LAMPIRAN A
LISTING PROGRAM

PROGRAM UTAMA PADA PENGONTROL MIKRO AVR ATMega 16

```
/*****************************************************
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CodeWizardAVR V1.25.3 Standard
Automatic Program Generator
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Project :
Version :
Date    : 11/12/2008
Author  : Leska
Company : Akselerasi Max
Comments:


Chip type           : ATmega16
Program type        : Application
Clock frequency     : 11.059200 MHz
Memory model        : Small
External SRAM size  : 0
Data Stack size     : 256
*****************************************************/

#include <mega16.h>
#include <stdio.h>
#include <delay.h>
#include <math.h>
#include <sensor_sht.c>

// Alphanumeric LCD Module functions
#asm
   .equ __lcd_port=0x15 ;PORTC
#endasm
#include <lcd.h>

#define ADC_VREF_TYPE 0x00

/*Variabel Kecepatan*/
int COUNTER;
int temp;
float kec;
int CHECK;
int ATTACK;

/*Variabel Arah Angin*/
float vin;
unsigned int temp_arah_angin;

// Read the AD conversion result
unsigned int read_adc(unsigned char adc_input)
{
ADMUX=adc_input | (ADC_VREF_TYPE & 0xff);
// Start the AD conversion
ADCSRA|=0x40;
// Wait for the AD conversion to complete
while ((ADCSRA & 0x10)==0);
ADCSRA|=0x10;
```

```
return ADCW;
}

/*Fungsi Arah Angin*/
void arah_angin (void)
{
        temp_arah_angin=read_adc(0);
        vin=(temp_arah_angin*0.3515625);  // vin=((float)temp_arah_angin*(360/1024))
}

/*Fungsi Kecepatan Angin*/
void kecepatan (void)
{

        temp=read_adc(1);
        if(temp>600)
        {
                if (CHECK > 0)
                {
                 goto keluar;
                }
         COUNTER++;
         CHECK++;
         }
        else
        {
         CHECK=0;
        }
      RPM = COUNTER;
      keluar:

        delay_ms(10);
        ATTACK++;


}

/*Fungsi Kirim Data*/
void kirim_data (void)
{

   printf("%.2f#",kec); //Data Kecepatan Angin
   printf("%.2f#",vin); //Data Arah Angin
   printf("%5.2f#",rhTrue); //Kelembaban
   printf("%5.2f",tC); //Suhu
}


void main(void)
{
int cnt_kec;

PORTA=0x00;
DDRA=0x00;

PORTB=0x00;
DDRB=0x00;

PORTC=0x00;
DDRC=0x00;

PORTD=0x00;
DDRD=0x00;
```

```
TCCR0=0x00;
TCNT0=0x00;
OCR0=0x00;

TCCR1A=0x00;
TCCR1B=0x00;
TCNT1H=0x00;
TCNT1L=0x00;
ICR1H=0x00;
ICR1L=0x00;
OCR1AH=0x00;
OCR1AL=0x00;
OCR1BH=0x00;
OCR1BL=0x00;

ASSR=0x00;
TCCR2=0x00;
TCNT2=0x00;
OCR2=0x00;

MCUCR=0x00;
MCUCSR=0x00;

TIMSK=0x00;

ACSR=0x80;
SFIOR=0x00;

ADMUX=ADC_VREF_TYPE & 0xff;
ADCSRA=0x87;

UCSRA=0x00;
UCSRB=0x18;
UCSRC=0x86;
UBRRH=0x00;
UBRRL=0x47;

// LCD module initialization
//lcd_init(16);

inisialisasi_sensor_sht();    //Inisialisasi sensor SHT

while (1)
      {


      arah_angin();   //Ukur Arah Angin

      /*Proses Baca Kecepatan*/
        for(cnt_kec = 0; cnt_kec < 100; cnt_kec++)
        {
             kecepatan();

             if (ATTACK >= 100)
             {
                kec = 0.811947 + ( 0.238938 * RPM ) ;
                ATTACK = 0;
                COUNTER = 0;
             }
        }

        proses_ukur_sht();   //Mengukur Suhu dan Kelembaban
```

```
        kirim_data();


      };
}
```

SUBPROGRAM SENSOR SHT 75

```
#define    SHT_DATA_OUT DDRB.4
#define    SHT_DATA_IN     PINB.4
#define    SHT_SCK             PORTB.5
#define    noACK                  0
#define    ACK                      1
#define No                           0
#define Yes                          1
#define MEASURE_TEMP 0x03
#define MEASURE_HUMI 0x05




unsigned char   jawab;
unsigned char   ioByte;
unsigned int    soT;
float           tC;
unsigned int    soRH;
float           rhLin;
float           rhTrue;
bit             timeOut;

void Init_Port(void);
void SHT_Transstart(void);
void SHT_Connectionreset(void);
void SHT_Write_Byte(unsigned char value);
void SHT_Read_Byte(unsigned char ack);
void SHT_Wait();
void SHT_Measure_Temperatur();
void SHT_Measure_Humidity();


char lcd_buffer[33];


void inisialisasi_sensor_sht (void)
{
   Init_Port();
   SHT_Connectionreset();
}

void proses_ukur_sht (void)
{
      SHT_Measure_Humidity();
      SHT_Measure_Temperatur();
}


void Init_Port(void)
{
PORTB.5= 0;
DDRB.5  = 1;
PORTB.4 = 0;
}


void SHT_Write_Byte(unsigned char value)
{
unsigned char i;
```

```
  for (i=0x80;i>0;i/=2)
              {
              if (i & value)          SHT_DATA_OUT=0;
    else SHT_DATA_OUT=1;
    SHT_SCK=1;
    delay_us(5);
    SHT_SCK=0;
              }

  SHT_DATA_OUT=0;
  SHT_SCK=1;
  delay_ms(1);
  jawab=SHT_DATA_IN;
  delay_ms(1);
  SHT_SCK=0;

}


void SHT_Read_Byte(unsigned char ack)
{
  unsigned char i,val=0;
  SHT_DATA_OUT=0;
  for (i=0x80;i>0;i/=2)
    {
    SHT_SCK=1;
    if (SHT_DATA_IN) val=(val | i);
    SHT_SCK=0;
    }
  SHT_DATA_OUT=ack;
  SHT_SCK=1;
  delay_us(5);
  SHT_SCK=0;
  SHT_DATA_OUT=0;
  ioByte=val;
}


void SHT_Transstart(void)
{
   SHT_DATA_OUT=0;
   SHT_SCK=0;
   delay_us(1);
   SHT_SCK=1;
   delay_us(1);
   SHT_DATA_OUT=1;
   delay_us(1);
   SHT_SCK=0;
   delay_us(5);
   SHT_SCK=1;
   delay_us(1);
   SHT_DATA_OUT=0;
   delay_us(1);
   SHT_SCK=0;
}


void SHT_Connectionreset(void)
{
  unsigned char i;
  SHT_DATA_OUT=0; SHT_SCK=0;
  for(i=0;i<9;i++)
```

```
            {
            SHT_SCK=1;
            delay_us(1);
   SHT_SCK=0;
  }
 SHT_Transstart();
}


void SHT_Wait()
{
   int check=0;
   timeOut=No;
   SHT_DATA_OUT=0;
   while(SHT_DATA_IN && timeOut==No)
         {
         delay_us(1);
         check++;
         if (check==250000)timeOut=Yes;
         }
}



void SHT_Measure_Temperatur()
{
       SHT_Transstart();
       SHT_Write_Byte(MEASURE_TEMP);
       if (jawab==0)
          {
          SHT_Wait();
          SHT_Read_Byte(ACK);
          soT = ioByte;
          soT<<=8;
          SHT_Read_Byte(noACK);
          soT |= ioByte;



           tC = soT * 0.01 - 40;


          }
       else SHT_Connectionreset();
}


void SHT_Measure_Humidity()
{
       SHT_Transstart();
       SHT_Write_Byte(MEASURE_HUMI);
       if (jawab==0)
          {
          SHT_Wait();
          SHT_Read_Byte(ACK);
          soRH = ioByte;
          soRH<<=8;
          SHT_Read_Byte(noACK);
          soRH |= ioByte;


               rhLin = (0.0405 * soRH) -(0.0000028 * pow(soRH,2))- 4;
```

```
            rhTrue = (tC - 25) * (0.01+0.00008*soRH) + rhLin;

        }
       else SHT_Connectionreset();

  if(rhTrue>100)rhTrue=100;
  if(rhTrue<0.1)rhTrue=0.1;
}
```

PROGRAM PADA VISUAL BASIC SEBAGAI TAMPILAN DI PC

```
Private Sub Form_Load()
    MSComm1.CommPort = 1
    MSComm1.RThreshold = 20
    MSComm1.SThreshold = 1
    MSComm1.Settings = "9600,n,8,1"
    MSComm1.PortOpen = True
    MSComm1.DTREnable = True

    rtb.Text = ""
End Sub

Private Sub MSComm1_OnComm()
    Dim SEMENTARA As Variant

    'Inisialisasi Waktu
Dim Waktu_Ukur As Date
Dim Waktu As String

'Inisialisasi Koneksi ke Database
Dim objKoneksi As ADODB.Connection
Dim objCommand As ADODB.Command
Dim namaDB, namaUser As String
Dim mSQL As String

'Inisialisasi variabel pengukuran
Dim suhu, kelembaban, arah_angin, kec_angin As String

    SEMENTARA = MSComm1.Input
    rtb.Text = SEMENTARA

    Data = Split(SEMENTARA, "#")

    lbl_KECEPATAN.Caption = Data(0)
    lbl_ARAH.Caption = Data(1)
    lbl_KELEMBAPAN.Caption = Data(2)
    lbl_SUHU.Caption = Data(3)

'Memulai Koneksi Database
Set objKoneksi = New ADODB.Connection
With objKoneksi
    .ConnectionString = "Provider=MSDASQL.1;Persist Security Info=False;Data
Source=dsn_pengukuran"
    .Open
    If Not .State = adStateOpen Then
```

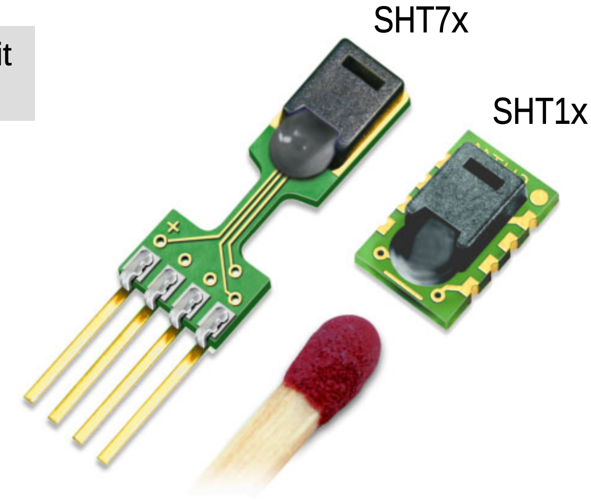
```
        MsgBox "Tidak dapat membuat hubungan ke database"
        End
    End If
End With

'Convert dari data
suhu = Data(3)
kelembaban = Data(2)
arah_angin = Data(1)
kec_angin = Data(0)

'Ambil data waktu dari komputer setiap kali pengiriman
Waktu_Ukur = Format(Now)
Waktu = Waktu_Ukur


'syntax input data ke database
mSQL = "insert into metering_1(waktu_ukur,suhu,kelembaban,arah_angin,kec_angin) values ('" & Waktu_Ukur & "','" & suhu & "','" & kelembaban & "','" & arah_angin & "','" & kec_angin & "')"

'Kirim Data ke database
Set objCommand = New ADODB.Command
objCommand.ActiveConnection = objKoneksi
objCommand.CommandText = mSQL
objCommand.Execute

End Sub
```

LAMPIRAN B

DATASHEET

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.

