LAMPIRAN A
FOTO ALAT MONITORING KONDISI GUNUNG BERAPI NIKRABEL
LAMPIRAN B
SKEMATIK MODUL PENGIRIM DAN PENERIMA
SKEMATIK PENERIMA
LAMPIRAN C
PROGRAM PADA PENGONTROL MIKRO
ATMEGA16
Program Mikrokontroler Pengirim

' Program Pembaca Suhu, Kelembaban, Tekanan dan Getaran
' Kirim via Wireless

$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

Declare Sub Getit()
Ddrb = &B11111111
  'all Port B Output
Ddra = &B00000000

Config Pinb.0 = Output
Config Pinb.1 = Output
  'sck
'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
  Suh = X / 32
  Hasil = X - 32
  Suh = 5 / 9
  Hasilsuhu = Hasil * Suh
  Dis = Fusing(hasilsuhu , "###.###")
  Suhustring = Fusing(hasilsuhu , "###.#")
Command = &B00000101 ;

Kelembaban

Call Getit

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
Di5 = Fusing(rhlintemp , "##.##")
Kelembabansring = Fusing(rhlintemp , "##.##")

--

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

--

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

C-4
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 Pengukur

Print A data tsb

Loop

End

'Tunggu data dari

'Kirim kekomputer
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;

dat, 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);
  end;
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;
end;

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

  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;
bntsimpan.enabled:=false;
bntberhenti.enabled:=true;
end;

procedure TForm1.BTNberhentiClick(Sender: TObject);
begin
  SimpanGetar:=false;
bntberhenti.enabled:=false;
bntsimpan.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
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MODUL RF TLP-RLP 315 ......................................................................... E-27
--------------------------------------------------------------------------
SHT1x / SHT7x
Humidity & Temperature Sensor

- 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

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Humidity accuracy</th>
<th>Temperature accuracy</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHT11</td>
<td>±3.5% RH</td>
<td>±0.5°C @ 25°C</td>
<td>SMT (LCC)</td>
</tr>
<tr>
<td>SHT15</td>
<td>±2.0% RH</td>
<td>±0.4°C</td>
<td>SMT (LCC)</td>
</tr>
<tr>
<td>SHT71</td>
<td>±3.5% RH</td>
<td>±0.5°C @ 25°C</td>
<td>4-pin single-in-line</td>
</tr>
<tr>
<td>SHT75</td>
<td>±2.0% RH</td>
<td>±0.4°C</td>
<td>4-pin single-in-line</td>
</tr>
</tbody>
</table>

www.sensirion.com  Sensirion, Eggbühlstr. 14, 8052 Zurich, Switzerland, Tel. +41 1 306 40 00, Fax. +41 1 306 40 30  v2.0

E-1
1 Sensor Performance Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution</td>
<td></td>
<td>0.5</td>
<td>0.03</td>
<td>0.03</td>
<td>% RH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>12</td>
<td>12</td>
<td>bit</td>
</tr>
<tr>
<td>Repeatability</td>
<td></td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.1</td>
<td>% RH</td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td>linearized</td>
<td>see figure 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertainty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interchangeability</td>
<td></td>
<td>Fully interchangeable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonlinearity</td>
<td></td>
<td>raw data</td>
<td>±3</td>
<td>% RH</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>linearized</td>
<td>&lt;1</td>
<td>% RH</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>% RH</td>
</tr>
<tr>
<td>Response time</td>
<td></td>
<td>1/c  (63%)</td>
<td>4</td>
<td>s</td>
<td></td>
</tr>
<tr>
<td>Hysteresis</td>
<td></td>
<td>±1</td>
<td>% RH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long term stability</td>
<td>Typical</td>
<td>&lt; 1</td>
<td>% RH/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution</td>
<td></td>
<td>0.04</td>
<td>0.01</td>
<td>0.01</td>
<td>°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.07</td>
<td>0.02</td>
<td>0.02</td>
<td>°F</td>
</tr>
<tr>
<td>Repeatability</td>
<td></td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>bit</td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td>±0.1</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.2</td>
<td>°F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td>40</td>
<td>123.8</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-40</td>
<td>254.9</td>
<td>°F</td>
<td></td>
</tr>
<tr>
<td>Response Time</td>
<td></td>
<td>1/c  (63%)</td>
<td>5</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Sensor Performance Specifications

2 Interface Specifications

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 PC 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 I/O characteristics.

