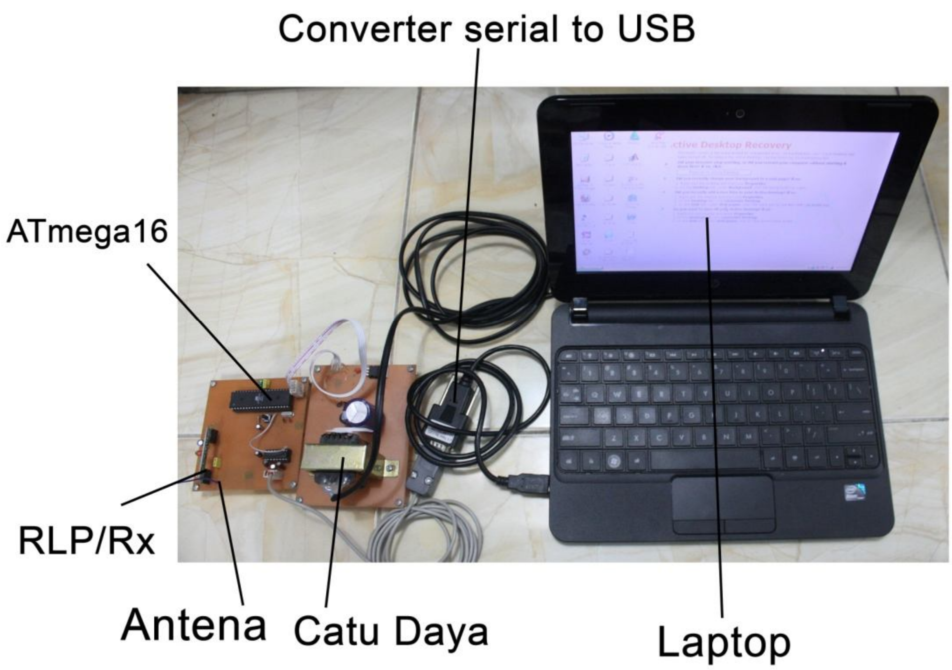
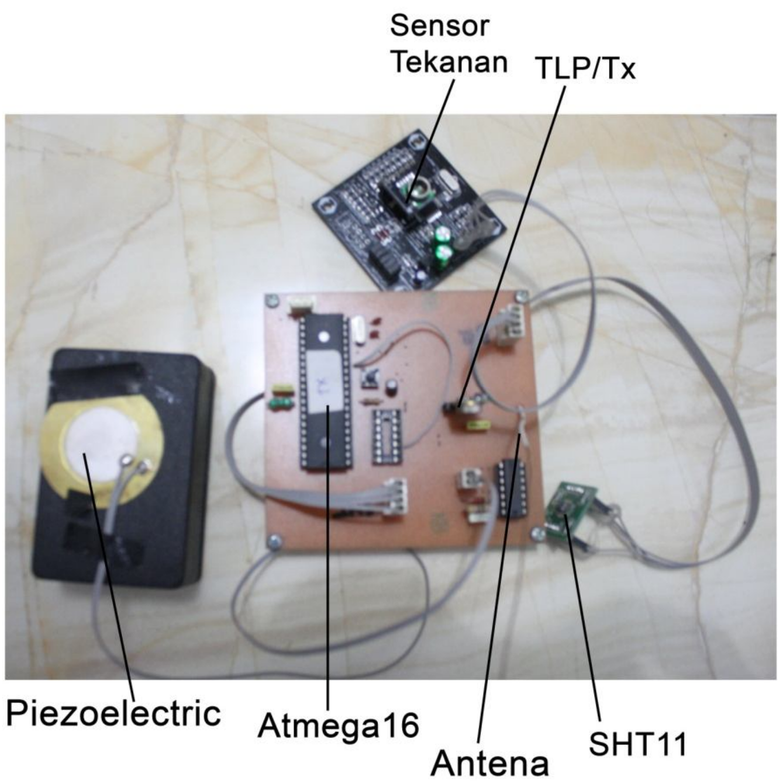
LAMPIRAN A

FOTO ALAT MONITORING KONDISI GUNUNG BERAPI NIRKABEL

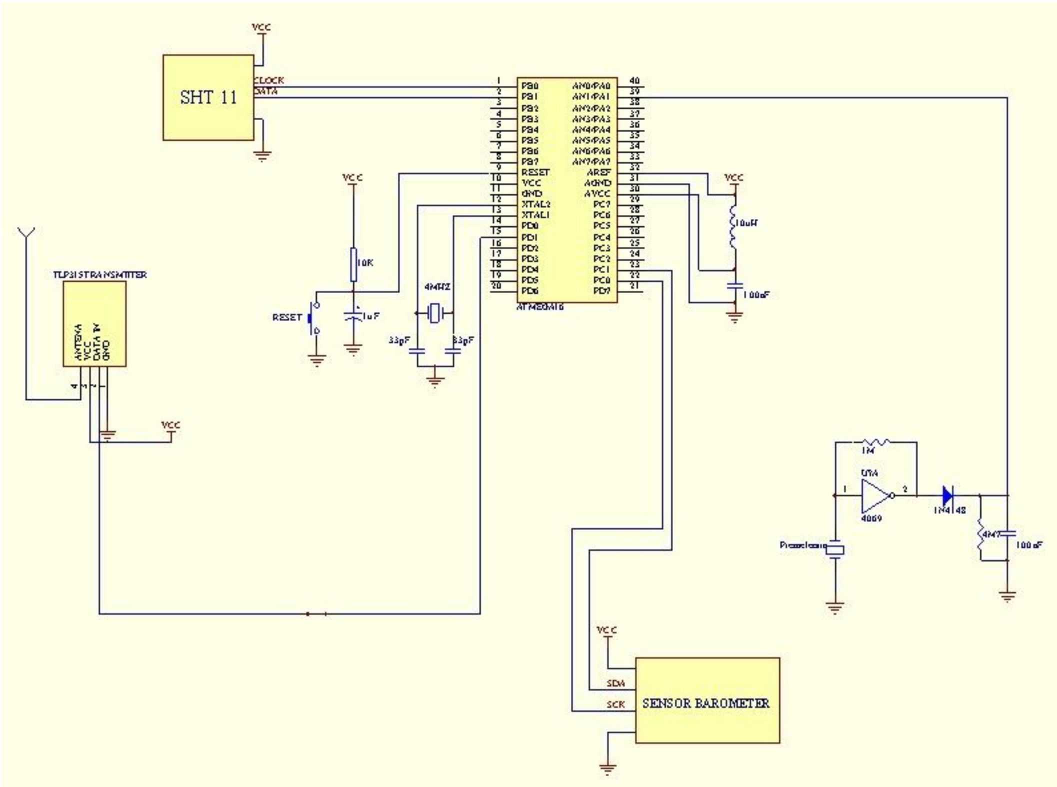

Converter serial to USB
ATmega16
RLP/Rx
Antena
Catu Daya
Laptop


Sensor
Tekanan
TLP/Tx
Piezoelectric
Atmega16
Antena
SHT11

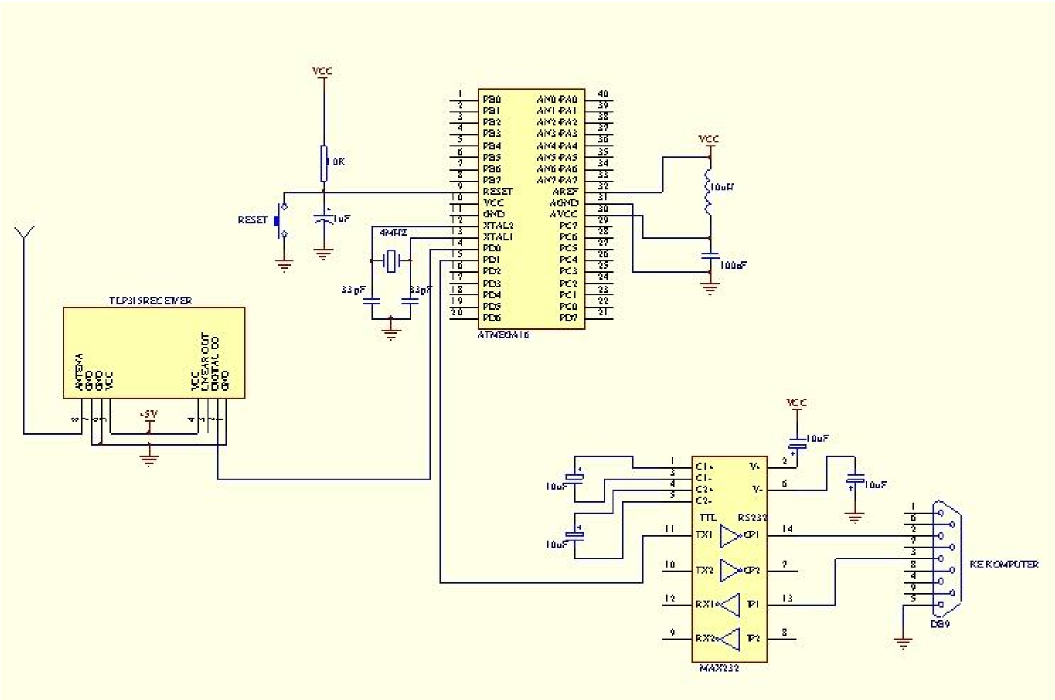
LAMPIRAN B

SKEMATIK MODUL PENGIRIM DAN PENERIMA

SKEMATIK PENGIRIM



SKEMATIK PENERIMA



LAMPIRAN C

PROGRAM PADA PENGONTROL MIKRO ATMEGA16

Program Mikrokontroler Pengirim

```
' Program Pembaca Suhu, Kelembaban, Tekanan dan Getaran
' Kirim via Wireles


$regfile = "m16def.dat"
$crystal = 4000000
$baud = 1200



Config Adc = Single , Prescaler = Auto



Dim Hasil As Single
Dim Hasilsuhu As Single
Dim Suhu As Single
Dim X As Single
Dim Ctr As Byte
Dim Dataword As Word
Dim Command As Byte
Dim Dis As String * 20
Dim Suhustring As String * 6
Dim Kelembabanstring As String * 5
Dim Tekananstring As String * 6
Dim Calc As Single
Dim Calc2 As Single
Dim Rhlinear As Single
Dim Rhlintemp As Single
Dim Tempc As Single
Dim Tempf As Single
Dim D_msb As Byte
Dim D_lsb As Byte
Dim Tekanan As Single
Dim Datagetaran As Word
Dim Sdatagetaran As String * 5
Dim Datakirim As String * 26
Dim Sgetaran As String * 1

Const C1 = -4
Const C2 = 0.0405
Const C3 = -0.0000028
Const T1c = .01
Const T2 = .00008
Const T1f = .018

Sck Alias Portb.0
Dataout Alias Portb.1
Datain Alias Pinb.1

Getaran Alias Pina.0                                        'input
getaran

Declare Sub Getit()
```

```
Ddrb = &B11111111                                        'all Port
B Output
Ddra = &B00000000

Config Pinb.0 = Output                                      'sck
Config Pinb.1 = Output
'datain

Config Scl = Portc.0
Config Sda = Portc.1
'Config Clock = User


Set Dataout

For Ctr = 1 To 12
   Set Sck
   Waitus 2
   Reset Sck
   Waitus 2
Next Ctr

Wait 2

Start Adc                                               'ADC mulai
konversi

Do

'-------------------------------
' Pengambilan Suhu SHT11
'-------------------------------

   Command = &B00000011                  'command untuk
mendapatkan suhu

   Call Getit                   'Panggil sub rutin pengambilan
data suhu

   Tempf = T1f * Dataword
   Tempf = Tempf - 40
   Tempc = T1c * Dataword                    'jadikan suhu derajat
celcius
   Tempc = Tempc - 40
   X = Tempf
   Hasil = X - 32
   Suhu = 5 / 9
   Hasilsuhu = Hasil * Suhu
   Dis = Fusing(hasilsuhu , "###.##")
   Suhustring = Fusing(hasilsuhu , "###.#")
```

```
'------------------------------
' Pengambilan Kelembaban SHT11
'------------------------------

   Command = &B00000101 ;                             'Untuk
Kelembaban

   Call Getit                    'panggil subrutin untuk mengambil
data

   Calc = C2 * Dataword
   Calc2 = Dataword * Dataword
   Calc2 = C3 * Calc2
   Calc = Calc + C1
   Rhlinear = Calc + Calc2
   Calc = T2 * Dataword
   Calc = Calc + T1c
   Calc2 = Tempc - 25
   Calc = Calc2 * Calc

   Rhlintemp = Calc + Rhlinear
   Dis = Fusing(rhlintemp , "##.##")
   Kelembabanstring = Fusing(rhlintemp , "##.#")

'-----------------------------------------------
' Pengambilan Data Tekanan dari sensor Barometric
'-----------------------------------------------

   I2cstart
   I2cwbyte &HE0
   I2cwbyte 0
   I2cstop
   Waitms 50
   I2cstart
   I2cwbyte &HE1
   I2crbyte D_msb , Ack
   I2crbyte D_lsb , Nack
   I2cstop

   Tekanan = D_msb * 256
   Tekanan = Tekanan + D_lsb
   Tekanan = Tekanan / 10
   Tekananstring = Fusing(tekanan , "####.#")

'--------------------------------------------
' Pengambilan Data Getaran Melalui ADC kanal 1
'--------------------------------------------
   Datagetaran = Getadc(1)


   If Getaran = 1 Then Sgetaran = "1"
   If Getaran = 0 Then Sgetaran = "0"
```

```
'-----------------------------------
' Pengiriman seluruh data
' Suhu, kelembaban, tekanan, getaran
'-----------------------------------

   Datakirim = " S" + Suhustring + "K" + Kelembabanstring + "T" +
Tekananstring + "G" + Sgetaran + "A"
   Print &HAA ; Datakirim ; Datagetaran ; "L"

   Waitms 300
Loop

End



'-------------------------------------------------------
'Sub rutin pengambilan data Suhu dan kelembaban SHT11
'-------------------------------------------------------
Sub Getit()

Local Datavalue As Word
Local Databyte As Byte

'Transmission start"

   Set Sck
   Reset Dataout
   Reset Sck
   Set Sck
   Set Dataout
   Reset Sck

'pengiriman command

   Shiftout Dataout , Sck , Command , 1

   Ddrb = &B11111101 ‘datain Is Now Input

   Config Pinb.1 = Input
'datain

   Set Sck
   Reset Sck
   Waitus 10
   Bitwait Pinb.1 , Reset

   Shiftin Datain , Sck , Databyte , 1
'pengambilan Msb
   Datavalue = Databyte

   Ddrb = &B11111111
   Config Pinb.1 = Output

   Reset Dataout
```

```
   Set Sck
   Reset Sck

   Ddrb = &B11111101 ‘datain Is Now Input
   Config Pinb.1 = Input

   Shiftin Datain , Sck , Databyte , 1
'pengambilan Lsb
   Shift Datavalue , Left , 8

   Datavalue = Datavalue Or Databyte


   Dataword = Datavalue
   Ddrb = &B11111111

   Config Pinb.1 = Output
   Reset Dataout
   Set Sck
   Reset Sck

   Ddrb = &B11111101 ‘datain Is Now Input
   Config Pinb.1 = Input
   Shiftin Datain , Sck , Databyte , 1



   Ddrb = &B11111111
   Config Pinb.1 = Output
   Set Dataout
   Set Sck
   Reset Sck

End Sub
```