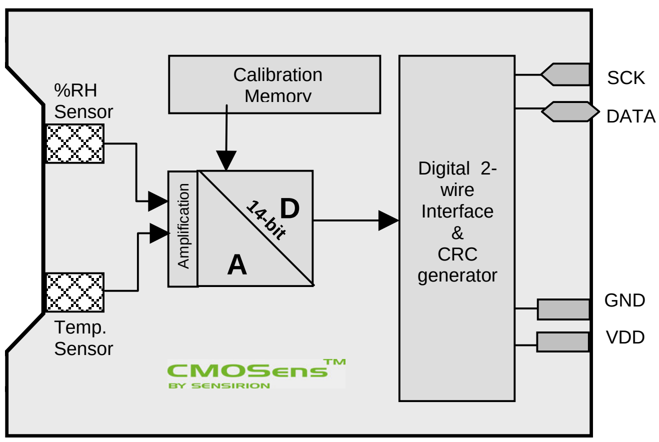
Applications

_ HVAC
_ Automotive
_ Consumer Goods
_ Weather Stations
_ Humidifiers
_ Dehumidifiers
_ Test & Measurement
_ Data Logging
_ Automation
_ White Goods
_ Medical

Ordering Information

Part Number	Humidity accuracy [%RH]	Temperature accuracy [K] @ 25 °C	Package
SHT11	±3.0	±0.4	SMD (LCC)
SHT15	±2.0	±0.3	SMD (LCC)
SHT71	±3.0	±0.4	4-pin single-in-line
SHT75	±1.8	±0.3	4-pin single-in-line

Block Diagram



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		< 0.5		%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

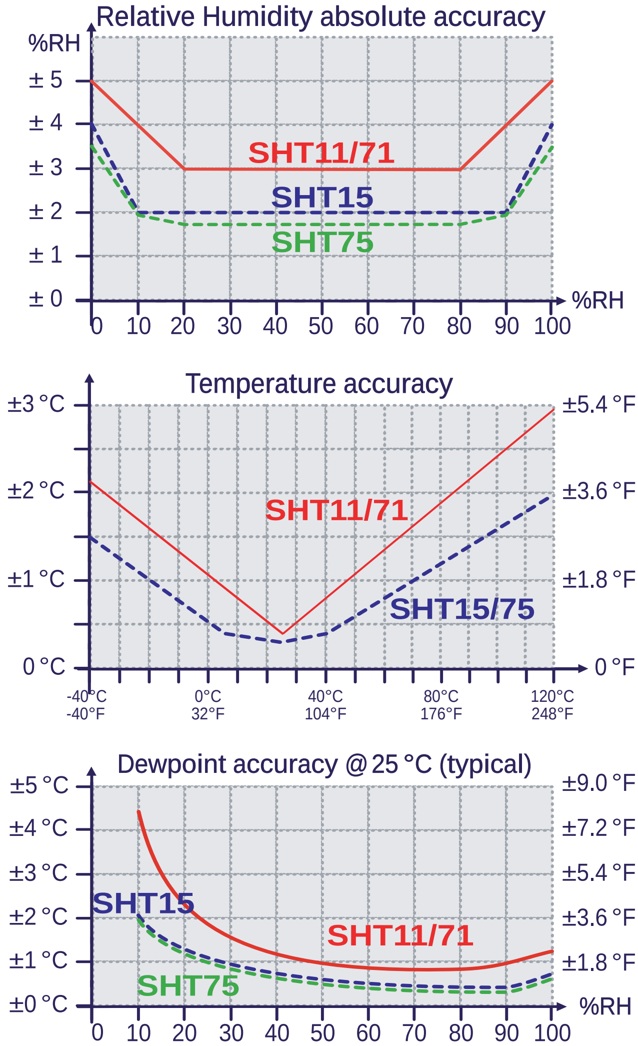


Figure 1 Rel. Humidity, Temperature and Dewpoint accuracies

2 Interface Specifications

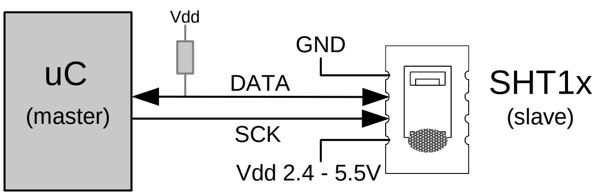


Figure 2 Typical application circuit

2.1 Power Pins

The SHTxx requires a voltage supply between 2.4 and 5.5 V. 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 SHTxx. 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 transmission 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. 10 kΩ) 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 fully 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.

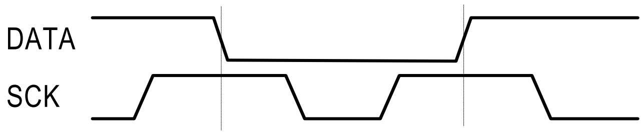


Figure 3 "Transmission Start" sequence

The subsequent command consists of three address bits (only "000" is currently supported) and five command bits. The SHTxx 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 11 ms 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 11/55/210 ms 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 SHTxx pulls down the data line and enters idle mode. The controller **must** wait for this "data ready" signal before restarting SCK to readout the data. Measurement data is stored until readout, therefore the controller can continue with other tasks and readout as convenient.

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 10% of the time (e.g. max. 2 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.

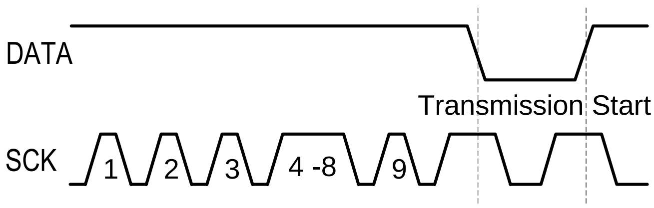


Figure 4 Connection reset sequence

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.

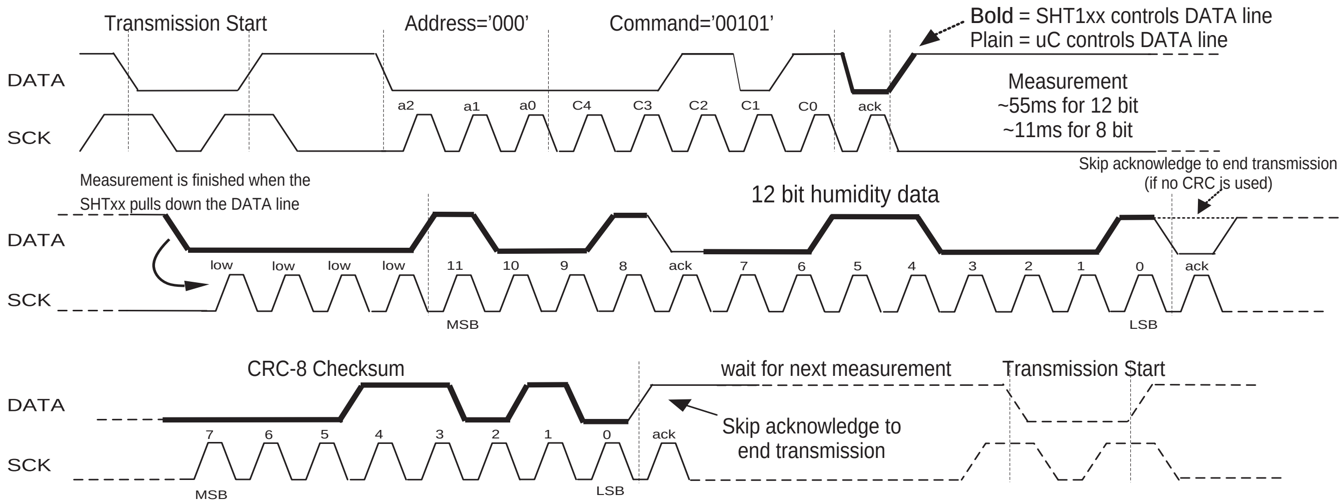


Figure 5 Example RH measurement sequence for value "0000'1001 ' 0011'0001"= 2353 = 75.79 %RH (without temperature compensation)

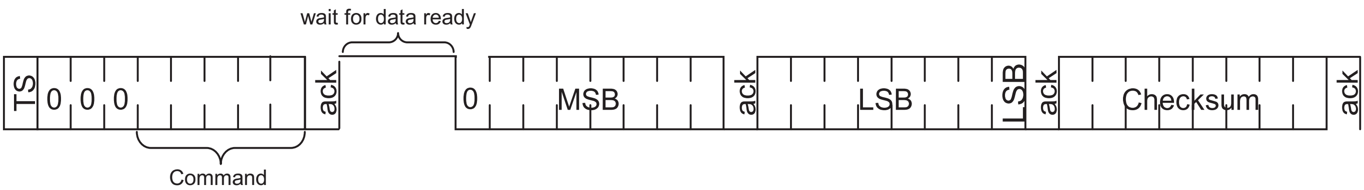


Figure 6 Overview of Measurement Sequence (TS = Transmission Start)

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”

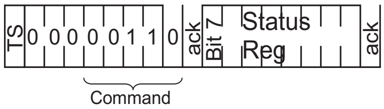


Figure 7 Status Register Write

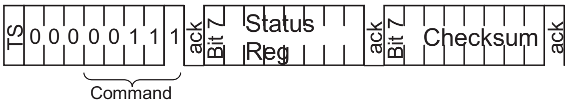


Figure 8 Status Register Read

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 8bit. 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 2.47 V. Accuracy is ±0.05 V

2.3.3 Heater

An on chip heating element can be switched on. It will increase the temperature of the sensor by 5-15 °C (9-27 °F). Power consumption will increase by ~8 mA @ 5 V.
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) 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

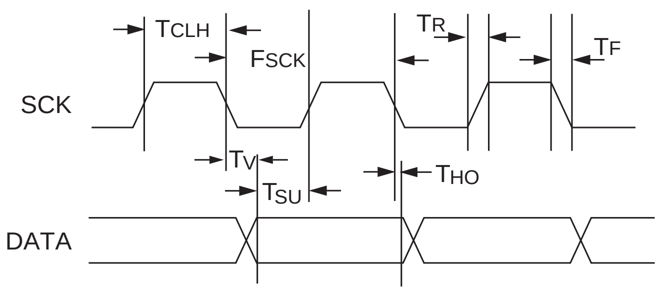


Figure 9 Timing Diagram

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.

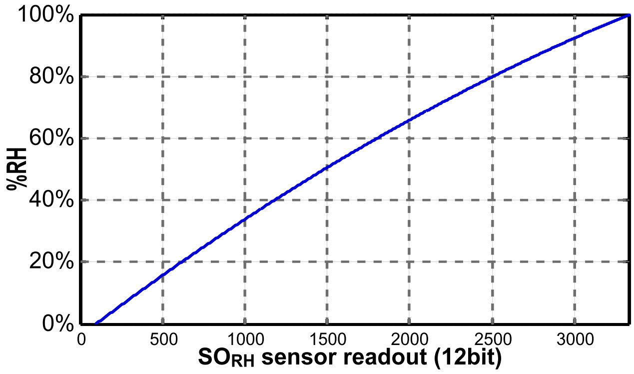


Figure 10 Conversion from SO_{RH} to relative humidity

3.1.1 Humidity Sensor RH/Temperature compensation

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:

$$Temperature = d_1 + d_2 \bullet SO_T$$

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

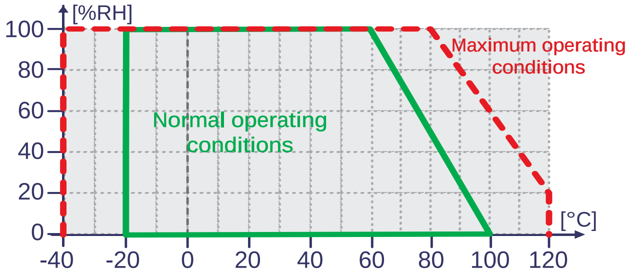


Figure 11 Recommended operating conditions

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

Chemical 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 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 13).

4.5 Membranes

A membrane may 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. For the SHT1x package Sensirion recommends the SF1 filter cap for optimal IP67 protection.