---

(1) Each SHTxx is tested to be within the accuracy specifications at 25°C (77°F) and 40°C (104°F)
(2) The default measurement resolution of 14bit (temperature) and 12bit (humidity) can be reduced to 12 and 8 bit through the status register.

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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](image)

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 9th SCK clock. The DATA line is released (and goes high) after the falling edge of the 9th SCK clock.

<table>
<thead>
<tr>
<th>Command</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reserved</td>
<td>0000x</td>
</tr>
<tr>
<td>Measure Temperature</td>
<td>00111</td>
</tr>
<tr>
<td>Measure Humidity</td>
<td>00110</td>
</tr>
<tr>
<td>Read Status Register</td>
<td>00111</td>
</tr>
<tr>
<td>Write Status Register</td>
<td>00110</td>
</tr>
<tr>
<td>Reserved</td>
<td>0101x-1101x</td>
</tr>
</tbody>
</table>

**Table 2 SHTxx list of commands**

<table>
<thead>
<tr>
<th>Command</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft reset, resets the interface, clears the status register to default values wait minimum 1 ms before next command</td>
<td>11110</td>
</tr>
</tbody>
</table>

![Table 2 SHTxx list of commands](image)

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/sec 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](image)

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.

![Example RH measurement sequence](image)

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E-3  
v2.0 March 2003
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.”

2.3.1 Measurement resolution

The default measurement resolution of 14 bit (temperature) and 12 bit (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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply DC</td>
<td></td>
<td>2.4</td>
<td>5</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Supply current</td>
<td>measuring</td>
<td>550</td>
<td></td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td>average</td>
<td>2¹</td>
<td></td>
<td>20²</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td>sleep</td>
<td>0.3</td>
<td></td>
<td>1</td>
<td>µA</td>
</tr>
<tr>
<td>Low level output voltage</td>
<td>0</td>
<td>20%</td>
<td></td>
<td></td>
<td>Vdd</td>
</tr>
<tr>
<td>High level output voltage</td>
<td>0</td>
<td>100%</td>
<td></td>
<td></td>
<td>Vdd</td>
</tr>
<tr>
<td>Low level input voltage</td>
<td>Negative going</td>
<td>0</td>
<td>20%</td>
<td></td>
<td>Vdd</td>
</tr>
<tr>
<td>High level input voltage</td>
<td>Positive going</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td>Vdd</td>
</tr>
<tr>
<td>Input current on pads</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td>Output peak current</td>
<td>on</td>
<td>4</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>off</td>
<td>10</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
</tbody>
</table>

Table 4 SHTxx DC Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCKL</td>
<td>SCK low time</td>
<td>100</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>TV</td>
<td>DATA valid time</td>
<td>250</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>TSL</td>
<td>DATA set up time</td>
<td>100</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>TSH</td>
<td>DATA hold time</td>
<td>10</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>Tq/Tf</td>
<td>SCK rise/fall time</td>
<td>200</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

Table 5 SHTxx I/O Signals Characteristics

---

1 Parameters are periodically sampled and not 100% tested
2 With one measurement of 8 bit accuracy without OTP relock per second
3 With one measurement of 12 bit 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:\footnote{When $SO_{RH}$ is the sensor output for relative humidity}

\[ RH_{\text{linear}} = c_1 + c_2 \cdot SO_{RH} + c_3 \cdot (SO_{RH})^2 \]

<table>
<thead>
<tr>
<th>$SO_{RH}$</th>
<th>$c_1$</th>
<th>$c_2$</th>
<th>$c_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 bit</td>
<td>4</td>
<td>0.0405</td>
<td>-2.8 $\times 10^{-4}$</td>
</tr>
<tr>
<td>8 bit</td>
<td>-4</td>
<td>0.048</td>
<td>-7.2 $\times 10^{-4}$</td>
</tr>
</tbody>
</table>

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.

