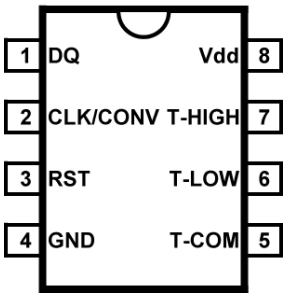
Dallas DS1620 Digital Thermometer
Cornerstone Electronics Technology and Robotics II

- **Administration:**
  - Prayer
- **PicBasic Pro Programs Used in The DS1620 Lesson:**
  - General PicBasic Pro Program Listing: http://www.cornerstonerobotics.org/picbasic.php
  - Lab 1: http://www.cornerstonerobotics.org/code/DS1620_1.pdf
  - Lab 1: http://www.cornerstonerobotics.org/code/DS1620_2.pdf
  - Lab 2: http://www.cornerstonerobotics.org/code/DS1620_3_heater.pdf
  - Lab 3: http://www.cornerstonerobotics.org/code/DS1620_4_fan.pdf
- **DS1620 Digital Thermometer:**
  - **Features:**
    - Measures temperatures from -55°C to +125°C in 0.5°C increments; Fahrenheit equivalent is -67°F to +257°F in 0.9°F increments
    - Temperature is read as a 9-bit value
    - Converts temperature to digital word in 750 ms (max)
    - Data is read from/written via a 3-wire serial interface (CLK, DQ, RST)
    - Applications include thermostatic controls, industrial systems, consumer products, thermometers, or any thermally sensitive system
    - 8-pin DIP or SOIC (208-mil) packages
  - **DIP Pin Layout:**

DS1620



  - **Pin Description:**

Pin	Description
DQ	3-Wire Data Input/Output
CLK/CONV	3-Wire Clock Input and Stand-alone Convert Input
RST	3-Wire Reset Input
GND	Ground
T_{HIGH}	High Temperature Trigger
T_{LOW}	Low Temperature Trigger
T_{COM}	High/Low Combination Trigger
V_{DD}	Power Supply Voltage (3V – 5V)

- **Operation – Measuring Temperature:**
  - Data is transferred between the DS1620 and the PIC microcontroller using synchronous serial communication. The PicBasic Pro commands designed for this purpose is SHIFTIN and SHIFTOUT.
    - Synchronous Serial Communication:
      - Serial communication ports send and receive information one bit at a time.
      - Synchronous communication is dependent upon a Clock pin. The Clock pin acts as a metronome for data transfer between the PIC and the DS1620.
  - The temperature reading is provided in a 9–bit, two's complement reading by issuing a READ TEMPERATURE command ($aa).
  - The data is transmitted serially through the 3–wire serial interface, LSB first.
- **Operation – Thermostat Control:**
  - With three thermal alarm outputs, the DS1620 can also act as a thermostat.
  - T_{HIGH} is driven high if the DS1620's temperature is greater than or equal to a user–defined temperature TH.
  - T_{LOW} is driven high if the DS1620's temperature is less than or equal to a user–defined temperature TL.
  - T_{COM} is driven high when the temperature exceeds TH and stays high until the temperature falls below that of TL.
- **3 – Wire Operation:**
  -
- **DS1620 Command Set (Partial Listing):**

Instruction	Description	HEX Command
Start Conversion of Temperature	Initiates temperature conversion.	$ee
Read Temperature	Reads last converted temperature value from temperature register.	$aa
Write TH	Writes high temperature limit value into TH register	$01
Write TL	Writes low temperature limit value into TL register	$02
Read TH	Reads stored value of high temperature limit from TH register	$a1
Read TL	Reads stored value of low temperature limit from TL register	$a2

- **Temperature, TH, and TL Register 9-Bit Format:**

MSB

X	X	X	X	X	X	X	1

LSB

1	1	0	0	1	1	1	0

Temperature = -25 °C

- **Sample Temperature/Binary Data Outputs:**

Temperature	Binary Digital Output	Hex Digital Output
+125°C	%0 11111010	$00FA
+25°C	%0 00110010	$0032
+½°C	%0 00000001	$0001
+0°C	%0 00000000	$0000
-½°C	%1 11111111	$01FF
-25°C	%1 11001110	$01CE
-55°C	%1 10010010	$0192

See Appendix A and B for a complete listing of binary and hex temperature outputs.

- For a more complete discussion of the DS1620, see: http://pdfserv.maxim-ic.com/en/ds/DS1620.pdf

- **New PicBasic Pro Command:**
  - **SHIFTIN and SHIFTOUT Commands:**
    - **SHIFTIN and SHIFTOUT are PicBasic Pro** commands that are designed for synchronous serial data transfer between the DS1620 and the PIC microcontroller.
  - **SHIFTIN:**

    Format:

    SHIFTIN *DataPin, ClockPin, Mode,* [Var.{\Bits}…]

    Explanation:

    Clock *ClockPin*, synchronously shift in bits on *DataPin* and store the data received into Var. *ClockPin and DataPin* may be a constant, 0-15, a variable that equates to 0-15 or a pin name such as DSCLK or PORTB.1.