4.6 Light

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

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. Outgassing of these materials may also contaminate the SHTxx (cf. 4.2). Store well ventilated after manufacturing or bake at 50°C for 24h to outgas contaminants before packing.

4.8 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.

Power supply pins (VDD, GND) should be decoupled with a 100 nF capacitor if wires are used.

4.9 Qualifications

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

Environment	Norm	Results(1)
Temperature Cycles	JESD22-A104-B -40 °C / 125 °C, 1000 cy	Within Specifications
HAST Pressure Cooker	JESD22-A110-B 2.3 bar 125 °C 85 %RH	Reversible shift by +2 %RH
High Temperature and Humidity	JESD22-A101-B 85 °C 85 %RH 1250h	Reversible shift by +2 %RH
Salt Atmosphere	DIN-50021ss	Within Spec.
Condensing Air	-	Within Spec.
Freezing cycles fully submerged	-20 / +90 °C, 100 cy 30min dwell time	Reversible shift by +2 %RH
Various Automotive Chemicals	DIN 72300-5	Within Specifications

Table 9 Qualification tests (excerpt)

4.10 ESD (Electrostatic Discharge)

ESD immunity is qualified according to MIL STD 883E, method 3015 (Human Body Model at ±2 kV)).

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.

(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 - 5.5 V
	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 0.8 mm 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 100 mg

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 12mm tape at 100pcs or 400pcs.. Reels are individually labelled with barcode and human readable labels. The Lot numbers allow full traceability through production, calibration and test.

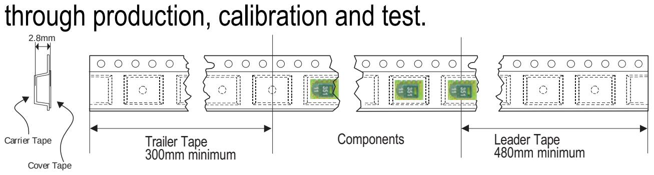


Figure 12 Tape configuration and unit orientation

5.1.3 Soldering Information

Standard reflow soldering ovens may be used. For details please see application note "soldering procedure".

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.

5.1.4 Mounting Examples

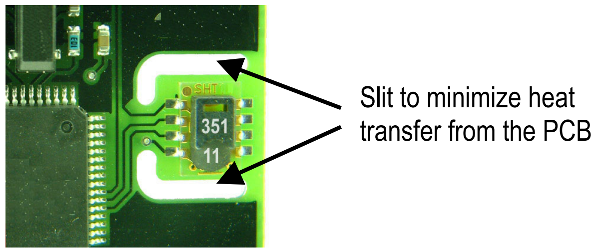


Figure 13 SHT1x PCB Mounting example

The SF1 membrane filter cap is available for optimal IP67 protection. When mounted through a housing the interior can be protected from the environment while still allowing high quality humidity measurements (see example below).

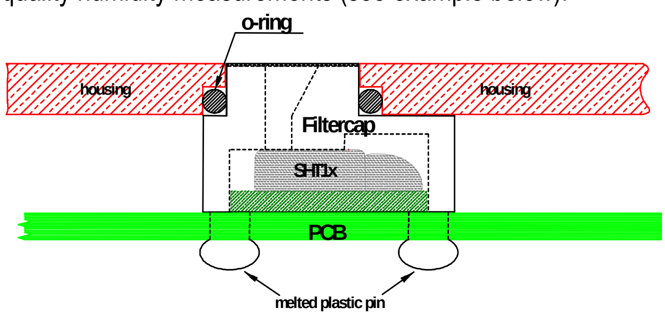


Figure 14 SF1 IP67 filter cap mounting example

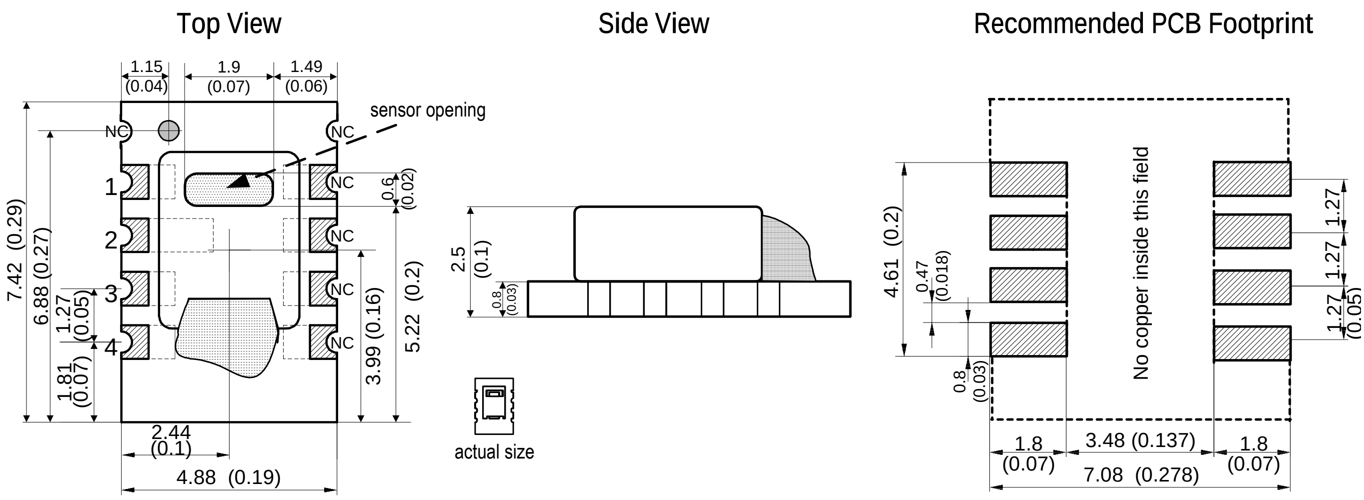


Figure 15 SHT1x drawing and footprint dimensions in mm (inch)

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

Pin	Name	Comment
1	*SCK*	*Serial clock input*
2	*VDD*	*Supply 2.4 - 5.5 V*
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 0.6 mm 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. The gold plated back side of the sensor head is connected to the GND pin.
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 1.27 mm (0.05'') sockets
e.g.: Preci-dip / Mill-Max 851-93-004-20-001 or similar
Total weight: 168 mg, weight of sensor head: 73 mg

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

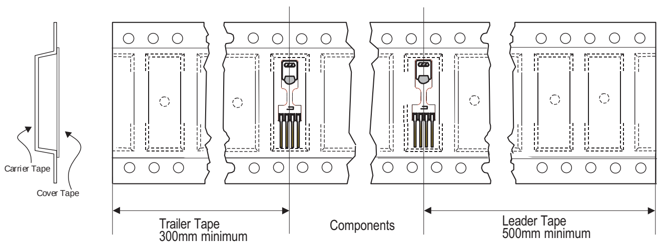


Figure 16 Tape configuration and unit orientation

5.2.3 Soldering Information[2]

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 24 h to allow the polymer to rehydrate.
Please consult the application note "Soldering procedure" for more information.

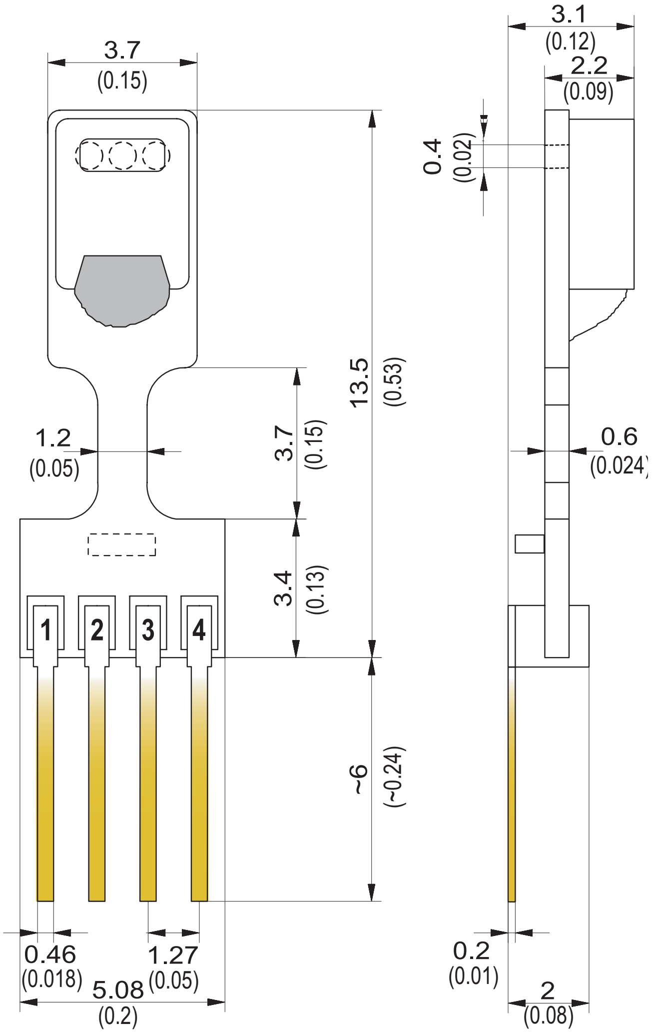


Figure 17 SHT7x dimensions in mm (inch)

[1] Other packaging options may be available on request.
[2] For maximum accuracy do not solder SHT75!

6 Revision history

Date	Version	Page(s)	Changes
February 2002	Preliminary	1-9	First public release
June 2002	Preliminary		Added SHT7x information
March 2003	Final v2.0	1-9	Major remake, added application information etc. Various small modifications
	V2.01	1-9	Typos, Graph labeling
July 2004	V2.02	1-9	Improved specifications, added SF1 information, improved wording

The latest version of this document and all application notes can be found at:
www.sensirion.com/en/download/humiditysensor/SHT1x_SHT7x.htm

7 Important Notices

7.1 Warning, personal injury

Do not use this product as safety or emergency stop devices or in any other application where failure of the product could result in personal injury. Failure to comply with these instructions could result in death or serious injury.

Should buyer purchase or use SENSIRION AG products for any such unintended or unauthorized application, Buyer shall indemnify and hold SENSIRION AG and its officers, employees, subsidiaries, affiliates and distributors harmless against all claims, costs, damages and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that SENSIRION AG was negligent regarding the design or manufacture of the part.

7.2 ESD Precautions

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take normal ESD precautions when handling this product.
See application note “ESD, Latchup and EMC” for more information.

7.3 Warranty

SENSIRION AG makes no warranty, representation or guarantee regarding the suitability of its product for any particular purpose, nor does SENSIRION AG assume any liability arising out of the application or use of any product or circuit and specifically disclaims any and all liability, including without limitation consequential or incidental damages. “Typical” parameters can and do vary in different applications. All operating parameters, including “Typical” must be validated for each customer applications by customer’s technical experts.

SENSIRION AG reserves the right, without further notice, to change the product specifications and/or information in this document and to improve reliability, functions and design.

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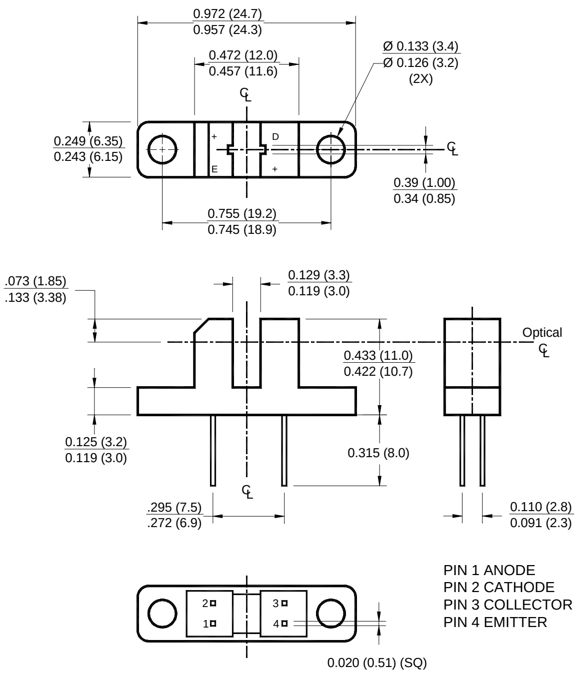
Sensirion humidity sensors are available from:

find your local representative at:
www.sensirion.com/reps

H21A1 / H21A2 / H21A3
PHOTOTRANSISTOR OPTICAL INTERRUPTER SWITCH

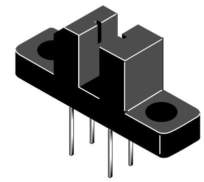
PACKAGE DIMENSIONS



NOTES:

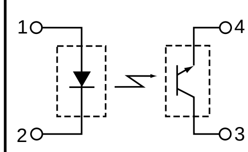
1. Dimensions for all drawings are in inches (mm).
2. Tolerance of ± .010 (.25) on all non-nominal dimensions unless otherwise specified.

