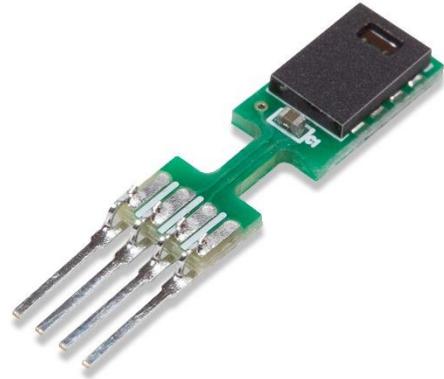


# HCS2D-3V

Humidity & Temperature Solution

## Enhanced Features

- ◆ Fully Calibrated & Temperature Compensated
- ◆ Improved Temperature Accuracy & Range  
( $\pm 0.2^{\circ}\text{C}$  for  $-20 \sim 60^{\circ}\text{C}$ )
- ◆ Extremely Low Current Consumption  
( $13\mu\text{A}$  operating)
- ◆ Enhanced Accuracy of RH% ( $\pm 2\% \text{RH}$ , 14bit )
- ◆ Fast Natural Recovery after Reflow Soldering
- ◆ Low Current Consumption
- ◆ SIP(Single-In-line-Package)
- ◆ Enhanced Reliability against Chemical



## Product Summary

**HCS2D-3V** is a Single In-Line Package type of **HCP2D-3V** with ready installed V-Core capacitor for easy and convenient application.

**HCS2D-3V** is an improved version of **HumiChip<sup>®</sup>**, the most advanced and cost effective humidity and temperature sensing solution for virtually any type of applications.

Capacitive polymer sensor chip developed and fabricated in-house and CMOS integrated circuit with EEPROM are integrated into one embedded system in a reflow solder-able SMD package.

Individually calibrated and tested, **HCS2D-3V** performs  $\pm 2\%$  from 20% to 80%RH ( $\pm 4\%$  over entire humidity range), and yet, is simple and ready to use without further calibration or temperature compensation.

Designed and manufactured by industry leading humidity and temperature sensing technology of **SAMYOUNG S&C** – field proven in HVAC and Auto industry for over 15 years, **HCS2D-3V** offers another smart sensing solution for excellent reliability, high accuracy, and cost effective sensing applications.

## Application

### Energy Saving HVAC Control

Air Conditioning, Refrigeration, IAQ monitoring, Vent Fans, Home Appliances, Humi/Dehumidifiers

### Process Control & Instrumentations

Medical Instruments, Handheld Devices, Weather Stations, Food Processing, Printers, RFIDs ...

### Automobile & Transportation

Cabin Climate Control, Defogging Control, Condensing Preventive Device ...

### Mass Quantity Application

OEM custom specification available

## Sensor Performance

### Relative Humidity (%RH)

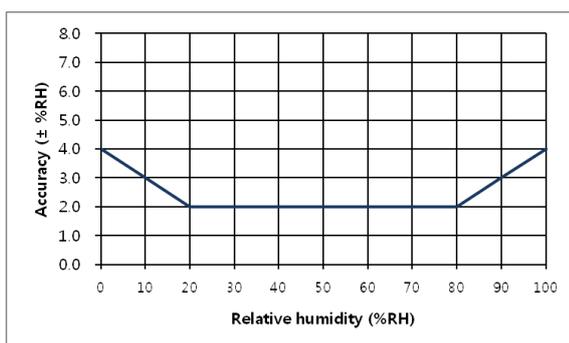
Resolution	<b>14 bit</b> (0.01%RH)
Accuracy <sup>1</sup>	<b>±2.0 %RH</b> (Figure 1)*
Repeatability	<b>±0.2 %RH</b>
Hysteresis	<b>±1.5 %RH</b>
Linearity	<b>&lt;2.0 %RH</b>
Response time <sup>2</sup>	<b>Max 8.0 sec</b> ( $\tau$ 63%)
Operating range	<b>0 ~ 100 %RH</b> (Non-Condensing)
Long term drift	<b>&lt;0.5 %RH/yr</b> (Normal condition)

### Temperature (°C)

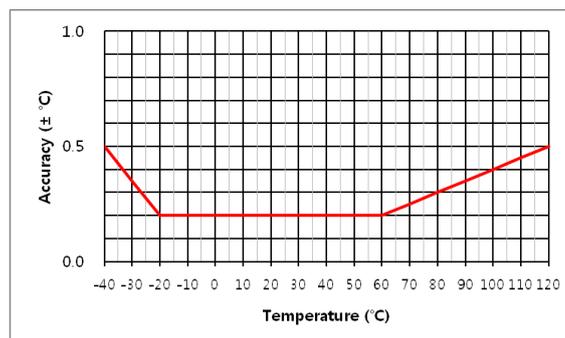
Resolution	<b>14 bit</b> (0.01°C)
Accuracy <sup>3</sup>	<b>±0.2 °C</b> (Figure 2)
Repeatability	<b>±0.1 °C</b>
Response time <sup>4</sup>	<b>10.0 sec</b> ( $\tau$ 63%)
Operating range	<b>- 40 ~ 125 °C</b>
Long term drift	<b>&lt;0.05 °C/yr</b> (Normal condition)

1. Accuracies measured at 25 °C, 3.3V.
2. Measured at 25 °C, 1m/sec airflow for achieving 63% of step from 10%RH to 90%RH
3. Accuracies measured at 25 °C, 3.3V.
4. Min 5.0 sec, Max 20 sec

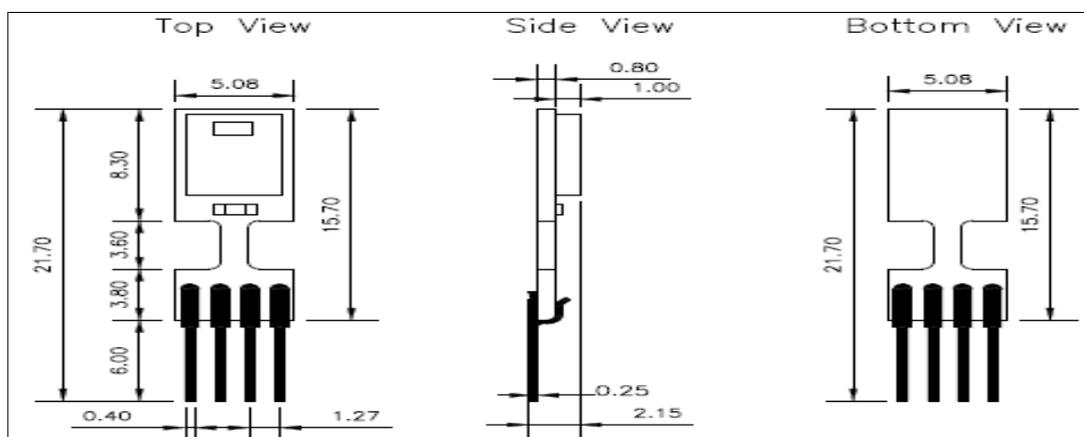
Typical %RH Accuracy at 25°C



Typical Temperature Accuracy



## Dimension



Units : mm (inch)