Program Mikrokontroler Penerima

```
'------------------------------------
' Program Penerima data Dari Penerima
'------------------------------------

$regfile = "m16def.dat"
$crystal = 4000000
$baud = 1200

Dim A As String * 50                                   'siapkan
buffer 50

Enable Interrupts

Print "Penerima"
Waitms 500
Do
```

```
   Input A                                              ' Tunggu data dari
Pengukur

   Print A                                               'Kirim kekomputer
data tsb

Loop

End
```

LAMPIRAN D

PROGRAM INTERFACING DELPHI

```
unit Unit1;

interface

uses
  Windows, Messages, SysUtils, Variants, Classes, Graphics,
Controls, Forms,
  Dialogs, ExtCtrls, QCCom32, StdCtrls, Buttons, TeEngine, Series,
  TeeProcs, Chart, Gauges, DB, DBTables, Grids, DBGrids;

type
  TForm1 = class(TForm)
    com: TQCCom32;
    Timer1: TTimer;
    BitBtn1: TBitBtn;
    psuhu: TPanel;
    pkelembaban: TPanel;
    ptekanan: TPanel;
    Label1: TLabel;
    Label2: TLabel;
    Label3: TLabel;
    Label4: TLabel;
    Label5: TLabel;
    Label6: TLabel;
    Bevel1: TBevel;
    pjam: TPanel;
    ptanggal: TPanel;
    Button1: TButton;
    DBGrid1: TDBGrid;
    DataSource1: TDataSource;
    Table1: TTable;
    Chart2: TChart;
    Series2: TFastLineSeries;
    DataSource2: TDataSource;
    Table2: TTable;
    DBGrid2: TDBGrid;
    BTNsimpan: TBitBtn;
    BTNBerhenti: TBitBtn;
    BitBtn2: TBitBtn;
    BitBtn4: TBitBtn;
    procedure Timer1Timer(Sender: TObject);
    procedure FormCreate(Sender: TObject);
    procedure Button1Click(Sender: TObject);
    procedure BTNsimpanClick(Sender: TObject);
    procedure BTNBerhentiClick(Sender: TObject);
    procedure BitBtn2Click(Sender: TObject);

    procedure BitBtn4Click(Sender: TObject);
  private
    { Private declarations }
  public
```

```
    { Public declarations }
  end;

var
  Form1: TForm1;
  datars232:string;

kode,x,posS,posK,posT,posG,posA,posB,STgetar,Bgetaran,BesarGetaran
:integer;
  menit:integer;
  menitlama,Bsgetaran:string;
  SimpanGetar:boolean;

implementation

{$R *.dfm}

procedure TForm1.Timer1Timer(Sender: TObject);
begin
pjam.caption:=formatdatetime('hh:mm:ss',time);
ptanggal.caption:=formatdatetime('dd/mm/yyyy',date);

if menit=5 then
   begin
      menit:=0;
{-------------------------------------------}
   table1.Refresh;
   table1.Last;
   table1.Insert;
   table1.FieldByName('TANGGAL').asstring:=ptanggal.caption;
   table1.FieldByName('JAM').asstring:=pjam.caption;
   table1.FieldByName('SUHU').asstring:=psuhu.caption;
   table1.FieldByName('KELEMBABAN').asstring:=pkelembaban.caption;
   table1.FieldByName('TEKANAN').asstring:=ptekanan.Caption;
   table1.Post;

   end;

if menitlama<>copy(pjam.caption,5,1) then
   begin
      menitlama:=copy(pjam.caption,5,1);
      menit:=menit+1;
   end;


datars232:=com.read;

if length(datars232)>20 then
  begin


    posS:=pos('S',datars232);
    posK:=pos('K',datars232);
    posT:=pos('T',datars232);
    posG:=pos('G',datars232);
    posA:=pos('A',datars232);
```

```
    posB:=pos('L',datars232);

    if (posS<>0) and (posK<>0) and (posT<>0)
        and (posG<>0) and (posA<>0) and (posB<>0) then
    begin

      Bsgetaran:=copy(datars232,posA+1,posB-posA-1);

      val(Bsgetaran,Bgetaran,kode);
      if bgetaran<>0 then
         begin
          BesarGetaran:=(bgetaran div 2)-189;

          if simpangetar then
          begin
            table2.refresh;
            table2.Last;
            table2.Insert;

table2.FieldByName('TANGGAL').asstring:=ptanggal.caption;
            table2.FieldByName('JAM').asstring:=pjam.caption;

table2.fieldbyname('DATA').asstring:=inttostr(BesarGetaran);
            table2.Post;
          end;
         end else Besargetaran:=0;



      psuhu.caption:=copy(datars232,posS+1,4);
      pkelembaban.caption:=copy(datars232,posK+1,4);
      ptekanan.caption:=copy(datars232,posT+1,posg-posT-1);
      x:=x+1;

      Chart2.Series[0].Add(besargetaran, inttostr(x), clTeeColor);


    end;

  end;
end;

procedure TForm1.FormCreate(Sender: TObject);
begin
com.pick;
x:=0;
menitlama:='0';
menit:=0;
simpangetar:=false;
end;

procedure TForm1.Button1Click(Sender: TObject);
begin
chart2.Series[0].clear;
x:=1;
end;
```

```
procedure TForm1.BTNsimpanClick(Sender: TObject);
begin
simpanGetar:=true;
btnsimpan.enabled:=false;
btnberhenti.enabled:=true;
end;

procedure TForm1.BTNBerhentiClick(Sender: TObject);
begin
SimpanGetar:=false;
btnberhenti.enabled:=false;
btnsimpan.enabled:=true;
end;

procedure TForm1.BitBtn2Click(Sender: TObject);
begin
table2.Refresh;
while not table2.eof do
begin
  table2.Last;
  table2.Delete;

end;
end;


procedure TForm1.BitBtn4Click(Sender: TObject);
begin
table1.Refresh;
while not table1.eof do
begin
  table1.Last;
  table1.Delete;

end;
end;

end
```

LAMPIRAN E

DATASHEET

SHT1x/SHT7x E-1

DT-SENSE BAROMETRIC PRESSURE E-9

ATMEL ATMEGA16/ATMEGA16L E-19

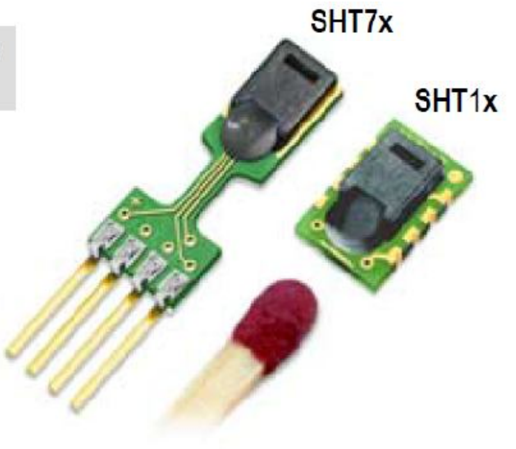
IC 4069UB (INVERTER) E-23

MODUL RF TLP-RLP 315 .... E-27

SHT1x / SHT7x

Humidity & Temperature Sensor

Evaluation Kit Available



_ Relative humidity and temperature sensors
_ Dew point
_ Fully calibrated, digital output
_ Excellent long-term stability
_ No external components required
_ Ultra low power consumption
_ Surface mountable or 4-pin fully interchangeable
_ Small size
Automatic power down

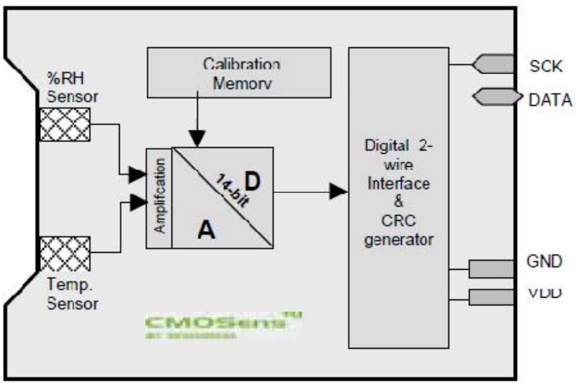
SHT1x / SHT7x Product Summary

The SHTxx is a single chip relative humidity and temperature multi sensor module comprising a calibrated digital output. Application of industrial CMOS processes with patented micro-machining (CMOSens® technology) ensures highest reliability and excellent long term stability. The device includes a capacitive polymer sensing element for relative humidity and a bandgap temperature sensor. Both are seamlessly coupled to a 14bit analog to digital converter and a serial interface circuit on the same chip. This results in superior signal quality, a fast response time and insensitivity to external disturbances (EMC) at a very competitive price.
Each SHTxx is individually calibrated in a precision humidity chamber with a chilled mirror hygrometer as reference. The calibration coefficients are programmed into the OTP memory. These coefficients are used internally during measurements to calibrate the signals from the sensors.
The 2-wire serial interface and internal voltage regulation allows easy and fast system integration. Its tiny size and low power consumption makes it the ultimate choice for even the most demanding applications.
The device is supplied in either a surface-mountable LCC (Leadless Chip Carrier) or as a pluggable 4-pin single-in-line type package. Customer specific packaging options may be available on request.