![Graph](image)

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:

\[ RH_{\text{bias}} = (T_C - 25) \cdot (t_1 + t_2 \cdot SO_{RH}) + RH_{\text{linear}} \]

<table>
<thead>
<tr>
<th>$SO_{RH}$</th>
<th>$t_1$</th>
<th>$t_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 bit</td>
<td>0.01</td>
<td>0.000108</td>
</tr>
<tr>
<td>8 bit</td>
<td>0.01</td>
<td>0.000125</td>
</tr>
</tbody>
</table>

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:

\[ T = c_1 + c_2 \cdot SO_{T} \]

<table>
<thead>
<tr>
<th>VDD</th>
<th>$d_1$ [°C]</th>
<th>$d_2$ [°C/°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5V</td>
<td>-40.00</td>
<td>-40.00</td>
</tr>
<tr>
<td>4V</td>
<td>-39.75</td>
<td>-39.50</td>
</tr>
<tr>
<td>3.6V</td>
<td>-39.66</td>
<td>-39.35</td>
</tr>
<tr>
<td>3V</td>
<td>-39.60</td>
<td>-39.28</td>
</tr>
<tr>
<td>2.5V</td>
<td>-39.55</td>
<td>-39.23</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$SO_{T}$</th>
<th>$d_3$ [°C]</th>
<th>$d_4$ [°C/°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>14bit</td>
<td>0.01</td>
<td>0.018</td>
</tr>
<tr>
<td>12bit</td>
<td>0.04</td>
<td>0.072</td>
</tr>
</tbody>
</table>

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.
4 Applications Information

4.1 Operating and Storage 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 (180°F) at <5%RH for 24h (baking) followed by 20-30°C (70°F) at >74%RH for 48h (re-hydration)

4.4 Qualifications

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

<table>
<thead>
<tr>
<th>Environment</th>
<th>Norm</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>JCGS22-A104-D-40°C / 125°C, 1000h</td>
<td>Within Specifications</td>
</tr>
<tr>
<td>Cyclical</td>
<td>HAST Pressure Cooker</td>
<td>JESD22-A110-B 2.3bar 125°C 85%RH Reversible shift by +2% RH</td>
</tr>
<tr>
<td>Salt Atmosphere</td>
<td>DIN 50021ss</td>
<td>Within Specifications</td>
</tr>
<tr>
<td>Temperature</td>
<td>DIN 50021ss</td>
<td>Within Specifications</td>
</tr>
<tr>
<td>Freezing cycles</td>
<td>-20 / +90°C, 100cy 30min dwell time</td>
<td>Reversible shift by +2% RH</td>
</tr>
<tr>
<td>Fully submerged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Various Automotive Chemicals</td>
<td>DIN 72300-5</td>
<td>Within Specifications</td>
</tr>
<tr>
<td>Cigarette smoke</td>
<td>Equivalent to 15 years in a mid-size car</td>
<td>Within Specifications</td>
</tr>
</tbody>
</table>

Table 9 Qualification tests (except)

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

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 source current of ±100 mA with Tamber=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.
5 Package Information

5.1 SHT1x (surface mountable)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>DATA</td>
<td>Serial data, bidirectional</td>
</tr>
<tr>
<td>3</td>
<td>SCK</td>
<td>Serial clock, input</td>
</tr>
<tr>
<td>4</td>
<td>VDD</td>
<td>Supply 2.4 – 5.5V</td>
</tr>
<tr>
<td>NC</td>
<td></td>
<td>Remaining pins must be left unconnected</td>
</tr>
</tbody>
</table>

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 wyy, 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

Slit to minimize heat transfer from the PCB

Figure 13 SHT1x housing 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 14 SHT1x PCB Mounting example

Figure 15 SHT1x drawing and footprint dimensions in mm (inch)
5.2 SHT7x (4-pin single-in-line)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SCK</td>
<td>Serial clock input</td>
</tr>
<tr>
<td>2</td>
<td>VDD</td>
<td>Supply 2.4 – 5.5V</td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>4</td>
<td>DATA</td>
<td>Serial data bidirectional</td>
</tr>
</tbody>
</table>

Table 11  SHT7x Pin Description

5.2.1 Package type

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 651-94-004-20-001 or similar.