### Electrical Specification

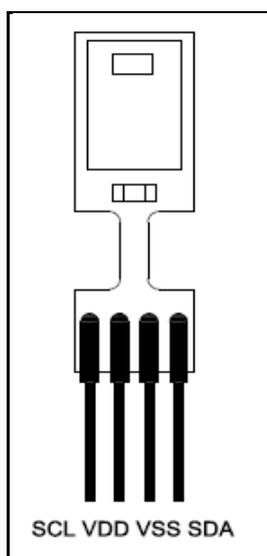
Supply Voltage	min 2.1v ~ max 3.3V
Supply Current (IDD)	13μA (typical)

\*1. at room temperature

### Environmental

Operating Temperature	-40 ~ 125 °C
Operating Humidity	0 ~ 100% RH (non condensing)

### Pin Connection



### Absolute Maximum Rating

Parameter	Min	Max
Supply Voltage(VDD)	-0.3V	4.0V
Storage Temp	-40 °C	125 °C
Junction Temp	-40 °C	125 °C

### Soldering Information

Standard or IR Solder Reflow.  
 IPC/JEDEC standard  
 $T_P \leq 250^\circ\text{C}$ ,  $t_P < 10\text{sec}$ ,  $T_L < 220^\circ\text{C}$ ,  $t_L < 60\text{sec}$ .  
 $T_P$ (Peak Temperature),  $t_P$ (Peak Time),  
 $T_L$ (Critical Zone Temperature),  $t_L$ (Critical Zone Time)  
 Ramp-up/down speed  $< 6^\circ\text{C}/\text{sec}$

\*. Chip on Board is 100nF capacitor for Vcore. (Figure. 2.1)

### Package Contents

HCS2D-3V consists of a **HCS2D-3V** and a V-core capacitor soldered on the top of a FR4 substrate. Lead Pins are made of Cu, Sn, P alloy and all parts are fully RoHS and REACH compliant.

### Shipping

Tray : 100 ea  
 Inner Box : 500 ea  
 Out Box : 5,000 ea

### Ordering Information

Output	Accuracy	VDD	Ordering P/N
D   I <sup>2</sup> C	±2%RH	3.3	HCS2D-3V

# Application Guide

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👉 **Demo Kit (EVB01-HCP)** is available.

A reference program source code can be downloaded from [www.samyounsgnc.com](http://www.samyounsgnc.com)

## 1. General Information

### 1.1 Preliminary Consideration

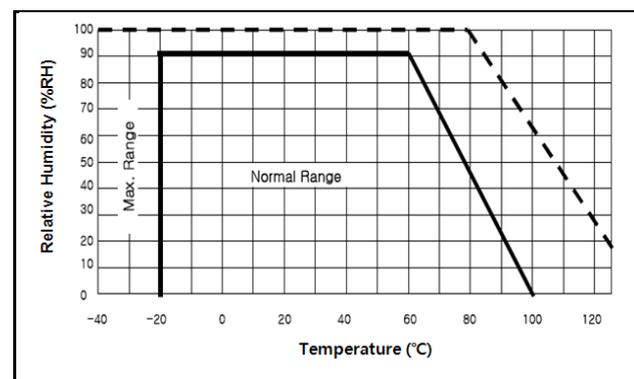
To maximize the performance of **HCS2D-3V**, it is important to plan an appropriate location of the sensor at the design stage. Airflow and proper exposure to ambient air must be secured for **HCS2D-3V** to ensure expected performance. Airflow holes must NOT be blocked. Any heat

generating parts near **HCS2D-3V** will distort the proper measurement of relative humidity and temperature reading, and either should be avoided or measures should be taken to prevent heat transfer.

### 1.2 Operating Conditions

**HCS2D-3V**'s maximum and recommended normal operating condition is shown in **Figure 1**. Within the Normal Range, **HCS2D-3V** performs stably. Prolonged exposures to conditions outside normal range, especially at humidity over 90%RH, may temporarily offset the RH signal up to  $\pm 3\%$ RH. When return to Normal Range, it will gradually recover back to the calibration state.

Re-Conditioning Procedure in section 1.6 will help reduce this recovery time. Long term exposure to extreme conditions may also accelerate aging of the sensor.



**Figure 1** Operating Conditions

### 1.3 Heating

Heat sources such as power electronics, microcontrollers, and display near the sensor may affect the accurate measurement. The location of Sensor near such heat sources should be

avoided by maintaining distance or thermal buffer. Thin metal pattern, or even better, 'milling slits' around the sensor also may help reduce the error.

### 1.4 Storage and Handling Information

**HCS2D-3V** contains polymer based capacitive humidity sensor sensitive to environment, and should NOT be handled as an ordinary electronic component.

Chemical vapors at high concentration may interface with the polymer layers, and coupled with long exposure time, may cause a shift in both offset and sensitivity of the sensor.

Despite the sensor endures the extreme conditions of  $-40^{\circ}\text{C}$ ~ $125^{\circ}\text{C}$ , 0%RH~100%RH (non condensing), long term exposure in such

environment may also offset the sensor reading. Hence, once the package is opened, it is recommended to store in clean environment of temperature at  $5^{\circ}\text{C}$ ~ $55^{\circ}\text{C}$  and humidity at 10%~70%RH.

**HCS2D-3V** is protected of ESD up to 2000V and Latch-up in the range of  $\pm 150\text{mA}$  to  $\pm 200\text{mA}$  and also packed in ESD protected shipping material. Normal ESD precaution is required when handling in assembly process.