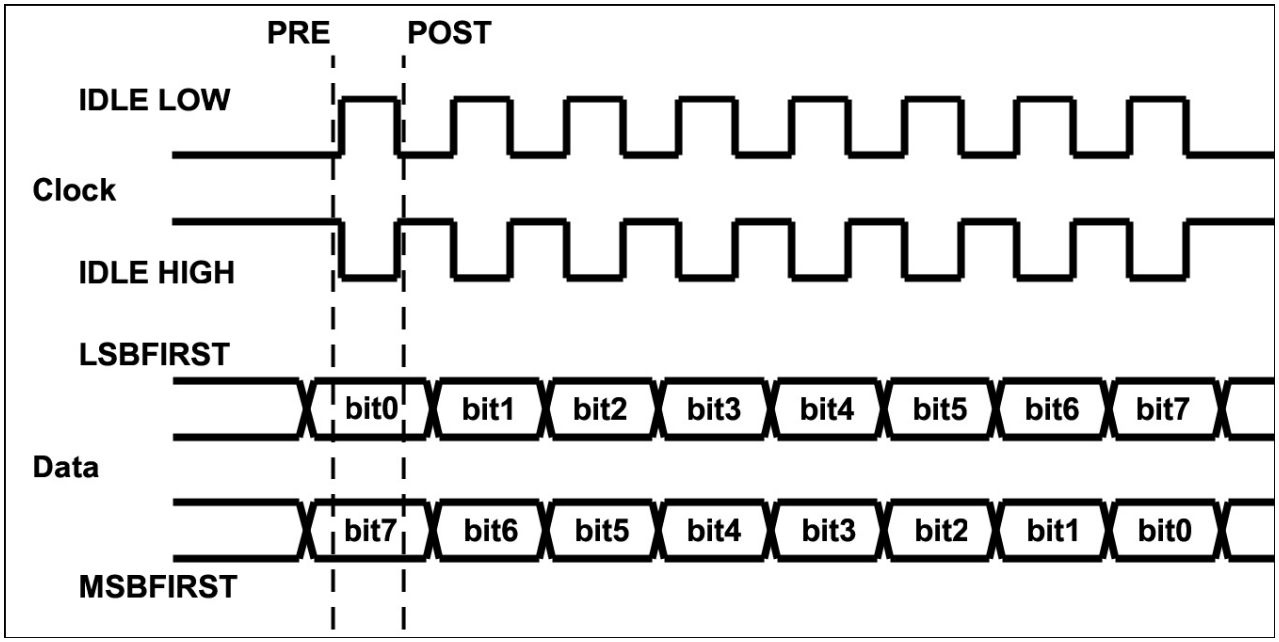
    Bits specifies the number of bits to be shifted in. Default is 8 bits. The *Bits* shifted are always the low order bits, regardless of the *Mode* used, LSB or MSB.

    The Mode names are defined in the file MODEDEFS.BAS. To use them, add the line:

    INCLUDE "Modedefs.bas"

Mode	Operation
MSBPRE	Shift data in highest bit first, Read data before sending clock. Clock idles low.
LSBPRE	Shift data in lowest bit first, Read data before sending clock. Clock idles low.
MSBPOST	Shift data in highest bit first, Read data after sending clock. Clock idles low.
LSBPOST	Shift data in lowest bit first, Read data after sending clock. Clock idles low.

- **Relationship of Clock to Various Modes:**



Examples:

SHIFTIN 0,1,MSBPRE,[B0,B1\4]
SHIFTIN DSDQ, DSCLK, LSBPRE, [temp\9]

For a more complete treatment of **SHIFTIN,** see:

Page 145 at: http://www.melabs.com/downloads/pbpm304.pdf

- **SHIFTOUT:**

  Format:

  SHIFTOUT *DataPin, ClockPin, Mode,* [Var.{\Bits}…]

  Explanation:
  Synchronously shift out Var on *ClockPin and DataPin. ClockPin and DataPin* may be a constant, 0-15, a variable that equates to 0-15 or a pin name such as DSCLK or PORTB.1.

  Bits specifies the number of bits to be shifted out. Default is 8 bits. The *Bits* shifted are always the low order bits, regardless of the *Mode* used, LSB or MSB.

  The Mode names are defined in the file MODEDEFS.BAS. To use them, add the line:

  INCLUDE "Modedefs.bas"

Mode	Operation
LSBFIRST	Shift data out lowest bit first. Clock idles low
MSBFIRST	Shift data out highest bit first. Clock idles low

  Examples:

  SHIFTOUT 0,1,MSBFIRST, [B0,B1]
  SHIFTOUT DSDQ, DSCLK, LSBFIRST, [$aa]

  For a more complete treatment of **SHIFTOUT,** see:

  Page 148 at: http://www.melabs.com/downloads/pbpm304.pdf

- Perform DS1620 LAB 1 – DS1620_1 and DS1620_2
- Perform DS1620 LAB 2 – DS1620_3_heater
- Perform DS1620 LAB 3 – DS1620_4_fan

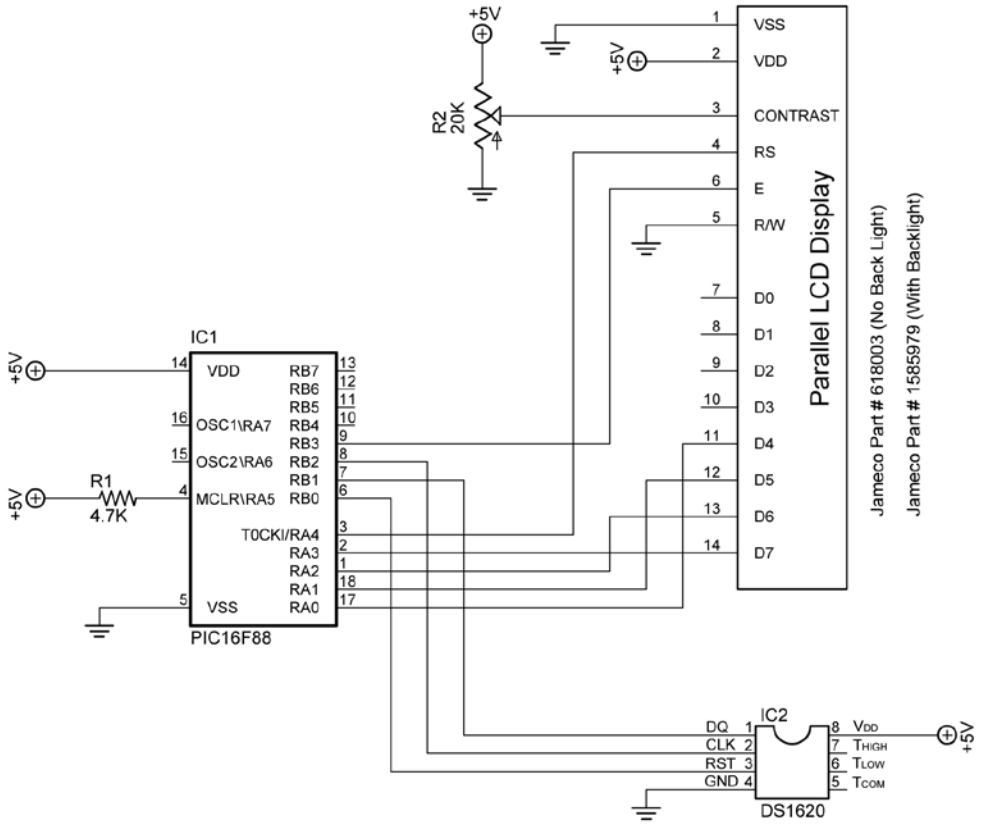
Cornerstone Electronics Technology and Robotics II
DS1620 Lab 1 – DD1620 _1 and DS1620 _2

- **Purpose:** The purpose of this lab is to have the student understand the basic operation of the Dallas DS1620 Digital Thermometer and be able to write and read temperature settings into the DS1620.