Total weight: 188mg, weight of sensor head: 73mg

The production date is printed onto the cap in white numbers in the form wyy w e.g. "3511" = 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](image)

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.

1 Other packaging options may be available on request.

www.sensirion.com  v2.0 March 2003
DT-SENSE

Barometric Pressure & Temperature Sensor

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1. **PENDAHULUAN**

DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR merupakan sebuah modul sensor cerdas berbasis sensor HPD3 yang dapat digunakan untuk mendeteksi beban tekanan dan temperatur udara di sekitarnya. Kelebihan DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR berupa data digital yang sudah terkalibrasi penuh sehingga dapat dipakai langsung tanpa perlu banyak perhitungan tambahan. Modul sensor ini dilengkapi dengan antarmuka UART TTL dan PC. Contoh aplikasi DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR untuk baik untuk sistem pengukuran dan kendali tekanan udara, sistem barometer/altimeter, produk-produk peralatan 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 listrik daya menggunakan tegangan 4,5 - 5,5 Volt.
- Range sensor tekanan udara 300 - 1100 hPa (hectopascal)*.
- Akurasi sensor tekanan udara ± 1 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 PC.
- Dilengkapi dengan jumper untuk pengaturan alamat, sehingga bisa di-rasalini sampai 8 modul tanpa perangkat keras tambahan (untuk sain master menggunakan antarmuka PC).

* 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 Pararel (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.
- File yang ada pada CD program:
  - CONTOH_UART.PRG, CONTOH_UART.C, CONTOH_I2C.PRG,
  - 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

![Diagram of DT-SENSE Barometric Pressure & Temperature Sensor](image)

2.2. KONEKTOR DAN PENGATURAN JUMPER

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

<table>
<thead>
<tr>
<th>Pin</th>
<th>Nama</th>
<th>Fungsi</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
<td>Titik referensi untuk catu daya input</td>
</tr>
<tr>
<td>2</td>
<td>VCC</td>
<td>Terhubung ke catu daya (4.8 - 5.5 Volt)</td>
</tr>
<tr>
<td>3</td>
<td>RXD</td>
<td>Input serial level TTL ke modul</td>
</tr>
<tr>
<td>4</td>
<td>TXD</td>
<td>Output serial level TTL dari modul</td>
</tr>
<tr>
<td>5</td>
<td>MAIN SDA</td>
<td>PC-bus data input / output</td>
</tr>
<tr>
<td>6</td>
<td>MAIN SCL</td>
<td>PC-bus clock input</td>
</tr>
</tbody>
</table>
Jumper PULL-UP SDA SCL (J4) berfungsi untuk mengaktifkan resistor pull-up untuk pin SDA dan SCL pada antarmuka I²C.

<table>
<thead>
<tr>
<th>Jumper PULL-UP SDA SCL J4</th>
<th>Fungsi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pull-up tidak aktif</td>
</tr>
<tr>
<td></td>
<td>(jumper terlepas)</td>
</tr>
<tr>
<td></td>
<td>Pull-up aktif (jumper</td>
</tr>
<tr>
<td></td>
<td>terpasang)</td>
</tr>
</tbody>
</table>

Penilaian!
Apabila lebih dari satu modul dihubungkan pada I²C-bus maka jumper J4 [SCL/SDA] salah satu modul saja yang perlu dipasang.

Jumper ADDR (J3) berfungsi untuk mengatur alamat I²C dari modul DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR.