DESCRIPTION



The H21A1, H21A2 and H21A3 consist of a gallium arsenide infrared emitting diode coupled with a silicon phototransistor in a plastic housing. The packaging system is designed to optimize the mechanical resolution, coupling efficiency, ambient light rejection, cost and reliability. The gap in the housing provides a means of interrupting the signal with an opaque material, switching the output from an "ON" to an "OFF" state.

SCHEMATIC



FEATURES

- Opaque housing
- Low cost
- .035" apertures
- High $I_{C(ON)}$

1. Derate power dissipation linearly 1.33 mW/°C above 25°C.
2. RMA flux is recommended.
3. Methanol or isopropyl alcohols are recommended as cleaning agents.
4. Soldering iron tip 1/16" (1.6mm) minimum from housing.

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise specified)

Parameter	Symbol	Rating	Unit
Operating Temperature	T_{OPR}	-55 to +100	°C
Storage Temperature	T_{STG}	-55 to +100	°C
Soldering Temperature (Iron)(2,3 and 4)	T_{SOL-I}	240 for 5 sec	°C
Soldering Temperature (Flow)(2 and 3)	T_{SOL-F}	260 for 10 sec	°C
INPUT (EMITTER)			
Continuous Forward Current	I_F	50	mA
Reverse Voltage	V_R	6	V
Power Dissipation (1)	P_D	100	mW
OUTPUT (SENSOR)			
Collector to Emitter Voltage	V_{CEO}	30	V
Emitter to Collector Voltage	V_{ECO}	4.5	V
Collector Current	I_C	20	mA
Power Dissipation (T_C = 25°C)(1)	P_D	150	mW

ELECTRICAL / OPTICAL CHARACTERISTICS (T_A =25°C)(All measurements made under pulse condition)

PARAMETER	TEST CONDITIONS	SYMBOL	DEVICES	MIN	TYP	MAX	UNITS
INPUT (EMITTER)							
Forward Voltage	I_F = 60 mA	V_F	All	—	—	1.7	V
Reverse Breakdown Voltage	I_R = 10 µA	V_R	All	6.0	—	—	V
Reverse Leakage Current	V_R = 3 V	I_R	All	—	—	1.0	µA
OUTPUT (SENSOR)							
Emitter to Collector Breakdown	I_F = 100 µA, Ee = 0	BV_{ECO}	All	6.0	—	—	V
Collector to Emitter Breakdown	I_C = 1 mA, Ee = 0	BV_{CEO}	All	30	—	—	V
Collector to Emitter Leakage	V_{CE} = 25 V, Ee = 0	I_{CEO}	All	—	—	100	nA
COUPLED							
On-State Collector Current	I_F = 5 mA, V_{CE} = 5 V	$I_{C(ON)}$	H21A1	0.15	—	—	mA
			H21A2	0.30	—	—	
			H21A3	0.60	—	—	
	I_F = 20 mA, V_{CE} = 5 V		H21A1	1.0	—	—	
			H21A2	2.0	—	—	
			H21A3	4.0	—	—	
	I_F = 30 mA, V_{CE} = 5 V		H21A1	1.9	—	—	
			H21A2	3.0	—	—	
			H21A3	5.5	—	—	
Saturation Voltage	I_F = 20 mA, I_C = 1.8 mA	$V_{CE(SAT)}$	H21A2/3	—	—	0.40	V
	I_F = 30 mA, I_C = 1.8 mA		H21A1	—	—	0.40	V
Turn-On Time	I_F = 30 mA, V_{CC} = 5 V, R_L = 2.5 KΩ	t_{on}	All	—	8	—	µs
Turn-Off Time	I_F = 30 mA, V_{CC} = 5 V, R_L = 2.5 KΩ	t_{off}	All	—	50	—	µs

Figure 1. Output Current vs. Input Current

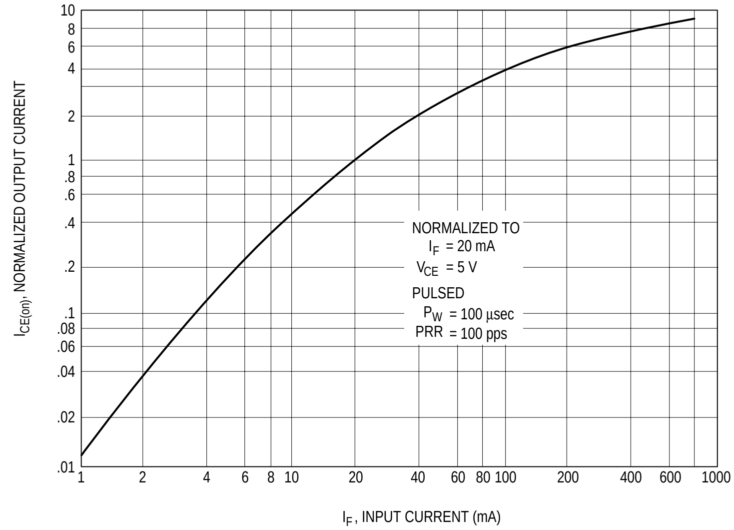


Figure 2. Output Current vs. Temperature

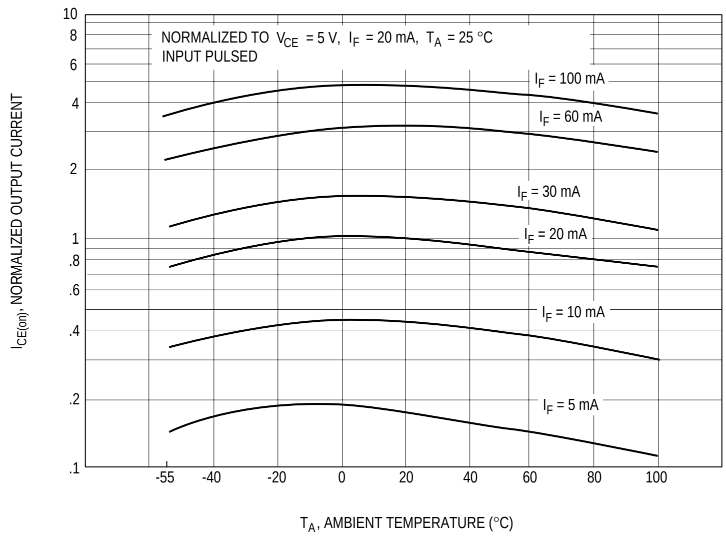


Figure 3. $V_{CE(SAT)}$ vs. Temperature

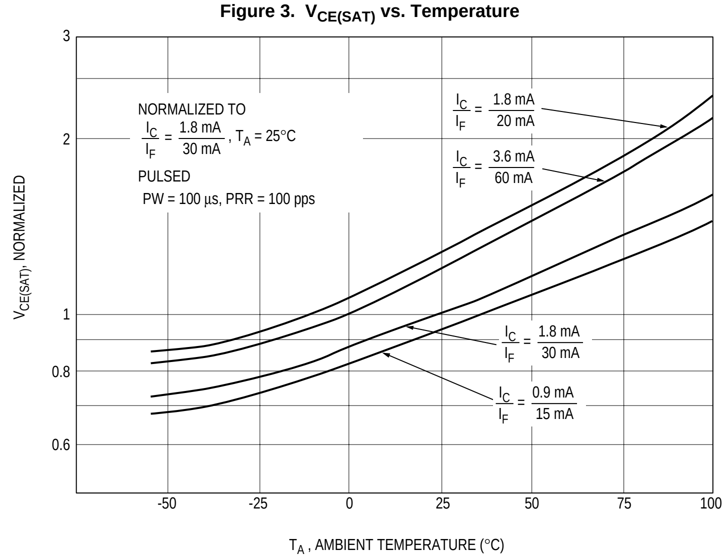


Figure 4. Leakage Current vs. Temperature

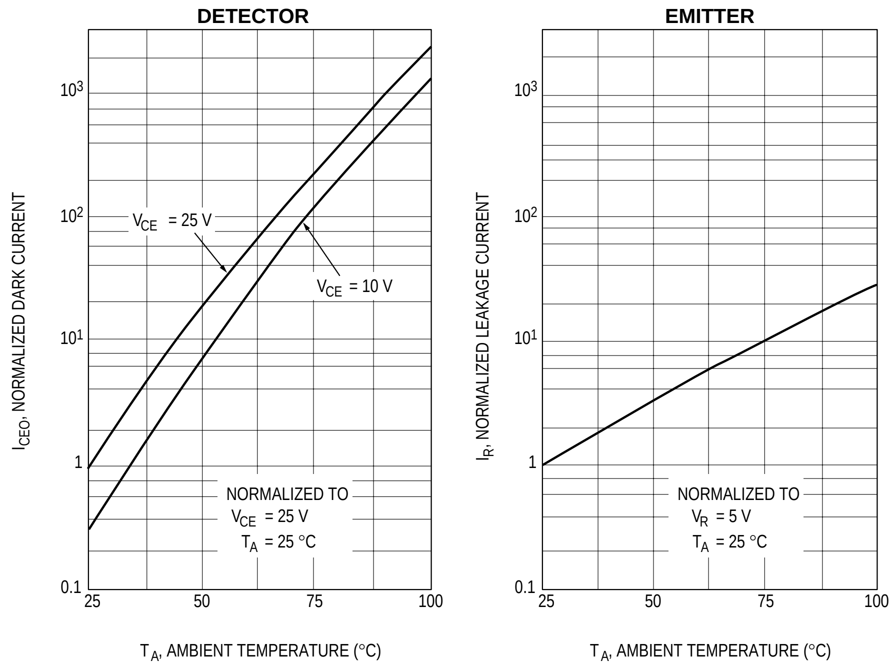


Figure 5. Switching Speed vs. R_L

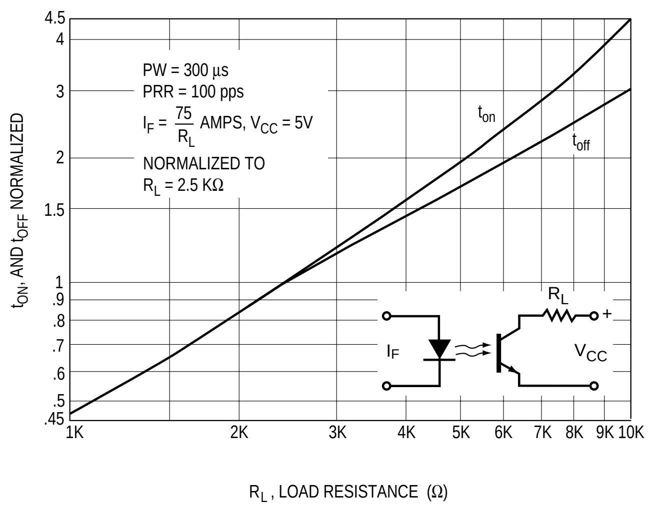
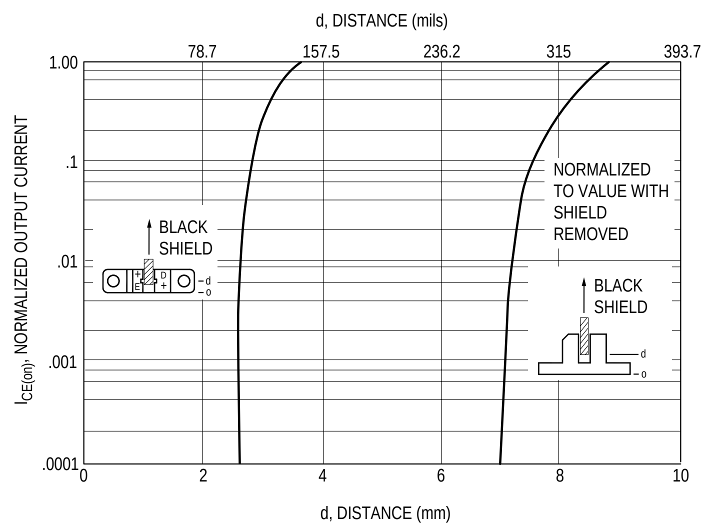