- **Apparatus and Materials:**

  - 1 – Breadboard
  - 1 – Dallas DS1620 Digital Thermometer
  - PIC16F88 Microcontroller
  - Hantronix HDM16216H-5-300S 16x2 LCD, Jameco #618003
  - 20 K Potentiometer
  - 4.7 K Resistor

- **Procedure:**
  - Wire the circuit below.
  - Program the PIC16F88 with **DS1620_1.pbp**. Place your finger on the DS1620 and observe the change in the LCD readout.
  - Now program the PIC16F88 with **DS1620_2.pbp**. Change the value of TH and TL using the digital hex values in the appendixes – save as **DS1620_10.pbp**. Input both positive and negative values.



DS1620_1 and DS1620_2

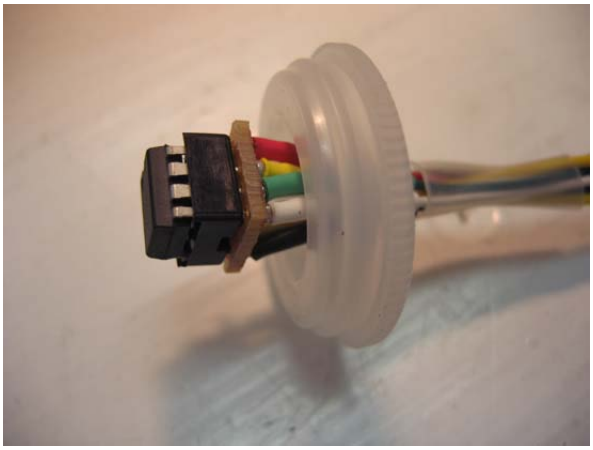
Cornerstone Electronics Technology and Robotics II
DS1620 Lab 2 – DD1620 _3_heater

- **Purpose:** The purpose of this lab is to demonstrate the DS1620 function as a thermostat used in conjunction with a heater.

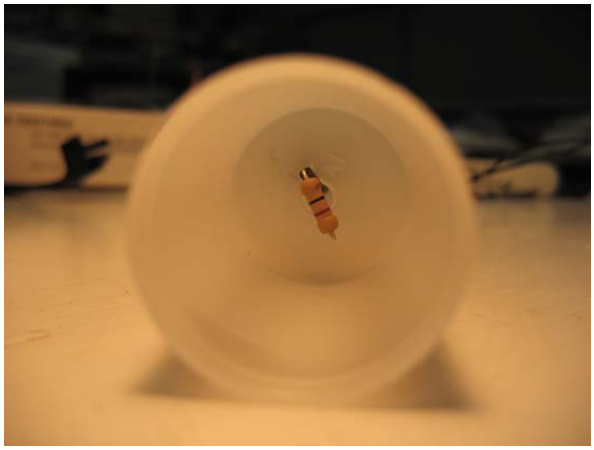
- **Apparatus and Materials:**

  - 1 – Breadboard
  - 1 – Dallas DS1620 Digital Thermometer
  - PIC16F88 Microcontroller
  - Hantronix HDM16216H-5-300S 16x2 LCD, Jameco #618003
  - 1 – 20 K Potentiometer
  - 1 – 4.7 K Resistor
  - 1 – 1 K Resistor
  - 1 – 150 Ohm resistor
  - 1 – 47 Ohm Resistor, ½ Watt
  - 1 – 2N2222A NPN Transistor
  - 1 – LED

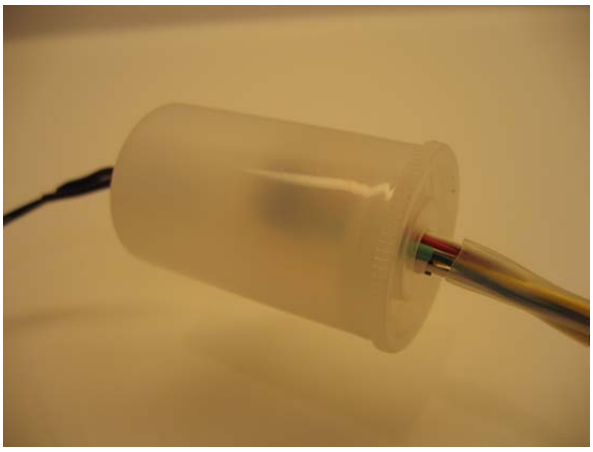
- **Procedure:**
  - Wire the circuit below.
  - Program the PIC16F88 with **DS1620_3_heater.pbp**. The high and low temperature limits may need changing depending upon the room temperature. See the Appendixes A and B for hexadecimal number of temperatures permitted for the DS1620. Use DS1620_2 to input the new TH and TL values into the DS1620 digital thermometer then reprogram with **DS1620_3_heater.pbp** and test the circuit's performance.
  - Note that the current through R5 is 0.19 A (I_{R5} = +9 V / 47 Ω) and the wattage value for R5 should exceed 1.72 watts (P_{R5} = 9 V * 0.19 A). The 1/2 watt resistor forces the resistor to overheat and act as a heater.
- **Other Resources:**
  - See Parallax version at: http://www.parallax.com/Portals/0/Downloads/docs/books/edu/ic.pdf
- **Photos:**



