Universidad del País Vasco Euskal Herriko Unibertsitatea
BILBOKO INGENIARITZA ESKOLA
ESCUELA DE INGENIERÍA DE BILBAO

GRADO EN ELECTRÓNICA INDUSTRIAL Y AUTOMÁTICA

TRABAJO FIN DE GRADO

DISEÑO E IMPLEMENTACIÓN DE SISTEMA DE REFRIGERACIÓN MEDIANTE CÉLULA PELTIER

ANEXO 2 – DATASHEETS

Alumno: Losa Blanco, Unai

Directora: Otaegi Aizpeolea, Aloña

Curso: 2019-2020

Fecha: 30/10/2019

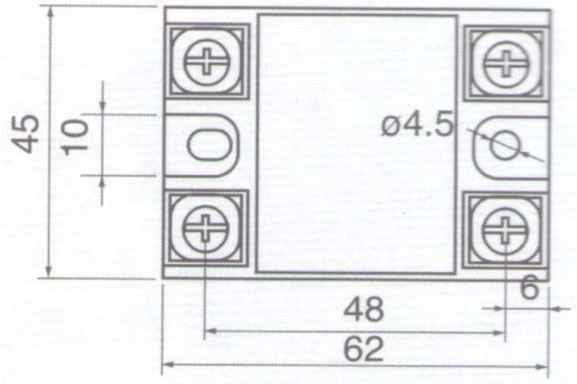
SOLID STATE RELAY

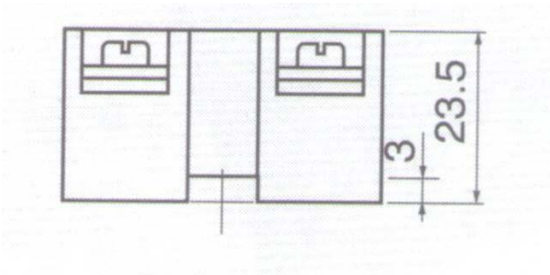
Model:SSR-80DD

Specifications:

- Load Current: 80A
- Load Voltage: 5-60VDC
- Control Voltage: 3-32VDC
- Control Current DC: 6-25mA
- On Voltage: <=1.5VAC
- Off Leakage Current: <=2mA
- On-off Time: <=10mS
- Dielectric Strength: 2000VAC
- Insulation Resistance: 1000MΩ/500VDC
- Ambient Temperature: -30°C~+75°C
- Mounting Methods: bolted
- The work instructions: LED

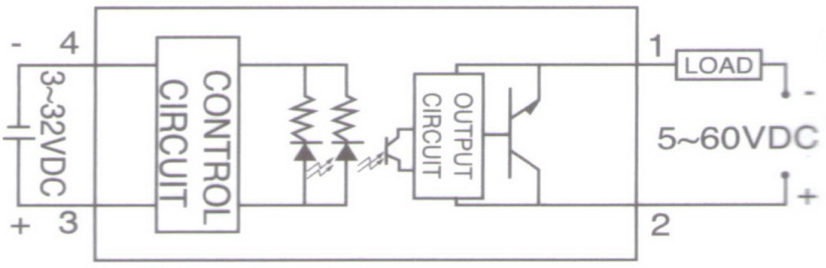
Outline Dimension with installation Size:





62.0L × 45.0W × 23.5H

Wiring Diagram:



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I2C interface for LCD

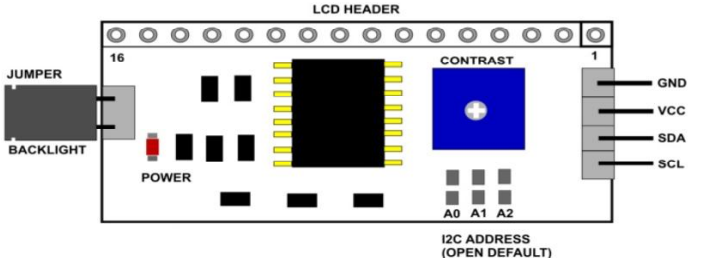
Discription:

This LCD2004 is a great I2C interface for 2x16 and 4x20 LCD displays. With the limited pin resources, your project may be out of resources using normal LCD shield. With this I2C interface LCD module, you only need 2 lines (I2C) to display the information. If you already has I2C devices in your project, this LCD module actually cost no more resources at all. Fantastic for Arduino based projects.

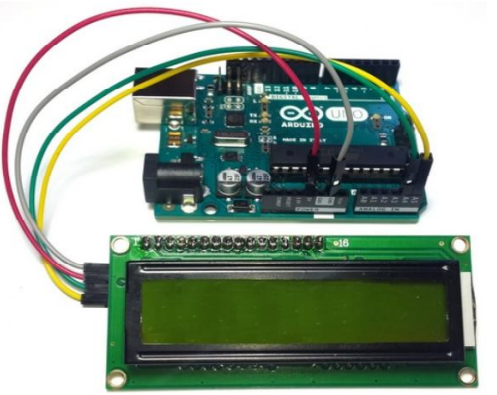
Specification:

Compatible with 16x2 and 20x4 LCD's
Default I2C Address = 0X27
Address selectable - Range 0x20 to 0x27

Board Layout:



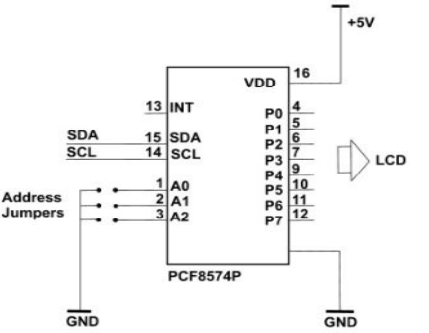
I2C Address Setup:

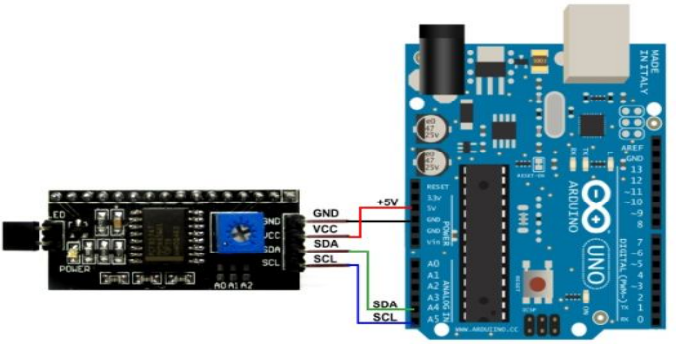


The LCD2004 board utilized the PCF8574 I/O expander. This nifty little chip provides eight bits of parallel I/O addressabl by a I2C bus address – 0x00 to 0x27. SainSmart tied all address leads to Vcc, so the LCD2004 board's I2C address is permanently fixed at hex 27. This is rather limiting since no additional LCD2004s can be added to the bus. Anyway, you simply address the board and write an eight bit value which is then presented on the output pins of the PCF8574, which, in this case, are connected to the HD44780 based LCD screen.

INPUTS			I2C SLAVE ADDRESS
A2	A1	A0	
L	L	L	0x20
L	L	H	0x21
L	H	L	0x22
L	H	H	0x23
H	L	L	0x24
H	L	H	0x25
H	H	L	0x26
H	H	H	0x27

H = Open Jumper L = Close Jumper






```
//Arduino Code
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27,2,1,0,4,5,6,7,3, POSITIVE); // Initialize LCD Display at address 0x27
                                                       // unmodified backpack
void setup() {
  // activate LCD module
  lcd.begin (16,2); // for 16 x 2 LCD module
  lcd.setBacklightPin(3,POSITIVE);
  lcd.setBacklight(HIGH);
  }

void loop() {
  lcd.home (); // set cursor to 0,0
  lcd.print(" Hello, world!");
  lcd.setCursor (0,1);        // go to start of 2nd line
  lcd.print(millis());
  delay(1000);
  lcd.setBacklight(LOW);      // Backlight off
  delay(500);
  lcd.setBacklight(HIGH);     // Backlight on

  delay(1000);
}       // END
```

Check for more info at
https://arduino-info.wikispaces.com/LCD-Blue-I2C

LM258, LM358, LM358A, LM358E, LM2904, LM2904A, LM2904E, LM2904V, NCV2904

Single Supply Dual Operational Amplifiers

Utilizing the circuit designs perfected for Quad Operational Amplifiers, these dual operational amplifiers feature low power drain, a common mode input voltage range extending to ground/V_{EE}, and single supply or split supply operation. The LM358 series is equivalent to one−half of an LM324.