Figure 6. Output Current vs. Distance



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1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body,or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

LM317, NCV317

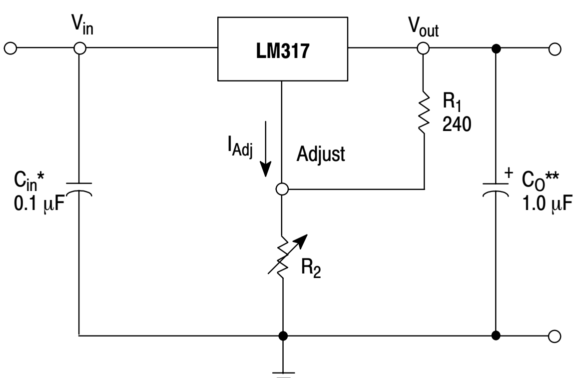
1.5 A Adjustable Output, Positive Voltage Regulator

The LM317 is an adjustable 3−terminal positive voltage regulator capable of supplying in excess of 1.5 A over an output voltage range of 1.2 V to 37 V. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, it employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow−out proof.

The LM317 serves a wide variety of applications including local, on card regulation. This device can also be used to make a programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the LM317 can be used as a precision current regulator.

Features

- Output Current in Excess of 1.5 A
- Output Adjustable between 1.2 V and 37 V
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting Constant with Temperature
- Output Transistor Safe−Area Compensation
- Floating Operation for High Voltage Applications
- Available in Surface Mount D^{2}PAK−3, and Standard 3−Lead Transistor Package
- Eliminates Stocking many Fixed Voltages
- Pb−Free Packages are Available



* C_{in} is required if regulator is located an appreciable distance from power supply filter.
** C_O is not needed for stability, however, it does improve transient response.

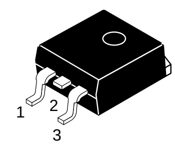
$$V_{out} = 1.25\,V\left(1 + \frac{R_2}{R_1}\right) + I_{Adj}R_2$$

Since I_{Adj} is controlled to less than 100 μA, the error associated with this term is negligible in most applications.

Figure 1. Standard Application

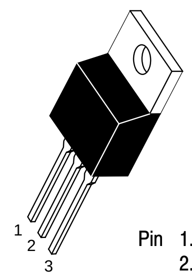
ON Semiconductor®

http://onsemi.com



D^{2}PAK−3
D2T SUFFIX
CASE 936

Heatsink surface (shown as terminal 4 in case outline drawing) is connected to Pin 2.



TO−220
T SUFFIX
CASE 221A

Pin 1. Adjust
2. V_{out}
3. V_{in}

Heatsink surface connected to Pin 2.

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 10 of this data sheet.

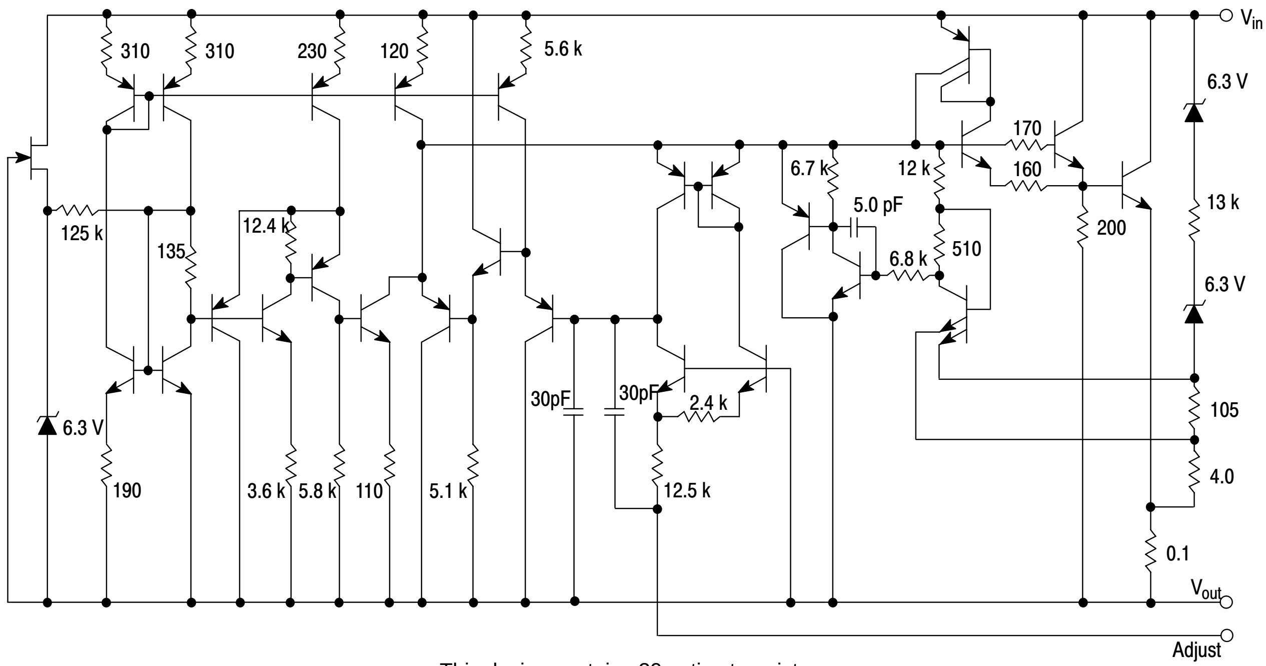
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input−Output Voltage Differential	$V_I - V_O$	40	Vdc
Power Dissipation			
Case 221A			
T_A = +25°C	P_D	Internally Limited	W
Thermal Resistance, Junction−to−Ambient	θ_{JA}	65	°C/W
Thermal Resistance, Junction−to−Case	θ_{JC}	5.0	°C/W
Case 936 (D^2PAK-3)			
T_A = +25°C	P_D	Internally Limited	W
Thermal Resistance, Junction−to−Ambient	θ_{JA}	70	°C/W
Thermal Resistance, Junction−to−Case	θ_{JC}	5.0	°C/W
Operating Junction Temperature Range	T_J	−55 to +150	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS ($V_I - V_O$ = 5.0 V; I_O = 0.5 A for D2T and T packages; $T_J = T_{low}$ to T_{high} (Note 1); I_{max} and P_{max} (Note 2); unless otherwise noted.)

Characteristics	Figure	Symbol	Min	Typ	Max	Unit
Line Regulation (Note 3), T_A = +25°C, 3.0 V ≤ $V_I - V_O$ ≤ 40 V	1	Reg_{line}	−	0.01	0.04	%/V
Load Regulation (Note 3), T_A = +25°C, 10 mA ≤ I_O ≤ I_{max}	2	Reg_{load}				
V_O ≤ 5.0 V			−	5.0	25	mV
V_O ≥ 5.0 V			−	0.1	0.5	% V_O
Thermal Regulation, T_A = +25°C (Note 4), 20 ms Pulse		Reg_{therm}	−	0.03	0.07	% V_O/W
Adjustment Pin Current	3	I_{Adj}	−	50	100	μA
Adjustment Pin Current Change, 2.5 V ≤ $V_I - V_O$ ≤ 40 V, 10 mA ≤ I_L ≤ I_{max}, P_D ≤ P_{max}	1, 2	ΔI_{Adj}	−	0.2	5.0	μA
Reference Voltage, 3.0 V ≤ $V_I - V_O$ ≤ 40 V, 10 mA ≤ I_O ≤ I_{max}, P_D ≤ P_{max}	3	V_{ref}	1.2	1.25	1.3	V
Line Regulation (Note 3), 3.0 V ≤ $V_I - V_O$ ≤ 40 V	1	Reg_{line}	−	0.02	0.07	% V
Load Regulation (Note 3), 10 mA ≤ I_O ≤ I_{max}	2	Reg_{load}				
V_O ≤ 5.0 V			−	20	70	mV
V_O ≥ 5.0 V			−	0.3	1.5	% V_O
Temperature Stability (T_{low} ≤ T_J ≤ T_{high})	3	T_S	−	0.7	−	% V_O
Minimum Load Current to Maintain Regulation ($V_I - V_O$ = 40 V)	3	I_{Lmin}	−	3.5	10	mA
Maximum Output Current	3	I_{max}				A
$V_I - V_O$ ≤ 15 V, P_D ≤ $P_{max,}$ T Package			1.5	2.2	−	
$V_I - V_O$ = 40 V, P_D ≤ P_{max}, T_A = +25°C, T Package			0.15	0.4	−	
RMS Noise, % of V_O, T_A = +25°C, 10 Hz ≤ f ≤ 10 kHz		N	−	0.003	−	% V_O
Ripple Rejection, V_O = 10 V, f = 120 Hz (Note 5)	4	RR				dB
Without C_{Adj}			−	65	−	
C_{Adj} = 10 μF			66	80	−	
Long−Term Stability, $T_J = T_{high}$ (Note 6), T_A = +25°C for Endpoint Measurements	3	S	−	0.3	1.0	%/1.0 k Hrs.
Thermal Resistance Junction to Case, T Package		$R_{\theta JC}$	−	5.0	−	°C/W

1. T_{low} to T_{high} = 0° to +125°C, for LM317T, D2T. T_{low} to T_{high} = −40° to +125°C, for LM317BT, BD2T, T_{low} to T_{high} = −55° to +150°C, for NCV317BT, BD2T.
2. I_{max} = 1.5 A, P_{max} = 20 W
3. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.
4. Power dissipation within an IC voltage regulator produces a temperature gradient on the die, affecting individual IC components on the die. These effects can be minimized by proper integrated circuit design and layout techniques. Thermal Regulation is the effect of these temperature gradients on the output voltage and is expressed in percentage of output change per watt of power change in a specified time.
5. C_{Adj}, when used, is connected between the adjustment pin and ground.
6. Since Long−Term Stability cannot be measured on each device before shipment, this specification is an engineering estimate of average stability from lot to lot.



This device contains 29 active transistors.