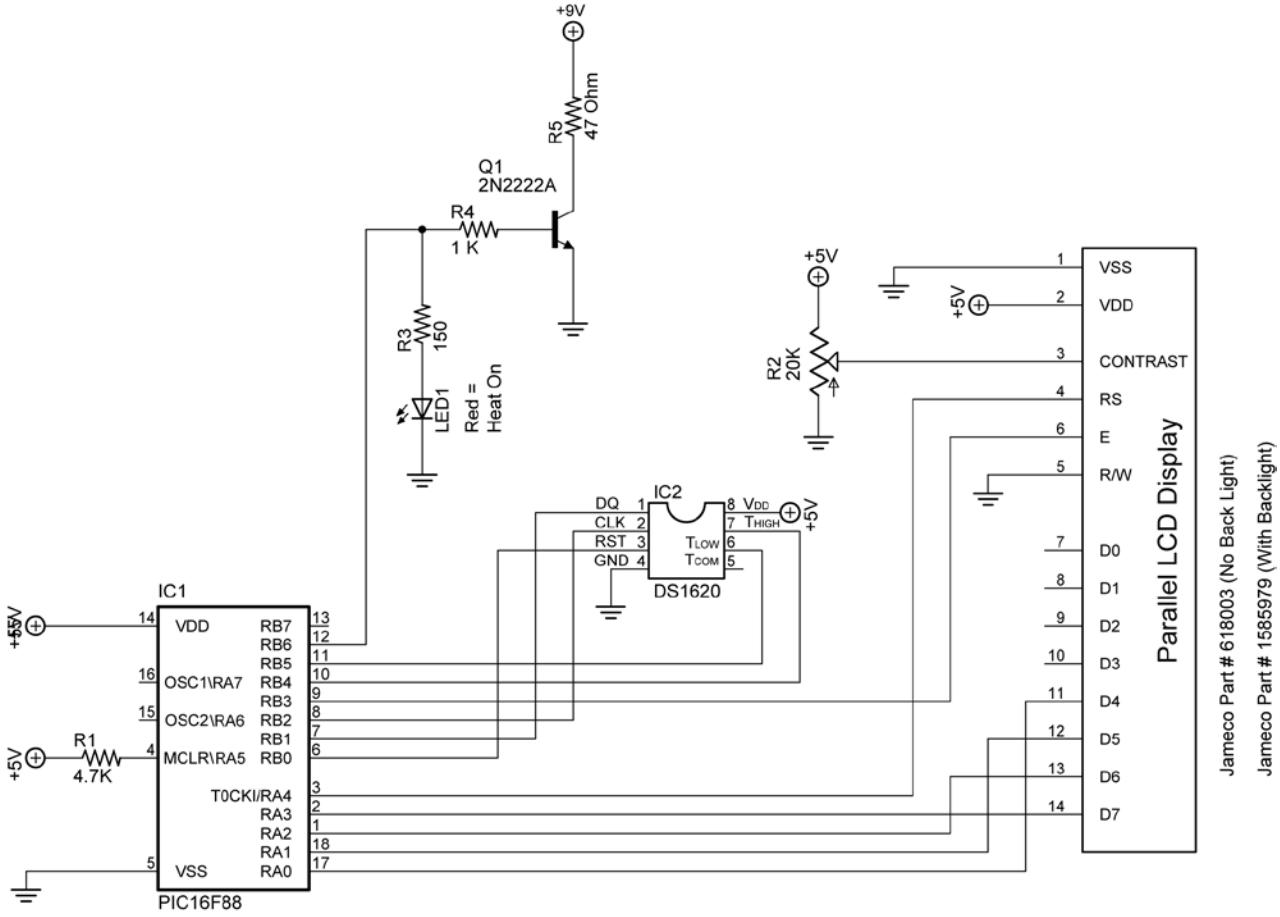
DS1620 Soldered Assembly



47 Ohm Resistor Inside Film Canister



Film Canister with DS1620 and Resistor



DS1620_3_heater

Cornerstone Electronics Technology and Robotics II
DS1620 Lab 2 – DD1620 _4_fan

- **Purpose:** The purpose of this lab is to demonstrate the DS1620 function as a thermostat used in conjunction with a cooling system, which in this case is a fan.

- **Apparatus and Materials:**

    - 1 – Breadboard
    - 1 – Dallas DS1620 Digital Thermometer
    - PIC16F88 Microcontroller
    - Hantronix HDM16216H-5-300S 16x2 LCD, Jameco #618003
    - 20 K Potentiometer
    - 4.7 K Resistor
    - 1 – 1 K Resistor
    - 1 – 150 Ohm resistor
    - 1 – 12 VDC Fan
    - 1 – 2N2222A NPN Transistor
    - 1 – LED

- **Procedure:**
    - Wire the circuit below.
    - Program the PIC16F88 with **DS1620_4_fan.pbp**. Notice that the cooling system (the fan) is driven directly from the DS1620 and not from the PIC16F88. This is because the TCOM output goes HIGH when the measured temperature meets or exceeds TH, and will remain HIGH until the temperature equals or falls below TL.
- **Other Resources:**
    - See Parallax version at: http://www.parallax.com/Portals/0/Downloads/docs/books/edu/ic.pdf
- **Photo:**