These amplifiers have several distinct advantages over standard operational amplifier types in single supply applications. They can operate at supply voltages as low as 3.0 V or as high as 32 V, with quiescent currents about one−fifth of those associated with the MC1741 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

Features

- Short Circuit Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 32 V
- Low Input Bias Currents
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Single and Split Supply Operation
- ESD Clamps on the Inputs Increase Ruggedness of the Device without Affecting Operation
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable
- These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

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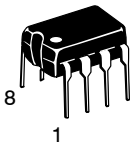
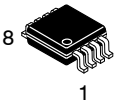


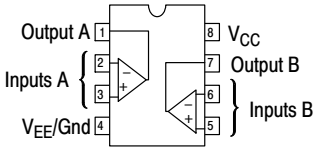
PDIP−8
N, AN, VN SUFFIX
CASE 626

SOIC−8
D, VD SUFFIX
CASE 751



Micro8™
DMR2 SUFFIX
CASE 846A

PIN CONNECTIONS



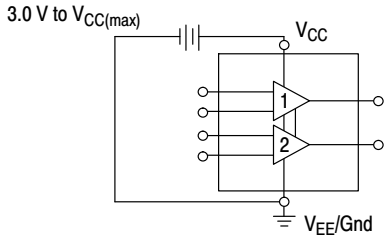
(Top View)

ORDERING INFORMATION

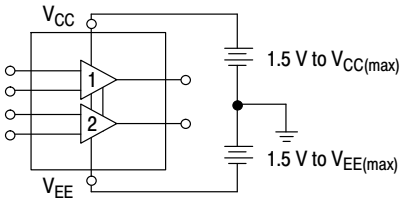
See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 11 of this data sheet.



Single Supply



Split Supplies

Figure 1.

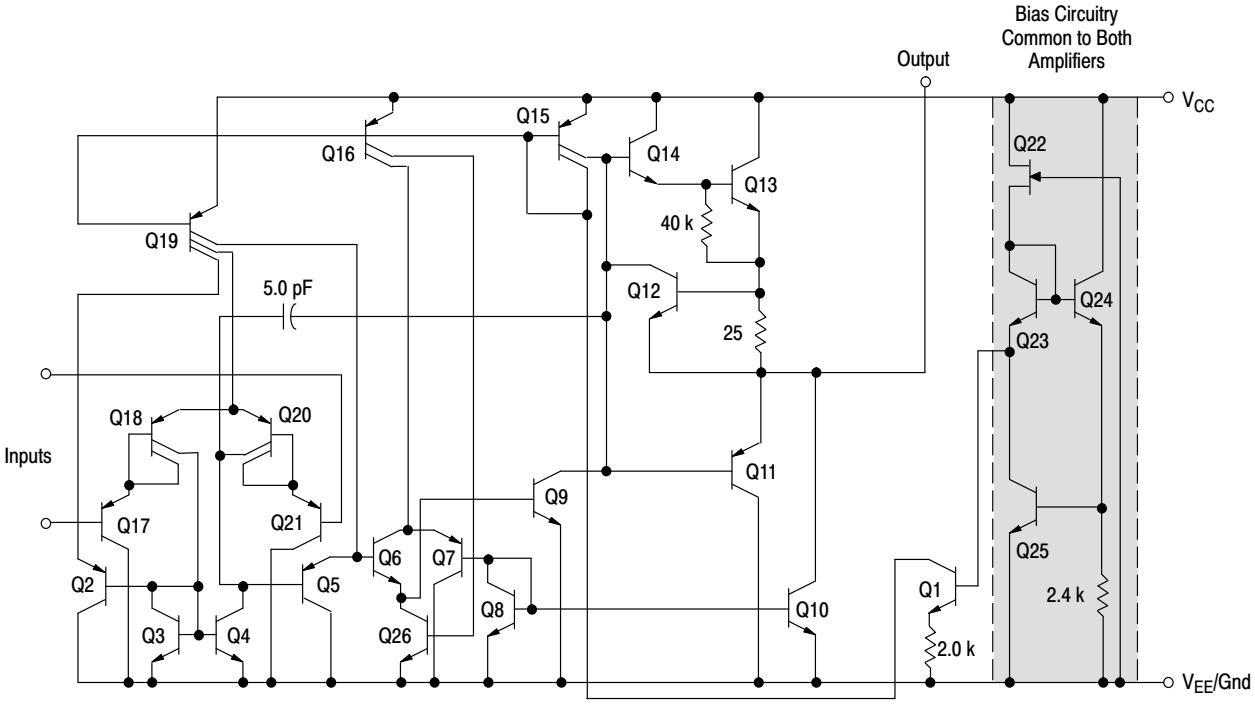


Figure 2. Representative Schematic Diagram
(One−Half of Circuit Shown)

MAXIMUM RATINGS (T_A = +25°C, unless otherwise noted.)

Rating		Symbol	Value	Unit
Power Supply Voltages Single Supply Split Supplies		 V_{CC} V_{CC}, V_{EE}	 32 ±16	Vdc
Input Differential Voltage Range (Note 1)		V_{IDR}	±32	Vdc
Input Common Mode Voltage Range		V_{ICR}	−0.3 to 32	Vdc
Output Short Circuit Duration		t_{SC}	Continuous	
Junction Temperature		T_J	150	°C
Thermal Resistance, Junction−to−Air (Note 2)	Case 846A Case 751 Case 626	$R_{\theta JA}$	238 212 161	°C/W
Storage Temperature Range		T_{stg}	−65 to +150	°C
Operating Ambient Temperature Range	 LM258 LM358, LM358A, LM358E LM2904, LM2904A, LM2904E LM2904V, NCV2904 (Note 3)	T_A	 −25 to +85 0 to +70 −40 to +105 −40 to +125	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Split Power Supplies.
2. All $R_{\theta JA}$ measurements made on evaluation board with 1 oz. copper traces of minimum pad size. All device outputs were active.
3. *NCV2904 is qualified for automotive use.*

ESD RATINGS

Rating	HBM	MM	Unit
ESD Protection at any Pin (Human Body Model − HBM, Machine Model − MM)			
NCV2904 (Note 3)	2000	200	V
LM358E, LM2904E	2000	200	V
LM358DG/DR2G, LM2904DG/DR2G	250	100	V
All Other Devices	2000	200	V

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, V_{EE} = GND, T_A = 25°C, unless otherwise noted.)

