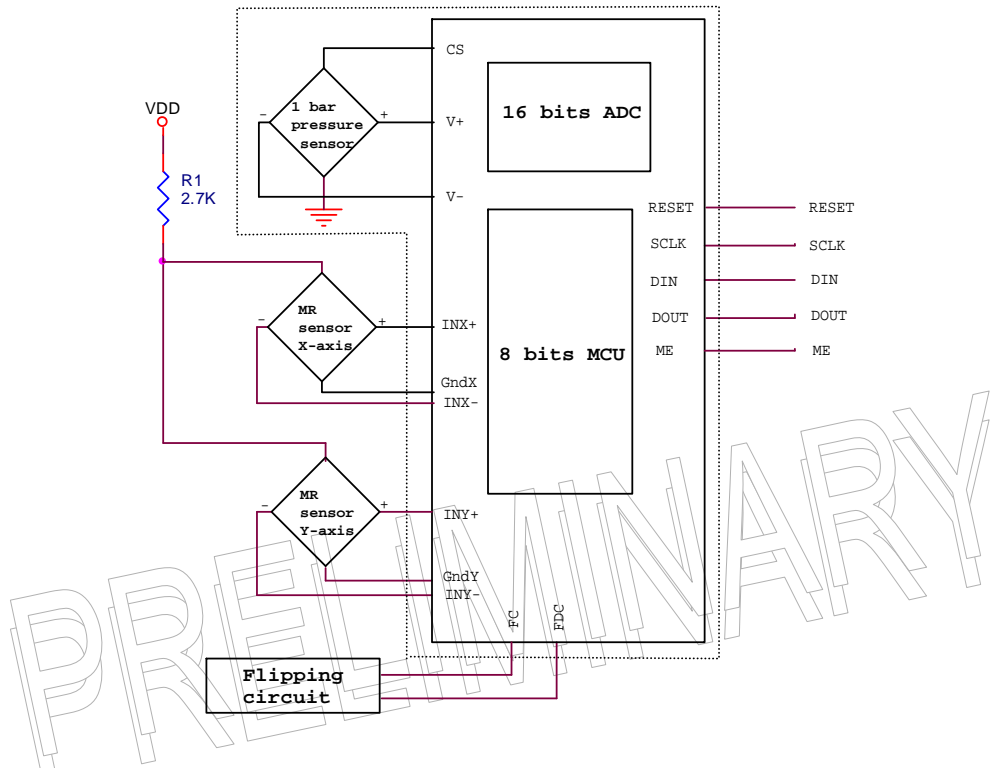
### Application

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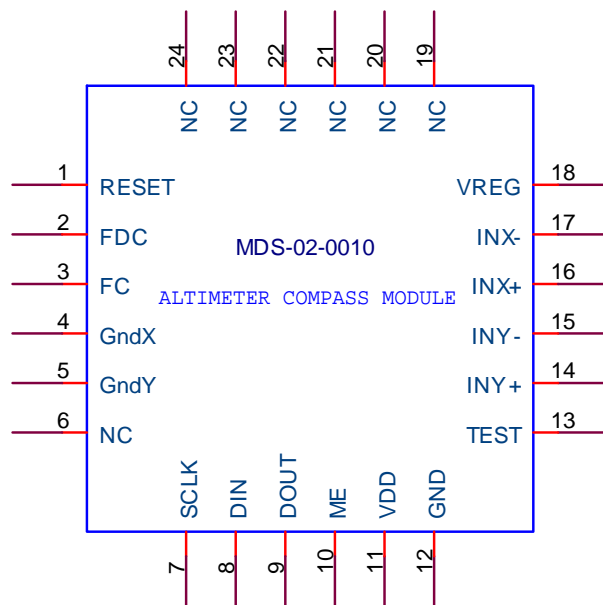
- Handheld high resolution 1 bar manometer. Res. up to 0.05 mbar.
- Mobile high resolution altimeter or barometer. Res. up to 0.5 m or 1.6 ft.
- High end weather station.
- Electronic compass with 1° resolution.
- High added-value sensor watches.



**Block diagram**



**Pins description**



Pinout of MDS-02-0010F

Note:

1/ Pins 6, 19, 20, 21, 22, 23, 24 are for factory use. Must be left open.



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Pin name	Pin no	Description	Sleep mode	Stand by mode	Active mode
RESET	1	Reset pin	GND	GND	Pulse High
FDC	2	Flipping pulse negative	Output High	Output High	Pulse Low
FC	3	Flipping pulse positive	Output Low	Output Low	Pulse High
GndX	4	Power control for MR sensor in X-axis	Input HZ	Input HZ	Output Low
GndY	5	Power control for MR sensor in Y-axis	Input HZ	Input HZ	Output Low
SCLK	7	Synchronous serial interface clock	Output Low	Output Low	Input Data
DIN	8	Data in of synchronous serial interface	Output Low	Output Low	Input Data
DOU	9	Data out of synchronous serial interface	Output Low	Output Low	Output Data
ME	10	Module enable – Wake up the module from standby mode	Input pull high	Input pull high	Input pull high
VDD	11	Positive power supply	VDD	VDD	VDD
GND	12	Negative power supply	GND	GND	GND
TEST	13	Production test pin. Connect to VDD	VDD	VDD	VDD
INY+	14	Positive output voltage of MR Sensor in Y-axis	X	X	Anal. Input
INY-	15	Negative output voltage of MR Sensor in Y-axis	X	X	Anal. Input
INX+	16	Positive output voltage of MR Sensor in X-axis	X	X	Anal. Input
INX-	17	Negative output voltage of MR Sensor in X-axis	X	X	Anal. Input
VREG	18	Internal voltage regulator	2V	2V	2V

## Absolute maximum ratings

Description	Value
Maximum voltage applied between any pin (but TEST VDD) and GND	5.5V
Voltage applied to any pin (but TEST VDD)	GND - 0.3V to VDD + 0.3V
Maximum storage temperature	85°C
Proof pressure	3 bars
Burst pressure	5 bars



## Normal operating conditions

Parameter	Symbol	Conditions	Min	Typical	Max	Unit
Power supply	$V_{DD}$		2.4	3.0	3.3	V
Supply current		$V_{DD} = 3V$ 1 reading per second				
Average in temperature mode	$I_{avgT}$		(*)	24	(*)	$\mu A$
Average in pressure mode	$I_{avgP}$		(*)	34	(*)	$\mu A$
Average in altitude mode	$I_{avgA}$		(*)	38	(*)	$\mu A$
Average in compass mode	$I_{avgC}$		(*)	35	(*)	$\mu A$
Powerdown in standby mode	$I_{stb}$			2	4	$\mu A$
Powerdown in sleep mode	$I_{slp}$			0.5	2	$\mu A$
Operating pressure range	P		300		1100	Mbar
Operating temperature range	$T_a$		-10		+60	$^{\circ}C$
Operating altitude range	A		-700		+9000	m
Synchronous serial clock	Sclk			32.768	70.000	KHz
Voltage level detector	Vld		2.4 -10%	2.4	2.4+10%	V