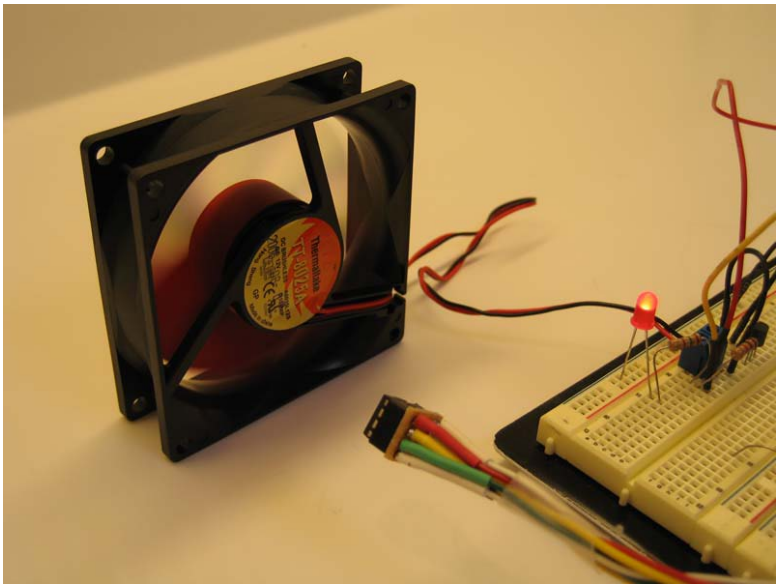
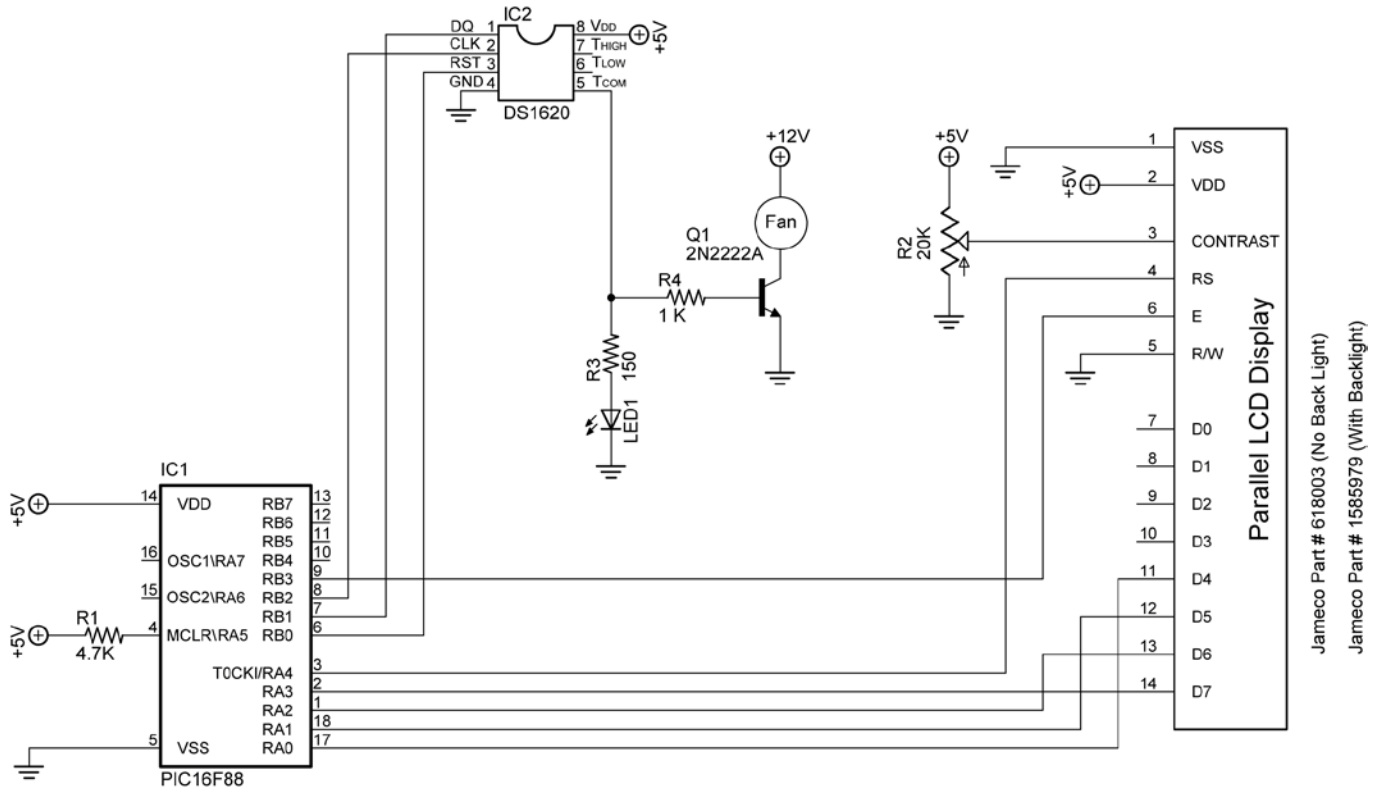


Photo Showing Fan Cooling the DS1620 Digital Thermometer


IC2
DQ 1
CLK 2
RST 3
GND 4
8 VDD
7 THIGH
6 TLOW
5 TCOM
DS1620
+5V
+12V
Fan
Q1
2N2222A
R4
1 K
R3
150
LED1
R2
20K
IC1
VDD
OSC1\RA7
OSC2\RA6
MCLR\RA5
T0CKI/RA4
VSS
RB7
RB6
RB5
RB4
RB3
RB2
RB1
RB0
RA3
RA2
RA1
RA0
R1
4.7K
PIC16F88
VSS
VDD
CONTRAST
RS
E
R/W
D0
D1
D2
D3
D4
D5
D6
D7
Parallel LCD Display
Jameco Part # 618003 (No Back Light)
Jameco Part # 1585979 (With Backlight)

DS1620_4_fan

Appendix A DS1620 Positive Temperatures:

DS1620 Positive Temperatures					DS1620 Positive Temperatures				
	°C	°F	Binary Digital Output	Hex Digital		°C	°F	Binary Digital Output	Hex Digital
+	125.0	257.0	%0 11111010	$00FA	+	100.0	212.0	%0 11001000	$00C8
+	124.5	256.1	%0 11111001	$00F9	+	99.5	211.1	%0 11000111	$00C7
+	124.0	255.2	%0 11111000	$00F8	+	99.0	210.2	%0 11000110	$00C6
+	123.5	254.3	%0 11110111	$00F7	+	98.5	209.3	%0 11000101	$00C5
+	123.0	253.4	%0 11110110	$00F6	+	98.0	208.4	%0 11000100	$00C4
+	122.5	252.5	%0 11110101	$00F5	+	97.5	207.5	%0 11000011	$00C3
+	122.0	251.6	%0 11110100	$00F4	+	97.0	206.6	%0 11000010	$00C2
+	121.5	250.7	%0 11110011	$00F3	+	96.5	205.7	%0 11000001	$00C1
+	121.0	249.8	%0 11110010	$00F2	+	96.0	204.8	%0 11000000	$00C0
+	120.5	248.9	%0 11110001	$00F1	+	95.5	203.9	%0 10111111	$00BF
+	120.0	248.0	%0 11110000	$00F0	+	95.0	203.0	%0 10111110	$00BE
+	119.5	247.1	%0 11101111	$00EF	+	94.5	202.1	%0 10111101	$00BD
+	119.0	246.2	%0 11101110	$00EE	+	94.0	201.2	%0 10111100	$00BC
+	118.5	245.3	%0 11101101	$00ED	+	93.5	200.3	%0 10111011	$00BB
+	118.0	244.4	%0 11101100	$00EC	+	93.0	199.4	%0 10111010	$00BA
+	117.5	243.5	%0 11101011	$00EB	+	92.5	198.5	%0 10111001	$00B9
+	117.0	242.6	%0 11101010	$00EA	+	92.0	197.6	%0 10111000	$00B8
+	116.5	241.7	%0 11101001	$00E9	+	91.5	196.7	%0 10110111	$00B7
+	116.0	240.8	%0 11101000	$00E8	+	91.0	195.8	%0 10110110	$00B6
+	115.5	239.9	%0 11100111	$00E7	+	90.5	194.9	%0 10110101	$00B5
+	115.0	239.0	%0 11100110	$00E6	+	90.0	194.0	%0 10110100	$00B4
+	114.5	238.1	%0 11100101	$00E5	+	89.5	193.1	%0 10110011	$00B3
+	114.0	237.2	%0 11100100	$00E4	+	89.0	192.2	%0 10110010	$00B2
+	113.5	236.3	%0 11100011	$00E3	+	88.5	191.3	%0 10110001	$00B1
+	113.0	235.4	%0 11100010	$00E2	+	88.0	190.4	%0 10110000	$00B0
+	112.5	234.5	%0 11100001	$00E1	+	87.5	189.5	%0 10101111	$00AF
+	112.0	233.6	%0 11100000	$00E0	+	87.0	188.6	%0 10101110	$00AE
+	111.5	232.7	%0 11011111	$00DF	+	86.5	187.7	%0 10101101	$00AD
+	111.0	231.8	%0 11011110	$00DE	+	86.0	186.8	%0 10101100	$00AC
+	110.5	230.9	%0 11011101	$00DD	+	85.5	185.9	%0 10101011	$00AB
+	110.0	230.0	%0 11011100	$00DC	+	85.0	185.0	%0 10101010	$00AA
+	109.5	229.1	%0 11011011	$00DB	+	84.5	184.1	%0 10101001	$00A9
+	109.0	228.2	%0 11011010	$00DA	+	84.0	183.2	%0 10101000	$00A8
+	108.5	227.3	%0 11011001	$00D9	+	83.5	182.3	%0 10100111	$00A7
+	108.0	226.4	%0 11011000	$00D8	+	83.0	181.4	%0 10100110	$00A6
+	107.5	225.5	%0 11010111	$00D7	+	82.5	180.5	%0 10100101	$00A5
+	107.0	224.6	%0 11010110	$00D6	+	82.0	179.6	%0 10100100	$00A4
+	106.5	223.7	%0 11010101	$00D5	+	81.5	178.7	%0 10100011	$00A3
+	106.0	222.8	%0 11010100	$00D4	+	81.0	177.8	%0 10100010	$00A2
+	105.5	221.9	%0 11010011	$00D3	+	80.5	176.9	%0 10100001	$00A1
+	105.0	221.0	%0 11010010	$00D2	+	80.0	176.0	%0 10100000	$00A0
+	104.5	220.1	%0 11010001	$00D1	+	79.5	175.1	%0 10011111	$009F
+	104.0	219.2	%0 11010000	$00D0	+	79.0	174.2	%0 10011110	$009E
+	103.5	218.3	%0 11001111	$00CF	+	78.5	173.3	%0 10011101	$009D
+	103.0	217.4	%0 11001110	$00CE	+	78.0	172.4	%0 10011100	$009C
+	102.5	216.5	%0 11001101	$00CD	+	77.5	171.5	%0 10011011	$009B
+	102.0	215.6	%0 11001100	$00CC	+	77.0	170.6	%0 10011010	$009A
+	101.5	214.7	%0 11001011	$00CB	+	76.5	169.7	%0 10011001	$0099
+	101.0	213.8	%0 11001010	$00CA	+	76.0	168.8	%0 10011000	$0098
+	100.5	212.9	%0 11001001	$00C9	+	75.5	167.9	%0 10010111	$0097