Characteristic	Symbol	LM258			LM358, LM358E			LM358A			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage V_{CC} = 5.0 V to 30 V, V_{IC} = 0 V to V_{CC} −1.7 V, $V_O \simeq$ 1.4 V, R_S = 0 Ω	V_{IO}										mV
T_A = 25°C		–	2.0	5.0	–	2.0	7.0	–	2.0	3.0	
T_A = T_{high} (Note 4)		–	–	7.0	–	–	9.0	–	–	5.0	
T_A = T_{low} (Note 4)		–	–	7.0	–	–	9.0	–	–	5.0	
Average Temperature Coefficient of Input Offset Voltage T_A = T_{high} to T_{low} (Note 4)	$\Delta V_{IO}/\Delta T$	–	7.0	–	–	7.0	–	–	7.0	–	μV/°C
Input Offset Current	I_{IO}	–	3.0	30	–	5.0	50	–	5.0	30	nA
T_A = T_{high} to T_{low} (Note 4)		–	–	100	–	–	150	–	–	75	
Input Bias Current	I_{IB}	–	−45	−150	–	−45	−250	–	−45	−100	
T_A = T_{high} to T_{low} (Note 4)		–	−50	−300	–	−50	−500	–	−50	−200	
Average Temperature Coefficient of Input Offset Current T_A = T_{high} to T_{low} (Note 4)	$\Delta I_{IO}/\Delta T$	–	10	–	–	10	–	–	10	–	pA/°C
Input Common Mode Voltage Range (Note 5), V_{CC} = 30 V	V_{ICR}	0	–	28.3	0	–	28.3	0	–	28.5	V
V_{CC} = 30 V, T_A = T_{high} to T_{low}		0	–	28	0	–	28	0	–	28	
Differential Input Voltage Range	V_{IDR}	–	–	V_{CC}	–	–	V_{CC}	–	–	V_{CC}	V
Large Signal Open Loop Voltage Gain	A_{VOL}										V/mV
R_L = 2.0 kΩ, V_{CC} = 15 V, For Large V_O Swing,		50	100	–	25	100	–	25	100	–	
T_A = T_{high} to T_{low} (Note 4)		25	–	–	15	–	–	15	–	–	
Channel Separation 1.0 kHz ≤ f ≤ 20 kHz, Input Referenced	CS	–	−120	–	–	−120	–	–	−120	–	dB
Common Mode Rejection R_S ≤ 10 kΩ	CMR	70	85	–	65	70	–	65	70	–	dB
Power Supply Rejection	PSR	65	100	–	65	100	–	65	100	–	dB
Output Voltage−High Limit T_A = T_{high} to T_{low} (Note 4)	V_{OH}										V
V_{CC} = 5.0 V, R_L = 2.0 kΩ, T_A = 25°C		3.3	3.5	–	3.3	3.5	–	3.3	3.5	–	
V_{CC} = 30 V, R_L = 2.0 kΩ		26	–	–	26	–	–	26	–	–	
V_{CC} = 30 V, R_L = 10 kΩ		27	28	–	27	28	–	27	28	–	
Output Voltage−Low Limit V_{CC} = 5.0 V, R_L = 10 kΩ, T_A = T_{high} to T_{low} (Note 4)	V_{OL}	–	5.0	20	–	5.0	20	–	5.0	20	mV
Output Source Current	I_{O+}										mA
V_{ID} = +1.0 V, V_{CC} = 15 V		20	40	–	20	40	–	20	40	–	
T_A = T_{high} to T_{low} (LM358A Only)								10	–	–	
Output Sink Current	I_{O-}										
V_{ID} = −1.0 V, V_{CC} = 15 V		10	20	–	10	20	–	10	20	–	mA
T_A = T_{high} to T_{low} (LM358A Only)								5.0	–	–	mA
V_{ID} = −1.0 V, V_O = 200 mV		12	50	–	12	50	–	12	50	–	μA
Output Short Circuit to Ground (Note 6)	I_{SC}	–	40	60	–	40	60	–	40	60	mA
Power Supply Current (Total Device) T_A = T_{high} to T_{low} (Note 4)	I_{CC}										mA
V_{CC} = 30 V, V_O = 0 V, R_L = ∞		–	1.5	3.0	–	1.5	3.0	–	1.5	2.0	
V_{CC} = 5 V, V_O = 0 V, R_L = ∞		–	0.7	1.2	–	0.7	1.2	–	0.7	1.2	

4. LM258: T_{low} = −25°C, T_{high} = +85°C
   LM358, LM358A, LM358E: T_{low} = 0°C, T_{high} = +70°C
   LM2904/A/E: T_{low} = −40°C, T_{high} = +105°C
   LM2904V & NCV2904: T_{low} = −40°C, T_{high} = +125°C
   NCV2904 is qualified for automotive use.
5. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is V_{CC} − 1.7 V.
6. Short circuits from the output to V_{CC} can cause excessive heating and eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, V_{EE} = Gnd, T_A = 25°C, unless otherwise noted.)

Characteristic	Symbol	LM2904/LM2904E			LM2904A			LM2904V, NCV2904			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage V_{CC} = 5.0 V to 30 V, V_{IC} = 0 V to V_{CC} −1.7 V, $V_O \simeq$ 1.4 V, R_S = 0 Ω	V_{IO}										mV
T_A = 25°C		–	2.0	7.0	–	2.0	7.0	–	–	7.0	
$T_A = T_{high}$ (Note 7)		–	–	10	–	–	10	–	–	13	
$T_A = T_{low}$ (Note 7)		–	–	10	–	–	10	–	–	10	
Average Temperature Coefficient of Input Offset Voltage $T_A = T_{high}$ to T_{low} (Note 7)	$\Delta V_{IO}/\Delta T$	–	7.0	–	–	7.0	–	–	7.0	–	μV/°C
Input Offset Current	I_{IO}	–	5.0	50	–	5.0	50	–	5.0	50	nA
$T_A = T_{high}$ to T_{low} (Note 7)		–	45	200	–	45	200	–	45	200	
Input Bias Current	I_{IB}	–	−45	−250	–	−45	−100	–	−45	−250	
$T_A = T_{high}$ to T_{low} (Note 7)		–	−50	−500	–	−50	−250	–	−50	−500	
Average Temperature Coefficient of Input Offset Current $T_A = T_{high}$ to T_{low} (Note 7)	$\Delta I_{IO}/\Delta T$	–	10	–	–	10	–	–	10	–	pA/°C
Input Common Mode Voltage Range (Note 8), V_{CC} = 30 V	V_{ICR}	0	–	28.3	0	–	28.3	0	–	28.3	V
V_{CC} = 30 V, $T_A = T_{high}$ to T_{low}		0	–	28	0	–	28	0	–	28	
Differential Input Voltage Range	V_{IDR}	–	–	V_{CC}	–	–	V_{CC}	–	–	V_{CC}	V
Large Signal Open Loop Voltage Gain	A_{VOL}										V/mV
R_L = 2.0 kΩ, V_{CC} = 15 V, For Large V_O Swing,		25	100	–	25	100	–	25	100	–	
$T_A = T_{high}$ to T_{low} (Note 7)		15	–	–	15	–	–	15	–	–	
Channel Separation 1.0 kHz ≤ f ≤ 20 kHz, Input Referenced	CS	–	−120	–	–	−120	–	–	−120	–	dB
Common Mode Rejection R_S ≤ 10 kΩ	CMR	50	70	–	50	70	–	50	70	–	dB
Power Supply Rejection	PSR	50	100	–	50	100	–	50	100	–	dB
Output Voltage−High Limit $T_A = T_{high}$ to T_{low} (Note 7)	V_{OH}										V
V_{CC} = 5.0 V, R_L = 2.0 kΩ, T_A = 25°C		3.3	3.5	–	3.3	3.5	–	3.3	3.5	–	
V_{CC} = 30 V, R_L = 2.0 kΩ		26	–	–	26	–	–	26	–	–	
V_{CC} = 30 V, R_L = 10 kΩ		27	28	–	27	28	–	27	28	–	
Output Voltage−Low Limit V_{CC} = 5.0 V, R_L = 10 kΩ, $T_A = T_{high}$ to T_{low} (Note 7)	V_{OL}	–	5.0	20	–	5.0	20	–	5.0	20	mV
Output Source Current V_{ID} = +1.0 V, V_{CC} = 15 V	I_{O+}	20	40	–	20	40	–	20	40	–	mA
Output Sink Current	I_{O-}										
V_{ID} = −1.0 V, V_{CC} = 15 V		10	20	–	10	20	–	10	20	–	mA
V_{ID} = −1.0 V, V_O = 200 mV		–	–	–	–	–	–	–	–	–	μA
Output Short Circuit to Ground (Note 9)	I_{SC}	–	40	60	–	40	60	–	40	60	mA
Power Supply Current (Total Device) $T_A = T_{high}$ to T_{low} (Note 7)	I_{CC}										mA
V_{CC} = 30 V, V_O = 0 V, R_L = ∞		–	1.5	3.0	–	1.5	3.0	–	1.5	3.0	
V_{CC} = 5 V, V_O = 0 V, R_L = ∞		–	0.7	1.2	–	0.7	1.2	–	0.7	1.2	