Note: (\*) not yet defined

## Pressure and temperature output characteristics

Parameter	Symbol	Test conditions	Min	Typ.	Max	Unit	Note
Resolution				0.1		mbar	
Absolute pressure accuracy		P = 500 ... 1100mbar T=30 $^{\circ}C$	-1.0		+1.0	mbar	1
Relative pressure accuracy		P = 500 ... 1100 mbar	- 0.5		+ 0.5	mbar	2
Maximum pressure error over temperature		Ta = 0 ... +50 $^{\circ}C$	-1.5		+1.5	mbar	3
Long-term stability		one year					
Maximum error over supply voltage		VDD = 2.7V ... 3.3V	-1		+1	mbar / $^{\circ}C$	4
Temperature accuracy		T= -10 $^{\circ}C$ ... + 60 $^{\circ}C$	-1		+1	$^{\circ}C$	5

Notes :

- 1/ Maximum error of pressure reading over the pressure range.
- 2/ Maximum error of pressure reading at one pressure point.
- 3/ Maximum error of pressure reading over the temperature range.
- 4/ Maximum error of pressure reading / temperature reading over supply voltage range.
- 5/ Maximum error of temperature reading over the temperature range.



Compass output characteristics

Parameter	Symbol	Conditions	Min	Typ	Max	Unit	Note
Resolution		VDD = 3V		1		°	
Heading accuracy		VDD = 3V	-3		+3	°	

Notes : The accuracy is defined by rotating the compass at horizontal level on the 360° degree gabarit.

Serial communication commands

- The module will enter standby mode after power on reset, reset by RESET pin or executing a command. The power on reset duration is 100ms.
- The reset of MDS will be active when the RESET pin goes to HIGH. When the RESET pin goes to LOW the MDS will enter reset cycle and the MDS will enter standby mode after releasing reset cycle. If the reset is applied, the MDS will re-load all calibrated data from the internal EEPROM and it will then enter standby mode after 100ms.
- For each byte, MSB is sent first and LSB at the end.
- The data is in hexadecimal format. Negative number is in 2's complement.
- When the module enters Sleep Mode, all calibration data will be saved in EEPROM. This mode can be used to reduce current consumption when the host MCU stops reading MDS for a long time. In this mode the oscillator is stopped.
- To wake up the module from sleep mode, the host MCU must pull HIGH the Reset pin for at least 10ms. The module will start and enter standby mode after 100ms. Then, the host MCU can send a new command.
- The maximum delay between active low of ME pin and active high of DOUT pin is 4ms.

The information supplied by the MDS-02-0010F module could be sent to the host MCU on request. Hereunder, the list of commands issued by the host MCU to the compass altimeter module.

Commands name	Note	Code	Host MCU	MDS-02-0010F
TEMP in deg C	1	44h	Send 1 byte code	Send 2 bytes temp data
TEMP in deg F	2	5Fh	Send 1 byte code	Send 2 bytes temp data
PRESSURE in mbar	3	45h	Send 1 byte code	Send 4 bytes pressure data
PRESSURE in inHg	4	5Ch	Send 1 byte code	Send 4 bytes pressure data
PRESSURE in psi	5	5Eh	Send 1 byte code	Send 4 bytes altitude data
ALTITUDE in m	6	48h	Send 1 byte code	Send 4 bytes altitude data
ALTITUDE in ft	7	5Dh	Send 1 byte code	Send 4 bytes altitude data
STORE PRESSURE WITH OFFSET in mbar	8	4Eh	Send 1 byte code and after receiving 4 bytes pressure data, will send 4 bytes pressure data (mbar) with offset	Send 4 bytes pressure data in mbar
STORE PRESSURE WITH OFFSET in inHg	9	55h	Send 1 byte code and after receiving 4 bytes pressure data, will send 4 bytes pressure data (inHg) with offset	Send 4 bytes pressure data in inHg



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STORE PRESSURE WITH OFFSET in PSI	10	56h	Send 1 byte code and after receiving 4 bytes pressure data, will send 4 bytes pressure data (PSI) with offset	Send 4 bytes pressure data in PSI
STORE TEMPERATURE WITH OFFSET in deg C	11	4Dh	Send 1 byte code and after receiving and 2 bytes temperature data, will send 2 bytes temperature data (deg C) with offset	Send 2 bytes temperature data in deg C
STORE TEMPERATURE WITH OFFSET in deg F	12	54h	Send 1 byte code and after receiving and 2 bytes temperature data, will send 2 bytes temperature data (deg F) with offset	Send 2 bytes temperature data in deg F
AZIMUTH 2D	13	4Ch	Send 1 byte code	Send 2 bytes data
COMPASS USER CALIBRATION	14			
Start calibration		4Ah	Send 1 byte code	Send 2 bytes data 004Ah
Calibration		4Bh	Send 1 byte code	Send 2 bytes data 004Bh
End calibration		49h	Send 1 byte code	Send 2 bytes data 0049h
VOLTAGE LEVEL DETECTOR	15	5Ah	Send 1 byte code	Send 2 bytes data 00h or F4h
SLEEP MODE	16	43h	Send 1 byte code and after send 2 bytes data 66h 77h	Go to sleep mode
COMMUNICATION TEST	17	40h	Send 1 byte code and 4 bytes data	Send 4 bytes data
STORE SEA LEVEL PRESSURE in mbar	18	47h	Send 1 byte code and 4 bytes data	
STORE SEA LEVEL PRESSURE in inHg	19	57h	Send 1 byte code and 4 bytes data	
STORE SEA LEVEL PRESSURE in PSI	20	5Bh	Send 1 byte code and 4 bytes data	
READ CURRENT SEA LEVEL PRESSURE	21	67h	Send 1 byte code and 2 bytes data	Send 4 bytes data
CALCULATE SEA LEVEL PRESSURE	22	68h	Send 1 byte code and 6 bytes data	Send 4 bytes data
LOAD CALIBRATION PARAMETERS	23	52h	Send 1 byte code	Send 2 bytes data 00h and 12h
READ PRESSURE in mbar AND ALTITUDE in m	24	51h	Send 1 byte code	Send 4 bytes pressure data and 4 bytes altitude data
SET MAGNETIC NORTH OFFSET	25	53h	Send 1 byte code and then send 2 bytes offset data	

**Notes:**

1. **Read Temperature in deg C:** the Host MCU sends 1 byte code, and then receives 2 bytes data of temperature from the MDS module. To get the correct temperature, temperature data must be divided by 10. Temperature range from -10°C to 60°C and res 0.1°C.