	DS1620 Positive Temperatures					DS1620 Positive Temperatures			
	°C	°F	Binary Digital Output	Hex Digital Output		°C	°F	Binary Digital Output	Hex Digital Output
+	75.0	167.0	%0 10010110	$0096	+	50.0	122.0	%0 01100100	$0064
+	74.5	166.1	%0 10010101	$0095	+	49.5	121.1	%0 01100011	$0063
+	74.0	165.2	%0 10010100	$0094	+	49.0	120.2	%0 01100010	$0062
+	73.5	164.3	%0 10010011	$0093	+	48.5	119.3	%0 01100001	$0061
+	73.0	163.4	%0 10010010	$0092	+	48.0	118.4	%0 01100000	$0060
+	72.5	162.5	%0 10010001	$0091	+	47.5	117.5	%0 01011111	$005F
+	72.0	161.6	%0 10010000	$0090	+	47.0	116.6	%0 01011110	$005E
+	71.5	160.7	%0 10001111	$008F	+	46.5	115.7	%0 01011101	$005D
+	71.0	159.8	%0 10001110	$008E	+	46.0	114.8	%0 01011100	$005C
+	70.5	158.9	%0 10001101	$008D	+	45.5	113.9	%0 01011011	$005B
+	70.0	158.0	%0 10001100	$008C	+	45.0	113.0	%0 01011010	$005A
+	69.5	157.1	%0 10001011	$008B	+	44.5	112.1	%0 01011001	$0059
+	69.0	156.2	%0 10001010	$008A	+	44.0	111.2	%0 01011000	$0058
+	68.5	155.3	%0 10001001	$0089	+	43.5	110.3	%0 01010111	$0057
+	68.0	154.4	%0 10001000	$0088	+	43.0	109.4	%0 01010110	$0056
+	67.5	153.5	%0 10000111	$0087	+	42.5	108.5	%0 01010101	$0055
+	67.0	152.6	%0 10000110	$0086	+	42.0	107.6	%0 01010100	$0054
+	66.5	151.7	%0 10000101	$0085	+	41.5	106.7	%0 01010011	$0053
+	66.0	150.8	%0 10000100	$0084	+	41.0	105.8	%0 01010010	$0052
+	65.5	149.9	%0 10000011	$0083	+	40.5	104.9	%0 01010001	$0051
+	65.0	149.0	%0 10000010	$0082	+	40.0	104.0	%0 01010000	$0050
+	64.5	148.1	%0 10000001	$0081	+	39.5	103.1	%0 01001111	$004F
+	64.0	147.2	%0 10000000	$0080	+	39.0	102.2	%0 01001110	$004E
+	63.5	146.3	%0 01111111	$007F	+	38.5	101.3	%0 01001101	$004D
+	63.0	145.4	%0 01111110	$007E	+	38.0	100.4	%0 01001100	$004C
+	62.5	144.5	%0 01111101	$007D	+	37.5	99.5	%0 01001011	$004B
+	62.0	143.6	%0 01111100	$007C	+	37.0	98.6	%0 01001010	$004A
+	61.5	142.7	%0 01111011	$007B	+	36.5	97.7	%0 01001001	$0049
+	61.0	141.8	%0 01111010	$007A	+	36.0	96.8	%0 01001000	$0048
+	60.5	140.9	%0 01111001	$0079	+	35.5	95.9	%0 01000111	$0047
+	60.0	140.0	%0 01111000	$0078	+	35.0	95.0	%0 01000110	$0046
+	59.5	139.1	%0 01110111	$0077	+	34.5	94.1	%0 01000101	$0045
+	59.0	138.2	%0 01110110	$0076	+	34.0	93.2	%0 01000100	$0044
+	58.5	137.3	%0 01110101	$0075	+	33.5	92.3	%0 01000011	$0043
+	58.0	136.4	%0 01110100	$0074	+	33.0	91.4	%0 01000010	$0042
+	57.5	135.5	%0 01110011	$0073	+	32.5	90.5	%0 01000001	$0041
+	57.0	134.6	%0 01110010	$0072	+	32.0	89.6	%0 01000000	$0040
+	56.5	133.7	%0 01110001	$0071	+	31.5	88.7	%0 00111111	$003F
+	56.0	132.8	%0 01110000	$0070	+	31.0	87.8	%0 00111110	$003E
+	55.5	131.9	%0 01101111	$006F	+	30.5	86.9	%0 00111101	$003D
+	55.0	131.0	%0 01101110	$006E	+	30.0	86.0	%0 00111100	$003C
+	54.5	130.1	%0 01101101	$006D	+	29.5	85.1	%0 00111011	$003B
+	54.0	129.2	%0 01101100	$006C	+	29.0	84.2	%0 00111010	$003A
+	53.5	128.3	%0 01101011	$006B	+	28.5	83.3	%0 00111001	$0039
+	53.0	127.4	%0 01101010	$006A	+	28.0	82.4	%0 00111000	$0038
+	52.5	126.5	%0 01101001	$0069	+	27.5	81.5	%0 00110111	$0037
+	52.0	125.6	%0 01101000	$0068	+	27.0	80.6	%0 00110110	$0036
+	51.5	124.7	%0 01100111	$0067	+	26.5	79.7	%0 00110101	$0035
+	51.0	123.8	%0 01100110	$0066	+	26.0	78.8	%0 00110100	$0034
+	50.5	122.9	%0 01100101	$0065	+	25.5	77.9	%0 00110011	$0033

DS1620 Positive Temperatures

	°C	°F	Binary Digital Output	Hex Digital Output
+	25.0	77.0	%0 00110010	$0032
+	24.5	76.1	%0 00110001	$0031
+	24.0	75.2	%0 00110000	$0030
+	23.5	74.3	%0 00101111	$002F
+	23.0	73.4	%0 00101110	$002E
+	22.5	72.5	%0 00101101	$002D
+	22.0	71.6	%0 00101100	$002C
+	21.5	70.7	%0 00101011	$002B
+	21.0	69.8	%0 00101010	$002A
+	20.5	68.9	%0 00101001	$0029
+	20.0	68.0	%0 00101000	$0028
+	19.5	67.1	%0 00100111	$0027
+	19.0	66.2	%0 00100110	$0026
+	18.5	65.3	%0 00100101	$0025
+	18.0	64.4	%0 00100100	$0024
+	17.5	63.5	%0 00100011	$0023
+	17.0	62.6	%0 00100010	$0022
+	16.5	61.7	%0 00100001	$0021
+	16.0	60.8	%0 00100000	$0020
+	15.5	59.9	%0 00011111	$001F
+	15.0	59.0	%0 00011110	$001E
+	14.5	58.1	%0 00011101	$001D
+	14.0	57.2	%0 00011100	$001C
+	13.5	56.3	%0 00011011	$001B
+	13.0	55.4	%0 00011010	$001A
+	12.5	54.5	%0 00011001	$0019
+	12.0	53.6	%0 00011000	$0018
+	11.5	52.7	%0 00010111	$0017
+	11.0	51.8	%0 00010110	$0016
+	10.5	50.9	%0 00010101	$0015
+	10.0	50.0	%0 00010100	$0014
+	9.5	49.1	%0 00010011	$0013
+	9.0	48.2	%0 00010010	$0012
+	8.5	47.3	%0 00010001	$0011
+	8.0	46.4	%0 00010000	$0010
+	7.5	45.5	%0 00001111	$000F
+	7.0	44.6	%0 00001110	$000E
+	6.5	43.7	%0 00001101	$000D
+	6.0	42.8	%0 00001100	$000C
+	5.5	41.9	%0 00001011	$000B
+	5.0	41.0	%0 00001010	$000A
+	4.5	40.1	%0 00001001	$0009
+	4.0	39.2	%0 00001000	$0008
+	3.5	38.3	%0 00000111	$0007
+	3.0	37.4	%0 00000110	$0006
+	2.5	36.5	%0 00000101	$0005
+	2.0	35.6	%0 00000100	$0004
+	1.5	34.7	%0 00000011	$0003
+	1.0	33.8	%0 00000010	$0002
+	0.5	32.9	%0 00000001	$0001
+	0.0	32.0	%0 00000000	$0000