Applications

_ HVAC
_ Automotive
_ Consumer Goods
_ Weather Stations
_ (De-) Humidifiers
_ Test & Measurement
_ Data Logging
_ Automation
White Goods
_ Medical

Block Diagram



Ordering Information

Part Number	Humidity accuracy	Temperature accuracy	Package
SHT11	±3.5%RH	±0.5°C @25°C	SMT (LCC)
SHT15	±2.0%RH	±0.4°C	SMT (LCC)
SHT71	±3.5%RH	±0.5°C @25°C	4-pin single-in-line
SHT75	±2.0%RH	±0.4°C	4-pin single-in-line

1 Sensor Performance Specifications

Parameter	Conditions	Min.	Typ.	Max.	Units
Humidity					
Resolution (2)		0.5	0.03	0.03	% RH
		8	12	12	bit
Repeatability			±0.1		% RH
Accuracy (1) Uncertainty	linearized	see figure 1			
Interchangeability		Fully interchangeable			
Nonlinearity	raw data		±3		% RH
	linearized		<<1		% RH
Range		0		100	% RH
Response time	1/e (63%) slowly moving air		4		s
Hysteresis			±1		% RH
Long term stability	Typical		< 1		% RH/yr
Temperature					
Resolution (2)		0.04	0.01	0.01	°C
		0.07	0.02	0.02	°F
		12	14	14	bit
Repeatability			±0.1		°C
			±0.2		°F
Accuracy		see figure 1			
Range		-40		123.8	°C
		-40		254.9	°F
Response Time	1/e (63%)	5		30	s

Table 1 Sensor Performance Specifications

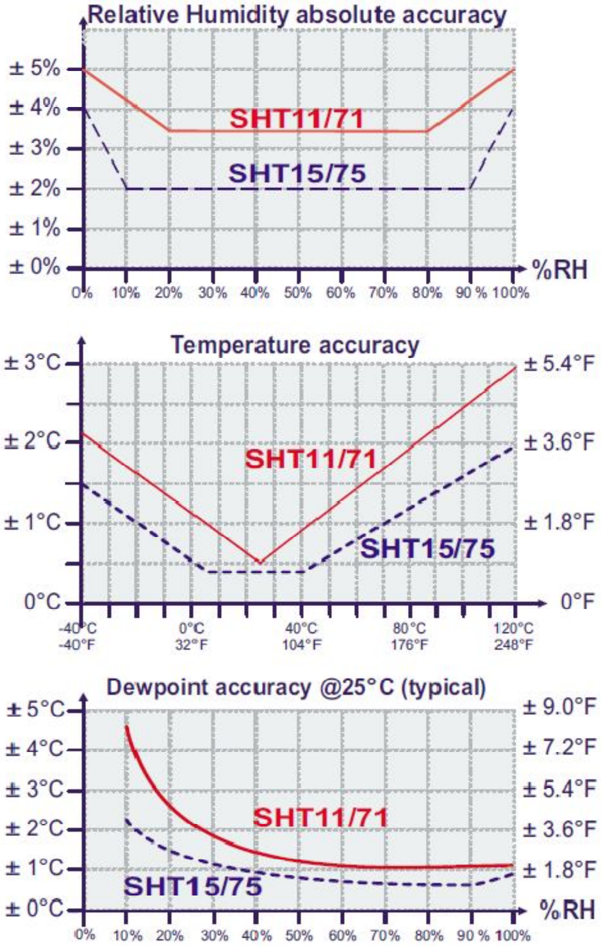


Figure 1 Rel. Humidity, Temperature and Dewpoint accuracies

2 Interface Specifications

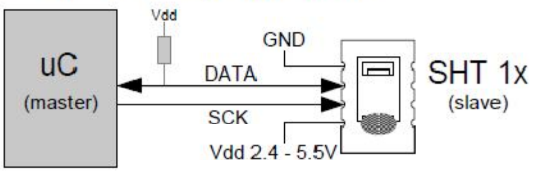


Figure 2 Typical application circuit

2.1 Power Pins

The SHTxx requires a voltage supply between 2.4V and 5.5V. After powerup the device needs 11ms to reach its "sleep" state. No commands should be sent before that time. Power supply pins (VDD, GND) may be decoupled with a 100 nF capacitor.

2.2 Serial Interface (Bidirectional 2-wire)

The serial interface of the SHTxx is optimized for sensor readout and power consumption and is not compatible with I²C interfaces, see FAQ for details.

2.2.1 Serial clock input (SCK)

The SCK is used to synchronize the communication between a microcontroller and the SHT1x / SHT7x. Since the interface consists of fully static logic there is no minimum SCK frequency.

2.2.2 Serial data (DATA)

The DATA tristate pin is used to transfer data in and out of the device. DATA **changes after the falling edge** and is **valid on the rising edge** of the serial clock SCK. During communication the DATA line must remain stable while SCK is high. To avoid signal contention the microcontroller should only drive DATA low. An external pull-up resistor (e.g 10kΩ) is required to pull the signal high. (See Figure 2) Pull-up resistors are often included in I/O circuits of microcontrollers. See Table 5 for detailed IO characteristics.

(1) Each SHTxx is tested to be within RH accuracy specifications at 25°C (77°F) and 48°C (118.4°F)
(2) The default measurement resolution of 14bit (temperature) and 12bit (humidity) can be reduced to 12 and 8 bit through the status register.

2.2.3 *Sending a command*

To initiate a transmission, a "Transmission Start" sequence has to be issued. It consists of a lowering of the DATA line while SCK is high, followed by a low pulse on SCK and raising DATA again while SCK is still high.

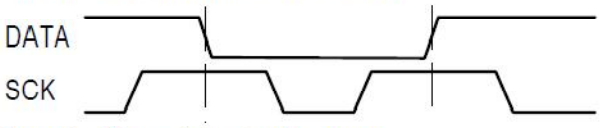


Figure 3 "Transmission Start" sequence

The subsequent command consists of three address bits (only "000" is currently supported) and five command bits. The SHT1x/SHT7x indicates the proper reception of a command by pulling the DATA pin low (ACK bit) after the falling edge of the 8th SCK clock. The DATA line is released (and goes high) after the falling edge of the 9th SCK clock.

Command	Code
Reserved	0000x
Measure Temperature	**00011**
Measure Humidity	**00101**
Read Status Register	00111
Write Status Register	00110
Reserved	0101x-1110x
Soft reset, resets the interface, clears the status register to default values wait minimum 11ms before next command	**11110**

Table 2 SHTxx list of commands

2.2.4 *Measurement sequence (RH and T)*

After issuing a measurement command ('00000101' for RH, '00000011' for Temperature) the controller has to wait for the measurement to complete. This takes approximately 11/55/210ms for a 8/12/14bit measurement. The exact time varies by up to ±15% with the speed of the internal oscillator. To signal the completion of a measurement, the SHT1x pulls down the data line. The controller **must** wait for this "data ready" signal before starting to toggle SCK again.

Two bytes of measurement data and one byte of CRC checksum will then be transmitted. The uC must acknowledge each byte by pulling the DATA line low. All values are MSB first, right justified. (e.g. the 5th SCK is MSB for a 12bit value, for a 8bit result the first byte is not used).

Communication terminates after the acknowledge bit of the CRC data. If CRC-8 checksum is not used the controller may terminate the communication after the measurement data LSB by keeping ack high.

The device automatically returns to sleep mode after the measurement and communication have ended.

Warning: To keep self heating below 0.1°C the SHTxx should not be active for more than 15% of the time (e.g. max. 3 measurements / second for 12bit accuracy).

2.2.5 *Connection reset sequence*

If communication with the device is lost the following signal sequence will reset its serial interface:

While leaving DATA high, toggle SCK 9 or more times. This must be followed by a "Transmission Start" sequence preceding the next command. This sequence resets the interface only. The status register preserves its content.

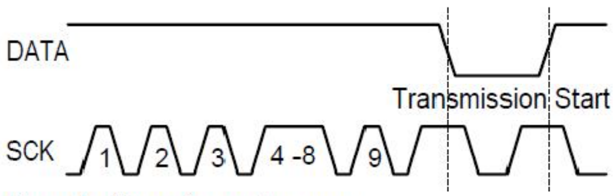


Figure 4 Connection reset sequence

2.2.6 *CRC-8 Checksum calculation*

The whole digital transmission is secured by a 8 bit checksum. It ensures that any wrong data can be detected and eliminated.

Please consult application note "CRC-8 Checksum Calculation" for information on how to calculate the CRC.

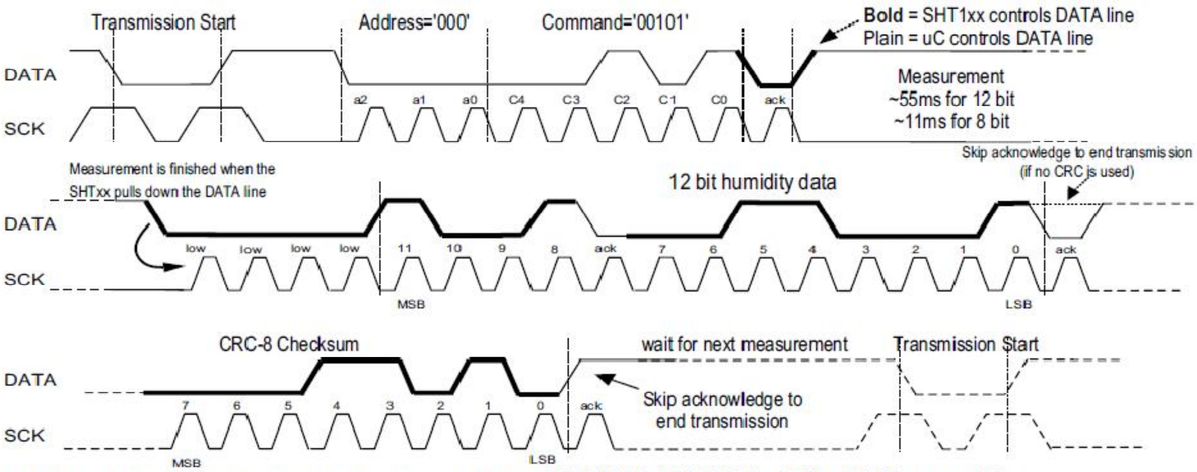


Figure 5 Example RH measurement sequence for value "0000'1001 ' 0011'0001"= 2353 = 75.79%RH @ 25°C

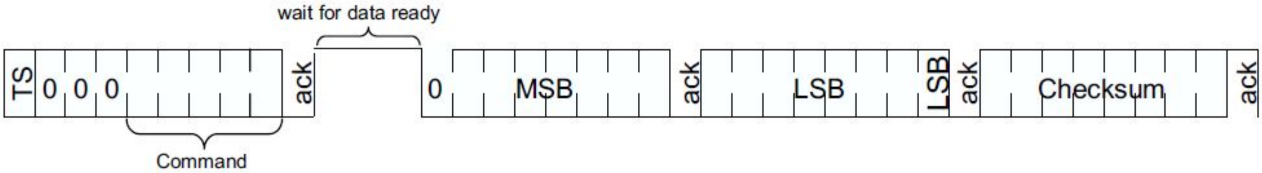


Figure 6 Overview of Measurement Sequence (TS =Transmission Start)

2.3 Status Register

Some of the advanced functions of the SHTxx are available through the status register. The following section gives a brief overview of these features. A more detailed description is available in the application note "Status Register"

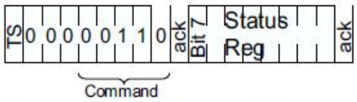


Figure 7 Status Register Write

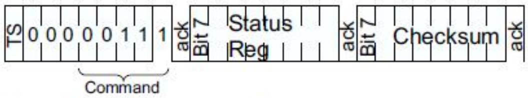


Figure 8 Status Register Read

Bit	Type	Description	Default	
7		reserved	0	
6	R	End of Battery (low voltage detection) '0' for Vdd > 2.47 '1' for Vdd < 2.47	X	No default value, bit is only updated after a measurement
5		reserved	0	
4		reserved	0	
3		For Testing only, do not use	0	
2	R/W	Heater	0	off
1	R/W	no reload from OTP	0	reload
0	R/W	'1' = 8bit RH / 12bit Temperature resolution '0' = 12bit RH / 14bit Temperature resolution	0	12bit RH 14bit Temp.

Table 3 Status Register Bits

2.3.1 Measurement resolution

The default measurement resolution of 14bit (temperature) and 12bit (humidity) can be reduced to 12 and 8 bit. This is especially useful in high speed or extreme low power applications.

2.3.2 End of Battery

The "End of Battery" function detects VDD voltages below 2.47V. Accuracy is ±0.05V

2.3.3 Heater

An on chip heating element can be switched on. It will increase the temperature of the sensor by approximately 5°C (9°F). Power consumption will increase by ~8mA @ 5V.
Applications:
By comparing temperature and humidity values before and after switching on the heater, proper functionality of both sensors can be verified.

- In high (>95%) RH environments heating the sensor element will prevent condensation, improve response time and accuracy

Warning: While heated the SHTxx will show higher temperatures and a lower relative humidity than with no heating.