Figure 2. Representative Schematic Diagram

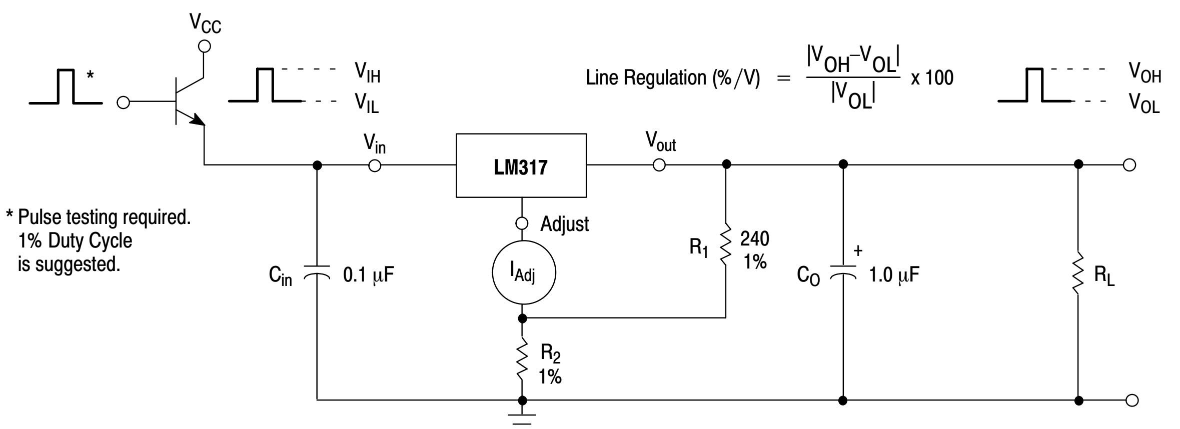
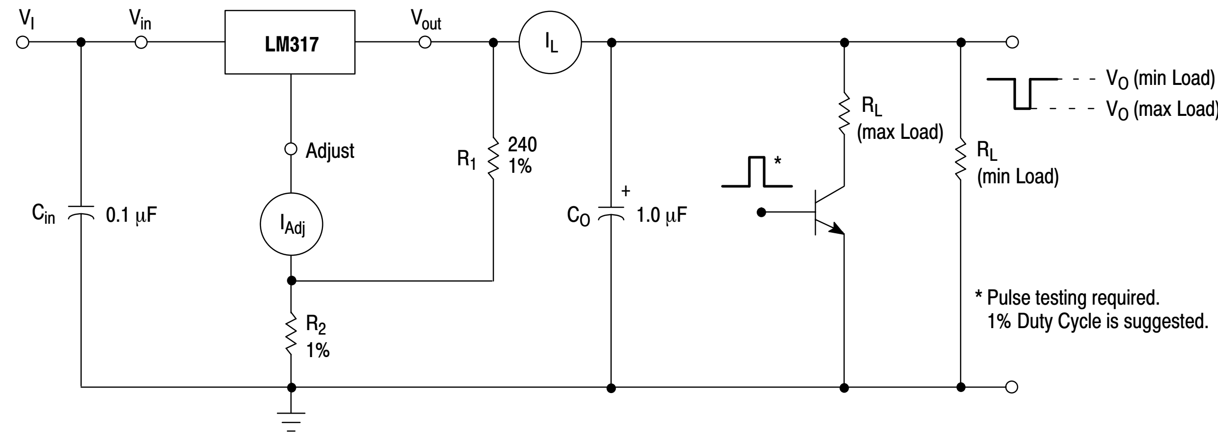


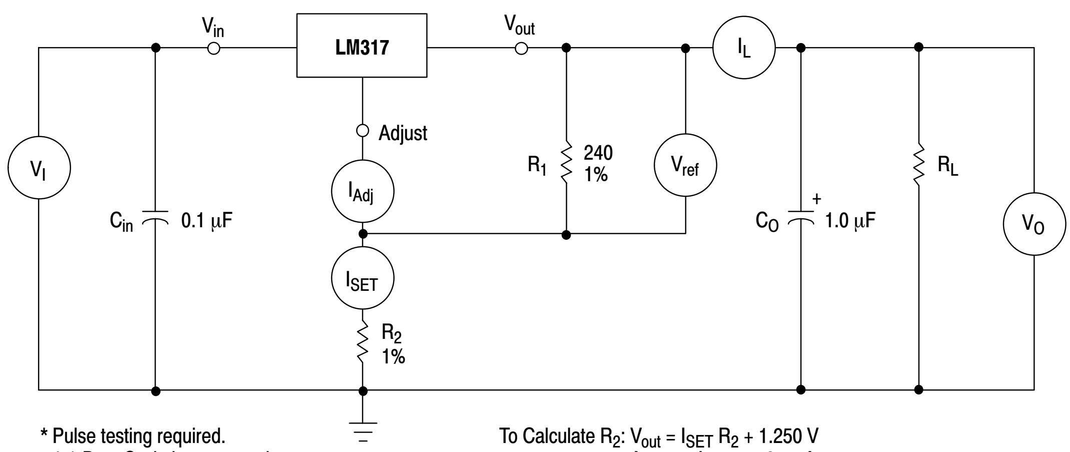
Figure 3. Line Regulation and ΔI_{Adj}/Line Test Circuit



Load Regulation (mV) = V_O (min Load) − V_O (max Load)

$$\text{Load Regulation (\% } V_O) = \frac{V_O \text{ (min Load)} - V_O \text{ (max Load)}}{V_O \text{ (min Load)}} \times 100$$

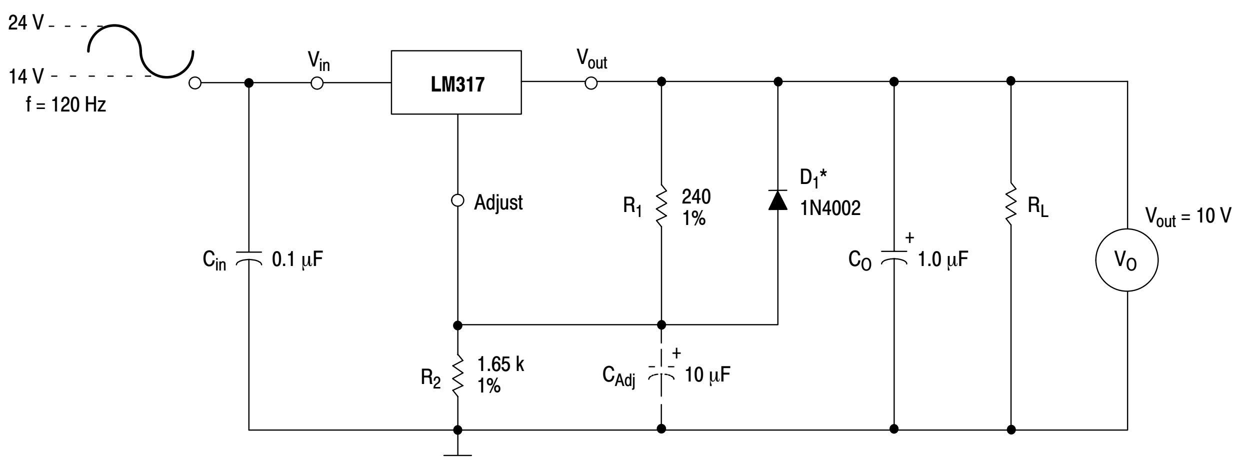
Figure 4. Load Regulation and ΔI_{Adj}/Load Test Circuit



* Pulse testing required.
1% Duty Cycle is suggested.

To Calculate R_2: $V_{out} = I_{SET} R_2 + 1.250$ V
Assume $I_{SET} = 5.25$ mA

Figure 5. Standard Test Circuit



* D_1 Discharges C_{Adj} if output is shorted to Ground.