Appendix B DS1620 Negative Temperatures:

DS1620 Negative Temperatures				DS1620 Negative Temperatures			
°C	°F	Binary Digital	Hex Digital	°C	°F	Binary Digital	Hex Digital
-0.5	31.1	%1 11111111	$01FF	-28.0	-18.4	%1 11001000	$01C8
-1.0	30.2	%1 11111110	$01FE	-28.5	-19.3	%1 11000111	$01C7
-1.5	29.3	%1 11111101	$01FD	-29.0	-20.2	%1 11000110	$01C6
-2.0	28.4	%1 11111100	$01FC	-29.5	-21.1	%1 11000101	$01C5
-2.5	27.5	%1 11111011	$01FB	-30.0	-22.0	%1 11000100	$01C4
-3.0	26.6	%1 11111010	$01FA	-30.5	-22.9	%1 11000011	$01C3
-3.5	25.7	%1 11111001	$01F9	-31.0	-23.8	%1 11000010	$01C2
-4.0	24.8	%1 11111000	$01F8	-31.5	-24.7	%1 11000001	$01C1
-4.5	23.9	%1 11110111	$01F7	-32.0	-25.6	%1 11000000	$01C0
-5.0	23.0	%1 11110110	$01F6	-32.5	-26.5	%1 10111111	$01BF
-5.5	22.1	%1 11110101	$01F5	-33.0	-27.4	%1 10111110	$01BE
-6.0	21.2	%1 11110100	$01F4	-33.5	-28.3	%1 10111101	$01BD
-6.5	20.3	%1 11110011	$01F3	-34.0	-29.2	%1 10111100	$01BC
-7.0	19.4	%1 11110010	$01F2	-34.5	-30.1	%1 10111011	$01BB
-7.5	18.5	%1 11110001	$01F1	-35.0	-31.0	%1 10111010	$01BA
-8.0	17.6	%1 11110000	$01F0	-35.5	-31.9	%1 10111001	$01B9
-8.5	16.7	%1 11101111	$01EF	-36.0	-32.8	%1 10111000	$01B8
-9.0	15.8	%1 11101110	$01EE	-36.5	-33.7	%1 10110111	$01B7
-9.5	14.9	%1 11101101	$01ED	-37.0	-34.6	%1 10110110	$01B6
-10.0	14.0	%1 11101100	$01EC	-37.5	-35.5	%1 10110101	$01B5
-10.5	13.1	%1 11101011	$01EB	-38.0	-36.4	%1 10110100	$01B4
-11.0	12.2	%1 11101010	$01EA	-38.5	-37.3	%1 10110011	$01B3
-11.5	11.3	%1 11101001	$01E9	-39.0	-38.2	%1 10110010	$01B2
-12.0	10.4	%1 11101000	$01E8	-39.5	-39.1	%1 10110001	$01B1
-12.5	9.5	%1 11100111	$01E7	-40.0	-40.0	%1 10110000	$01B0
-13.0	8.6	%1 11100110	$01E6	-40.5	-40.9	%1 10101111	$01AF
-13.5	7.7	%1 11100101	$01E5	-41.0	-41.8	%1 10101110	$01AE
-14.0	6.8	%1 11100100	$01E4	-41.5	-42.7	%1 10101101	$01AD
-14.5	5.9	%1 11100011	$01E3	-42.0	-43.6	%1 10101100	$01AC
-15.0	5.0	%1 11100010	$01E2	-42.5	-44.5	%1 10101011	$01AB
-15.5	4.1	%1 11100001	$01E1	-43.0	-45.4	%1 10101010	$01AA
-16.0	3.2	%1 11100000	$01E0	-43.5	-46.3	%1 10101001	$01A9
-16.5	2.3	%1 11011111	$01DF	-44.0	-47.2	%1 10101000	$01A8
-17.0	1.4	%1 11011110	$01DE	-44.5	-48.1	%1 10100111	$01A7
-17.5	0.5	%1 11011101	$01DD	-45.0	-49.0	%1 10100110	$01A6
-18.0	-0.4	%1 11011100	$01DC	-45.5	-49.9	%1 10100101	$01A5
-18.5	-1.3	%1 11011011	$01DB	-46.0	-50.8	%1 10100100	$01A4
-19.0	-2.2	%1 11011010	$01DA	-46.5	-51.7	%1 10100011	$01A3
-19.5	-3.1	%1 11011001	$01D9	-47.0	-52.6	%1 10100010	$01A2
-20.0	-4.0	%1 11011000	$01D8	-47.5	-53.5	%1 10100001	$01A1
-20.5	-4.9	%1 11010111	$01D7	-48.0	-54.4	%1 10100000	$01A0
-21.0	-5.8	%1 11010110	$01D6	-48.5	-55.3	%1 10011111	$019F
-21.5	-6.7	%1 11010101	$01D5	-49.0	-56.2	%1 10011110	$019E
-22.0	-7.6	%1 11010100	$01D4	-49.5	-57.1	%1 10011101	$019D
-22.5	-8.5	%1 11010011	$01D3	-50.0	-58.0	%1 10011100	$019C
-23.0	-9.4	%1 11010010	$01D2	-50.5	-58.9	%1 10011011	$019B
-23.5	-10.3	%1 11010001	$01D1	-51.0	-59.8	%1 10011010	$019A
-24.0	-11.2	%1 11010000	$01D0	-51.5	-60.7	%1 10011001	$0199
-24.5	-12.1	%1 11001111	$01CF	-52.0	-61.6	%1 10011000	$0198
-25.0	-13.0	%1 11001110	$01CE	-52.5	-62.5	%1 10010111	$0197
-25.5	-13.9	%1 11001101	$01CD	-53.0	-63.4	%1 10010110	$0196
-26.0	-14.8	%1 11001100	$01CC	-53.5	-64.3	%1 10010101	$0195
-26.5	-15.7	%1 11001011	$01CB	-54.0	-65.2	%1 10010100	$0194
-27.0	-16.6	%1 11001010	$01CA	-54.5	-66.1	%1 10010011	$0193
-27.5	-17.5	%1 11001001	$01C9	-55.0	-67.0	%1 10010010	$0192