2. **Read Temperature in deg F:** the Host MCU sends 1 byte code, and then receives 2 bytes data of temperature from the MDS module. To get the correct temperature, temperature data must be divided by 10. Temperature range from 14°F to 140°F and res 0.1°F.
3. **Read Pressure in mbar:** the Host MCU sends 1 byte code, and then receives 4 bytes data of pressure the MDS module. Pressure data must be divided by 100 to get the actual pressure. Pressure range is from 300.0 mbar to 1100.0 mbar res 0.1 mbar.
4. **Read Pressure in inHg:** the Host MCU sends 1 byte code, and then receives 4 bytes data of pressure the MDS module. Pressure data must be divided by 10000 to get the actual pressure. Pressure range is from 8.8472 inHg to 32.4400 inHg res 0.0001 inHg.
5. **Read Pressure in PSI:** the Host MCU sends 1 byte code, and then receives 4 bytes data of pressure the MDS module. Pressure data must be divided by 10000 to get the actual pressure. Pressure range is from 4.3511 PSI to 15.9543 psi res 0.0001 PSI.
6. **Read Altitude in m:** the Host MCU sends 1 byte code and then receives 4 bytes data of altitude from the MDS module. To get the correct altitude in m, data must be divided by 10.
7. **Read Altitude in ft:** the Host MCU sends 1 byte code and then receives 4 bytes data of altitude from the MDS module. The received data is the correct data.
8. **Calculate and store pressure with offset in mbar:** the Host MCU sends 1 byte code, waits for 4 bytes pressure data (without offset) from the MDS module and then the Host MCU will send 4 bytes of corrected pressure data (pressure data with offset). Before, the corrected pressure data must be multiplied by 100.  
To reset the pressure offset stored in MDS module, the host MCU must re-send 4 bytes pressure data (without offset) that just received from MDS module to MDS module.
9. **Calculate and store pressure with offset in inHg:** the Host MCU sends 1 byte code, waits for 4 bytes pressure data (without offset) from the MDS module and then the Host MCU will send 4 bytes of corrected pressure data (pressure data with offset). Before, the corrected pressure data must be multiplied by 10000.  
To reset the pressure offset stored in MDS module, the host MCU must re-send 4 bytes pressure data (without offset) that just received from MDS module to MDS module.
10. **Calculate and store pressure with offset in PSI:** the Host MCU sends 1 byte code, waits for 4 bytes pressure data (without offset) from the MDS module and then the Host MCU will send 4 bytes of corrected pressure data (pressure data with offset). Before, the corrected pressure data must be multiplied by 10000.  
To reset the pressure offset stored in MDS module, the host MCU must re-send 4 bytes pressure data (without offset) that just received from MDS module to MDS module.
11. **Calculate and store temperature offset in deg C:** the Host MCU sends 1 byte code, waits for 2 bytes temperature data from the MDS module and then the Host MCU will send 2 bytes of corrected temperature data (temperature data with offset). Before, the corrected temperature data must be multiplied by 10.  
To reset the temperature offset stored in MDS module, the host MCU must re-send 2 bytes temperature data (without offset) that just received from MDS module to MDS module.



12. **Calculate and store temperature offset in deg F:** the Host MCU sends 1 byte code, waits for 2 bytes temperature data from the MDS module and then the Host MCU will send 2 bytes of corrected temperature data (temperature data with offset). Before, the corrected temperature data must be multiplied by 10.

To reset the temperature offset stored in MDS module, the host MCU must re-send 2 bytes temperature data (without offset) that just received from MDS module to MDS module.

13. **Read Azimuth 2D compass:** the Host MCU sends 1 byte code and then receives 2 bytes data from MDS-02-0010F module. At 2 bytes data: 12 bits LSB for azimuth (AZI), 3 bits LSB of 4 bits MSB for cardinal and semicardinal points (CP), and 1 bit MSB for error due to strong magnetic field (Err).

- AZI : 0°...359°
- CP = 0 : North
- CP = 1 : North - East
- CP = 2 : East
- CP = 3 : South - East
- CP = 4 : South
- CP = 5 : South - West
- CP = 6 : West
- CP = 7 : North - West
- Err = 1 : error strong magnetic field.
- Err = 0 : normal magnetic field.

There will be error if the read values of MR sensors are 20% more than the maximum values or 20% less than the minimum values. Maximum and minimum values are those got during calibration. There will be error also if the compass is not calibrated.

14. **User calibration for compass :** the Host MCU must follow this order of commands : START calib, CALIB and END calib. START command is sent once at start calibration and END command once at the end of calibration, CALIB command must be sent continuously (i.e. every 1s) during calibration and the compass must be turned very slowly at horizontal level for at least 360°. Each time, CALIB Code is sent by the MCU, the module will acknowledge the Host MCU order by returning 2 bytes data (4Bh). If CR2032 battery is used, it is recommended that the host MCU sends in maximum 4 CALIB command (4Bh) per second.

After the Host MCU sends 1 byte code then the Host MCU will receive 2 bytes data from the module.

15. **Voltage level detector :** the Host MCU sends 1 byte code and then receives 2 bytes data. If the power supply voltage is less than 2.44V then the module will be returned F4h, and if the power supply voltage is more than 2.44V then the module will be returned 00h. The absolute precision of the detection voltage level is  $\pm 10\%$ . The maximum duration of measurement is 4ms. After measurement, the module will send 2 bytes data and return to standby mode.

16. **Sleep mode :** the Host MCU sends 1 byte code and then continuously 2 bytes data 66h and 77h to ask the module to enter sleep mode.

17. **Communication test :** the Host MCU sends 1 byte code and 4 bytes data. The module gets the 4 bytes data and returns them to the Host MCU. Then, this latter can check that the communication is correct.

18. **Store sea level pressure in mbar:** the Host MCU sends 1 byte code and 4 bytes data. The module gets the 4 bytes data new pressure at sea level. The default pressure at sea level is 1013.25 mbar

19. **Store sea level pressure in inHg:** the Host MCU sends 1 byte code and 4 bytes data. The module gets the 4 bytes data new pressure at sea level.



20. **Store sea level pressure in PSI:** the Host MCU sends 1 byte code and 4 bytes data. The module gets the 4 bytes data new pressure at sea level.

21. **Read current sea level pressure:** the Host MCU sends 1 byte code and then sends 2 bytes data 150xH to the MDS module. According to xH value, MDS module will send 4 bytes sea level pressure data to the Host MCU.

x = 0 → MDS will send 4 bytes sea level pressure data in mbar

x = 1 → MDS will send 4 bytes sea level pressure data in inHg

x = 2 → MDS will send 4 bytes sea level pressure data in PSI

22. **Calculate sea level pressure:** the Host MCU sends 1 byte code and then 2 bytes data 15xyH to the MDS. After sending 2 bytes 15xyH, the host MCU will then send 4 bytes altitude data to the MDS. MDS module will then calculate the sea level pressure according to received altitude data and the latest pressure data stored in the module.

To get the correct sea level pressure the host MCU should read the pressure before executing **calculate sea level pressure** command.