2.4 Electrical Characteristics[1]

VDD=5V, Temperature= 25°C unless otherwise noted

Parameter	Conditions	Min.	Typ.	Max.	Units
Power supply DC		2.4	5	5.5	V
Supply current	measuring		550		µA
	average	2[2]	28[3]		µA
	sleep		0.3	1	µA
Low level output voltage		0		20%	Vdd
High level output voltage		75%		100%	Vdd
Low level input voltage	Negative going	0		20%	Vdd
High level input voltage	Positive going	80%		100%	Vdd
Input current on pads				1	µA
Output peak current	on			4	mA
	Tristated (off)		10		µA

Table 4 SHTxx DC Characteristics

	Parameter	Conditions	Min	Typ.	Max.	Unit
F_{SCK}	SCK frequency	VDD > 4.5 V			10	MHz
		VDD < 4.5 V			1	MHz
T_{RFO}	DATA fall time	Output load 5 pF	3.5	10	20	ns
		Output load 100 pF	30	40	200	ns
T_{CLx}	SCK hi/low time		100			ns
T_V	DATA valid time			250		ns
T_{SU}	DATA set up time		100			ns
T_{HO}	DATA hold time		0	10		ns
T_R/T_F	SCK rise/fall time			200		ns

Table 5 SHTxx I/O Signals Characteristics

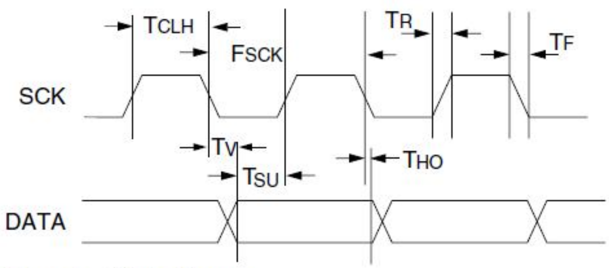


Figure 9 Timing Diagram

[1] Parameters are periodically sampled and not 100% tested
[2] With one measurement of 8 bit accuracy without OTP reload per second
[3] With one measurement of 12bit accuracy per second

3 Converting Output to Physical Values

3.1 Relative Humidity

To compensate for the non-linearity of the humidity sensor and to obtain the full accuracy it is recommended to convert the readout with the following formula[1]:

$$RH_{linear} = c_1 + c_2 \bullet SO_{RH} + c_3 \bullet SO_{RH}^{\ 2}$$

SO_{RH}	c_1	c_2	c_3
12 bit	-4	0.0405	$-2.8 * 10^{-6}$
8 bit	-4	0.648	$-7.2 * 10^{-4}$

Table 6 Humidity conversion coefficients

For simplified, less computation intense conversion formulas see application note "RH and Temperature Non-Linearity Compensation".

The humidity sensor has no significant voltage dependency.

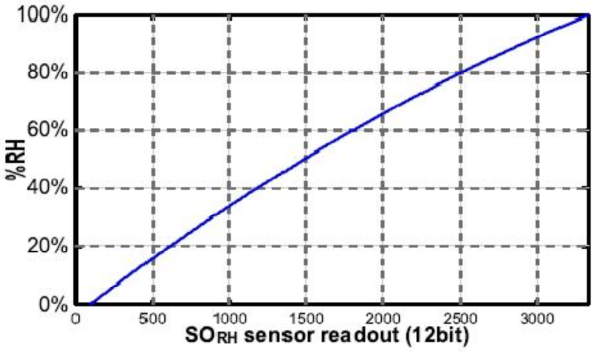


Figure 10 Conversion from SO_{RH} to relative humidity

3.1.1 Compensation of RH/Temperature dependency

For temperatures significantly different from 25°C (~77°F) the temperature coefficient of the RH sensor should be considered:

$$RH_{true} = (T_{°C} - 25) \bullet (t_1 + t_2 \bullet SO_{RH}) + RH_{linear}$$

SO_{RH}	t_1	t_2
12 bit	0.01	0.00008
8 bit	0.01	0.00128

Table 7 Temperature compensation coefficients

This equals ~0.12%RH / °C @ 50%RH

3.2 Temperature

The bandgap PTAT (Proportional To Absolute Temperature) temperature sensor is very linear by design. Use the following formula to convert from digital readout to temperature:

$$\text{Temperature} = d_1 + d_2 \bullet SO_T$$

VDD	d_1 [°C]	d_1 [°f]
5V	-40.00	-40.00
4V	-39.75	-39.50
3.5V	-39.66	-39.35
3V	-39.60	-39.28
2.5V	-39.55	-39.23

SO_T	d_2 [°C]	d_2 [°f]
14bit	0.01	0.018
12bit	0.04	0.072

Table 8 Temperature conversion coefficients

For improved accuracies in extreme temperatures with more computation intense conversion formulas see application note "RH and Temperature Non-Linearity Compensation".

3.3 Dewpoint

Since humidity and temperature are both measured on the same monolithic chip, the SHTxx allows superb dewpoint measurements. See application note "Dewpoint calculation" for more.

[1] Where SO_{RH} is the sensor output for relative humidity

4 Applications Information

4.1 Operating and Storage Conditions

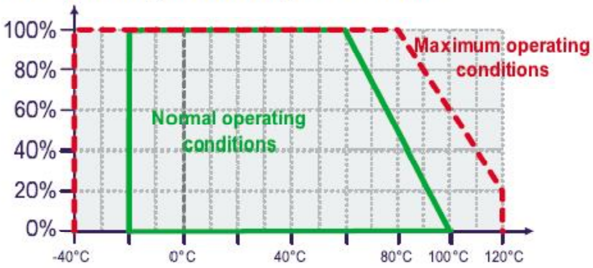


Figure 11 Recommended operating conditions

Conditions outside the recommended range may temporarily offset the RH signal up to ±3%RH. After return to normal conditions it will slowly return towards calibration state by itself. See 4.3 "Reconditioning Procedure" to accelerate this process. Prolonged exposure to extreme conditions may accelerate ageing.

4.2 Exposure to Chemicals

Vapors may interfere with the polymer layers used for capacitive humidity sensors. The diffusion of chemicals into the polymer may cause a shift in both offset and sensitivity. In a clean environment the contaminants will slowly outgas. The reconditioning procedure described below will accelerate this process.
High levels of pollutants may cause permanent damage to the sensing polymer.

4.3 Reconditioning Procedure

The following reconditioning procedure will bring the sensor back to calibration state after exposure to extreme conditions or chemical vapors.
80-90°C (176-194°F) at < 5%RH for 24h (baking) followed by
20-30°C (70-90°F) at > 74%RH for 48h (re-hydration)

4.4 Qualifications

Extensive tests were performed in various environments. Please contact SENSIRION for additional information.

Environment	Norm	Results(1)
Temperature Cycles	JESD22-A104-B -40°C / 125°C, 1000cy	Within Specifications
HAST Pressure Cooker	JESD22-A110-B 2.3bar 125°C 85%RH	Reversible shift by +2% RH
Salt Atmosphere	DIN-50021ss	Within Specifications
Freezing cycles fully submerged	-20 / +90°C, 100cy 30min dwell time	Reversible shift by +2% RH
Various Automotive Chemicals	DIN 72300-5	Within Specifications
Cigarette smoke	Equivalent to 15years in a mid-size car	Within Specifications

Table 9 Qualification tests (excerpt)

4.5 ESD (Electrostatic Discharge)

ESD immunity is qualified according to MIL STD 883E, method 3015 (Human Body Model at ±2kV)).
Latch-up immunity is provided at a force current of ±100 mA with T_{amb}=80°C according to JEDEC 17.
See application note "ESD, Latchup and EMC" for more information.

4.6 Temperature Effects

The relative humidity of a gas strongly depends on its temperature. It is therefore essential to keep humidity sensors at the same temperature as the air of which the relative humidity is to be measured.
If the SHTxx shares a PCB with electronic components that give off heat it should be mounted far away and below the heat source and the housing must remain well ventilated.
To reduce heat conduction copper layers between the SHT1x and the rest of the PCB should be minimized and a slit may be milled in between. (See figure 14)

4.7 Materials Used for Sealing / Mounting

Many materials absorb humidity and will act as a buffer, increasing response times and hysteresis. Materials in the vicinity of the sensor must therefore be carefully chosen. Recommended materials are:
All Metals, LCP, POM (Delrin), PTFE (Teflon), PE, PEEK, PP, PB, PPS, PSU, PVDF, PVF
For sealing and gluing (use sparingly):
high filled epoxy for electronic packaging (e.g. glob top, underfill), and Silicone are recommended.

4.8 Membranes

A membrane can be used to prevent dirt from entering the housing and to protect the sensor. It will also reduce peak concentrations of chemical vapors. For optimal response times air volume behind the membrane must be kept to a minimum.

4.9 Light

The SHTxx is not light sensitive. However prolonged direct exposure to sunshine or strong UV radiation may age the housing.

4.10 Wiring Considerations and Signal Integrity

Carrying the SCK and DATA signal parallel and in close proximity (e.g. in wires) for more than 10cm may result in cross talk and loss of communication. This may be resolved by routing VDD and/or GND between the two data signals.
Please see the application note "ESD, Latchup and EMC" for more information.

(1) The temperature sensor passed all tests without any detectable drift. Package and electronics also passed 100%

5 Package Information

5.1 SHT1x (surface mountable)

Pin	Name	Comment
1	GND	Ground
2	DATA	Serial data, bidirectional
3	SCK	Serial clock, input
4	VDD	Supply 2.4 – 5.5V
	NC	Remaining pins must be left unconnected

Table 10 SHT1x Pin Description

5.1.1 Package type

The SHT1x is supplied in a surface-mountable LCC (Leadless Chip Carrier) type package. The sensors housing consists of a Liquid Crystal Polymer (LCP) cap with epoxy glob top on a standard 0.8mm FR4 substrate. The device is free of lead, Cd and Hg.
Device size is 7.42 x 4.88 x 2.5 mm (0.29 x 0.19 x 0.1 inch)
Weight 100mg

The production date is printed onto the cap in white numbers in the form wwy. e.g. "351" = week 35, 2001.

5.1.2 Delivery Conditions

The SHT1x are shipped in standard IC tubes by 80 units per tube or in 12mm tape. Reels are individually labelled with barcode and human readable labels.

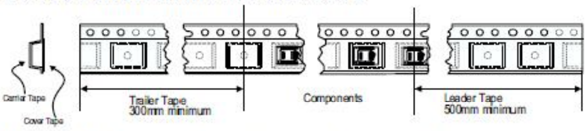


Figure 12 Tape configuration and unit orientation

5.1.3 Mounting Examples

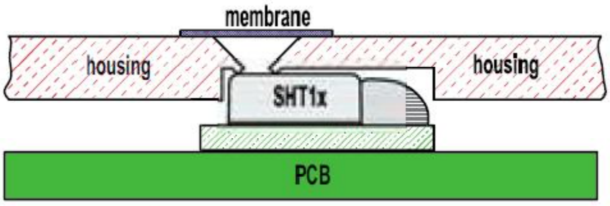


Figure 13 SHT1x housing mounting example

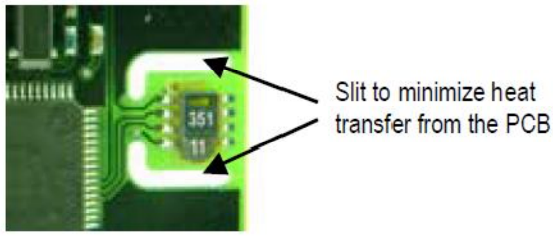


Figure 14 SHT1x PCB Mounting example

5.1.4 Soldering Information

Standard reflow soldering ovens may be used at maximum 235°C for 20 seconds.
For manual soldering contact time must be limited to 5 seconds at up to 350°C.
After soldering the devices should be stored at >74%RH for at least 24h to allow the polymer to rehydrate.
Please consult the application note "Soldering procedure" for more information.