### 1.5 Manual soldering

Contact time must be limited to 5 seconds at up to  $350^{\circ}\text{C}$

### 1.6 Material Contents

**HCS2D-3V** consists of sensor cell and IC (polymer / glass & silicon substrate) packaged in a surface mountable LCC (Leadless Chip Carrier) type package. The sensor housing consists of a PPS (Poly Phenylene Sulfide) cap with epoxy glob top on a standard FR4 substrate. Pads are

made of Au plated Cu. The device is free of Pb, Cd and Hg.

**RoHS compliant / REACH report available**

### 1.7 Traceability Information

**HCS2D-3V** is laser marked with product type and lot identification.

The first line denotes the sensor type: **I<sup>2</sup>C** output. Lot identification is printed on the second line with 5

digit alphanumeric code. Further information about individual sensor is electronically stored on the chip

### 1.8 Shipping Package

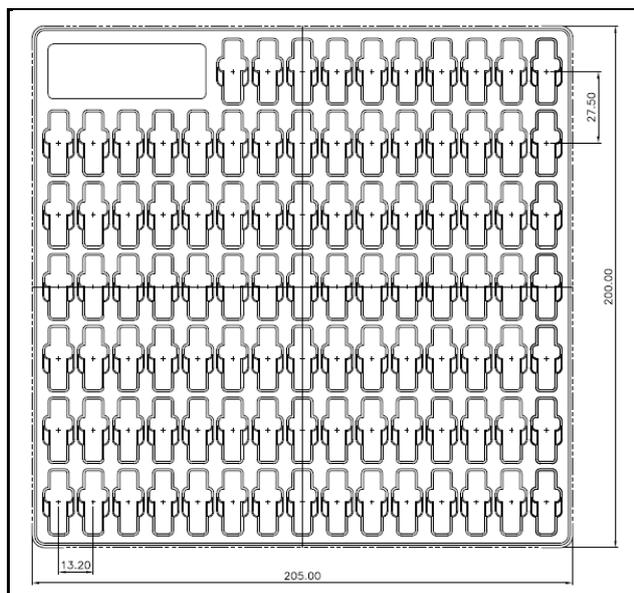
**HCS2D-3V** is provided in a tray shipment packaging, sealed into antistatic ESD trays. The drawing of the

packaging tapes with sensor orientation and packing box dimensions are shown in **Drawing**

**Drawing 1**

**Packing Tray : 100ea**

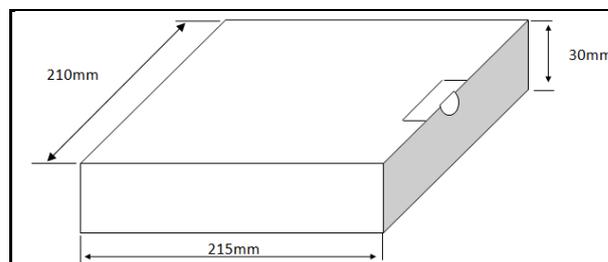
Dimension: 205 x 200 mm



**Drawing 2** Packing (Box)

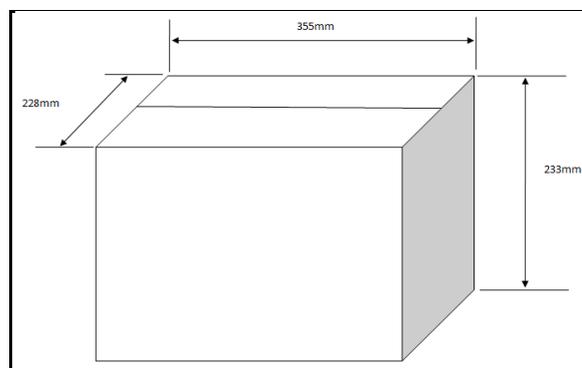
**Inbox: 500ea** (5+1Tray(For Cover) X 100ea)

Dimension: 215 x 210 x 30 mm



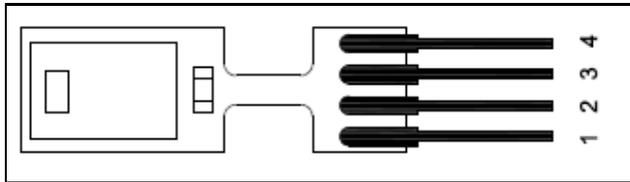
**Outbox: 5,000ea** (5 x Inbox 500)

Dimension: 355 x 228 x 233 mm



## 2. Interface Specification

### 2.1 Digital Output ( I<sup>2</sup>C Interface )



Pin-No	Name	Description
1	SCL	I <sup>2</sup> C clock
2	VDD	Supply voltage (2.1~3.3V)
3	VSS	Ground
4	SDA	I <sup>2</sup> C data

#### 2.1.1 Power Pads (2: VDD)

**HCS2D-3V** is capable of operating on wide range of power supply voltage from 2.1V to 3.3V. Recommended supply voltage is either 2.1±0.5V or 3.3±0.5V. Power supply should be connected to

VDD (power supply pad 2). VDD and VSS (Ground pad 3) should be decoupled with a 4.7µF capacitor.

#### 2.1.2 Serial Clock & Data Pads (1: SCL, 4: SDA)

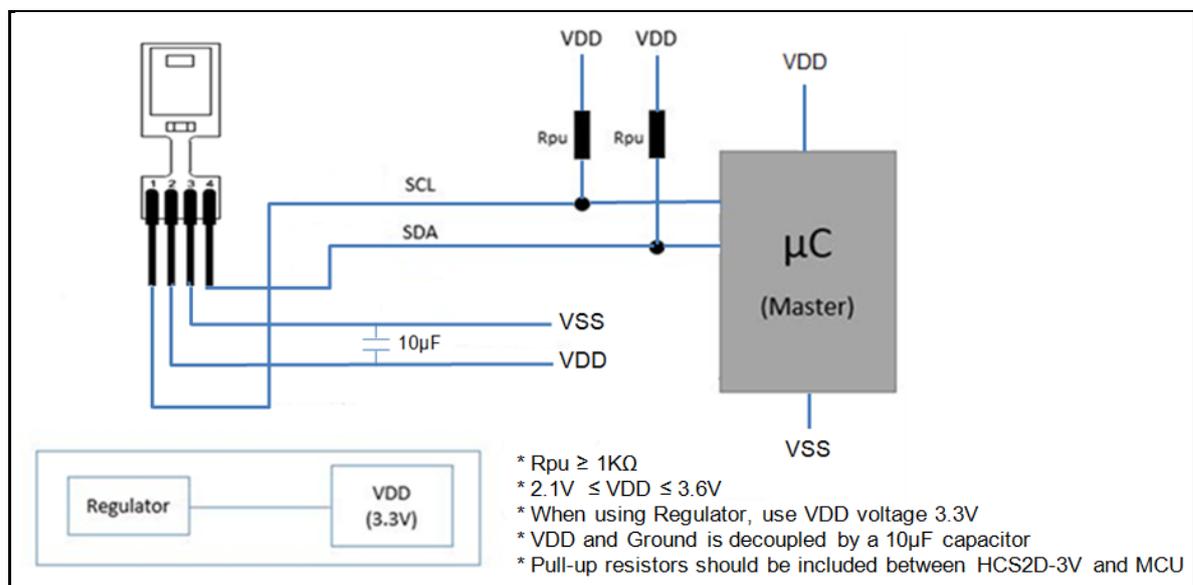
The sensor's data is transferred in and out through the SDA pad while the communication between **HCS2D-3V** and microcontroller (MCU) is synchronized through the SCL pad.