7. LM258: T_{low} = −25°C, T_{high} = +85°C
   LM358, LM358A, LM358E: T_{low} = 0°C, T_{high} = +70°C
   LM2904/A/E: T_{low} = −40°C, T_{high} = +105°C
   LM2904V & NCV2904: T_{low} = −40°C, T_{high} = +125°C
   NCV2904 is qualified for automotive use.
8. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is V_{CC} − 1.7 V.
9. Short circuits from the output to V_{CC} can cause excessive heating and eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

CIRCUIT DESCRIPTION

The LM358 series is made using two internally compensated, two−stage operational amplifiers. The first stage of each consists of differential input devices Q20 and Q18 with input buffer transistors Q21 and Q17 and the differential to single ended converter Q3 and Q4. The first stage performs not only the first stage gain function but also performs the level shifting and transconductance reduction functions. By reducing the transconductance, a smaller compensation capacitor (only 5.0 pF) can be employed, thus saving chip area. The transconductance reduction is accomplished by splitting the collectors of Q20 and Q18. Another feature of this input stage is that the input common mode range can include the negative supply or ground, in single supply operation, without saturating either the input devices or the differential to single−ended converter. The second stage consists of a standard current source load amplifier stage.

Each amplifier is biased from an internal−voltage regulator which has a low temperature coefficient thus giving each amplifier good temperature characteristics as well as excellent power supply rejection.

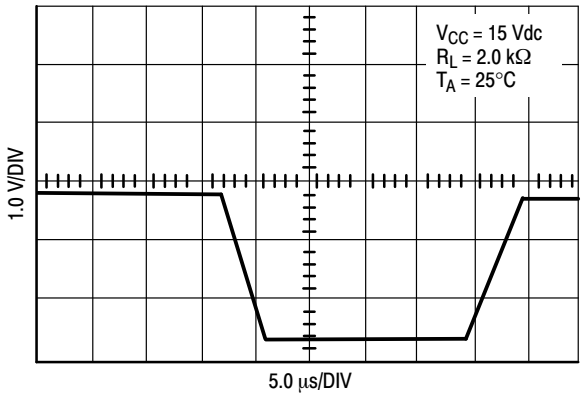


Figure 3. Large Signal Voltage Follower Response

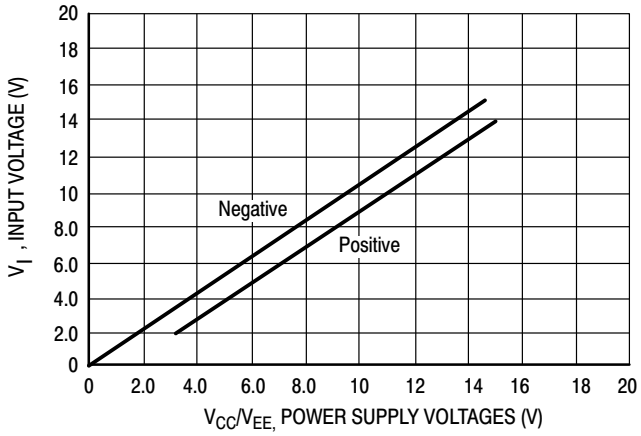


Figure 4. Input Voltage Range

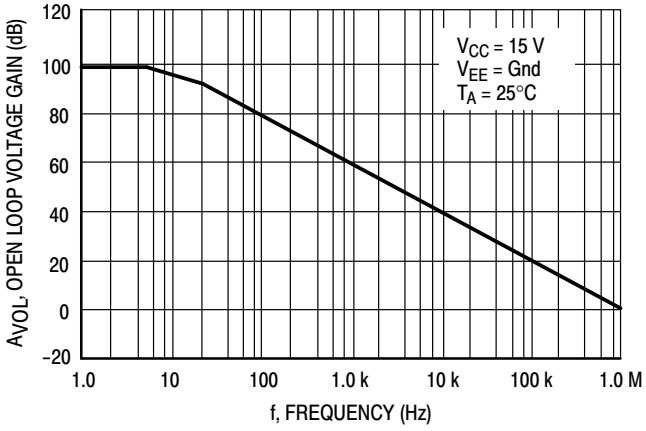


Figure 5. Large−Signal Open Loop Voltage Gain

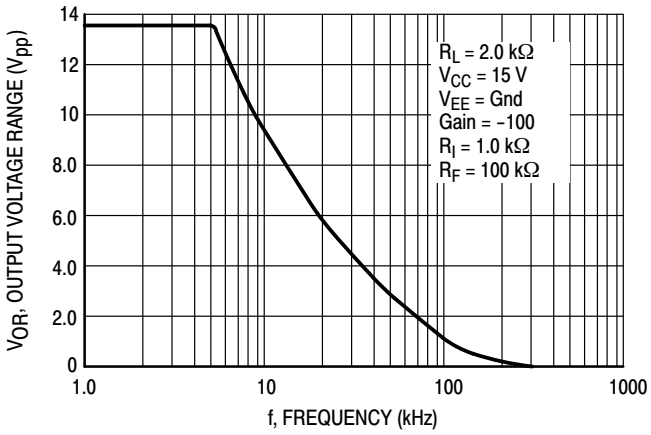


Figure 6. Large−Signal Frequency Response

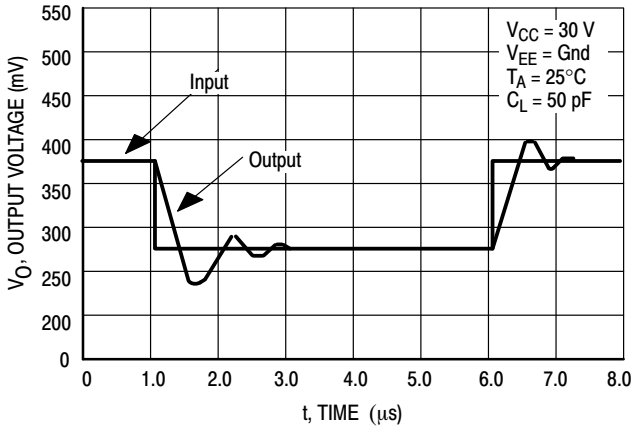


Figure 7. Small Signal Voltage Follower Pulse Response (Noninverting)