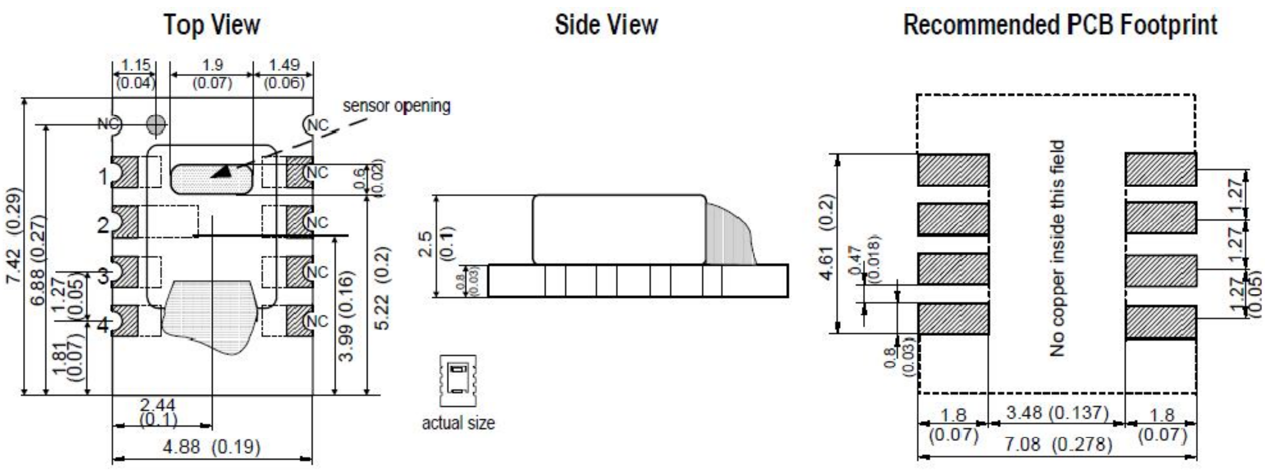


Figure 15 SHT1x drawing and footprint dimensions in mm (inch)

5.2 SHT7x (4-pin single-in-line)

Pin	Name	Comment
1	*SCK*	*Serial clock input*
2	*VDD*	*Supply 2.4 – 5.5V*
3	*GND*	*Ground*
4	*DATA*	*Serial data bidirectional*

Table 11 SHT7x Pin Description

5.2.1 Package type[1]

The device is supplied in a single-in-line pin type package. The sensor housing consists of a Liquid Crystal Polymer (LCP) cap with epoxy glob top on a standard 0.6mm FR4 substrate. The device is Cd and Hg free.

The sensor head is connected to the pins by a small bridge to minimize heat conduction and response times.

A 100nF capacitor is mounted on the back side between VDD and GND.

All pins are gold plated to avoid corrosion. They can be soldered or mate with most 1.27mm (0.05'') sockets e.g.: Preci-dip / Mill-Max 851-93-004-20-001 or similar

Total weight: 168mg, weight of sensor head: 73mg

The production date is printed onto the cap in white numbers in the form wwy. e.g. "351" = week 35, 2001.

5.2.2 Delivery Conditions

The SHT7x are shipped in 32mm tape. These reeled parts in standard option are shipped with 500 units per 13inch diameter reel. Reels are individually labelled with barcode and human readable labels.

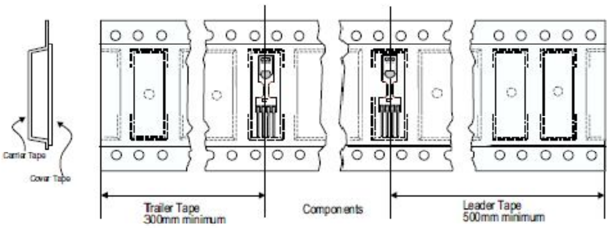


Figure 16 Tape configuration and unit orientation

5.2.3 Soldering Information

Standard wave SHT7x soldering ovens may be used at maximum 235°C for 20 seconds.

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

After wave soldering the devices should be stored at >74%RH for at least 24h to allow the polymer to rehydrate.

Please consult the application note "Soldering procedure" for more information.

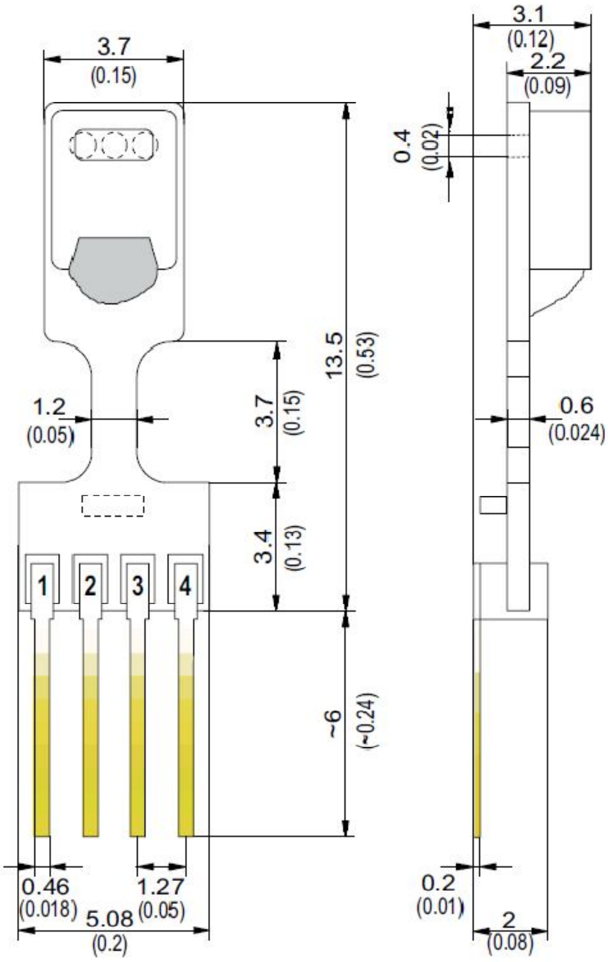


Figure 17 SHT7x dimensions in mm (inch)

[1] Other packaging options may be available on request.

DT-SENSE

Barometric Pressure & Temperature Sensor

1. PENDAHULUAN

DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR merupakan sebuah modul sensor cerdas berbasis sensor **HP03** yang dapat digunakan untuk mendeteksi besarnya tekanan dan temperatur udara di sekitar sensor. Keluaran **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR** berupa data digital yang sudah terkalibrasi penuh sehingga dapat dipakai langsung tanpa terlalu banyak perhitungan tambahan. Modul sensor ini dilengkapi dengan antarmuka UART TTL dan I^2C. Contoh aplikasi **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR** antara lain untuk sistem pengukuran dan kendali tekanan udara, sistem barometer/altimeter, produk-produk perkiraan cuaca, atau aplikasi-aplikasi lain yang menggunakan informasi tekanan udara dan temperatur.

1.1. SPESIFIKASI DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR

Spesifikasi DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR sebagai berikut:

- Sumber catu daya menggunakan tegangan **4,5 - 5,5 Volt**.
- *Range* sensor tekanan udara 300 - 1100 hpa (hectopascal)*.
- Akurasi sensor tekanan udara ± 1,5 hpa.
- Resolusi sensor tekanan udara 0,1 hpa.
- *Range* sensor temperatur -20 - 60 °C.
- Akurasi sensor temperatur ± 0,8 °C.
- Resolusi sensor temperatur 0,1 °C.
- Pin Input/Output kompatibel dengan level tegangan TTL dan CMOS.
- Dilengkapi dengan antarmuka UART TTL dan I^2C.
- Dilengkapi dengan *jumper* untuk pengaturan alamat, sehingga bisa di-*cascade* sampai 8 modul tanpa perangkat keras tambahan (untuk satu *master* menggunakan antarmuka I^2C).

* 1 hpa = 1 millibar

1.2. SISTEM YANG DIANJURKAN

Sistem yang dianjurkan untuk penggunaan DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR adalah:

Perangkat keras:

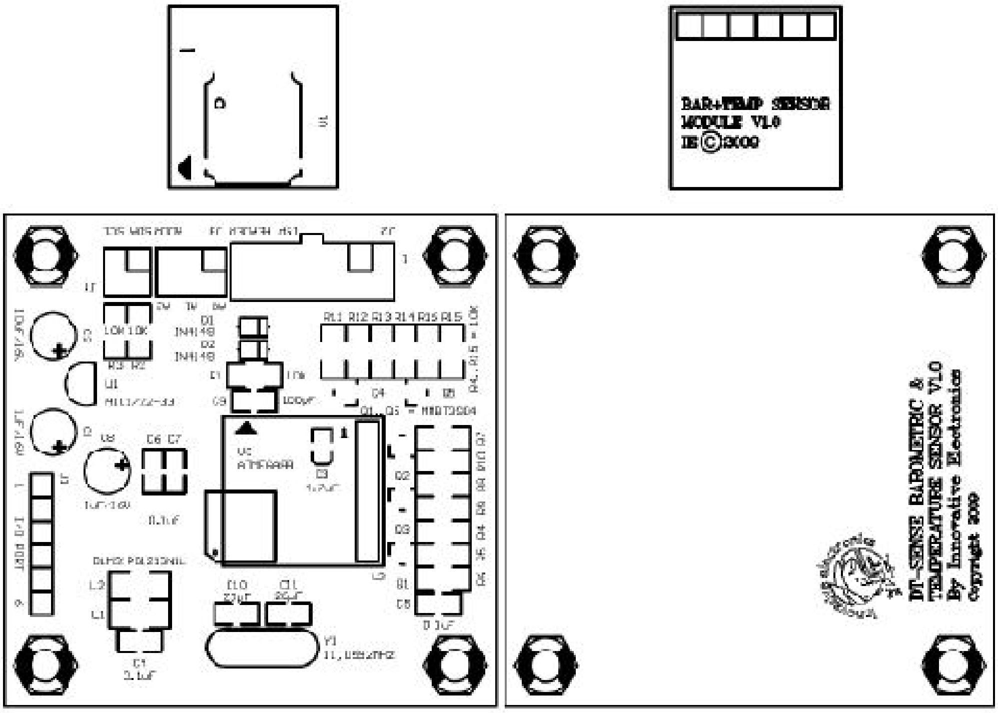
- PC™ AT™ Pentium® IBM™ Compatible dengan *port* Serial (COM1/COM2) dan Paralel (LPT) atau USB.
- DT-51 Minimum System, DT-51 Low Cost Series, atau DT-AVR Low Cost Series.
- CD-ROM Drive dan Hard disk.

Perangkat lunak:

- Sistem operasi Windows® 98 SE.
- BASCOM-8051®, BASCOM-AVR®, atau CodeVisionAVR®.
- *File* yang ada pada CD program:
  CONTOH_UART.PRJ, CONTOH_UART.C, CONTOH_I2C.PRJ, CONTOH I2C.C, MANUAL DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR, dan QUICK START DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR.

2. PERANGKAT KERAS DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR

2.1. TATA LETAK KOMPONEN DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR

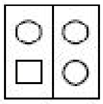
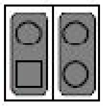


2.2. KONEKTOR DAN PENGATURAN JUMPER

Konektor I/O PORT (J1) berfungsi sebagai konektor untuk catu daya modul, antarmuka UART TTL, dan antarmuka I^2C.

Pin	Nama	Fungsi
1	GND	Titik referensi untuk catu daya input
2	VCC	Terhubung ke catu daya (4,8 - 5,5 Volt)
3	RXD	Input serial level TTL ke modul
4	TXD	Output serial level TTL dari modul
5	MAIN SDA	I^2C-bus data input / output
6	MAIN SCL	I^2C-bus clock input

Jumper PULL-UP SDA SCL (J4) berfungsi untuk mengaktifkan resistor *pull-up* untuk pin SDA dan SCL pada antarmuka I^2C.

Jumper **PULL-UP SDA SCL J4**	**Fungsi**
1 	*Pull-up* tidak aktif (*jumper* terlepas)
1 	*Pull-up* aktif (*jumper* terpasang)

Penting !
Apabila lebih dari satu modul dihubungkan pada I^2C-bus maka *jumper* J4 (SCL/SDA) salah satu modul saja yang perlu dipasang.

Jumper ADDR (J3) berfungsi untuk mengatur alamat I^2C dari modul DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR.

J3 (A2) Pin 5-6	**J3 (A1) Pin 3-4**	**J3(A0) Pin 1-2**	**Alamat I^2C**	
			Alamat Tulis I^2C	**Alamat Baca I^2C**
■	■	■	E0H	E1H
■	■		E2H	E3H
■		■	E4H	E5H
■			E6H	E7H
	■	■	E8H	E9H
	■		EAH	EBH
		■	ECH	EDH
			EEH	EFH

Keterangan:
■ : *jumper* terpasang

3. PERANGKAT LUNAK DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR

DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR memiliki antarmuka UART TTL dan I^2C yang dapat digunakan untuk menerima perintah atau mengirim data.

3.1. ANTARMUKA UART TTL

Parameter komunikasi UART TTL adalah sebagai berikut:

- 38400 bps
- 8 data bit
- 1 stop bit
- tanpa *parity* bit
- tanpa ***flow control***

Semua perintah yang dikirim melalui antarmuka **UART TTL** dimulai dengan mengirim 1 byte data yang berisi **<nomor perintah>** dan (jika diperlukan) 1 byte data parameter perintah.

Jika perintah yang telah dikirimkan merupakan perintah yang meminta data dari modul **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR**, maka **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR** akan mengirimkan data melalui jalur **TX TTL**.