<table>
<thead>
<tr>
<th>J3 (A2) Pin 5-6</th>
<th>J3 (A1) Pin 3-4</th>
<th>J3 (A0) Pin 1-2</th>
<th>Alamat I²C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alamat Tulis I²C Alamat Baca I²C</td>
</tr>
<tr>
<td>■</td>
<td>■</td>
<td>■</td>
<td>E0H E1H</td>
</tr>
<tr>
<td>■</td>
<td>■</td>
<td></td>
<td>E2H E3H</td>
</tr>
<tr>
<td>■</td>
<td>■</td>
<td></td>
<td>E4H E5H</td>
</tr>
<tr>
<td>■</td>
<td>■</td>
<td>■</td>
<td>E6H E7H</td>
</tr>
<tr>
<td>■</td>
<td>■</td>
<td></td>
<td>E8H E9H</td>
</tr>
<tr>
<td>■</td>
<td>■</td>
<td>■</td>
<td>EAH EBH</td>
</tr>
<tr>
<td>■</td>
<td>■</td>
<td>■</td>
<td>ECH EDH</td>
</tr>
<tr>
<td>■</td>
<td>■</td>
<td>■</td>
<td>EEH EFH</td>
</tr>
</tbody>
</table>

Keterangan:
■: jumper terpasang

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

DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR memiliki antarmuka UART TTL dan I²C 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 dikuti 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. ANTARMAKU I²C

Modul DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR memiliki antarmuka I²C. Pada antarmuka I²C ini, modul DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR berfungsi sebagai slave dengan alamat sesuai dengan telah ditentukan sebelumnya melalui pengaturan jumper (lihat bagian 2.2). Antarmuka I²C pada modul DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR mendukung bit rate sampai dengan maksimum 100 kHz.

Semua perintah yang dikirim melalui antarmuka I²C diawali dengan start condition dan kemudian dikuti 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 I²C.

```
Start  +  1 1 1 0  X X X 0  +

Alamat Tulus

X X X X X X X X X + X X X X X X X X

Command

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.
Seluas data parameter yang memiliki range lebih besar dari 255 desimal (lebih besar dari 1 byte) diktirin/diterima secara dua tahap. Satu byte data MSB diktirin/diterima lebih dahulu kemudian dilikuti dengan data LSB. Misalnya parameter \texttt{<P16bit>} yang memiliki range 3000 - 11000. Jika \texttt{<P16bit>} bernilai 1234 maka byte MSB yang diktirin/diterima adalah 4 dan byte LSB yang diktirin/diterima adalah 210 (4 \times 256 + 210 = 1234).

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

3.3. **COMMAND SET**
Berkur ini daftar lengkap perintah-perintah dalam antarmuka UART dan l'C.

### 3.3.1. **GET PRESSURE DATA**

<table>
<thead>
<tr>
<th>Fungsi</th>
<th>Untuk membaca data tekanan udara</th>
</tr>
</thead>
<tbody>
<tr>
<td>Command</td>
<td>00H</td>
</tr>
<tr>
<td>Parameter</td>
<td>-</td>
</tr>
<tr>
<td>Respon</td>
<td>\texttt{&lt;P16bit&gt;}</td>
</tr>
<tr>
<td></td>
<td>3000 - 11000 \rightarrow data tekanan dalam satuan 0,1 hpa.</td>
</tr>
<tr>
<td></td>
<td>Range data tekanan untuk perintah ini adalah 300,0 - 1100,0 hpa.</td>
</tr>
<tr>
<td>Delay antara Command dan Respon</td>
<td>15 ms</td>
</tr>
</tbody>
</table>

Keterangan: Setelah power-up, rata-rata 250 ms sebelum mengirimkan perintah ini (agar data sensor stabil).

Contoh dengan antarmuka UART:

\begin{verbatim}
User : 00H
DT SENSE : <P16bit MSB> <P16bit LSB>
\end{verbatim}

Tekanan = \((P16bit MSB \times 256 + P16bit LSB) / 10\) (dalam satuan hpa)

Berkur ini contoh pseudo code C untuk menggunakan perintah ini dengan antarmuka l'C (misalkan alamat l'C = \texttt{0EH}):\n
\begin{verbatim}
i2c_start();    // Start Condition
i2c_write(0x00); // Tulis ke modal BAROMETRIC PRESSURE
i2c_write(0x00); // Dorisnition "Get Pressure Data"
i2c_stop();    // Stop Condition

delay_ms(15);   // delay 15 ms

i2c_start();    // Start Condition
i2c_write(0x01); // Baca ke modal BAROMETRIC PRESSURE
temp1 = i2c_read(1); // tekanan MOD
\end{verbatim}
3.3.2. GET TEMPERATURE DATA

<table>
<thead>
<tr>
<th>Fungsi</th>
<th>Untuk membaca data temperatur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Command</td>
<td>01H</td>
</tr>
<tr>
<td>Parameter</td>
<td>-</td>
</tr>
<tr>
<td>Respon</td>
<td>&lt;T16bit&gt;</td>
</tr>
<tr>
<td></td>
<td>0 - 500 \rightarrow data temperatur + offset 200, dalam satuan 0,1 °C.</td>
</tr>
<tr>
<td></td>
<td>Range data temperatur untuk perintah ini adalah -20,0 - 60,0 °C.</td>
</tr>
<tr>
<td>Delay antara</td>
<td>15 ms</td>
</tr>
<tr>
<td>Command dan</td>
<td>Respon</td>
</tr>
<tr>
<td>Keterangan</td>
<td>- Setelah power up, tunggu 250 ms sebelum mengirimkan perintah ini (agar data sensor stabil).</td>
</tr>
<tr>
<td></td>
<td>- Nilai T16bit adalah nilai temperatur sesungguhnya yang sudah ditambah 200. Untuk mendapatkan data temperatur sesungguhnya, nilai tersebut harus dikurangi 200 lalu dibagi 10.</td>
</tr>
</tbody>
</table>

Contoh dengan antarmuka UART:

User : 01H
DT-SENSE : <T16bit MSB> <T16bit LSB>

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

Berikut ini contoh pseudo code C untuk menggunakan perintah ini dengan antarmuka I²C (misalkan alamat I²C = E0H):