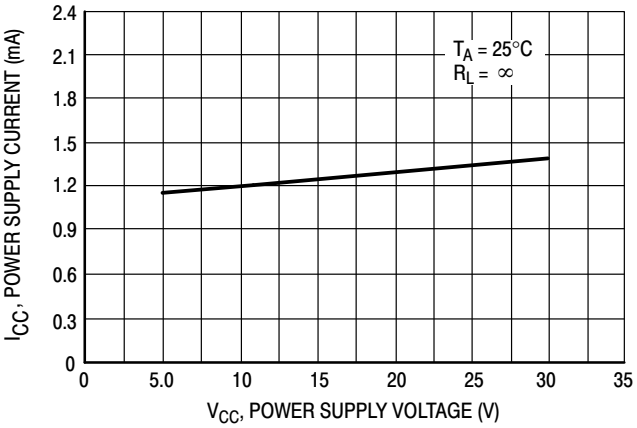


Figure 8. Power Supply Current versus Power Supply Voltage

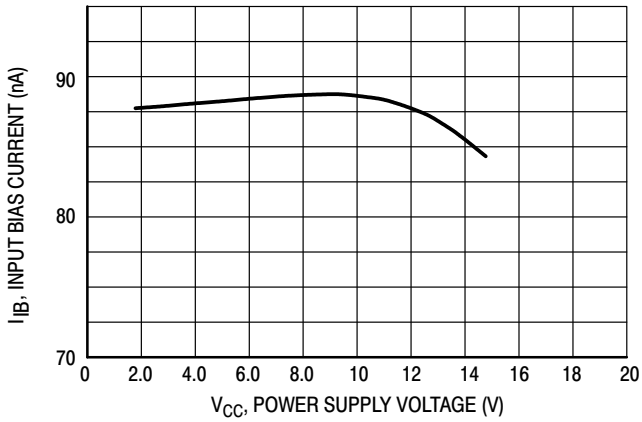


Figure 9. Input Bias Current versus Supply Voltage

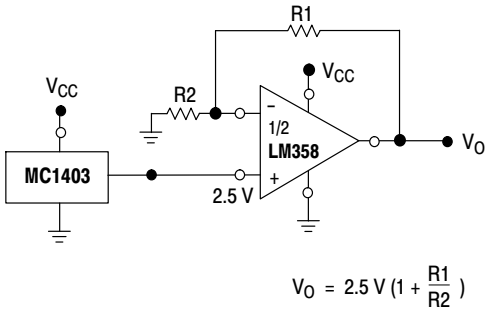


Figure 10. Voltage Reference

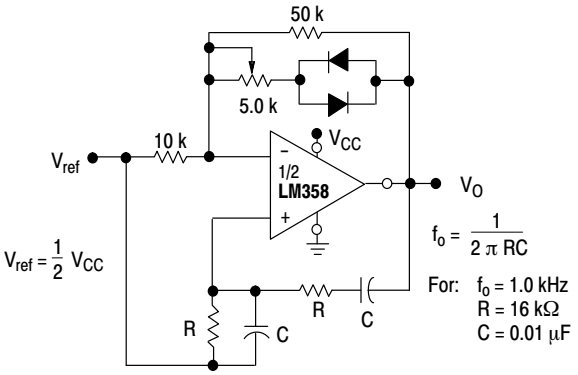


Figure 11. Wien Bridge Oscillator

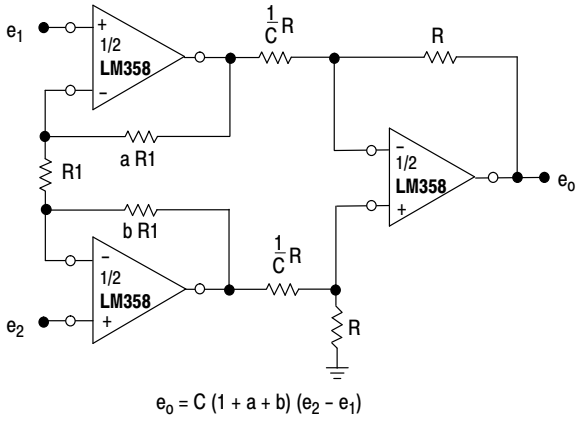


Figure 12. High Impedance Differential Amplifier

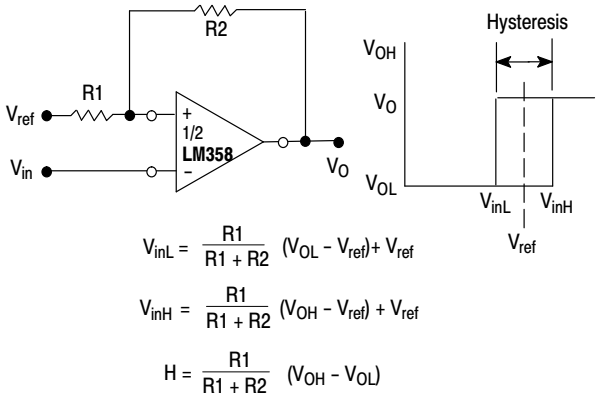


Figure 13. Comparator with Hysteresis

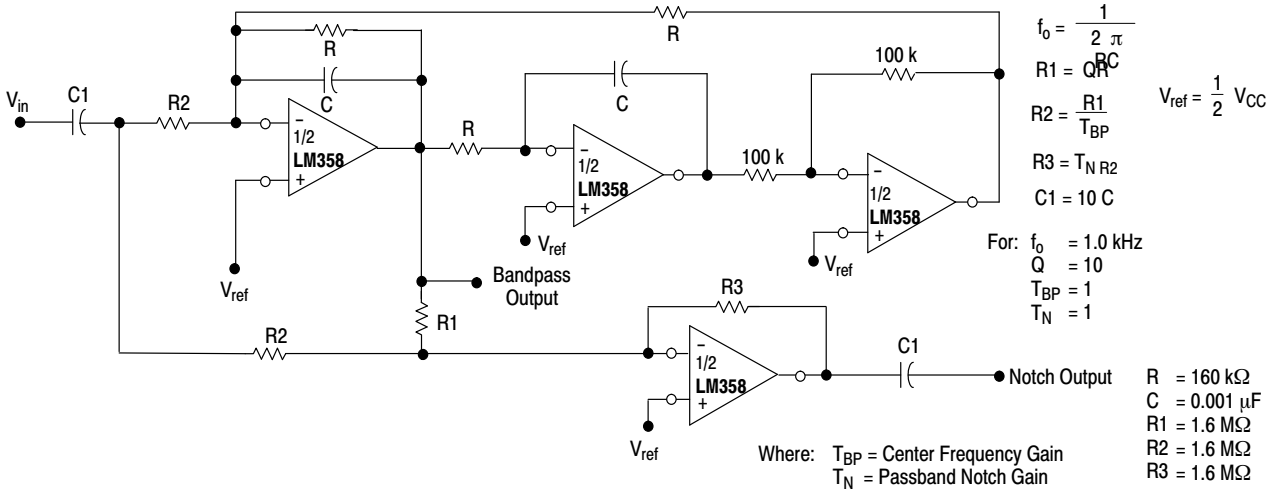
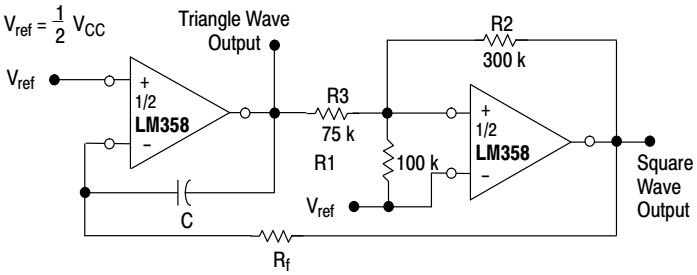
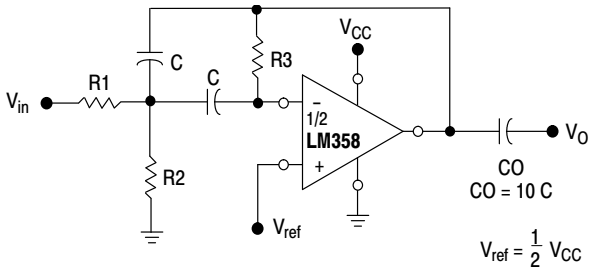


Figure 14. Bi−Quad Filter



$$f = \frac{R1 + R_C}{4\,CR_f\,R1} \quad \text{if,} \quad R3 = \frac{R2\,R1}{R2 + R1}$$

Figure 15. Function Generator



Given: f_o = center frequency

$A(f_o)$ = gain at center frequency

Choose value f_o, C

Then: $R3 = \frac{Q}{\pi\, f_o\, C}$

$$R1 = \frac{R3}{2\,A(f_o)}$$

$$R2 = \frac{R1\,R3}{4Q^2\,R1 - R3}$$

For less than 10% error from operational amplifier. $\frac{Q_o\, f_o}{BW} < 0.1$

Where f_o and BW are expressed in Hz.