Defination of xyH value:

x = 0 → MDS will receive 4 bytes altitude data in m

x = 1 → MDS will receive 4 bytes altitude data in ft

y = 0 → MDS will return 4 bytes sea level pressure data in mbar

y = 1 → MDS will return 4 bytes sea level pressure data in inHg

y = 2 → MDS will return 4 bytes sea level pressure data in PSI

23. **Load calibration parameters :** the Host MCU sends 1 bytes code and then receives 2 bytes data 00h and 12h. In this code, the module will load all calibration parameters : temperature, temperature offset, pressure, pressure offset, sea level pressure and compass. . After sending 1 byte code, the Host MCU will receive 2 bytes data 00h and 12h from the MDS module.

24. **Read Pressure in mbar and Altitude in m:** the Host MCU sends 1 byte code and then receives 4 bytes pressure data and 4 bytes altitude data.

25. **Set Magnetic North Offset:** the Host MCU sends 1 byte code and then sends 2 bytes Magnetic North Offset to MDS module. The Magnetic North Offset will be stored in MDS module until a new Magnetic North Offset is set. The range of Magnetic North Offset is from -45 deg to 45 deg. The heading returned by code 4Ch will be as below:

Heading = Heading (without offset) – Magnetic North Offset

For example: the heading without offset at the True Magnetic North direction is 7 deg, the Magnetic North Offset will be 7 deg (0007H). If the heading without offset at the True Magnetic North is 353 deg, the Magnetic North Offset will be -7 deg (FFF9H).



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**Note:** when communicating with MDS module, if the Host MCU writes code or writes data to MDS module, the MDS module will receive data at the rising edge of SCLK. If the Host MCU receives the data from MDS module the Host MCU should receive data at the falling edge of SCLK. The MDS will start executing the command after the rising edge of the 8<sup>th</sup> clock pulse in the receiving command state.

Please see the below table for the detail of data sending by MDS module:

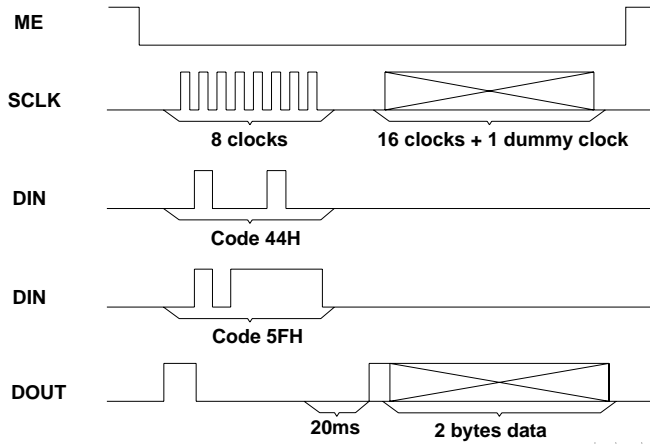
Item	Description	Unit	MDS's data	Real data
1	Temperature data	°C/°F	00FFh	25.5
2	Temperature data	°C/°F	FF9Ch	-10.0
3	Altitude data	m	00000FFh	25.5
4	Altitude data	m	FFFFFF9Ch	-10.0
5	Altitude data	ft	00000FFh	255
6	Altitude data	ft	FFFFFF9Ch	-100
7	Pressure data	mbar	000186A0h	1000.00
8	Pressure data	inHg	00048828h	29.7000
9	Pressure data	PSI	00023668h	14.5000