```c
i2c_start(); // Start Condition
i2c_write(0x0); // 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(0x01); // Data ke modul BAROMETRIC PRESSURE
temp1 = i2c_read(1); // Temperatur MSB
temp2 = i2c_read(0); // Temperatur LSB
i2c_stop(); // Stop Condition

Temperatur = ((temp1 x 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 HPGS dan mengirimkan hasilnya melalui antarmuka UART TTL. Untuk ketinggian normal (di atas permukaan tanah dataan rendah), data tekanan bersih sekitar 1000,0 - 1020,0 hPa.

5. **CONTOH APLIKASI DAN PROGRAM**


   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 1.28.2 versi evaluasi. Untuk menggunakan antarmuka UART pada contoh program contoh_uart.c, maka konfigurasi antara modul DT-SENSE BAROMETRIC PRESSURE & TEMPERATURE SENSOR dan modul DT-AVR LCMS adalah sebagai berikut.
Sedangkan untuk menggunakan antarmuka PC pada contoh program
contoh_19.c, maka konfigurasi antara modul DT-SENSE BAROMETRIC
PRESSURE & TEMPERATURE SENSOR dan modul DT-AVR LCMS adalah sebagai berikut:

- Terima Kasih atas kepercayaan Anda menggunakan produk kami, bila ada kesulitan,
  pertanyaan atau saat mengenai produk ini silakan menghubungi technical support kami:
support@innovativeelectronics.com

E-17
Features

- High-performance, Low-power AVR® 8-bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single-cycle Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 18 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 Head-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 UART
  - 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-pin TQFP, and 44-pad MLF
- Operating Voltages
  - 2.7 - 5.5V for ATmega16L
  - 4.5 - 5.5V for ATmega16
- Speed Grades
  - 0 - 6 MHz for ATmega16L
  - 0 - 16 MHz for ATmega16
Pin Configurations