If source impedance varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

Figure 16. Multiple Feedback Bandpass Filter

ORDERING INFORMATION

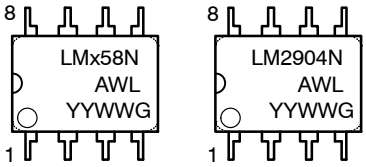
Device	Operating Temperature Range	Package	Shipping†
LM358ADR2G	0°C to +70°C	SOIC−8 (Pb−Free)	2500 / Tape & Reel
LM358DG			98 Units / Rail
LM358DR2G			2500 / Tape & Reel
LM358EDR2G		SOIC−8 (Pb−Free)	2500 / Tape & Reel
LM358DMR2G		Micro8 (Pb−Free)	4000 / Tape & Reel
LM358NG		PDIP−8 (Pb−Free)	50 Units / Rail
LM258DG	−25°C to +85°C	SOIC−8 (Pb−Free)	98 Units / Rail
LM258DR2G			2500 / Tape & Reel
LM258DMR2G		Micro8 (Pb−Free)	4000 / Tape & Reel
LM258NG		PDIP−8 (Pb−Free)	50 Units / Rail
LM2904DG	−40°C to +105°C	SOIC−8 (Pb−Free)	98 Units / Rail
LM2904DR2G			2500 / Tape & Reel
LM2904EDR2G		SOIC−8 (Pb−Free)	2500 / Tape & Reel
LM2904DMR2G		Micro8 (Pb−Free)	2500 / Tape & Reel
LM2904NG		PDIP−8 (Pb−Free)	50 Units / Rail
LM2904ADMG		Micro8 (Pb−Free)	4000 / Tape & Reel
LM2904ADMR2G			4000 / Tape & Reel
LM2904ANG		PDIP−8 (Pb−Free)	50 Units / Rail
LM2904VDG	−40°C to +125°C	SOIC−8 (Pb−Free)	98 Units / Rail
LM2904VDR2G			2500 / Tape & Reel
LM2904VDMR2G		Micro8 (Pb−Free)	4000 / Tape & Reel
LM2904VNG		PDIP−8 (Pb−Free)	50 Units / Rail
NCV2904DR2G*		SOIC−8 (Pb−Free)	2500 / Tape & Reel
NCV2904DMR2G*		Micro8 (Pb−Free)	4000 / Tape & Reel

†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.

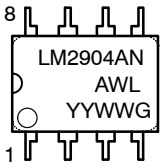
*NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable.

MARKING DIAGRAMS

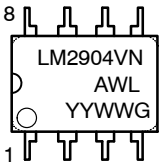
PDIP−8
N SUFFIX
CASE 626



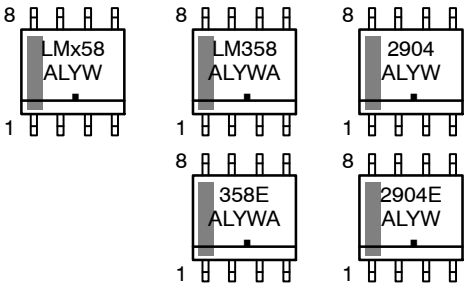
PDIP−8
AN SUFFIX
CASE 626



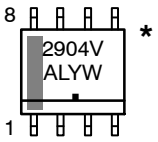
PDIP−8
VN SUFFIX
CASE 626



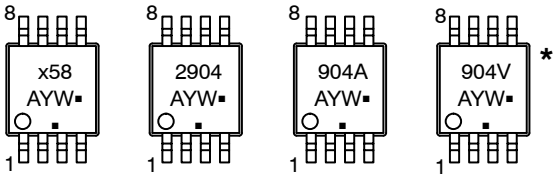
SOIC−8
D SUFFIX
CASE 751



SOIC−8
VD SUFFIX
CASE 751



Micro8
DMR2 SUFFIX
CASE 846A

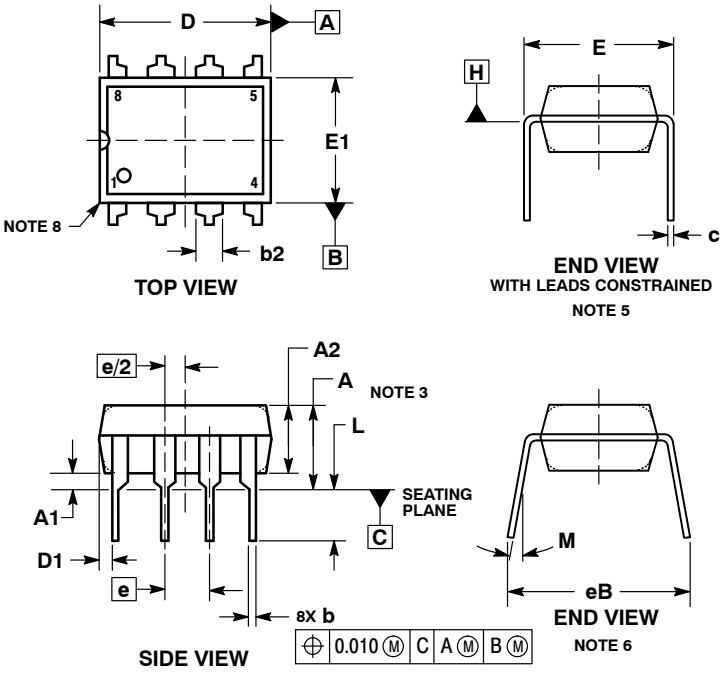


*This diagram also applies to NCV2904

x = 2 or 3
A = Assembly Location
WL, L = Wafer Lot
YY, Y = Year
WW, W = Work Week
G = Pb−Free Package
▪ = Pb−Free Package − (Note: Microdot may be in either location)

PACKAGE DIMENSIONS

PDIP−8
N, AN, VN SUFFIX
CASE 626−05
ISSUE P

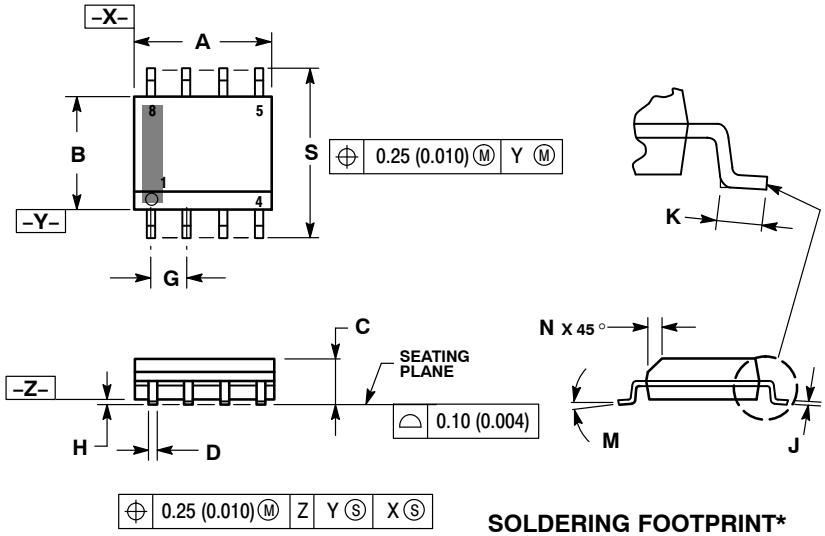


NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSIONS A, A1 AND L ARE MEASURED WITH THE PACKAGE SEATED IN JEDEC SEATING PLANE GAUGE GS−3.
4. DIMENSIONS D, D1 AND E1 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS ARE NOT TO EXCEED 0.10 INCH.
5. DIMENSION E IS MEASURED AT A POINT 0.015 BELOW DATUM PLANE H WITH THE LEADS CONSTRAINED PERPENDICULAR TO DATUM C.
6. DIMENSION eB IS MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.
7. DATUM PLANE H IS COINCIDENT WITH THE BOTTOM OF THE LEADS, WHERE THE LEADS EXIT THE BODY.
8. PACKAGE CONTOUR IS OPTIONAL (ROUNDED OR SQUARE CORNERS).