**HCS2D-3V** has an internal temperature compensated oscillator that provide time base for all operation, and uses an I<sup>2</sup>C-compatible communication protocol with support up to 100kHz bit rates.

External pull-up resistors are required to pull the drive signal high, that can be included in I/O circuits of microcontroller. (see **Figure 3**) If pads (SDA and SCL) are not used, SCL should be connected to VDD and SDA should be connected GND.

Further information about timing and communication between the sensor and microcontroller is explained in Section 4. Communicating with **HCS2D-3V**

Figure 2 Typical Application Circuit (I<sup>2</sup>C)



### 3. Electrical Specification

#### 3.1 Absolute Maximum Rating

[Table 1](#) shows the Absolute Maximum Ratings for **HCS2D-3V**. Exposure to these extreme conditions for extended period may deteriorate

the sensor performance and accelerate aging. Functional operation is not implied at these conditions.

#### 3.2 Electrical Specification and Recommended Operating Conditions

The operating conditions recommended for **HCS2D-3V** are given in [Table 2](#) and the electrical specification is shown in [Table 3](#).

#### 3.3 Output Pad Drive Strength

Output pad drive strength is 4mA.

#### 3.4 ESD

All pins have an ESD rating of up to 2kV. The ESD test follows the Human Body Model with C=150pF

and R=330Ω based on IEC61000-4-2

**Table 1 Absolute Maximum Rating**

PARAMETER	SYMBOL	MIN	MAX	Unit
Supply Voltage (VDD to GND)	V <sub>SUPPLY</sub>	-0.3	4.0	V
Storage Temperature Range	T <sub>STG</sub>	-40	125	°C
Junction Temperature	T <sub>J</sub>	-40	125	°C

**Table 2 Recommended Operating Conditions**

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
Supply Voltage	V <sub>DD</sub>	2.1		3.6	V
Ambient Temperature Range	T <sub>AMB</sub>	-40		125	°C
External Capacitance between V <sub>DD</sub> pin and Gnd	C <sub>V<sub>SUPPLY</sub></sub>		10		μF
Pull-up on SDA and SCL*1	R <sub>PU</sub>	1			kΩ

\*1 : The SDA and SCL should not be left in the open state.

\*2 : For the capacitor, the X7R or C0G is recommended.

Table 3 Electrical Characteristics Specifications

PARAMETER	SYMBOL	REMARKS	MIN	TYP	MAX	UNIT
Supply Current	$I_{DD}$	At 3V, 1Hz		13		$\mu A$
Digital port voltage	$V_{IO\_DIGITAL}$	Relative to ground	-0.6	3.3	$V_{DD}+0.6$ $\leq 3.6$	V
Digital ports switching level		HIGH $\rightarrow$ LOW LOW $\rightarrow$ HIGH		$0.3*V_{DD}$ $0.7*V_{DD}$		V
Start-Up-Time Power-on (POR) to data ready	$t_{STA}$				10	ms
Measuring Rate				5		Hz
EEPROM Data Retention Period		at 95°C temperature			10	Year
OTP Data Retention Period		at 95°C temperature			10	Year

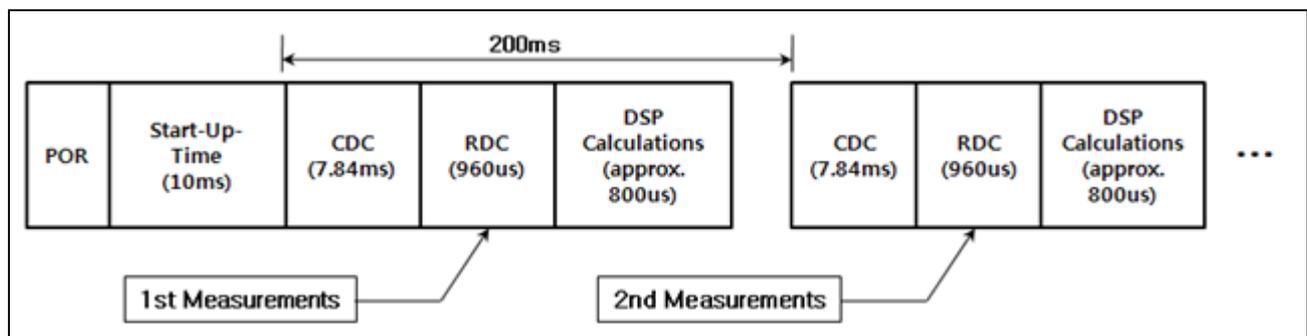
## 4. Communicating with HCS2D-3V

### 4.1 Power-On Sequence

On system Power-On-Reset, the HCS2D-3V wakes as an I<sup>2</sup>C device. After power-on-reset, start-up-time is required 10ms. The CDC is triggered by the conversion timer. After the CDC is completed, the RDC will be

performed sequentially. Then the DSP calculate and update the humidity and temperature to Result Register. The measurement rate is 5Hz (200ms) by conversion timer. See the Figure 4 Power-on Sequence.

Figure 3 Power-On Sequence



### 4.2 I<sup>2</sup>C Compatible Interface

The present paragraph outlines the HCS2D-3V device specific use of the I<sup>2</sup>C interface. The external master (HCS2D-3V cannot be master) begins the communication by creating a start condition, falling edge on the SDA line while SCL is HIGH. It stops the communication by a stop condition, a rising edge on the SDA line while SCK is high. Data bits are transferred with the rising edge of SCK.