Figure 1. Pinouts ATmega16

PDIP

(XCK/T0) PB0  1  40  PA0 (ADC0)
(T1) PB1  2  39  PA1 (ADC1)
(INT2/AIN0) PB2  3  38  PA2 (ADC2)
(OC3/AIN1) PB3  4  37  PA3 (ADC3)
(SS) PB4  5  36  PA4 (ADC4)
(MISO) PB5  6  35  PA5 (ADC5)
(MISO) PB6  7  34  PA6 (ADC6)
(SCK) PB7  8  33  PA7 (ADC7)
RESET  9  32  AREF
VCC  10  31  GND
GND  11  30  AVCC
XTAL2  12  29  PC7 (TOSC2)
XTAL1  13  28  PC8 (TOSC1)
(RXD) PD0  14  27  PC5 (TDI)
(TXD) PD1  15  26  PC4 (TDO)
(INT0) PD2  16  25  PC3 (TMS)
(INT1) PD3  17  24  PC2 (TCK)
(CC1B) PD4  18  23  PC1 (SDA)
(OC1A) PD5  19  22  PC0 (SCL)
(ICP) PD6  20  21  PD7 (OC2)

TQFP/MLF

(MISO) PB5  1  33  PA4 (ADC4)
(MISO) PB6  2  32  PA5 (ADC5)
(SCK) PB7  3  31  PA6 (ADC6)
RESET  4  30  PA7 (ADC7)
VCC  5  29  AREF
GND  6  28  GND
XTAL2  7  27  AVCC
XTAL1  8  26  PC7 (TOSC2)
(RXD) PD0  9  25  PC6 (TOSC1)
(TXD) PD1  10  24  PC5 (TDI)
(INT0) PD2  11  23  PC4 (TDO)

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.

ATmega16(L)

2486E-AVR-10/02
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 AVH 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 RISC 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 (TOQFP 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 USAH, I/O conversion, A/D Converter, SHAM, 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 AVH is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debuggers/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.

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.
MEDIUM-SPEED OPERATION
- tPLH, tPHL = 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"

ORDER CODES:
- HCC4069UBF
- HCF4069UBM1
- HCF4069UBEY
- HCF4069UBC1

PIN CONNECTIONS

DESCRIPTION
The HCC4069UB (extended temperature range) and HCF4069UB (intermediate temperature range) are monolithic integrated circuits 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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{DD}^*$</td>
<td>Supply Voltage : HCC Types</td>
<td>-0.5 to +20</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>HCF Types</td>
<td>-0.5 to +18</td>
<td>V</td>
</tr>
<tr>
<td>$V_I$</td>
<td>Input Voltage</td>
<td>-0.5 to $V_{DD} + 0.5$</td>
<td>V</td>
</tr>
<tr>
<td>$I_I$</td>
<td>DC Input Current (any one input)</td>
<td>±10</td>
<td>mA</td>
</tr>
<tr>
<td>$P_{T\text{tot}}$</td>
<td>Total Power Dissipation (per package)</td>
<td>200</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td>Dissipation per Output Transistor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>for Top = Full Package-temperature Range</td>
<td>100</td>
<td>mW</td>
</tr>
<tr>
<td>$T_{op}$</td>
<td>Operating Temperature : HCC Types</td>
<td>-55 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>$T_{stg}$</td>
<td>Storage Temperature</td>
<td>-65 to +150</td>
<td>°C</td>
</tr>
</tbody>
</table>

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 $V_{DD}$ pin voltage.