Sebuah data parameter yang memiliki *range* lebih besar dari 255 desimal (lebih besar dari 1 byte) dikirim/diterima secara dua tahap. Satu byte data **MSB** dikirim/diterima lebih dahulu kemudian diikuti dengan data **LSB**. Misalnya parameter <P16bit> yang memiliki *range* 3000 - 11000. Jika <P16bit> bernilai 1234 maka byte MSB yang dikirim/diterima adalah 4 dan byte LSB yang dikirim/diterima adalah 210 ((4*256) + 210 = 1234).

Perintah dan parameter yang bisa digunakan dapat dilihat pada **bagian 3.3**.

3.2. ANTARMUKA I^{2}C

Modul **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR** memiliki antarmuka I^{2}C. Pada antarmuka I^{2}C ini, modul **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR** bertindak sebagai *slave* dengan alamat sesuai dengan telah ditentukan sebelumnya melalui pengaturan *jumper* (lihat **bagian 2.2**). Antarmuka I^{2}C pada modul **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR** mendukung *bit rate* sampai dengan maksimum 100 kHz.

Semua perintah yang dikirim melalui antarmuka I^{2}C diawali dengan ***start condition*** dan kemudian diikuti dengan pengiriman 1 byte alamat modul **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR**. Setelah pengiriman alamat, selanjutnya *master* harus mengirim 1 byte data yang berisi **<nomor perintah>** dan (jika diperlukan) 1 byte data parameter perintah. Selanjutnya, setelah seluruh parameter perintah telah dikirim, urutan perintah diakhiri dengan ***stop condition***.

Berikut urutan yang harus dilakukan untuk mengirimkan perintah melalui antarmuka I^{2}C.

Start +

1	1	1	0	X	X	X	0

\+

Alamat Tulis

X	X	X	X	X	X	X	X

Command

\+

X	X	X	X	X	X	X	X

Parameter (jika ada)

\+

Stop

Jika perintah yang telah dikirimkan merupakan perintah yang meminta data dari modul **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR**, maka data-data tersebut dapat dibaca dengan menggunakan urutan perintah baca. Berikut urutan yang harus dilakukan untuk membaca data dari **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR**.

Start | 1 | 1 | 1 | 0 | X | X | X | 1 |

Alamat Baca

| X | X | X | X | X | X | X | X | + Stop

Data (jika ada)

Sebuah data parameter yang memiliki *range* lebih besar dari 255 desimal (lebih besar dari 1 byte) dikirim/diterima secara dua tahap. Satu byte data MSB dikirim/diterima lebih dahulu kemudian diikuti dengan data LSB. Misalnya parameter <P16bit> yang memiliki *range* 3000 - 11000. Jika <P16bit> bernilai 1234 maka byte MSB yang dikirim/diterima adalah 4 dan byte LSB yang dikirim/diterima adalah 210 ((4*256) + 210 = 1234).

Perintah dan parameter yang bisa digunakan dapat dilihat pada **bagian 3.3.**

3.3. COMMAND SET

Berikut ini daftar lengkap perintah-perintah dalam antarmuka UART dan I^2C.

3.3.1. GET PRESSURE DATA

Fungsi	Untuk membaca data tekanan udara
Command	**00H**
Parameter	-
Respon	<P16bit> 3000 - 11000 → data tekanan dalam satuan 0,1 hpa. *Range* data tekanan untuk perintah ini adalah 300,0 - 1100,0 hpa.
Delay antara Command dan Respon	15 ms
Keterangan	• Setelah ***power-up***, tunggu 250 ms sebelum mengirimkan perintah ini (agar data sensor stabil).

Contoh dengan antarmuka UART:

User : 00H

DT-SENSE : <P16bit MSB> <P16bit LSB>

Tekanan = (P16bitMSB*256 + P16bitLSB) / 10 (dalam satuan hpa)

Berikut ini contoh ***pseudo code*** **C** untuk menggunakan perintah ini dengan antarmuka I^2C (misalkan alamat I^2C = E0H):

```
i2c_start();            // Start Condition
i2c_write(0xE0);        // Tulis ke modul BAROMETRIC PRESSURE
i2c_write(0x00);        // Perintah "Get Pressure Data"
i2c_stop();             // Stop Condition

delay_ms(15);           // delay 15 ms

i2c_start();            // Start Condition
i2c_write(0xE1);        // Baca ke modul BAROMETRIC PRESSURE
temp1 = i2c_read(1);    // tekanan MSB
```

```
temp2 = i2c_read(0); // tekanan LSB
i2c_stop();          // Stop Condition
```

Tekanan = (temp1*256 + temp2) / 10 (dalam satuan hpa)

3.3.2. GET TEMPERATURE DATA

Fungsi	Untuk membaca data temperatur
Command	01H
Parameter	-
Respon	<T16bit> 0 - 800 → data temperatur + *offset* 200, dalam satuan 0,1 °C. *Range* data temperatur untuk perintah ini adalah -20,0 - 60,0 °C.
Delay antara Command dan Respon	15 ms
Keterangan	• Setelah *power-up*, tunggu 250 ms sebelum mengirimkan perintah ini (agar data sensor stabil). • Nilai T16bit adalah nilai temperatur sesungguhnya yang sudah ditambah 200. Untuk mendapatkan data temperatur sesungguhnya, nilai tersebut harus dikurangi 200 lalu dibagi 10.

Contoh dengan antarmuka UART:

User : 01H

DT-SENSE : <T16bit MSB> <T16bit LSB>

Temperatur = ((T16bitMSB*256 + T16bitLSB) - 200) / 10 (dalam satuan °C)

Berikut ini contoh *pseudo code* C untuk menggunakan perintah ini dengan antarmuka I^2C (misalkan alamat I^2C = E0H):

```
i2c_start();         // Start Condition
i2c_write(0xE0);     // Tulis ke modul BAROMETRIC PRESSURE
i2c_write(0x01);     // Perintah "Get Temperature Data"
i2c_stop();          // Stop Condition

delay_ms(15);        // delay 15 ms

i2c_start();         // Start Condition
i2c_write(0xE1);     // Baca ke modul BAROMETRIC PRESSURE
temp1 = i2c_read(1); // temperatur MSB
temp2 = i2c_read(0); // temperatur LSB
i2c_stop();          // Stop Condition
```

Temperatur = ((temp1*256 + temp2) - 200) / 10 (dalam satuan °C)

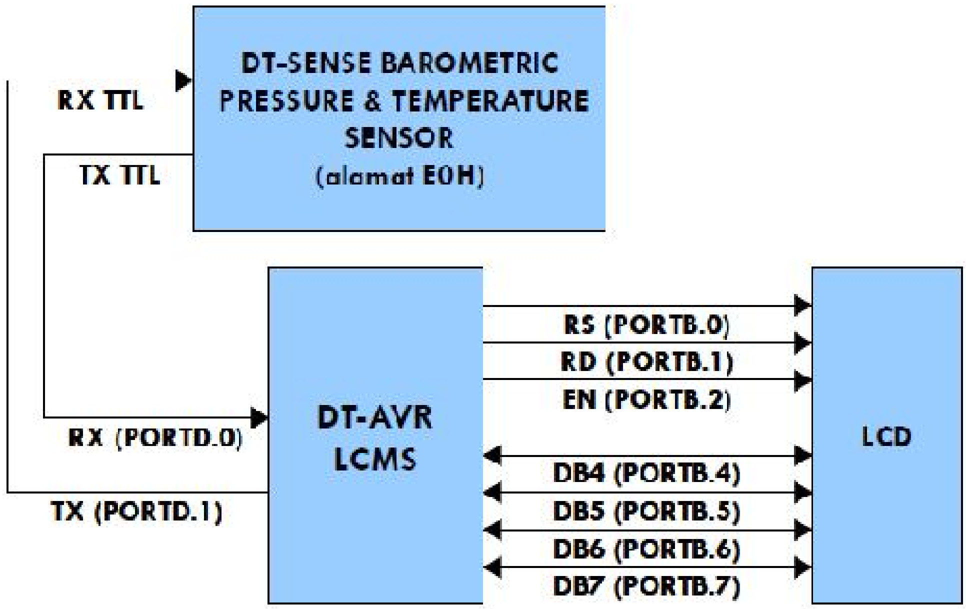
4. PROSEDUR PENGUJIAN

1. Hubungkan sumber catu daya **5** Volt ke modul **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR.**
2. Kirimkan perintah "Get Pressure Data" melalui antarmuka **UART TTL.**
3. Modul **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR** akan mengambil data tekanan melalui sensor **HP03** dan mengirimkan hasilnya melalui antarmuka **UART TTL.** Untuk ketinggian normal (di atas permukaan tanah dataran rendah), data tekanan bernilai sekitar **1000,0 - 1030,0** hpa.

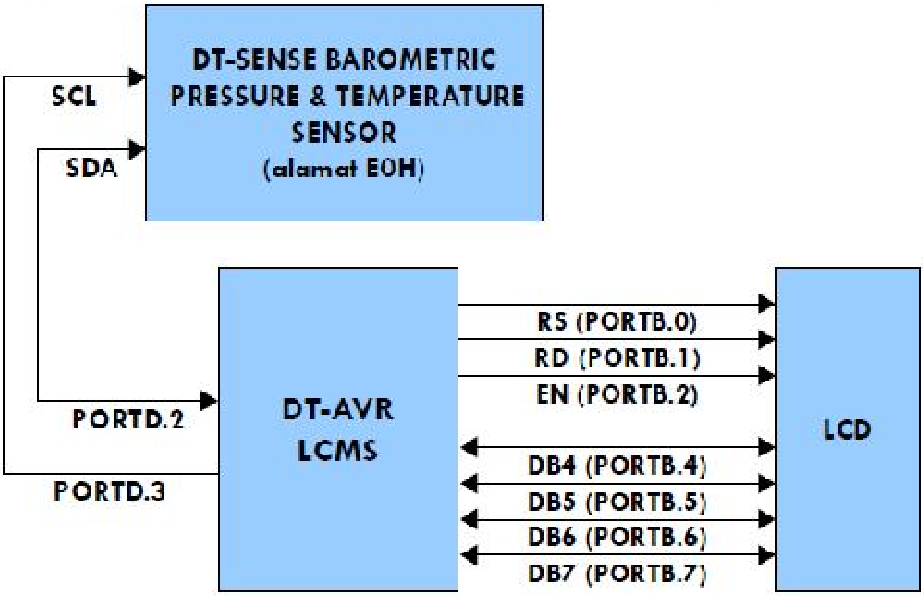
5. CONTOH APLIKASI DAN PROGRAM

Sebagai contoh aplikasi, misalkan modul **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR** digunakan untuk memantau temperatur dan tekanan udara dalam sebuah ruangan dengan antarmuka **UART** atau dengan antarmuka I^2C. Master yang akan mengirimkan perintah pembacaan dan menampilkan ke **LCD** karakter 16x2 digunakan modul **DT-AVR** Low Cost Micro System **(LCMS)** dengan mikrokontroler ATmega**8535.** Pada contoh aplikasi ini, **DT-AVR LCMS** akan mengirimkan perintah baca tekanan dan baca temperatur ke **DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR** (alamat I^2C = **E0H**). Setelah data tekanan dan data temperatur diperoleh, maka **DT-AVR LCMS** akan menampilkannya data tersebut di LCD. Kemudian **DT-AVR LCMS** menunggu selama 250 ms sebelum mengulangi seluruh proses pemantauan kembali.