PRELIMINARY

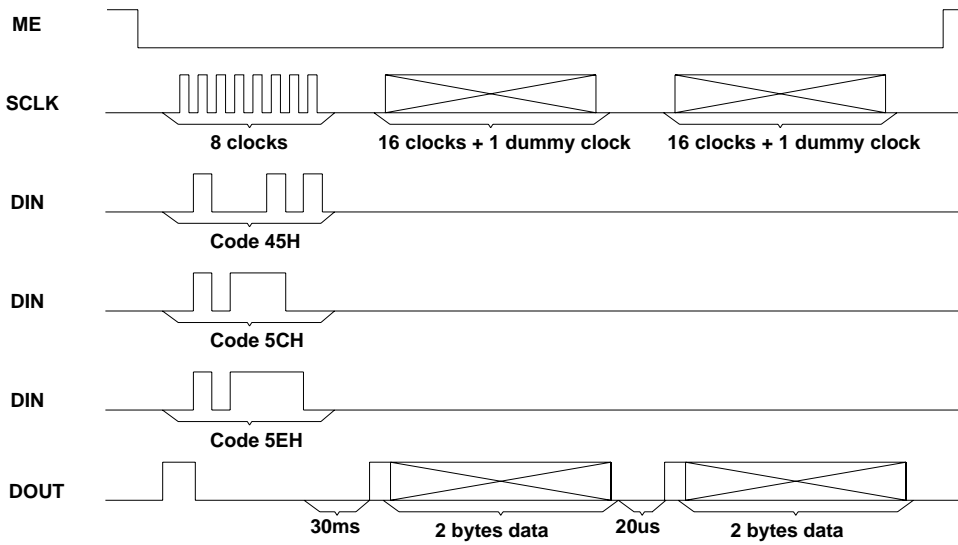


Timing diagrams

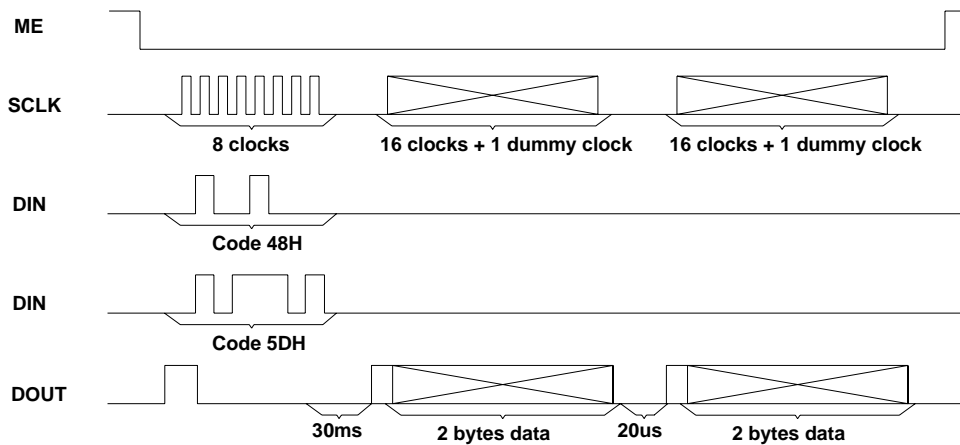
TEMPERATURE



PRESSURE

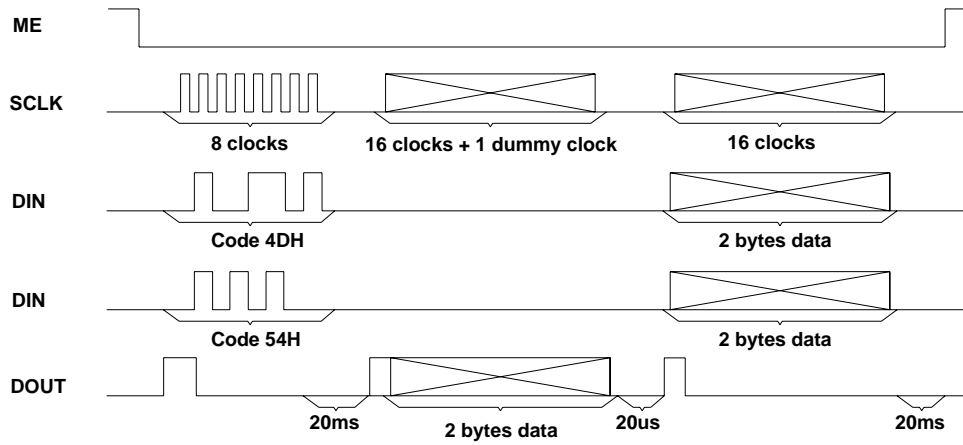


ALTITUDE

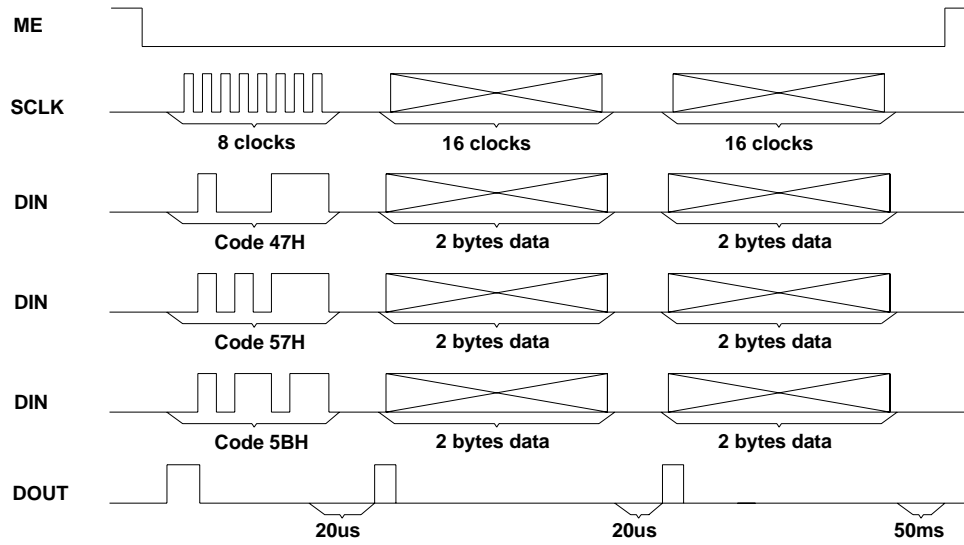




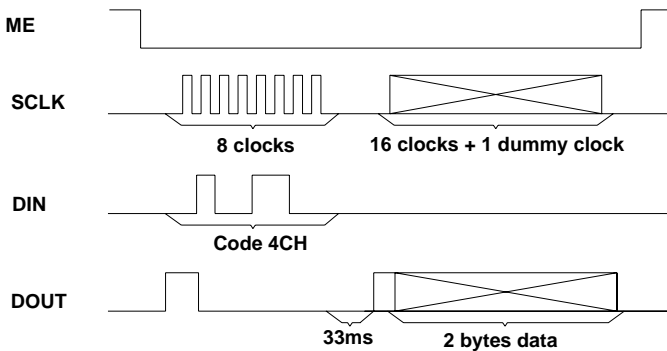
STORE TEMPERATURE WITH OFFSET



STORE PRESSURE SEA LEVEL

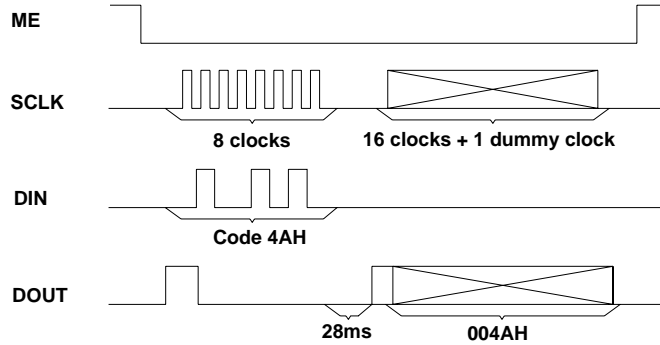


AZIMUTH 2D

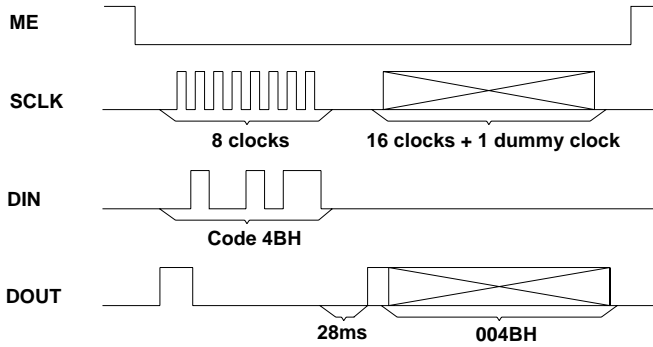




**START CALIBRATION**

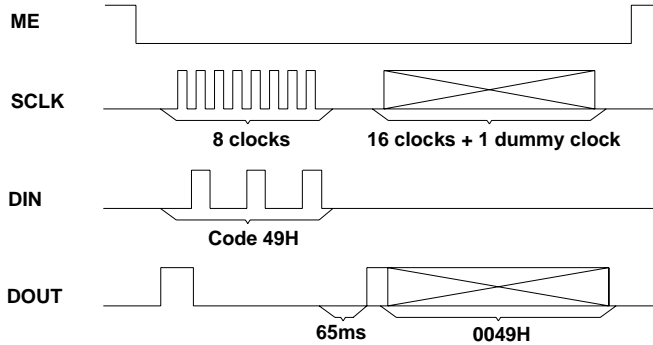


**CALIBRATION**

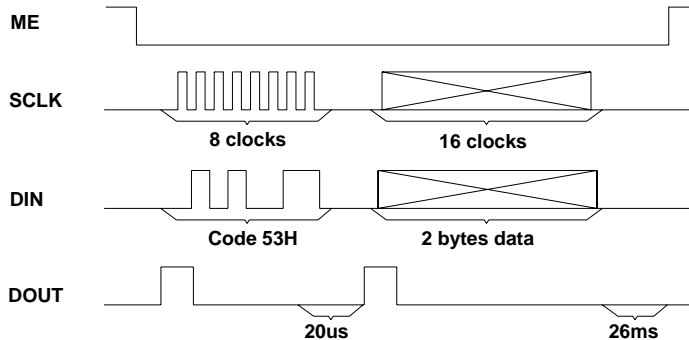