On I<sup>2</sup>C buses, every slave holds an individual 7-bit device address (0x28 fixed). This address has always to be sent as the first byte after the start condition. The eighth bit indicating the direction of the following data transfer (Read : 1 and Write : 0). The address byte is followed by the opcode and eventually the payload. Each byte is followed by an acknowledge bit (0 : when a slave acknowledges).

Figure 4 Address Byte

<b>MSB</b>							<b>LSB</b>
0	1	0	1	0	0	0	R/W

Figure 5 START and STOP condition

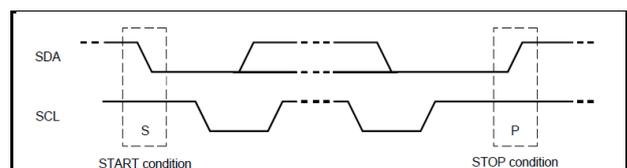
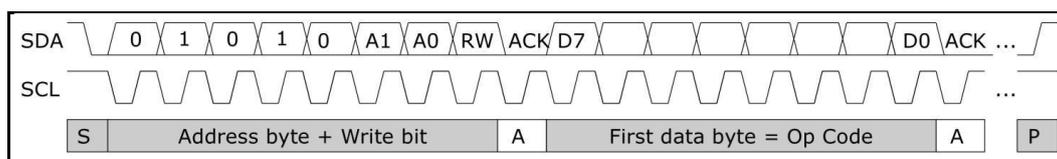


Figure 6 I<sup>2</sup>C principle sequence

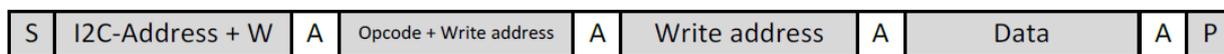


### 4.2.1 I<sup>2</sup>C Write

During write transactions, the master alone sends data, the addressed slave just sends the acknowledge bit. The master first sends the slave address plus the write bit. Then it sends the

HCS2D-3V specific opcode including the register address in the slave. Finally it sends the payload (“Data”).

Figure 7 I<sup>2</sup>C Write procedure

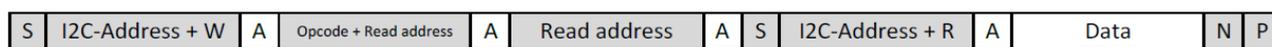


### 4.2.2 I<sup>2</sup>C Read

During read transactions, the direction of communication has to be commuted. Therefore, the master creates again a start condition and

sends the slave address plus the read bit (instead of the write bit) to switch into read mode. Figure 8 shows.

Figure 8 I<sup>2</sup>C Read procedure



After arrival of the first (or any) data byte, the master may be either signal Not-Acknowledge or Acknowledge. Not-Acknowledge (=N=1) indicate “end of read” and “stop sending” to the slave.

Acknowledge (=A=0) indicate “continue in automatic address-increment mode” and thus receive many bytes in a row. As one can see, automatic address increment is particularly useful and efficient with the I<sup>2</sup>C interface.

### 4.2.3 I<sup>2</sup>C Timing

The HCS2D-3V uses I<sup>2</sup>C -compatible communication protocol with support for Max 100 kHz bit rates. See Figure 10 and [Table 4](#).

**Note :** Please refer to the I<sup>2</sup>C-bus specification for Detailed Timing Chart. And Reference Programming Code are available upon request.

Figure 9 Definition of timing for device on the I<sup>2</sup>C-bus

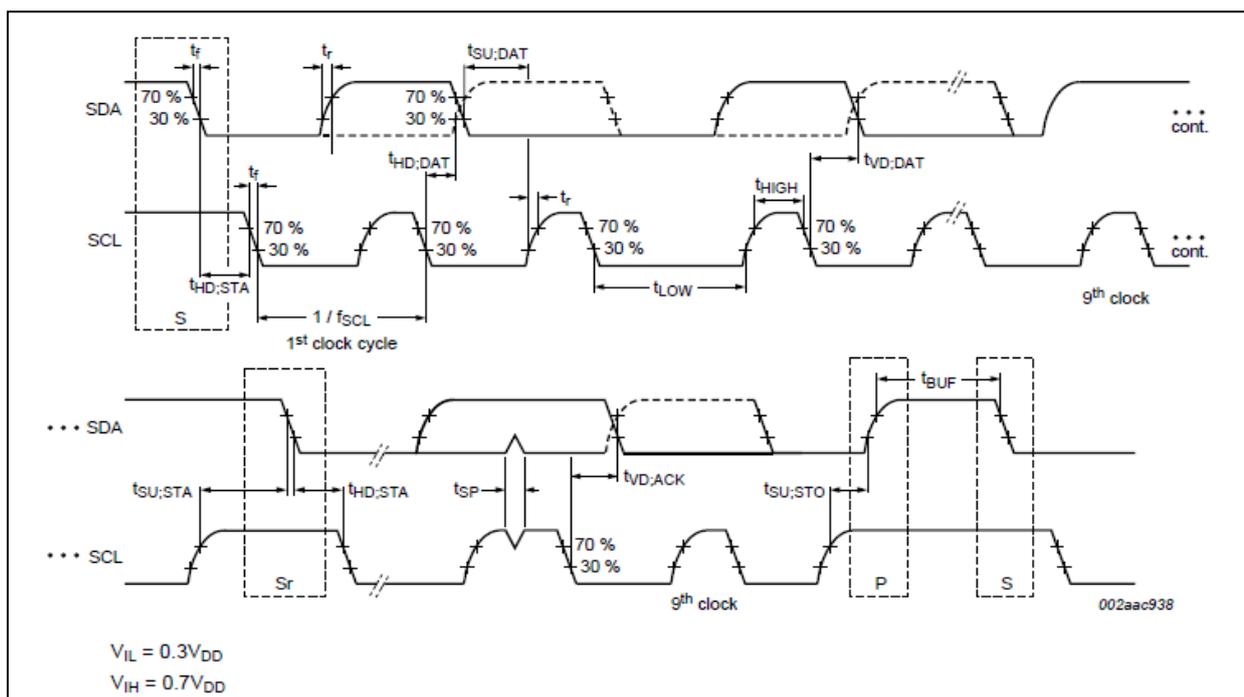


Table 4 Characteristics of the SDA and SCL bus lines

PARAMETER	SYMBOL	MIN	MAX	UNIT
SCL clock frequency <sup>1</sup>	$f_{SCL}$	0	100	kHz
hold time (repeated) START condition	$t_{HD:STA}$	4.0		$\mu s$
LOW period of the SCL clock	$t_{LOW}$	4.7		
HIGH period of the SCL clock	$t_{HIGH}$	4.0		
set-up time for a repeated START condition	$t_{SU:STA}$	4.7		
data hold time <sup>2</sup>	$t_{HD:DAT}$	0		
data set-up time	$t_{SU:DAT}$	250		ns
rise time of both SDA and SCL signals	$t_r$		1000	ns
Fall time of both SDA and SCL signals	$t_f$		300	ns
set-up time for STOP condition	$t_{SU:STO}$	4.0		$\mu s$
Bus free time between a STOP and START condition	$t_{BUF}$	4.7		$\mu s$
capacitive load for each bus line	$C_b$		400	pF
data valid time	$t_{VD:DAT}$		3.45	$\mu s$
data valid acknowledge time	$t_{VD:ACK}$		3.45	$\mu s$