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	----	0.210	---	5.33
A1	0.015	----	0.38	---
A2	0.115	0.195	2.92	4.95
b	0.014	0.022	0.35	0.56
b2	0.060 TYP		1.52 TYP	
C	0.008	0.014	0.20	0.36
D	0.355	0.400	9.02	10.16
D1	0.005	----	0.13	---
E	0.300	0.325	7.62	8.26
E1	0.240	0.280	6.10	7.11
e	0.100 BSC		2.54 BSC	
eB	----	0.430	---	10.92
L	0.115	0.150	2.92	3.81
M	----	10°	---	10°

PACKAGE DIMENSIONS

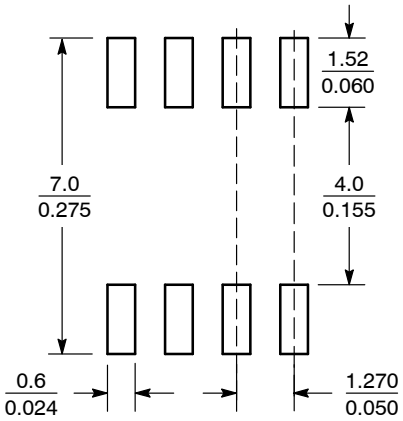
SOIC−8 NB
CASE 751−07
ISSUE AK



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. 751−01 THRU 751−06 ARE OBSOLETE. NEW STANDARD IS 751−07.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0 °	8 °	0 °	8 °
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

SOLDERING FOOTPRINT*

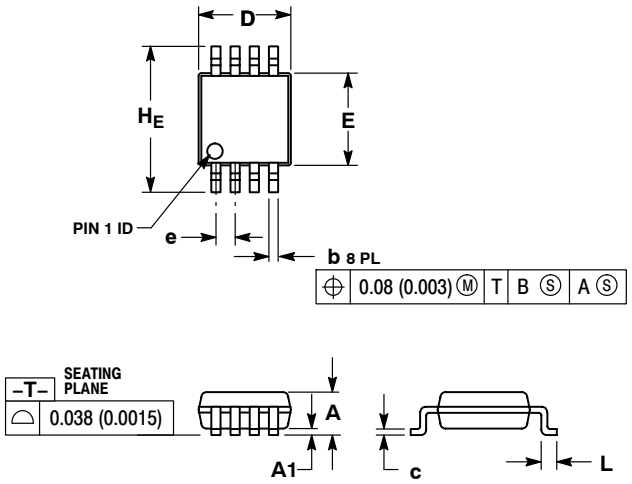


SCALE 6:1 (mm / inches)

*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

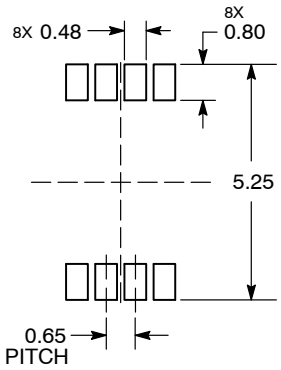
Micro8™
CASE 846A−02
ISSUE J



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. 846A−01 OBSOLETE, NEW STANDARD 846A−02.

	MILLIMETERS			INCHES		
DIM	MIN	NOM	MAX	MIN	NOM	MAX
A	−−	−−	1.10	−−	−−	0.043
A1	0.05	0.08	0.15	0.002	0.003	0.006
b	0.25	0.33	0.40	0.010	0.013	0.016
c	0.13	0.18	0.23	0.005	0.007	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	2.90	3.00	3.10	0.114	0.118	0.122
e	0.65 BSC			0.026 BSC		
L	0.40	0.55	0.70	0.016	0.021	0.028
H_E	4.75	4.90	5.05	0.187	0.193	0.199

RECOMMENDED SOLDERING FOOTPRINT*



DIMENSION: MILLIMETERS

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

Micro8 is a trademark of International Rectifier.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
19521 E. 32nd Pkwy, Aurora, Colorado 80011 USA
Phone: 303−675−2175 or 800−344−3860 Toll Free USA/Canada
Fax: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800−282−9855 Toll Free USA/Canada
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Phone: 421 33 790 2910

ON Semiconductor Website: **www.onsemi.com**

Order Literature: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative

8-bit AVR Microcontrollers

ATmega328/P

DATASHEET SUMMARY

Introduction

The Atmel® picoPower® ATmega328/P 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 ATmega328/P achieves throughputs close to 1MIPS per MHz. This empowers system designer to optimize the device for power consumption versus processing speed.

Feature

High Performance, Low Power Atmel®AVR® 8-Bit Microcontroller Family

- Advanced RISC Architecture
  - 131 Powerful Instructions
  - Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 20 MIPS Throughput at 20MHz
  - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
  - 32KBytes of In-System Self-Programmable Flash program Memory
  - 1KBytes EEPROM
  - 2KBytes Internal SRAM
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  - Data Retention: 20 years at 85°C/100 years at 25°C(1)
  - Optional Boot Code Section with Independent Lock Bits
    - In-System Programming by On-chip Boot Program
    - True Read-While-Write Operation
  - Programming Lock for Software Security
- Atmel® QTouch® Library Support
  - Capacitive Touch Buttons, Sliders and Wheels
  - QTouch and QMatrix® Acquisition
  - Up to 64 sense channels

- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Six PWM Channels
  - 8-channel 10-bit ADC in TQFP and QFN/MLF package
    - Temperature Measurement
  - 6-channel 10-bit ADC in PDIP Package
    - Temperature Measurement
  - Two Master/Slave SPI Serial Interface
  - One Programmable Serial USART
  - One Byte-oriented 2-wire Serial Interface (Philips I^2C compatible)
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - One On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated 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
  - 23 Programmable I/O Lines
  - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF
- Operating Voltage:
  - 1.8 - 5.5V
- Temperature Range:
  - -40°C to 105°C
- Speed Grade:
  - 0 - 4MHz @ 1.8 - 5.5V
  - 0 - 10MHz @ 2.7 - 5.5V
  - 0 - 20MHz @ 4.5 - 5.5V
- Power Consumption at 1MHz, 1.8V, 25°C
  - Active Mode: 0.2mA
  - Power-down Mode: 0.1µA
  - Power-save Mode: 0.75µA (Including 32kHz RTC)

Table of Contents

1. Description

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

The ATmega328/P provides the following features: 32Kbytes of In-System Programmable Flash with Read-While-Write capabilities, 1Kbytes EEPROM, 2Kbytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), three flexible Timer/Counters with compare modes and PWM, 1 serial programmable USARTs , 1 byte-oriented 2-wire Serial Interface (I2C), a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages) , 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 SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next 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.

Atmel offers the QTouch® library for embedding capacitive touch buttons, sliders and wheels functionality into AVR microcontrollers. The patented charge-transfer signal acquisition offers robust sensing and includes fully debounced reporting of touch keys and includes Adjacent Key Suppression® (AKS™) technology for unambiguous detection of key events. The easy-to-use QTouch Suite toolchain allows you to explore, develop and debug your own touch applications.

The device is manufactured using Atmel’s high density non-volatile 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 ATmega328/P is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

The ATmega328/P is supported with a full suite of program and system development tools including: C Compilers, Macro Assemblers, Program Debugger/Simulators, In-Circuit Emulators, and Evaluation kits.

2. Configuration Summary

Features	ATmega328/P
Pin Count	28/32
Flash (Bytes)	32K
SRAM (Bytes)	2K
EEPROM (Bytes)	1K
Interrupt Vector Size (instruction word/vector)	1/1/2
General Purpose I/O Lines	23
SPI	2
TWI (I^2C)	1
USART	1
ADC	10-bit 15kSPS
ADC Channels	8
8-bit Timer/Counters	2
16-bit Timer/Counters	1

and support a real Read-While-Write Self-Programming mechanism. There is a separate Boot Loader Section, and the SPM instruction can only execute from there. In , there is no Read-While-Write support and no separate Boot Loader Section. The SPM instruction can execute from the entire Flash.

3. Ordering Information

3.1. ATmega328

Speed [MHz][3]	Power Supply [V]	Ordering Code[2]	Package[1]	Operational Range
20	1.8 - 5.5	ATmega328-AU ATmega328-AUR[5] ATmega328-MMH[4] ATmega328-MMHR[4][5] ATmega328-MU ATmega328-MUR[5] ATmega328-PU	32A 32A 28M1 28M1 32M1-A 32M1-A 28P3	Industrial (-40°C to 85°C)

Note:

1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. Please refer to *Speed Grades* for Speed vs. V_{CC}
4. Tape & Reel.
5. NiPdAu Lead Finish.