INARY

**STOP CALIBRATION**

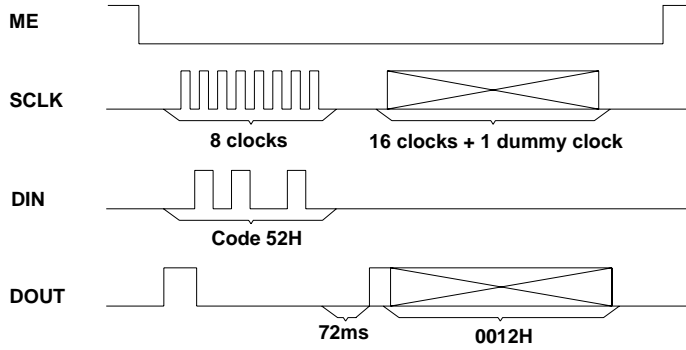


**SET MAGNETIC NORTH OFFSET**

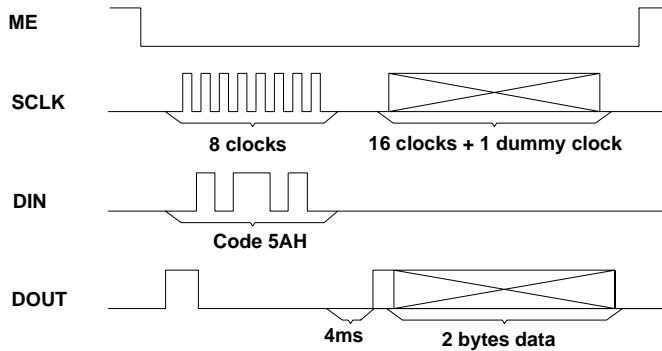




LOAD CALIBRATION PARAMETERS

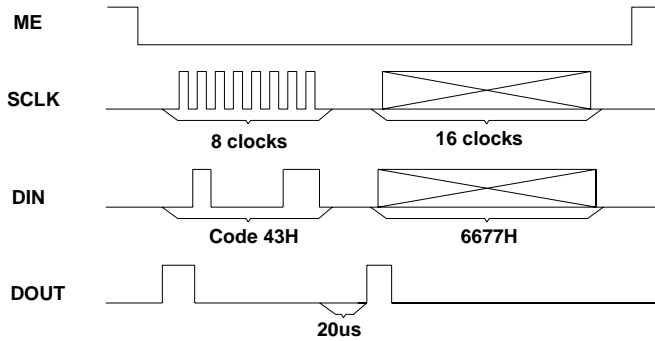


VOLTAGE LEVEL DETECTOR

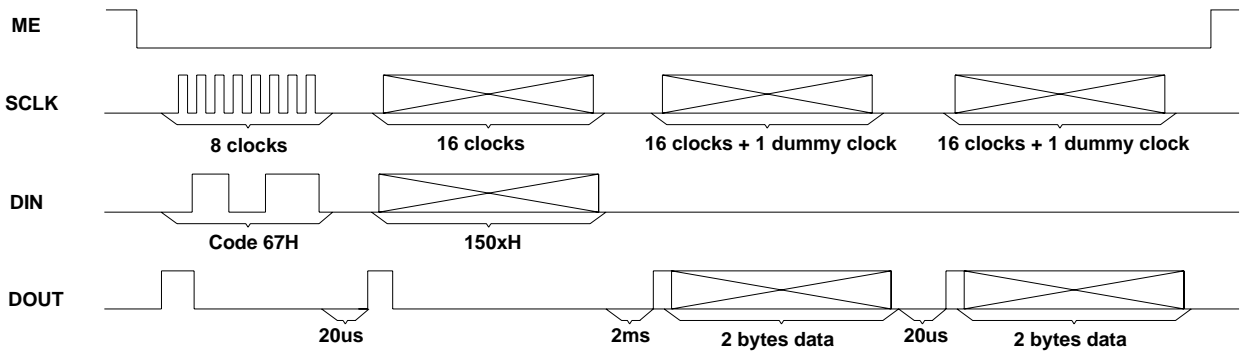


NARY

SLEEP MODE

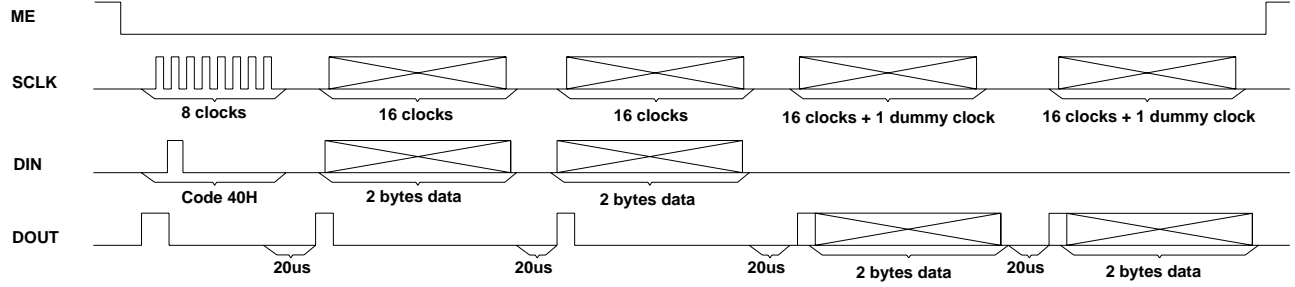


READ CURRENT SEA LEVEL PRESSURE

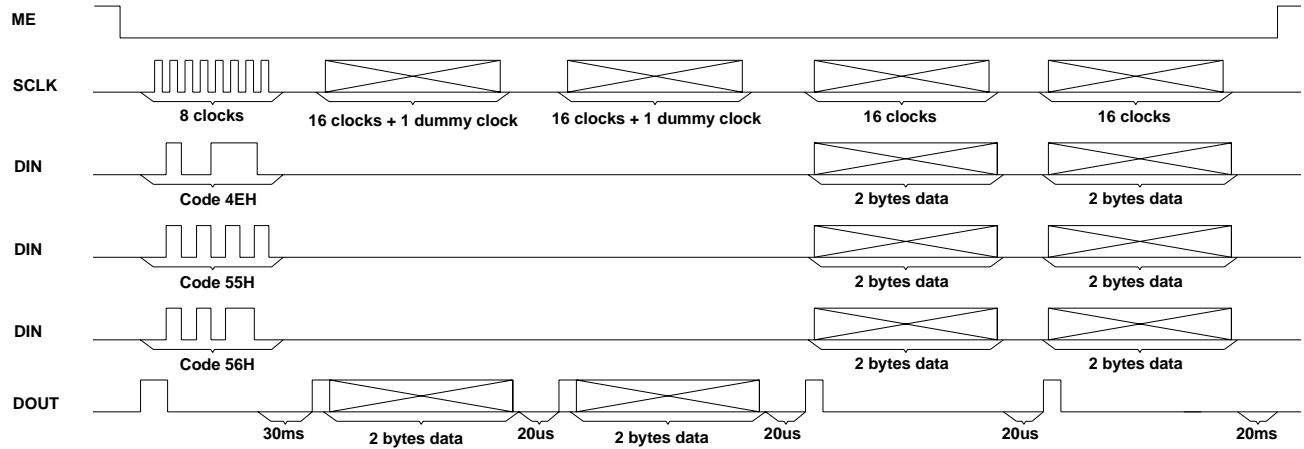




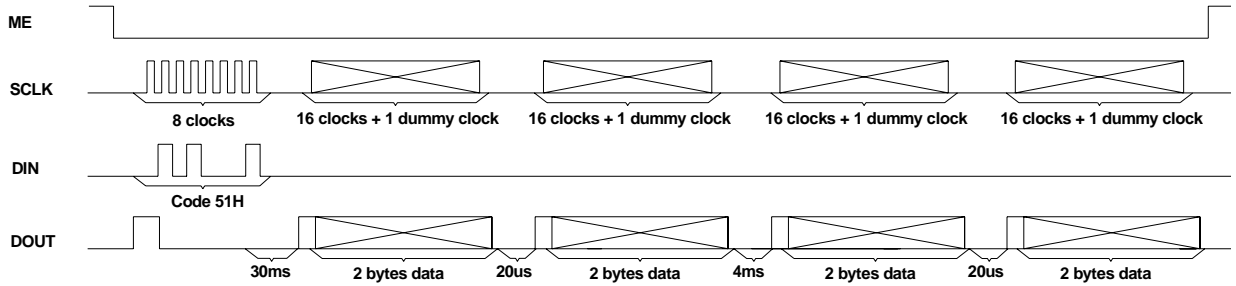
## COMMUNICATION TEST



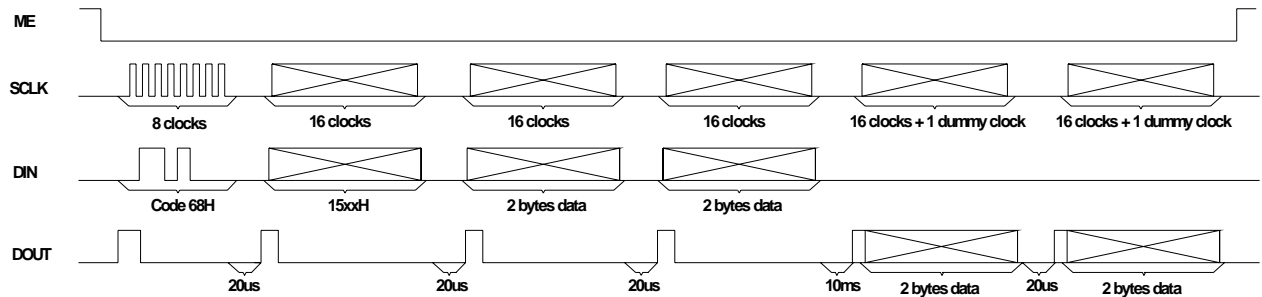