Figure 6. Ripple Rejection Test Circuit

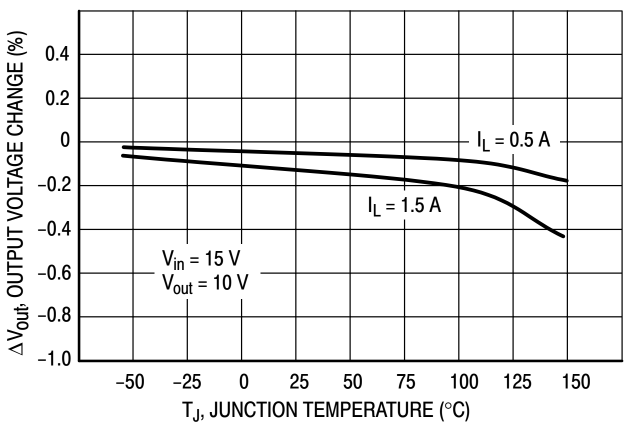


Figure 7. Load Regulation

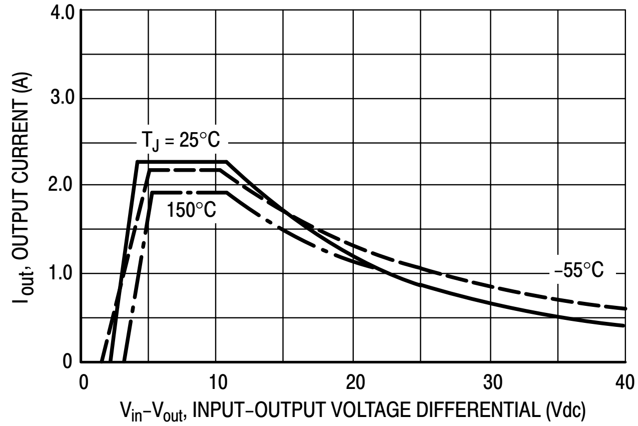


Figure 8. Current Limit

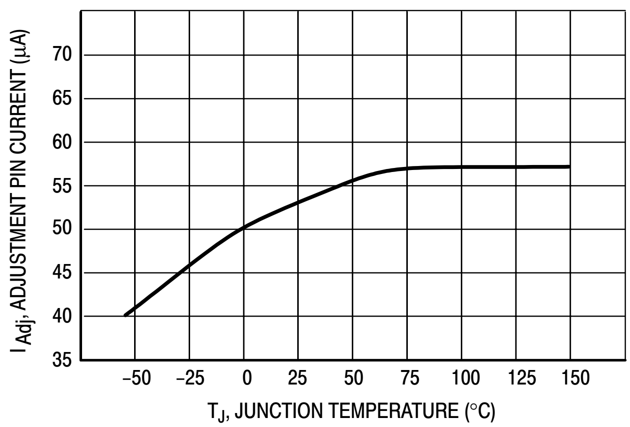


Figure 9. Adjustment Pin Current

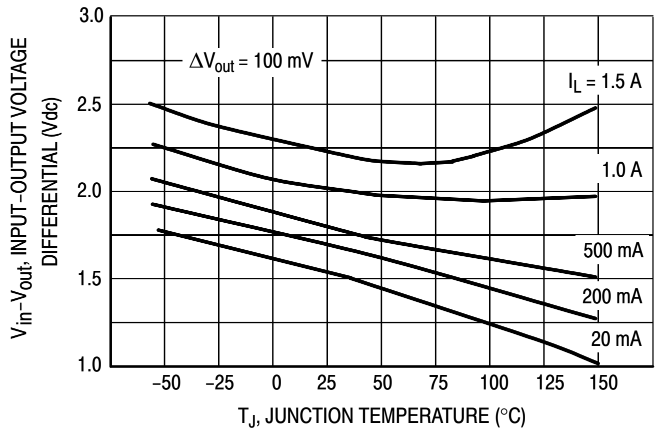


Figure 10. Dropout Voltage

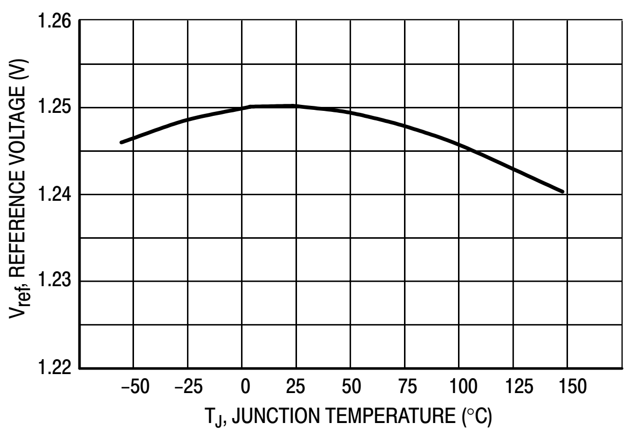


Figure 11. Temperature Stability

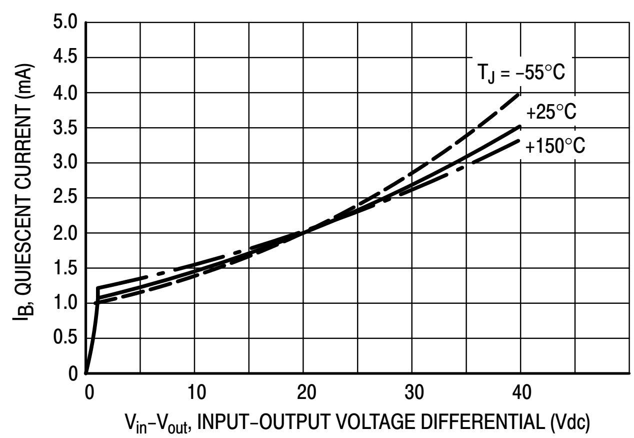


Figure 12. Minimum Operating Current

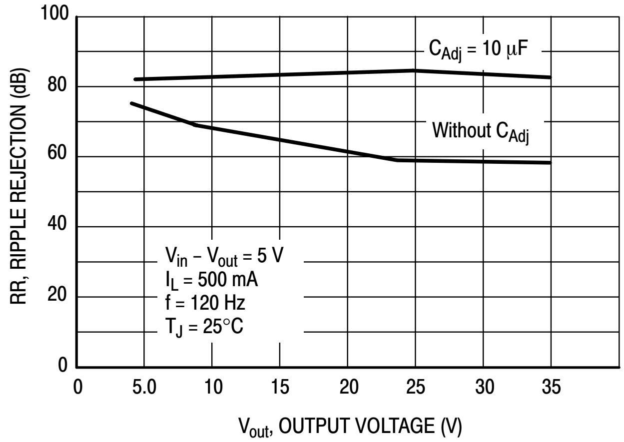


Figure 13. Ripple Rejection versus Output Voltage

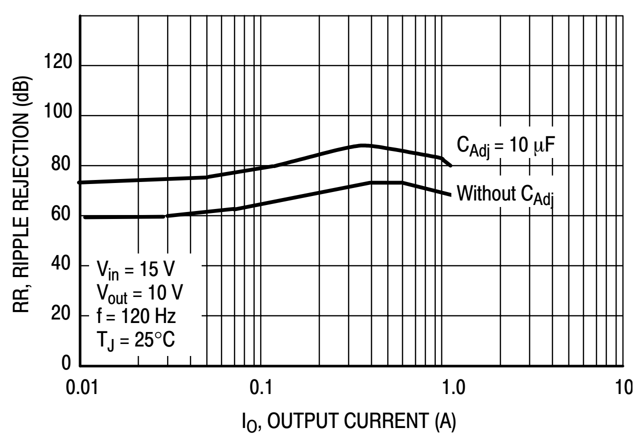


Figure 14. Ripple Rejection versus Output Current

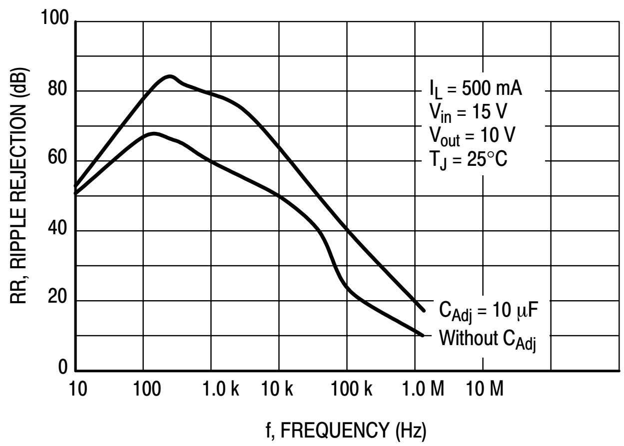


Figure 15. Ripple Rejection versus Frequency

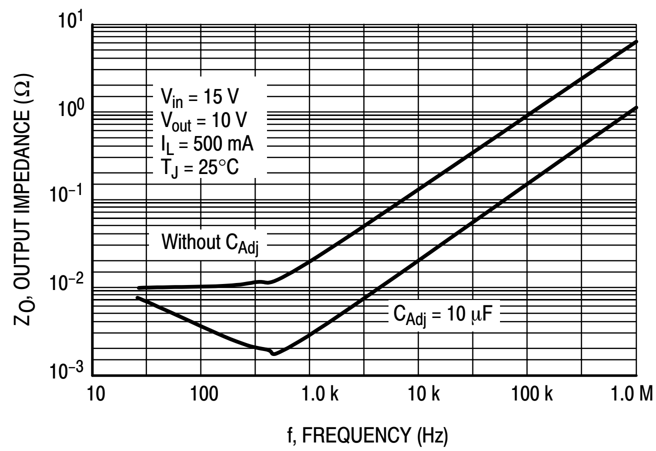


Figure 16. Output Impedance

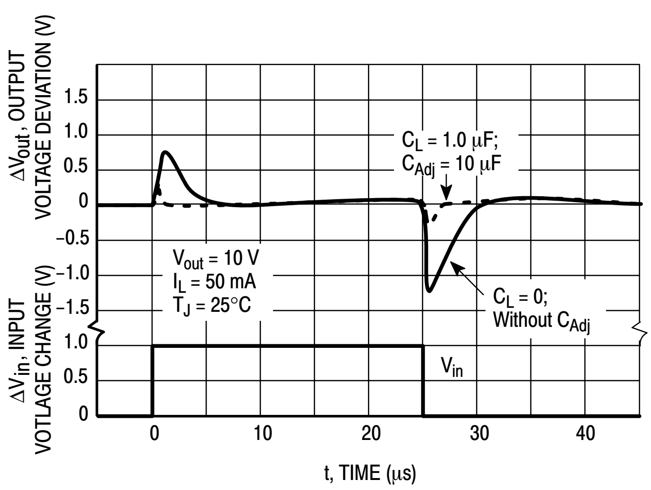


Figure 17. Line Transient Response

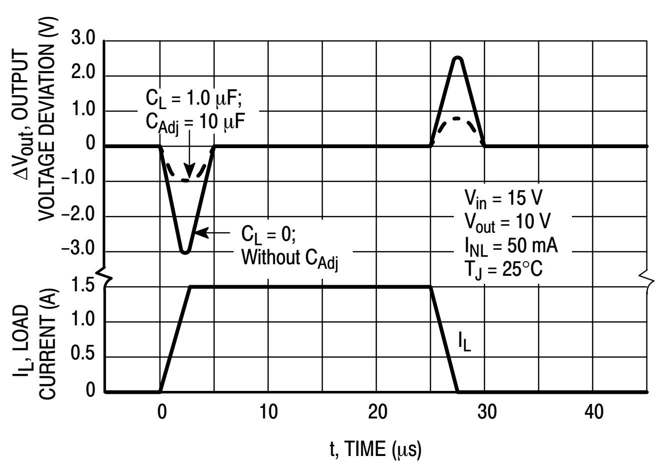


Figure 18. Load Transient Response

APPLICATIONS INFORMATION

Basic Circuit Operation

The LM317 is a 3−terminal floating regulator. In operation, the LM317 develops and maintains a nominal 1.25 V reference (V_{ref}) between its output and adjustment terminals. This reference voltage is converted to a programming current (I_{PROG}) by R_1 (see Figure 17), and this constant current flows through R_2 to ground.

The regulated output voltage is given by:

$$V_{out} = V_{ref}\left(1 + \frac{R_2}{R_1}\right) + I_{Adj} R_2$$

Since the current from the adjustment terminal (I_{Adj}) represents an error term in the equation, the LM317 was designed to control I_{Adj} to less than 100 μA and keep it constant. To do this, all quiescent operating current is returned to the output terminal. This imposes the requirement for a minimum load current. If the load current is less than this minimum, the output voltage will rise.

Since the LM317 is a floating regulator, it is only the voltage differential across the circuit which is important to performance, and operation at high voltages with respect to ground is possible.

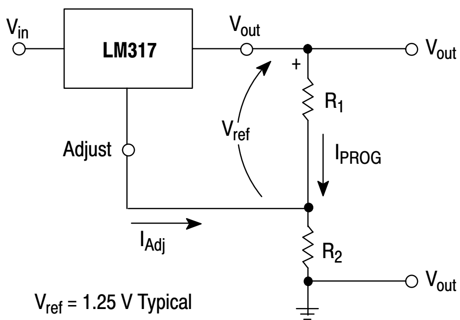


Figure 19. Basic Circuit Configuration

Load Regulation

The LM317 is capable of providing extremely good load regulation, but a few precautions are needed to obtain maximum performance. For best performance, the programming resistor (R_1) should be connected as close to the regulator as possible to minimize line drops which effectively appear in series with the reference, thereby degrading regulation. The ground end of R_2 can be returned near the load ground to provide remote ground sensing and improve load regulation.

External Capacitors

A 0.1 μF disc or 1.0 μF tantalum input bypass capacitor (C_{in}) is recommended to reduce the sensitivity to input line impedance.

The adjustment terminal may be bypassed to ground to improve ripple rejection. This capacitor (C_{Adj}) prevents ripple from being amplified as the output voltage is increased. A 10 μF capacitor should improve ripple rejection about 15 dB at 120 Hz in a 10 V application.

Although the LM317 is stable with no output capacitance, like any feedback circuit, certain values of external capacitance can cause excessive ringing. An output capacitance (C_O) in the form of a 1.0 μF tantalum or 25 μF aluminum electrolytic capacitor on the output swamps this effect and insures stability.

Protection Diodes

When external capacitors are used with any IC regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points into the regulator.

Figure 18 shows the LM317 with the recommended protection diodes for output voltages in excess of 25 V or high capacitance values (C_O > 25 μF, C_{Adj} > 10 μF). Diode D_1 prevents C_O from discharging thru the IC during an input short circuit. Diode D_2 protects against capacitor C_{Adj} discharging through the IC during an output short circuit. The combination of diodes D_1 and D_2 prevents C_{Adj} from discharging through the IC during an input short circuit.

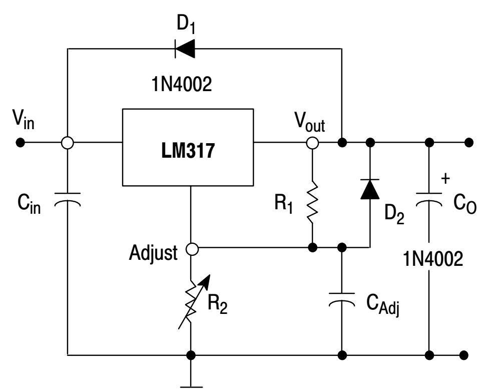


Figure 20. Voltage Regulator with Protection Diodes

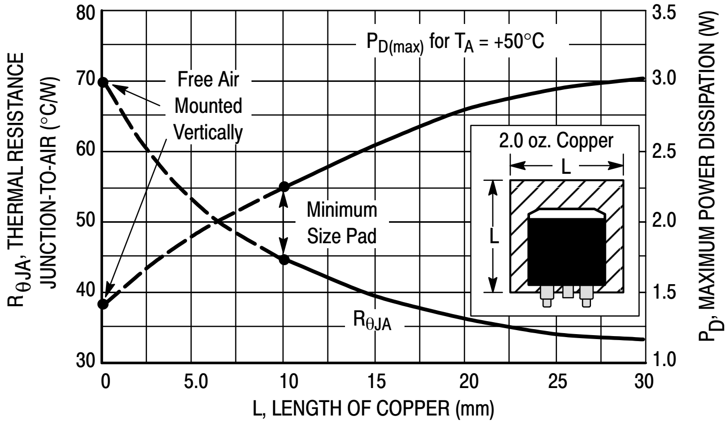


Figure 21. D^2PAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length

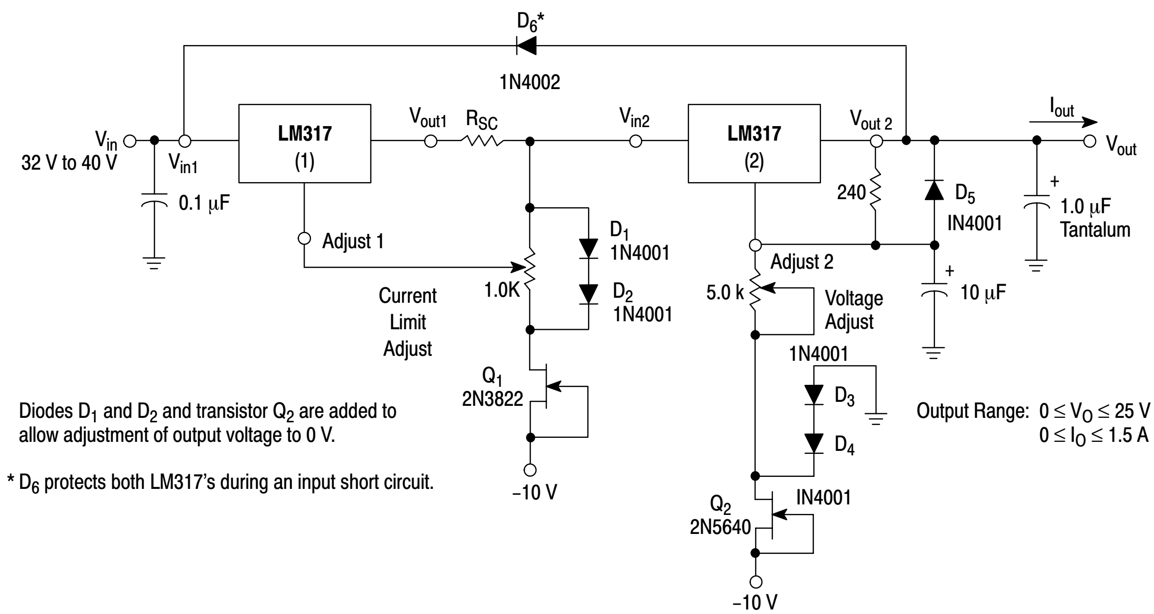


Figure 22. "Laboratory" Power Supply with Adjustable Current Limit and Output Voltage