1. Overclocking is technically possible but within the sole responsibility of the customer (a license may be necessary)  
 2. The data hold time that is measured from the falling edge of SCL, applies to data in transmission and the acknowledge.  
 A device must internally provide a hold time of at least 300 ns for the SDA signal to bridge the undefined region of the falling edge of SCL.

### 4.3 Opcode

All commands for write or read to memory or configuration or result registers may use explicit addressing or address auto-increment.

**Note :** Besides the case of reading the result registers, it is recommended to deactivate the

converter for any communication to configuration registers or EEPROM. This is done by setting the RunBit to '0'. After the communication process the RunBit needs to be set back to '1'. For more details, see the **Section 4.7**.

**Table 5 Opcode**

Description	BYTE 2	BYTE 1	BYTE 0
Read Result	0 1 0 0 0 0 0 0	0 Addr <6..0>	
Write configuration	1 1 0 0 0 0 0 0	0 Addr <6..0>	Data <7..0>
Write EEPROM	1 1 1 0 0 0 0 0	0 Addr <6..0>	Data <7..0>
Read EEPROM	0 1 1 0 0 0 0 0	0 Addr <6..0>	
Erase EEPROM	1 1 1 0 0 0 1 0	0 Addr <6..0>	[ Dummy Byte ]
Power-on Reset <sup>1</sup>	1 0 0 0 1 0 0 0		

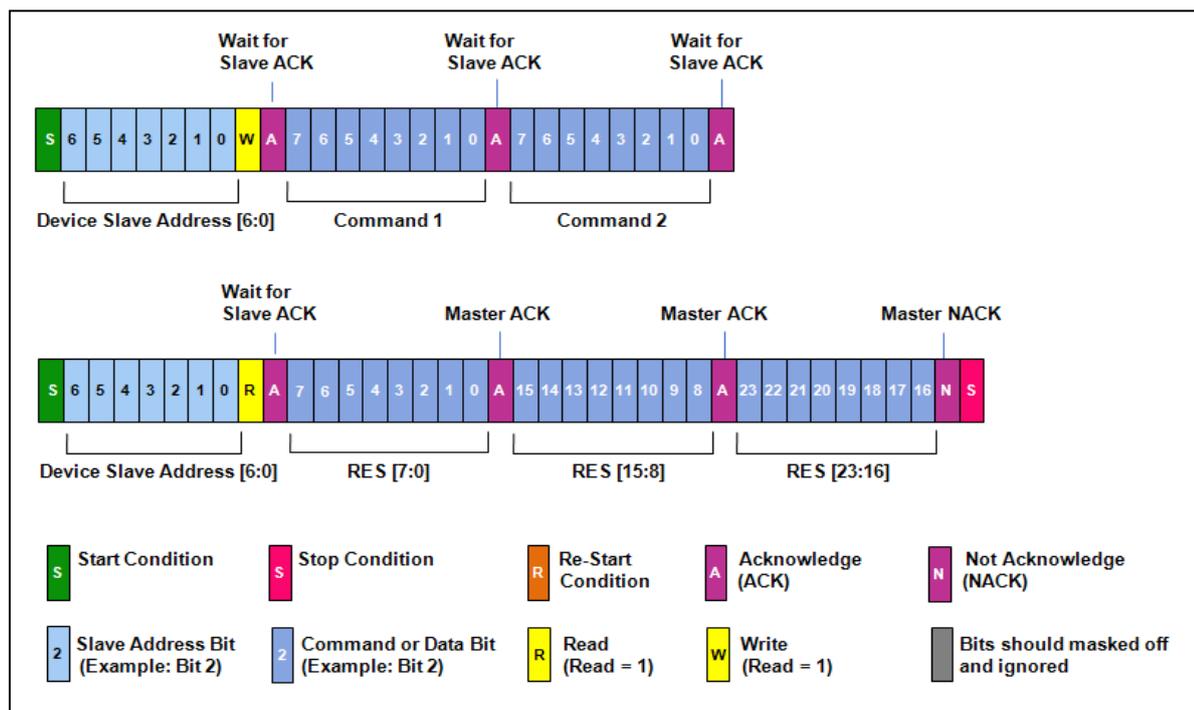
1. It takes about 280us until the first(cdc) measurement starts.

### 4.4 Data Fetch

The Data Fetch (DF) command is used to fetch data from HCS2D-3V. An I<sup>2</sup>C Data Fetch command starts with the 7-bit slave address and the 8<sup>th</sup> bit 1(Read). The HCS2D-3V as the slave sends an acknowledgement (ACK) indicating success.

The number of data bytes returned by the HCS2D-3V is determined by when the master sends the NACK and stop condition. Figure 11 shows examples of fetching three bytes respectively.

**Figure 10 I<sup>2</sup>C Measurement Packet Reads**



The data has to be read from Result Register using the Read Result command in order to fetch the humidity and temperature. Read Result command consists of 0x40 and 7-bit address. 7-bit address is 0x00(for temperature) or 0x03(for humidity). After commands are transferred, 3-bytes data is read from HCS2D-3V. First 2-bytes are humidity or temperature. They are signed integer, two's complement fixed- point. The lower

byte is fractional digits and the higher byte is integer values. Third byte is Checksum. If it isn't used, only 2-bytes can be read.

The checksum and output data are calculated as [Table 6](#).

To read temperature and humidity at a time, data of 6-Bytes can be fetched from HCS2D-3V after commands (0x40+0x00) are sent. The first 3-bytes are temperature and the next 3-bytes are humidity.