Sebagai contoh program untuk aplikasi di atas, pada CD yang disertakan pada saat pembelian modul DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR disertakan contoh program contoh_uart.c dan contoh_i2c.c yang ditulis dengan menggunakan CodeVisionAVR 1.25.2 versi evaluasi. Untuk menggunakan antarmuka UART pada contoh program contoh_uart.c, maka koneksi antara modul DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR dan modul DT-AVR LCMS adalah sebagai berikut:



Sedangkan untuk menggunakan antarmuka I^2C pada contoh program contoh_i2c.c, maka koneksi antara modul DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR dan modul DT-AVR LCMS adalah sebagai berikut:



Features

- High-performance, Low-power AVR® 8-bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single-clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16 MHz
  - On-chip 2-cycle Multiplier
- Nonvolatile Program and Data Memories
  - 16K Bytes of In-System Self-Programmable Flash
    Endurance: 10,000 Write/Erase Cycles
  - Optional Boot Code Section with Independent Lock Bits
    In-System Programming by On-chip Boot Program
    True Read-While-Write Operation
  - 512 Bytes EEPROM
    Endurance: 100,000 Write/Erase Cycles
  - 1K Byte Internal SRAM
  - Programming Lock for Software Security
- JTAG (IEEE std. 1149.1 Compliant) Interface
  - Boundary-scan Capabilities According to the JTAG Standard
  - Extensive On-chip Debug Support
  - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Four PWM Channels
  - 8-channel, 10-bit ADC
    8 Single-ended Channels
    7 Differential Channels in TQFP Package Only
    2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
  - Byte-oriented Two-wire Serial Interface
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated RC Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
- I/O and Packages
  - 32 Programmable I/O Lines
  - 40-pin PDIP, 44-lead TQFP, and 44-pad MLF
- Operating Voltages
  - 2.7 - 5.5V for ATmega16L
  - 4.5 - 5.5V for ATmega16
- Speed Grades
  - 0 - 8 MHz for ATmega16L
  - 0 - 16 MHz for ATmega16

8-bit AVR® Microcontroller with 16K Bytes In-System Programmable Flash

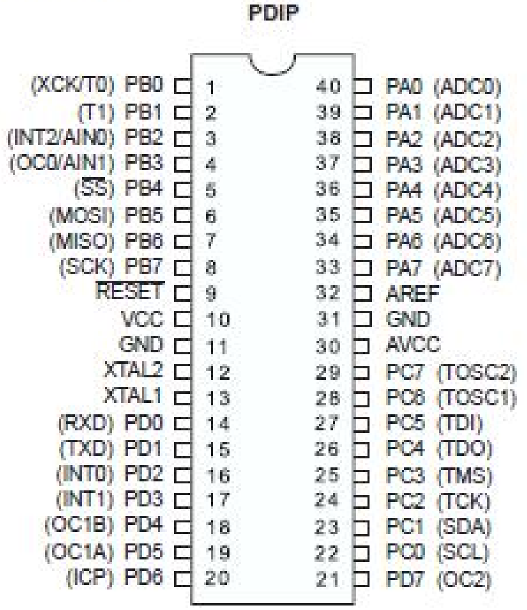
ATmega16
ATmega16L

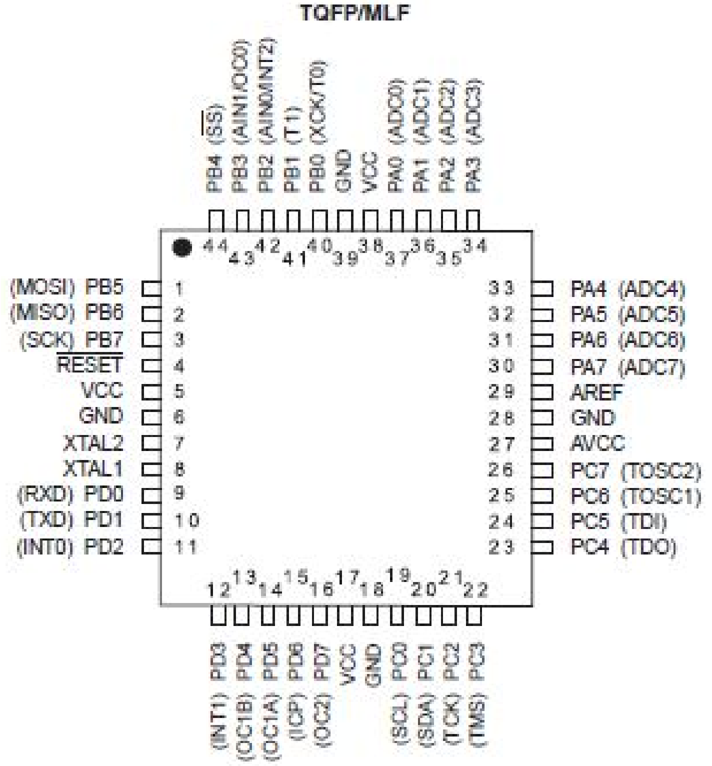
Preliminary

Rev. 2466E–AVR–10/02

Pin Configurations

Figure 1. Pinouts ATmega16





Disclaimer

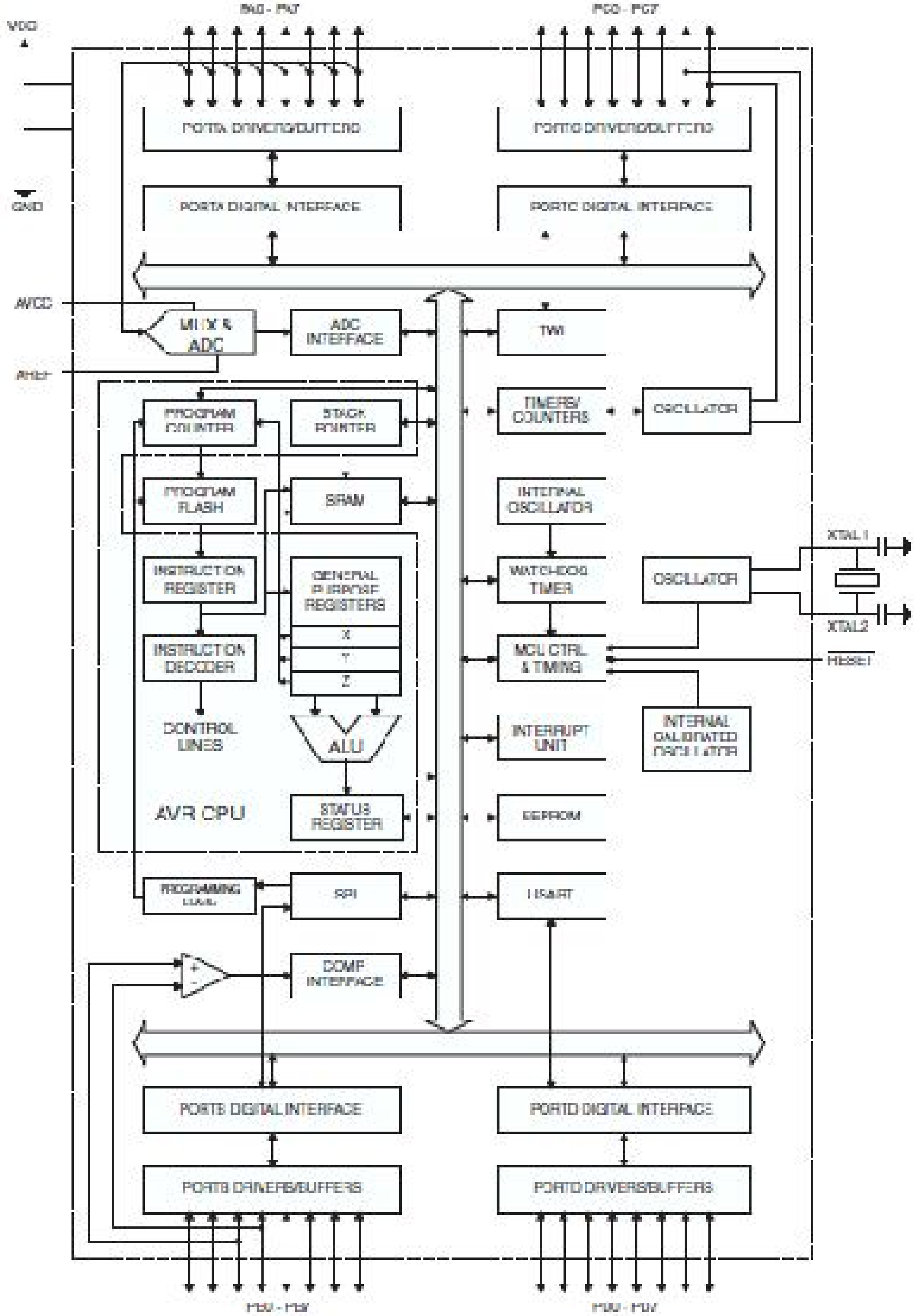
Typical values contained in this data sheet are based on simulations and characterization of other AVR microcontrollers manufactured on the same process technology. Min and Max values will be available after the device is characterized.

Overview

The ATmega16 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega16 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

Block Diagram

Figure 2. Block Diagram



The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega16 provides the following features: 16K bytes of In-System Programmable Flash Program memory with Read-While-Write capabilities, 512 bytes EEPROM, 1K byte SRAM, 32 general purpose I/O lines, 32 general purpose working registers, a JTAG interface for Boundary-scan, On-chip Debugging support and programming, three flexible Timer/Counters with compare modes, Internal and External Interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain (TQFP package only), a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the USART, Two-wire interface, A/D Converter, SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next External Interrupt or Hardware Reset. In Power-save mode, the Asynchronous Timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. In Extended Standby mode, both the main Oscillator and the Asynchronous Timer continue to run.

The device is manufactured using Atmel's high density nonvolatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed in-system through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core. The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega16 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

The ATmega16 AVR is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, in-circuit emulators, and evaluation kits.

Pin Descriptions

VCC

Digital supply voltage.

GND

Ground.

Port A (PA7..PA0)

Port A serves as the analog inputs to the A/D Converter.

Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B (PB7..PB0)

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B also serves the functions of various special features of the ATmega16 as listed on page 55.

Port C (PC7..PC0)

Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PC5(TDI), PC3(TMS) and PC2(TCK) will be activated even if a reset occurs.

Port C also serves the functions of the JTAG interface and other special features of the ATmega16 as listed on page 58.

Port D (PD7..PD0)

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port D also serves the functions of various special features of the ATmega16 as listed on page 60.

$\overline{\text{RESET}}$

Reset Input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The minimum pulse length is given in Table 15 on page 35. Shorter pulses are not guaranteed to generate a reset.

XTAL1

Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2

Output from the inverting Oscillator amplifier.

AVCC

AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to V_{CC}, even if the ADC is not used. If the ADC is used, it should be connected to V_{CC} through a low-pass filter.

AREF

AREF is the analog reference pin for the A/D Converter.

About Code Examples

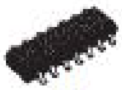
This documentation contains simple code examples that briefly show how to use various parts of the device. These code examples assume that the part specific header file is included before compilation. Be aware that not all C Compiler vendors include bit definitions in the header files and interrupt handling in C is compiler dependent. Please confirm with the C Compiler documentation for more details.

HEX INVERTER

- MEDIUM-SPEED OPERATION
  – t_{PHL}, t_{PLH} = 30ns (typ.) AT 10V
- QUIESCENT CURRENT SPECIFIED TO 20V FOR HCC DEVICE
- STANDARDIZED SYMMETRICAL OUTPUT CHARACTERISTICS
- 5V, 10V, AND 15V PARAMETRIC RATINGS
- INPUT CURRENT OF 100nA AT 18V AND 25°C FOR HCC DEVICE
- 100% TESTED FOR QUIESCENT CURRENT
- MEETS ALL REQUIREMENTS OF JEDEC TENTATIVE STANDARD N° 13A, "STANDARD SPECIFICATIONS FOR DESCRIPTION OF "B" SERIES CMOS DEVICES"

EY
(Plastic Package)

F
(Ceramic Frit Seal Package)

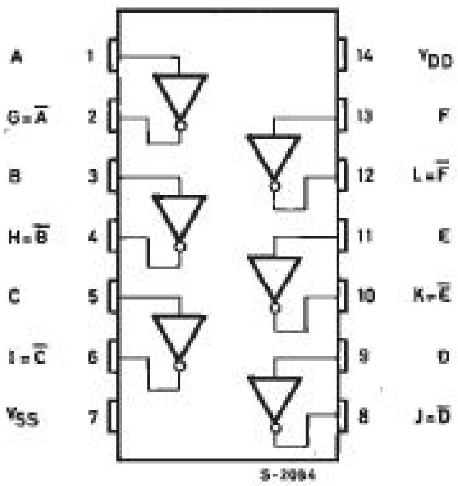


M1
(Micro Package)

C1
(Plastic Chip Carrier)

ORDER CODES :
HCC4069UBF HCF4069UBM1
HCF4069UBEY HCF4069UBC1

PIN CONNECTIONS



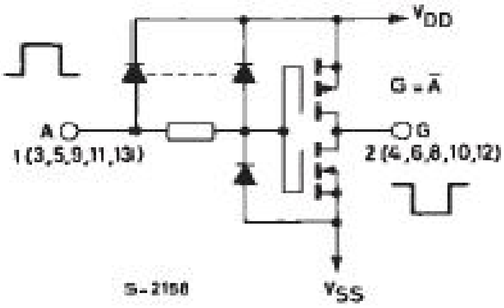
DESCRIPTION

The **HCC4069UB** (extended temperature range) and **HCF4069UB** (intermediate temperature range) are monolithic integrated circuit, available in 14-lead dual in-line plastic or ceramic package and plastic micro package.

The **HCC/HCF4069UB** consists of six COS/MOS inverter circuits. This device is intended for all general-purpose inverter applications where the medium-power TTL-drive and logic-level-conversion capabilities of circuits such as **HCC/HCF4049B** Hex Inverter/Buffers are not required.