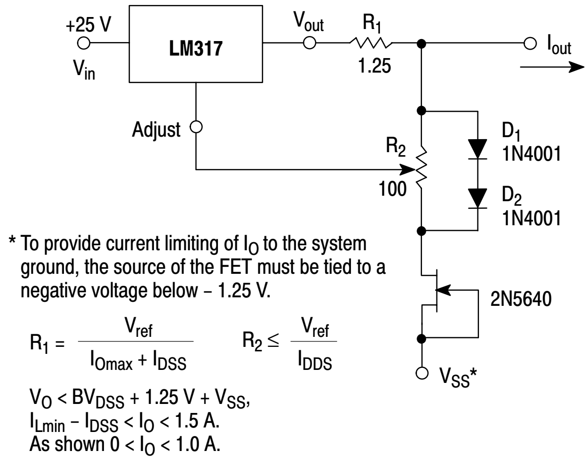


Figure 23. Adjustable Current Limiter

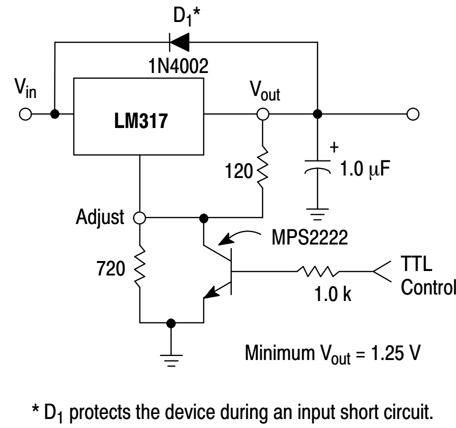


Figure 24. 5.0 V Electronic Shutdown Regulator

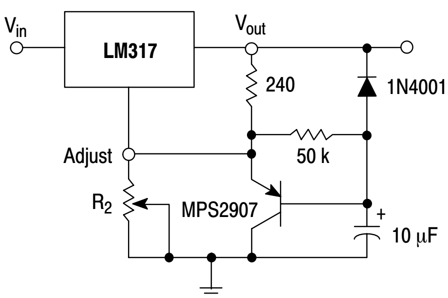


Figure 25. Slow Turn−On Regulator

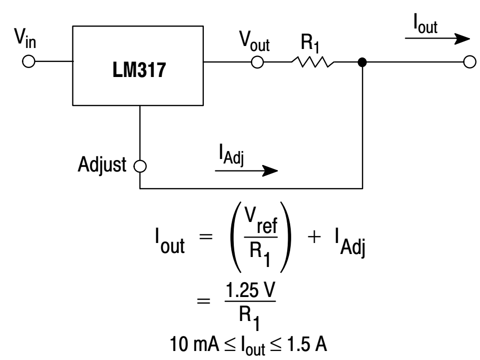
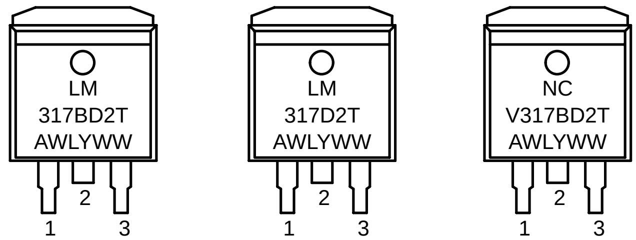


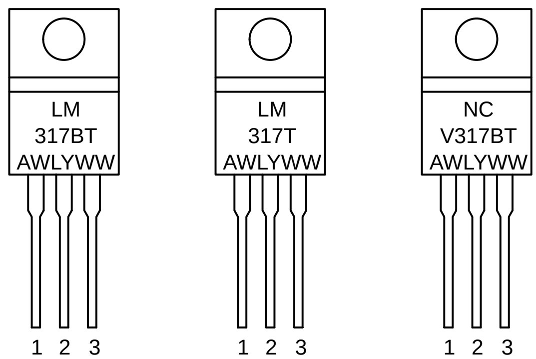
Figure 26. Current Regulator

MARKING DIAGRAMS

D^2PAK−3
D2T SUFFIX
CASE 936



TO−220
T SUFFIX
CASE 221A



A = Assembly Location
WL = Wafer Lot
Y = Year
WW = Work Week

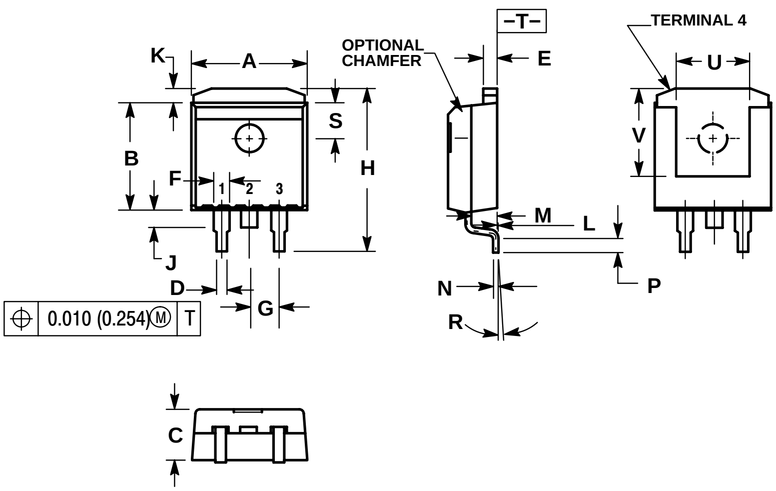
ORDERING INFORMATION

Device	Operating Temperature Range	Package	Shipping†
LM317BD2T	T_J = −40° to +125°C	D^2PAK−3	50 Units / Rail
LM317BD2TG		D^2PAK−3 (Pb−Free)	
LM317BD2TR4		D^2PAK−3	800 Tape & Reel
LM317BD2TR4G		D^2PAK−3 (Pb−Free)	
LM317BT		TO−220	50 Units / Rail
LM317BTG		TO−220 (Pb−Free)	
LM317D2T	T_J = 0° to +125°C	D^2PAK−3	50 Units / Rail
LM317D2TR4		D^2PAK−3	800 Tape & Reel
LM317T		TO−220	50 Units / Rail
LM317TG		TO−220 (Pb−Free)	
NCV317BD2T*	T_J = −55° to +150°C	D^2PAK−3	50 Units / Rail
NCV317BD2TR4*		D^2PAK−3	800 Tape & Reel
NCV317BT*		TO−220	50 Units / Rail

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
*Devices are qualified for automotive use.

PACKAGE DIMENSIONS

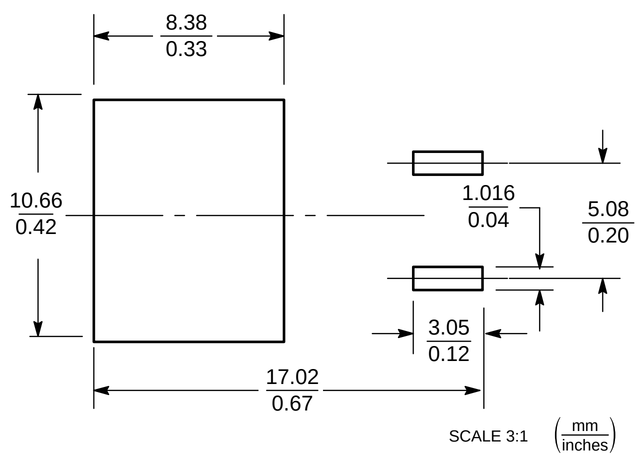
D²PAK−3
D2T SUFFIX
PLASTIC PACKAGE
CASE 936−03
ISSUE B



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. TAB CONTOUR OPTIONAL WITHIN DIMENSIONS A AND K.
4. DIMENSIONS U AND V ESTABLISH A MINIMUM MOUNTING SURFACE FOR TERMINAL 4.
5. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH OR GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.025 (0.635) MAXIMUM.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.386	0.403	9.804	10.236
B	0.356	0.368	9.042	9.347
C	0.170	0.180	4.318	4.572
D	0.026	0.036	0.660	0.914
E	0.045	0.055	1.143	1.397
F	0.051 REF		1.295 REF	
G	0.100 BSC		2.540 BSC	
H	0.539	0.579	13.691	14.707
J	0.125 MAX		3.175 MAX	
K	0.050 REF		1.270 REF	
L	0.000	0.010	0.000	0.254
M	0.088	0.102	2.235	2.591
N	0.018	0.026	0.457	0.660
P	0.058	0.078	1.473	1.981
R	5° REF		5° REF	
S	0.116 REF		2.946 REF	
U	0.200 MIN		5.080 MIN	
V	0.250 MIN		6.350 MIN	

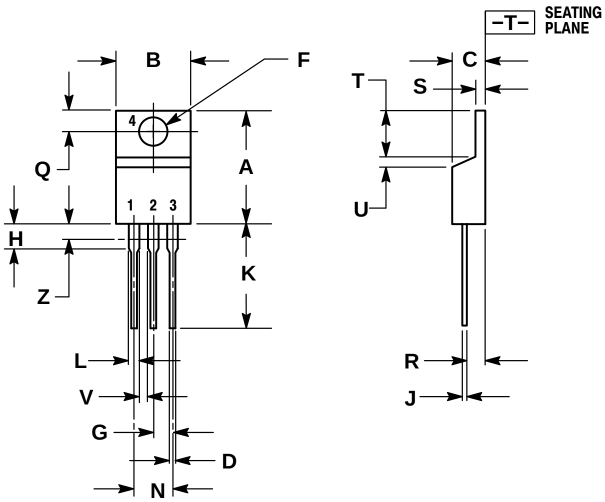
SOLDERING FOOTPRINT*



*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PACKAGE DIMENSIONS

TO−220
T SUFFIX
PLASTIC PACKAGE
CASE 221A−09
ISSUE AA



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.570	0.620	14.48	15.75
B	0.380	0.405	9.66	10.28
C	0.160	0.190	4.07	4.82
D	0.025	0.035	0.64	0.88
F	0.142	0.147	3.61	3.73
G	0.095	0.105	2.42	2.66
H	0.110	0.155	2.80	3.93
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.15	1.52
N	0.190	0.210	4.83	5.33
Q	0.100	0.120	2.54	3.04
R	0.080	0.110	2.04	2.79
S	0.045	0.055	1.15	1.39
T	0.235	0.255	5.97	6.47
U	0.000	0.050	0.00	1.27
V	0.045	−−−	1.15	−−−
Z	−−−	0.080	−−−	2.04

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