RECOMMENDED OPERATING CONDITIONS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{DD}$</td>
<td>Supply Voltage : HCC Types</td>
<td>3 to 18</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>HCF Types</td>
<td>3 to 15</td>
<td>V</td>
</tr>
<tr>
<td>$V_I$</td>
<td>Input Voltage</td>
<td>0 to $V_{DD}$</td>
<td>V</td>
</tr>
<tr>
<td>$T_{op}$</td>
<td>Operating Temperature : HCC Types</td>
<td>-55 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>$T_{stg}$</td>
<td>Storage Temperature</td>
<td>-40 to +85</td>
<td>°C</td>
</tr>
</tbody>
</table>
### Static Electrical Characteristics

(over recommended operating conditions)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( I_L )</td>
<td>Quiescent Current</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HCC Types</td>
<td>( V_{i} ) (V)</td>
<td>( V_{o} ) (V)</td>
<td>( I_{o} ) (( \mu A ))</td>
</tr>
<tr>
<td></td>
<td>0/5</td>
<td>10</td>
<td>5</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>0/10</td>
<td>15</td>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>0/15</td>
<td>20</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0/20</td>
<td>20</td>
<td>6</td>
<td>0.02</td>
</tr>
<tr>
<td>HCF Types</td>
<td>( V_{o} ) (V)</td>
<td>0/5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0/10</td>
<td>10</td>
<td>2</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>0/15</td>
<td>15</td>
<td>4</td>
<td>0.01</td>
</tr>
<tr>
<td>( V_{OH} )</td>
<td>Output High Voltage</td>
<td>( V_{i} ) (V)</td>
<td>( V_{o} ) (V)</td>
<td>( T_{\text{LOW}}^{*} )</td>
</tr>
<tr>
<td></td>
<td>0/5</td>
<td>&lt; 1</td>
<td>5</td>
<td>4.95</td>
</tr>
<tr>
<td></td>
<td>0/10</td>
<td>&lt; 1</td>
<td>10</td>
<td>9.05</td>
</tr>
<tr>
<td></td>
<td>0/15</td>
<td>&lt; 1</td>
<td>15</td>
<td>14.95</td>
</tr>
<tr>
<td>( V_{OL} )</td>
<td>Output Low Voltage</td>
<td>( V_{i} ) (V)</td>
<td>( V_{o} ) (V)</td>
<td>( T_{\text{LOW}}^{*} )</td>
</tr>
<tr>
<td></td>
<td>5/0</td>
<td>&lt; 1</td>
<td>5</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>10/10</td>
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<td>10</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>15/0</td>
<td>&lt; 1</td>
<td>15</td>
<td>0.05</td>
</tr>
<tr>
<td>( V_{IH} )</td>
<td>Input High Voltage</td>
<td>( V_{i} ) (V)</td>
<td>( V_{o} ) (V)</td>
<td>( T_{\text{LOW}}^{*} )</td>
</tr>
<tr>
<td></td>
<td>0.5/4.5</td>
<td>&lt; 1</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1/10</td>
<td>&lt; 1</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>1.5/13.5</td>
<td>&lt; 1</td>
<td>15</td>
<td>12.5</td>
</tr>
<tr>
<td>( V_{IL} )</td>
<td>Input Low Voltage</td>
<td>( V_{i} ) (V)</td>
<td>( V_{o} ) (V)</td>
<td>( T_{\text{LOW}}^{*} )</td>
</tr>
<tr>
<td></td>
<td>4.5/0.5</td>
<td>&lt; 1</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
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<td>10/10</td>
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</table>

\* \( T_{\text{LOW}} \) = –55°C for HCC device; –40°C for HCF device.
\* \( T_{\text{HIGH}} \) = +125°C for HCC device; +85°C for HCF device.

The Noise Margin for both "1" and "0" level is: 1V min. with \( V_{o} \) = 5V, 2V min. with \( V_{o} \) = 10V, 2.5V min. with \( V_{o} \) = 15V.
HCC/HCF4069UB

**DYNAMIC ELECTRICAL CHARACTERISTICS** (T\textsubscript{amb} = 25°C, C\textsubscript{L} = 50pF, R\textsubscript{L} = 200kΩ, typical temperature coefficient for all V\textsubscript{DD} = 0.3%/°C values, all input rise and fall time = 20ns)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
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<th>Value</th>
<th>Unit</th>
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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.