Figure 11 Example : Temperature and Humidity data fetch

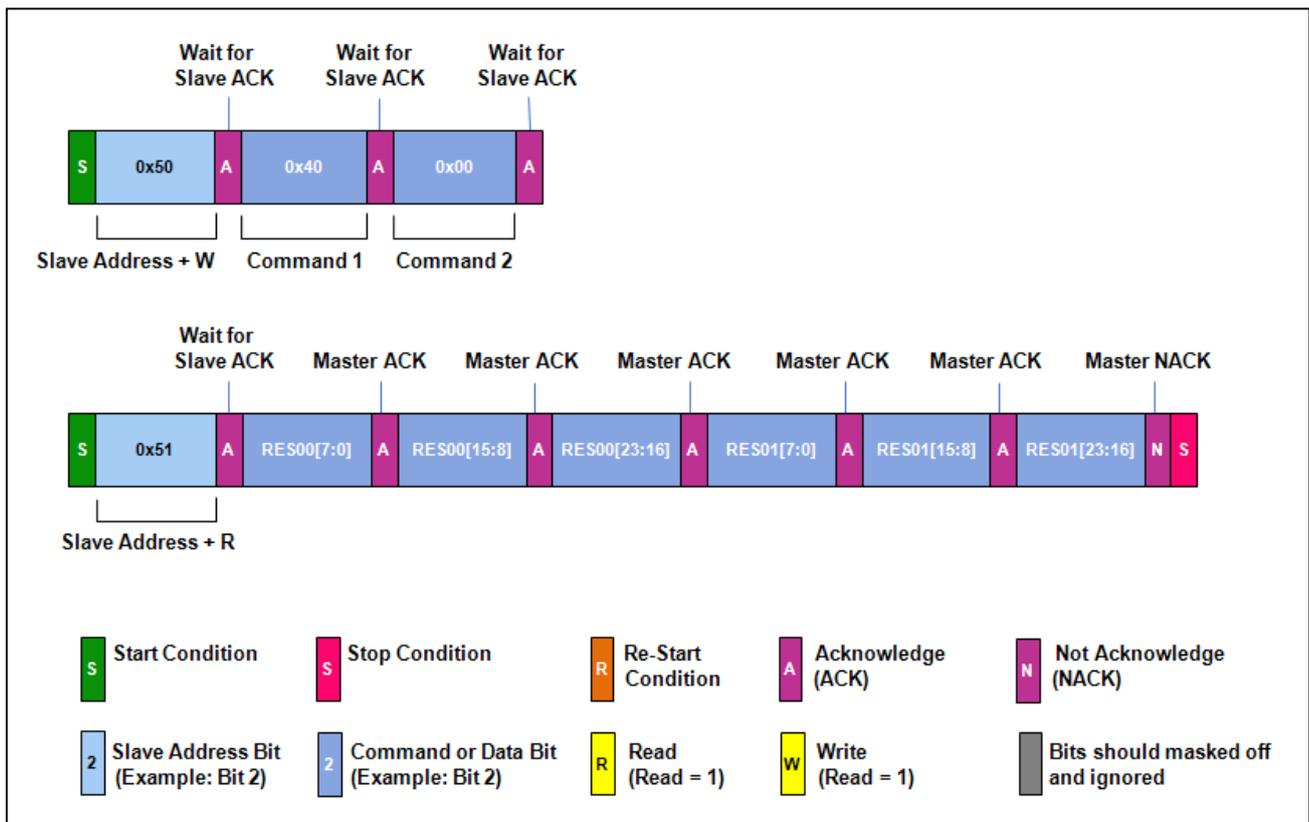


Table 6 Humidity &amp; Temperature Conversion Formula

Humidity & Temperature Conversion Formula	
Humidity Output (%RH)	$RES01[15:0] / 256$
Temperature Output (°C)	$RES00[15:0] / 256$
Checksum	$RES[23..16] = (RES[15..8] + RES[7:0]) \% 256$

**Note :** '%' symbol in Checksum Formula means mod operation.

#### 4.5 EEPROM

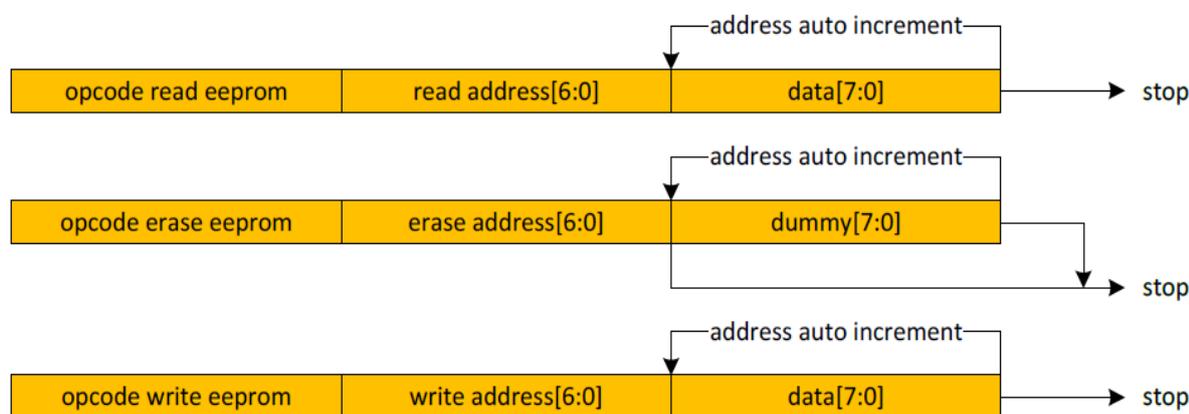
The EEPROM array contains the calibration coefficients for gain and offset, etc., and the configuration bits for the output modes, measuring rate, etc.. The **HCS2D-3V** EEPROM is arranged as 127 Bytes.

See **Section 4.3** for instructions on reading and writing to the EEPROM via the I<sup>2</sup>C interface. When programming the EEPROM, an internal

charge pump voltage is used; therefore a high voltage supply is not needed.

Only 1's can be written to the EEPROM. Therefore, it is necessary to erase the EEPROM cells before writing new data. EEPROM communication may use address auto-increment. In case of "Erase EEPROM" the incremental write is achieved by sending additional dummy bytes.

Figure 12 EEPROM communication



It is necessary to wake up the EEPROM before each write access. Therefore, Enable EEPROM after clear RunBit. The EEPROM wakeup can be

done explicitly or automatically. It is mandatory to take care of the setup timings, for each individual byte.