## STORE PRESSURE WITH OFFSET



## READ PRESSURE AND ALTITUDE

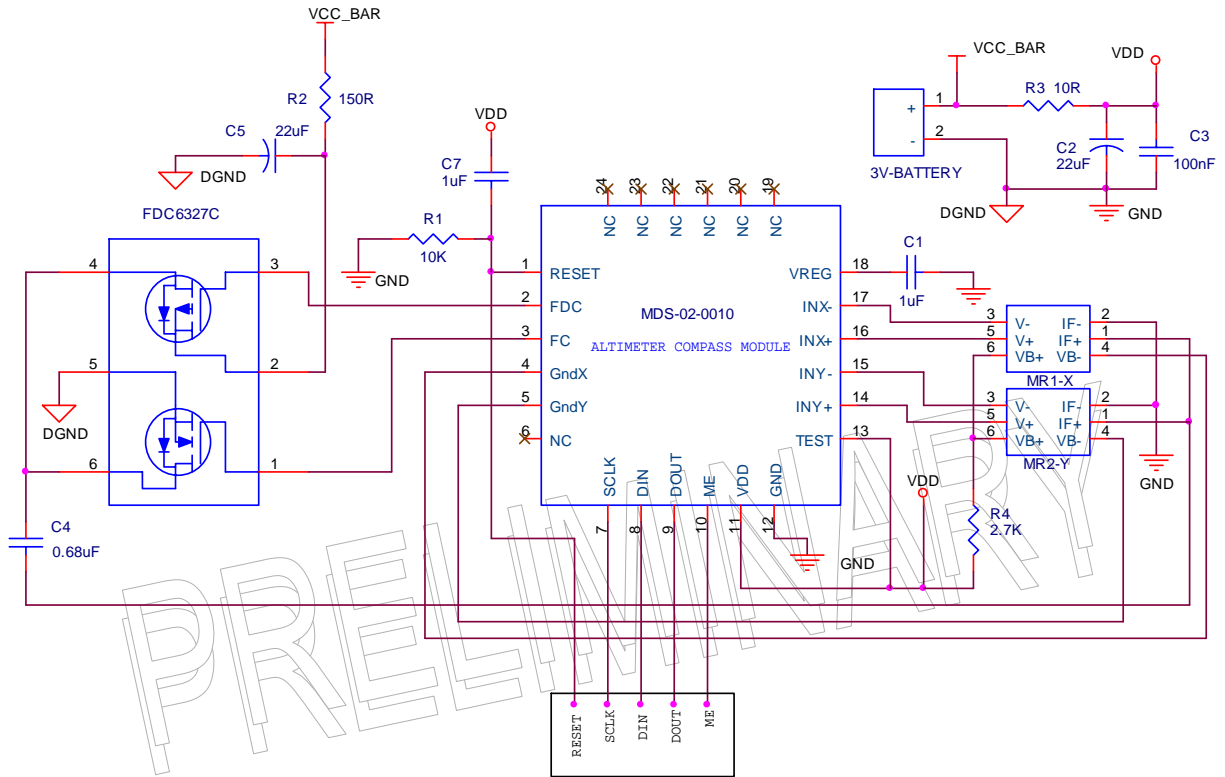


## CALCULATE SEA LEVEL PRESSURE

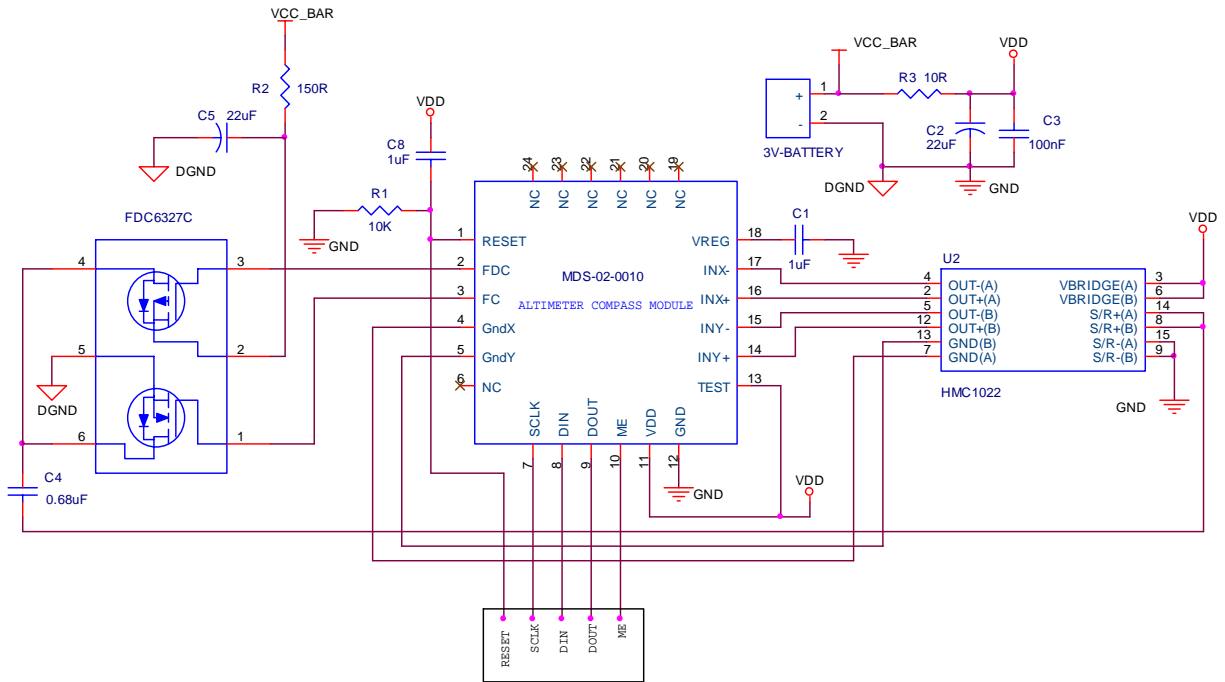




Application schematic



The application schematic of MDS-02-0010F with Two Magnetic Sensors MF1\_B.



The application schematic of MDS-02-0010F with HMC1022



## **Important notice : Magnetic sensors placement**

Place the magnetoresistive sensors such a way that their x or y axis passes through the center of the battery.

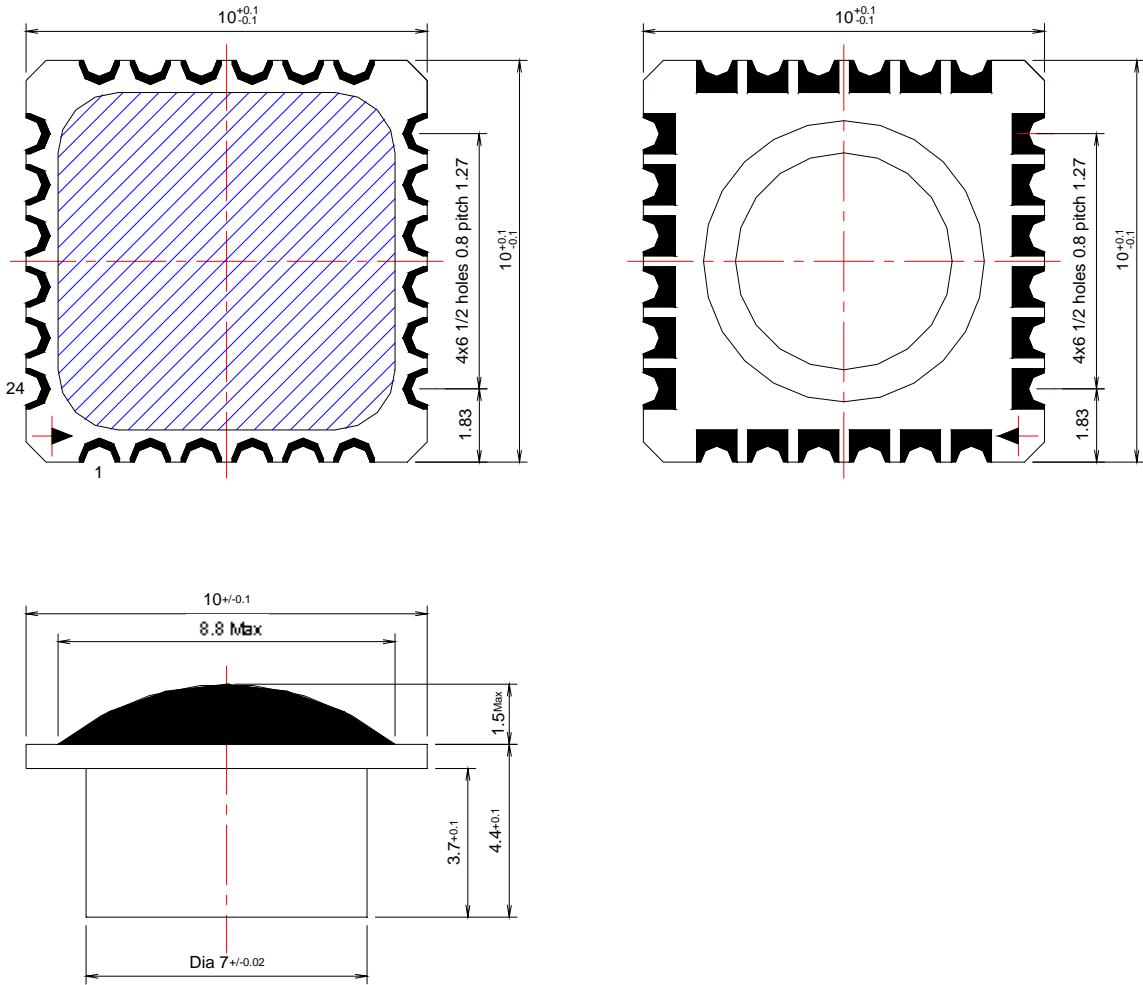
**Note:** pcb layout of the MDS.

1. Keep very short the connections from compass sensor to the analog inputs of MDS (INX+, INX-, INY+, INY-).
2. The filter capacitors of the MDS (C2&C3) should be placed as close as possible to the VDD and GND of the MDS module.
3. When the compass is not used, connect the GndX and GndY of the MDS to the GND.

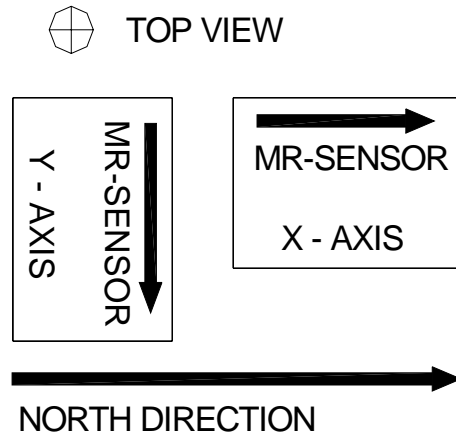
PRELIMINARY



Physical size



MR sensors direction







LIST OF UPDATES:

1. Update notes about changing data.
2. Rev25: update company's address

PRELIMINARY