June 1989

SCHEMATIC DIAGRAM OF ONE OF SIX IDENTICAL INVERTERS.



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DD}*	Supply Voltage : HCC Types HCF Types	– 0.5 to + 20 – 0.5 to + 18	V V
V_i	Input Voltage	– 0.5 to V_{DD} + 0.5	V
I_i	DC Input Current (any one input)	± 10	mA
P_{tot}	Total Power Dissipation (per package) Dissipation per Output Transistor for Top = Full Package-temperature Range	200 100	mW mW
T_{op}	Operating Temperature : HCC Types HCF Types	– 55 to + 125 – 40 to + 85	°C °C
T_{stg}	Storage Temperature	– 65 to + 150	°C

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for external periods may affect device reliability.
* All voltage values are referred to V_{SS} pin voltage.

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Value	Unit
V_{DD}	Supply Voltage : HCC Types HCF Types	3 to 18 3 to 15	V V
V_I	Input Voltage	0 to V_{DD}	V
T_{op}	Operating Temperature : HCC Types HCF Types	– 55 to + 125 – 40 to + 85	°C °C

STATIC ELECTRICAL CHARACTERISTICS (over recommended operating conditions)

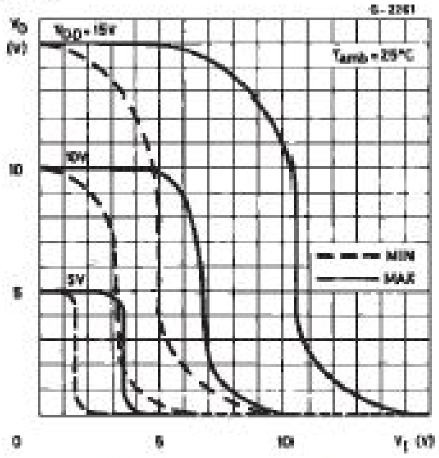
Symbol	Parameter		Test Conditions				Value							Unit
			V_I (V)	V_O (V)	$\|I_O\|$ (μA)	V_{DD} (V)	T_{Low}* Min.	T_{Low}* Max.	25°C Min.	25°C Typ.	25°C Max.	T_{High}* Min.	T_{High}* Max.	
I_L	Quiescent Current	HCC Types	0/ 5			5		0.25		0.01	0.25		7.5	μA
			0/10			10		0.5		0.01	0.5		15	
			0/15			15		1		0.01	1		30	
			0/20			20		5		0.02	5		150	
		HCF Types	0/ 5			5		1		0.01	1		7.5	
			0/10			10		2		0.01	2		15	
			0/15			15		4		0.01	4		30	
V_{OH}	Output High Voltage		0/ 5		< 1	5	4.95		4.95			4.95		V
			0/10		< 1	10	9.95		9.95			9.95		
			0/15		< 1	15	14.95		14.95			14.95		
V_{OL}	Output Low Voltage		5/0		< 1	5		0.05			0.05		0.05	V
			10/0		< 1	10		0.05			0.05		0.05	
			15/0		< 1	15		0.05			0.05		0.05	
V_{IH}	Input High Voltage			0.5/4.5	< 1	5	4		4			4		V
				1/9	< 1	10	8		8			8		
				1.5/13.5	< 1	15	12.5		12.5			12.5		
V_{IL}	Input Low Voltage			4.5/0.5	< 1	5		1			1		1	V
				9/1	< 1	10		2			2		2	
				13.5/1.5	< 1	15		2.5			2.5		2.5	
I_{OH}	Output Drive Current	HCC Types	0/ 5	2.5		5	– 2		– 1.6	– 3.2		– 1.15		mA
			0/ 5	4.6		5	– 0.64		– 0.51	– 1		– 0.36		
			0/10	9.5		10	– 1.6		– 1.3	– 2.6		– 0.9		
			0/15	13.5		15	– 4.2		– 3.4	– 6.8		– 2.4		
		HCF Types	0/ 5	2.5		5	– 1.53		– 1.36	– 3.2		– 1.1		
			0/ 5	4.6		5	– 0.52		– 0.44	– 1		– 0.36		
			0/10	9.5		10	– 1.3		– 1.1	– 2.6		– 0.9		
			0/15	13.5		15	– 3.6		– 3.0	– 6.8		– 2.4		
I_{OL}	Output Sink Current	HCC Types	0/ 5	0.4		5	0.64		0.51	1		0.36		mA
			0/10	0.5		10	1.6		1.3	2.6		0.9		
			0/15	1.5		15	4.2		3.4	6.8		2.4		
		HCF Types	0/ 5	0.4		5	0.52		0.44	1		0.36		
			0/10	0.5		10	1.3		1.1	2.6		0.9		
			0/15	1.5		15	3.6		3.0	6.8		2.4		
I_{IH}, I_{IL}	Input Leakage Current	HCC Types	0/18	Any Input		18		± 0.1		$\pm 10^{-5}$	± 0.1		± 1	μA
		HCF Types	0/15	Any Input		15		± 0.3		$\pm 10^{-5}$	± 0.3		± 1	
C_I	Input Capacitance			Any Input						5	7.5			pF

* T_{Low} = – 55°C for HCC device : – 40°C for HCF device.
* T_{High} = + 125°C for HCC device : + 85°C for HCF device.
The Noise Margin for both "1" and "0" level is : 1V min. with V_{DD} = 5V, 2V min. with V_{DD} = 10V, 2.5V min. with V_{DD} = 15V.

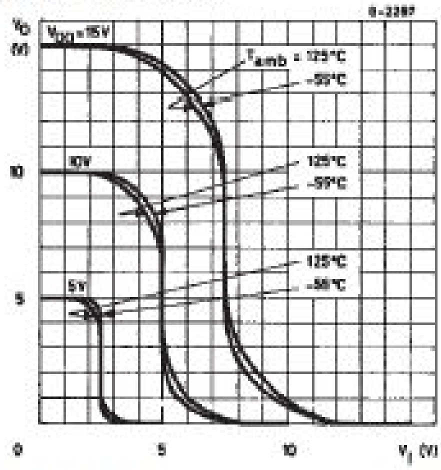
DYNAMIC ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C, C_L = 50pF, R_L = 200kΩ, typical temperature coefficient for all V_{DD} = 0.3%/°C values, all input rise and fall time = 20ns)

Symbol	Parameter	Test Conditions		Value			Unit
			V_{DD} (V)	Min.	Typ.	Max.	
t_{PLH}, t_{PHL}	Propagation Delay Time		5		55	110	ns
			10		30	60	
			15		25	50	
t_{TLH}, t_{THL}	Transition Time		5		100	200	ns
			10		50	100	
			15		40	80	

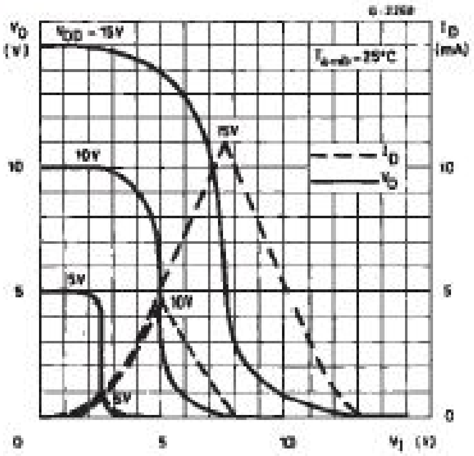
Minimum and Maximum Voltage Transfer Characteristics.



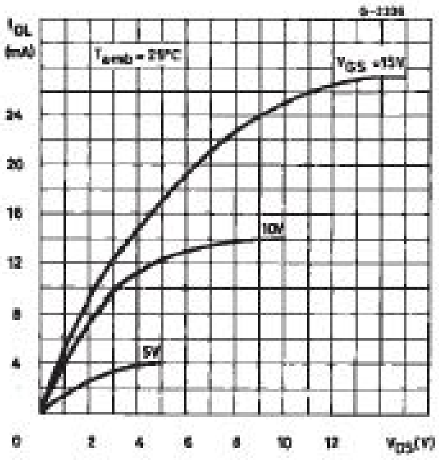
Typical Voltage Transfer Characteristics as a Function of Temperature.



Typical Current and Voltage Transfer Characteristics.

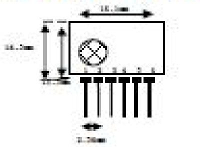


Typical Output Low (sink) Current Characteristics.



Easy-Link Wireless

TLP-434 Transmitter



pin 1 : Vcc
pin 2 : Vcc
pin 3 : Gnd
pin 4 : Gnd
pin 5 : RF Output
pin 6 : Digital Data Input

Frequency 315, 418 and 433.92MHz

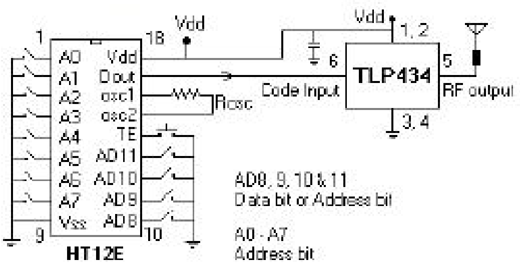
Modulation : ASK
Operation Voltage : 2 - 12 VDC
RF Output Power max : 8mW

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Vcc	Operating supply voltage		2.0	-	12.0	V
Icc	Peak Current		-	5	-	mA
Vh	Input High Voltage	Idata= 100uA (High)	Vcc-0.5	Vcc	Vcc+0.5	V
Vl	Input Low Voltage	Idata= 0 uA (Low)	-	-	0.3	V
FO	Absolute Frequency	315Mhz module	314.8	315	315.2	MHz
	Relative To 433.92MHz			+/-150	+/-200	KHz
PO	RF Output Power- 50ohm	Vcc = 9V to 12V	-	14	-	dBm
		Vcc = 5V to 6V	-	16	-	dBm
DR	Data Rate	External Encoding	-	2.4K	3K	bps

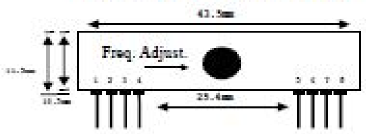
Notes : (Case Temperature = 25°C +- 2°C , Test Load Impedance = 50 ohm)

Application Circuit I:

Typical Key-chain Transmitter using HT12E-18DIP, a Binary 12 bit Encoder from Holtek Semiconductor Inc.



RLP-434 Receiver



pin 1 : Gnd
pin 2 : Digital Data Output
pin 3 : Linear Output
pin 4 : Vcc
pin 5 : Vcc
pin 6 : Gnd
pin 7 : Gnd
pin 8 : Antenna (About 30 - 35 cm)

Frequency 315, 418 and 433.92MHz

Modulation : ASK
Supply Voltage : 4.5 - 5.5 VDC
Output : Digital & Linear
Sensitivity : 3uVrms

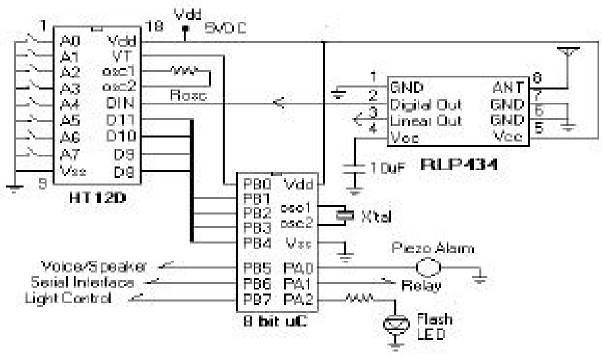
Symbol	Parameter	Conditions	Min	Typ	Max	
Vcc	Operating supply voltage		4.5	5	5.5	V
Itot	Operating Current		-	3.5	4.5	mA
Vdata	Data Out	Idata = +200 uA (High)	Vcc-0.5	-	Vcc	V
		Idata = -10 uA (Low)	-	-	0.3	V

Electrical Characteristics

Characteristics	SYM	Min	Typ	Max	Unit
Operation Radio Frequency	FC	315, 418 and 434			MHz
Sensitivity	Pref	-100	-103	-106	dBm
Channel Width			+-1.5		Khz
Receiver Turn On Time			5		ms
Noise equivalent BW	NEB		4		Khz
Baseboard Data Rate			3	5	Khz

Application Circuit II:

Typical RF Receiver using HT12D-18DIP, a Binary 12 bit Decoder with 8 bit uC HT48RXX from Holtek Semiconductor Inc.



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105 West Beaver Creek Rd. Unit 207 Richmond Hill Ontario L4B 1C6 Canada
Tel: (905)762-1228 Fax: (905)770-6143 e-mail: info@laipac.com