**Table 7 EEPROM Timings**

Symbol	Description	Typ.
$t_{rdsu}$	Set-up Time for reading	300 $\mu$ s
$t_{rd}$	Read Time from EEPROM	600ns
$t_{wrsu}$	Set-up Time for Writing	200 $\mu$ s
$t_{wr}$	Write Time to EEPROM	6.8ms

## 4.6 Configurations

### 4.6.1 RunBit

The RunBit enables or disables the front-end and the DSP. It is indicated in the Status Register bit0. When the Configuration Register or EEPROM is accessed, the Runbit should be '0'. Then, as a last

step, RunBit should be set to '1' again. Use the POR command in order to re-start the measurement after access is completed.

**Table 8 Commands for configurations**

Command	CMD1	CMD2	CMD3
Set RunBit	0xC0	0x4D	0x01
Clear RunBit	0xC0	0x4D	0x00
Enable EEPROM	0xC0	0x1C	0xC4
Disable EEPROM	0xC0	0x1C	0x44

### 4.6.2 Status Register

Address 24 in the Result Register is the Status Register. The EEPROM state and the RunBit are displayed in the Status Register.

For more information, see **Section 4.6 EEPROM** and **Section 4.7.1 RunBit**.

**Table 9 Status Register Details**

Bit#	Name	Description
0	RunBit	Run Bit (0: Disable, 1: Enable)
2:1	Reserved	
3	EE_BUSY	EEPROM busy
7:4	Reserved	

Figure 13 EEPROM power controlled by user : Write / Erase

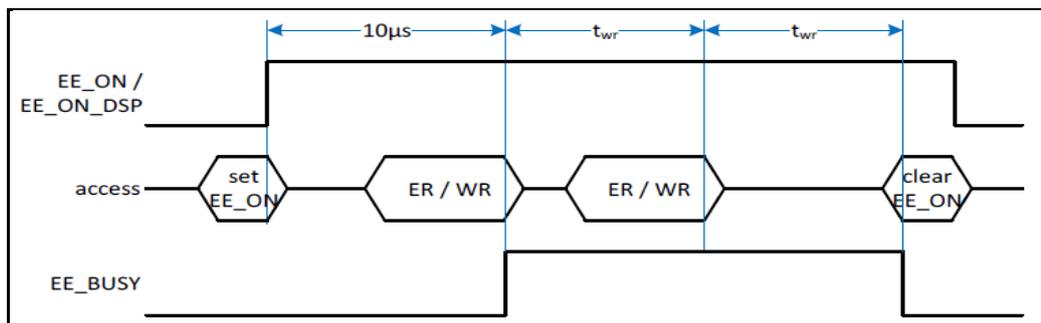


Figure 14 EEPROM power controlled by user : Read

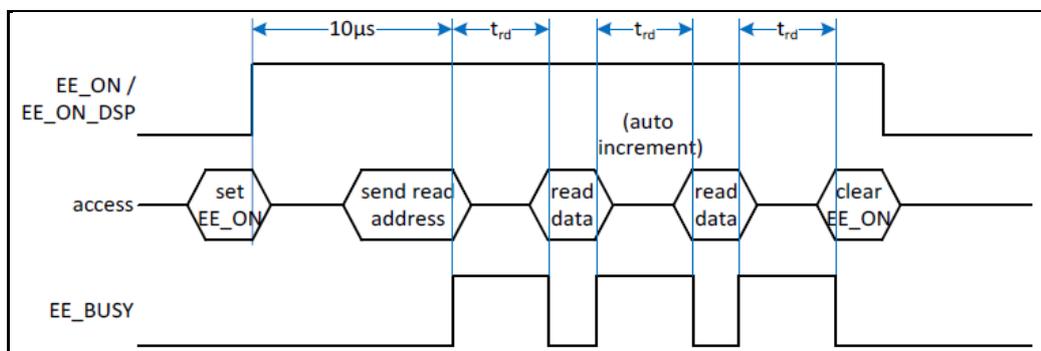


Figure 15 EEPROM power controlled automatically : Write / Erase

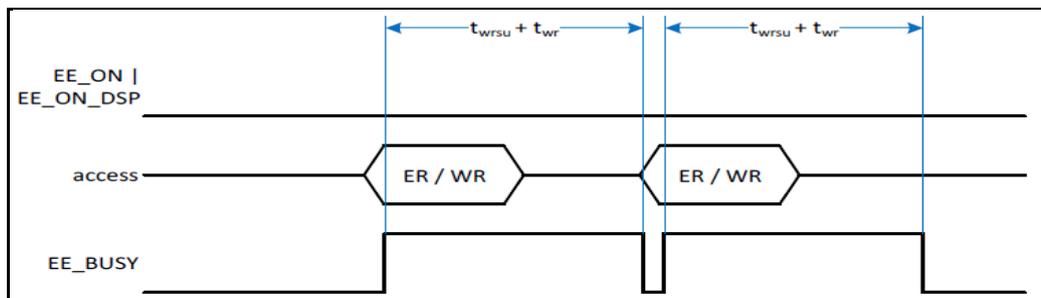
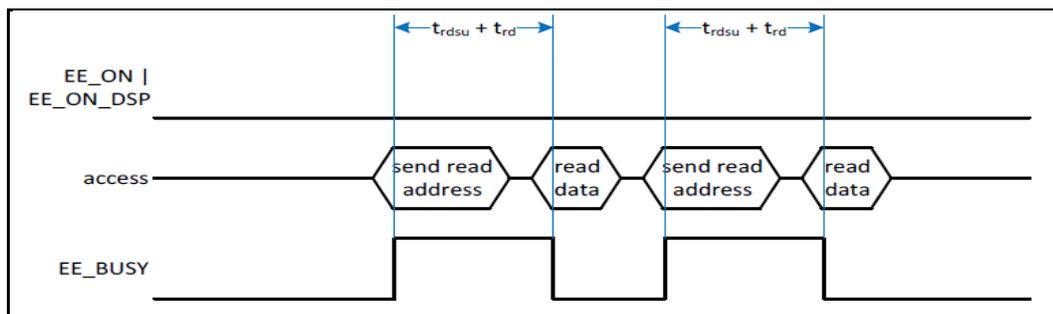


Figure 16 EEPROM power controlled automatically : Read



## 5. Revision History

Date	Version	Page(s)	Changes
16 SEPTEMBER 2015	1.0		First Release