Package Type	
28M1	28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)
28P3	28-lead, 0.300” Wide, Plastic Dual Inline Package (PDIP)
32M1-A	32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)
32A	32-lead, Thin (1.0mm) Plastic Quad Flat Package (TQFP)

3.2. ATmega328P

Speed [MHz][3]	Power Supply [V]	Ordering Code[2]	Package[1]	Operational Range
20	1.8 - 5.5	ATmega328P-AU ATmega328P-AUR[5] ATmega328P-MMH[4] ATmega328P-MMHR[4][5] ATmega328P-MU ATmega328P-MUR[5] ATmega328P-PU	32A 32A 28M1 28M1 32M1-A 32M1-A 28P3	Industrial (-40°C to 85°C)
		ATmega328P-AN ATmega328P-ANR[5] ATmega328P-MN ATmega328P-MNR[5] ATmega328P-PN	32A 32A 32M1-A 32M1-A 28P3	Industrial (-40°C to 105°C)

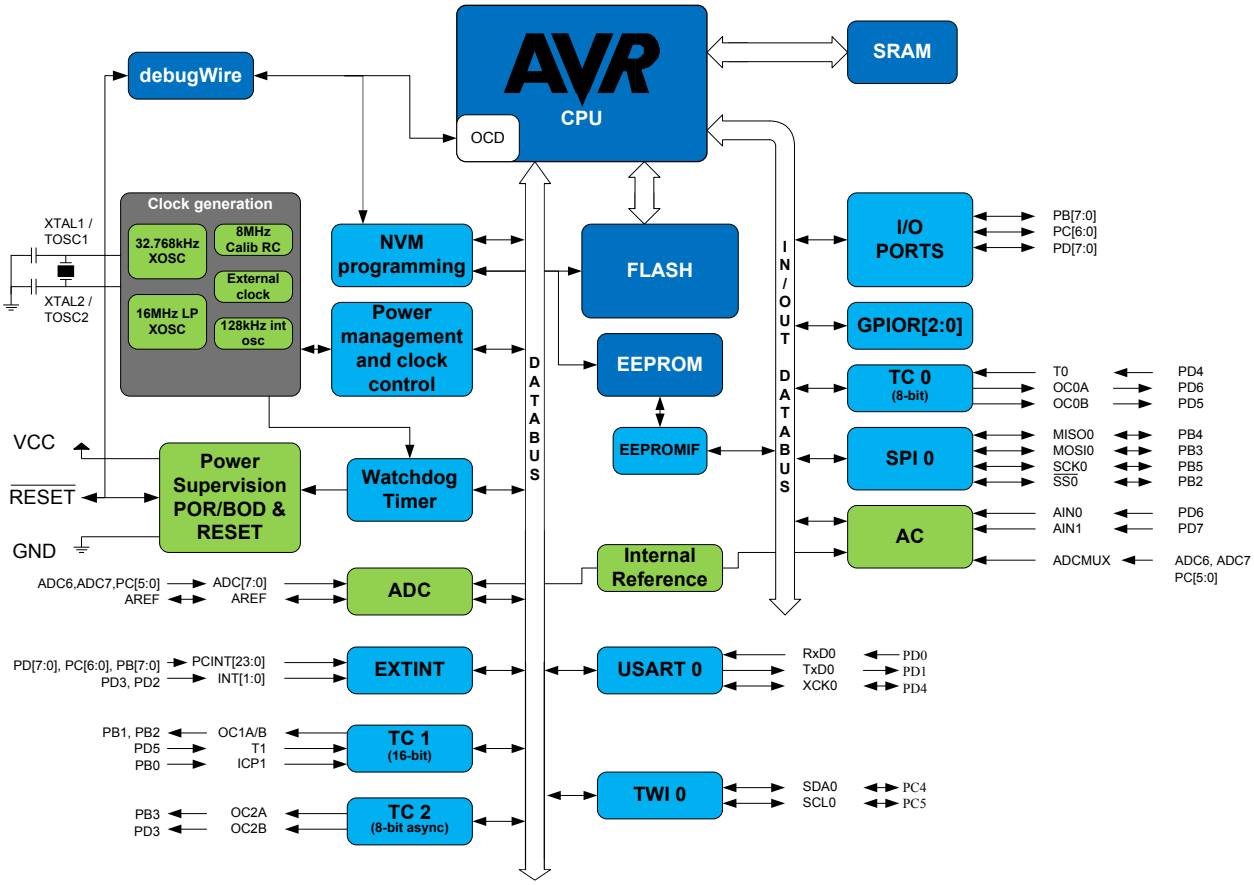
Note:

1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. Please refer to *Speed Grades* for Speed vs. V_{CC}
4. Tape & Reel.
5. NiPdAu Lead Finish.

Package Type	
28M1	28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)
28P3	28-lead, 0.300” Wide, Plastic Dual Inline Package (PDIP)
32M1-A	32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)
32A	32-lead, Thin (1.0mm) Plastic Quad Flat Package (TQFP)

4. Block Diagram

Figure 4-1. Block Diagram



5. Pin Configurations

5.1. Pin-out

Figure 5-1. 28-pin PDIP

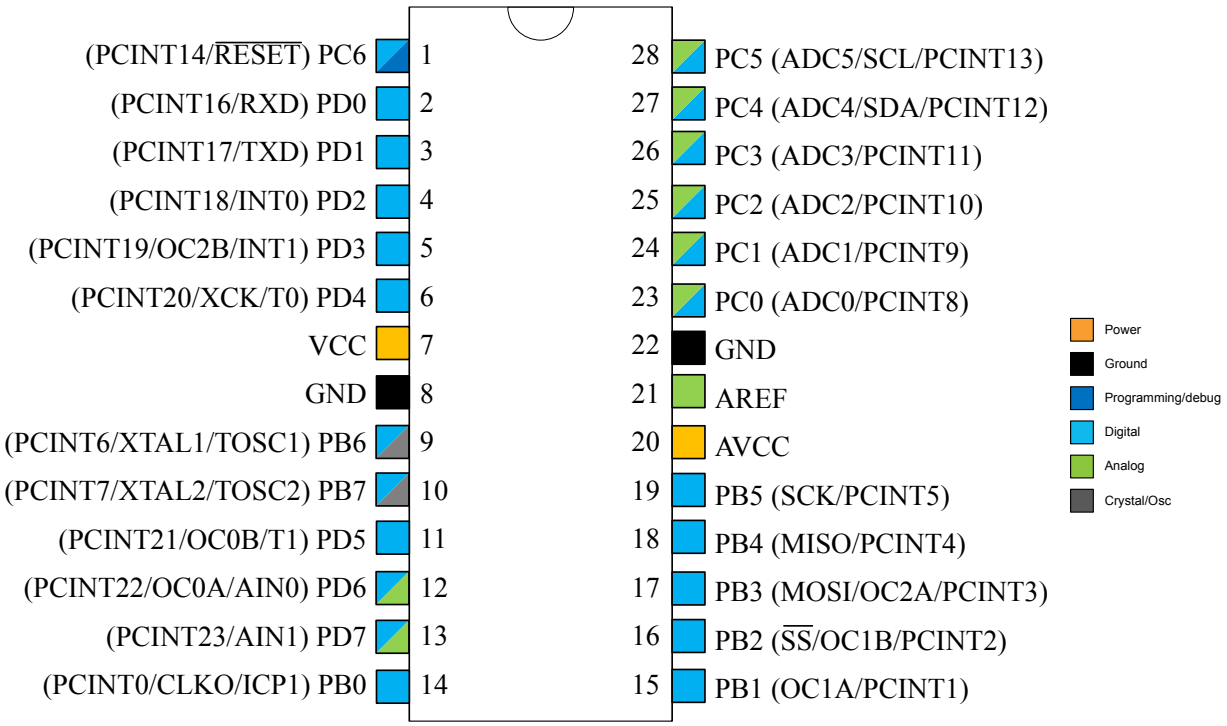


Figure 5-2. 28-pin MLF Top View

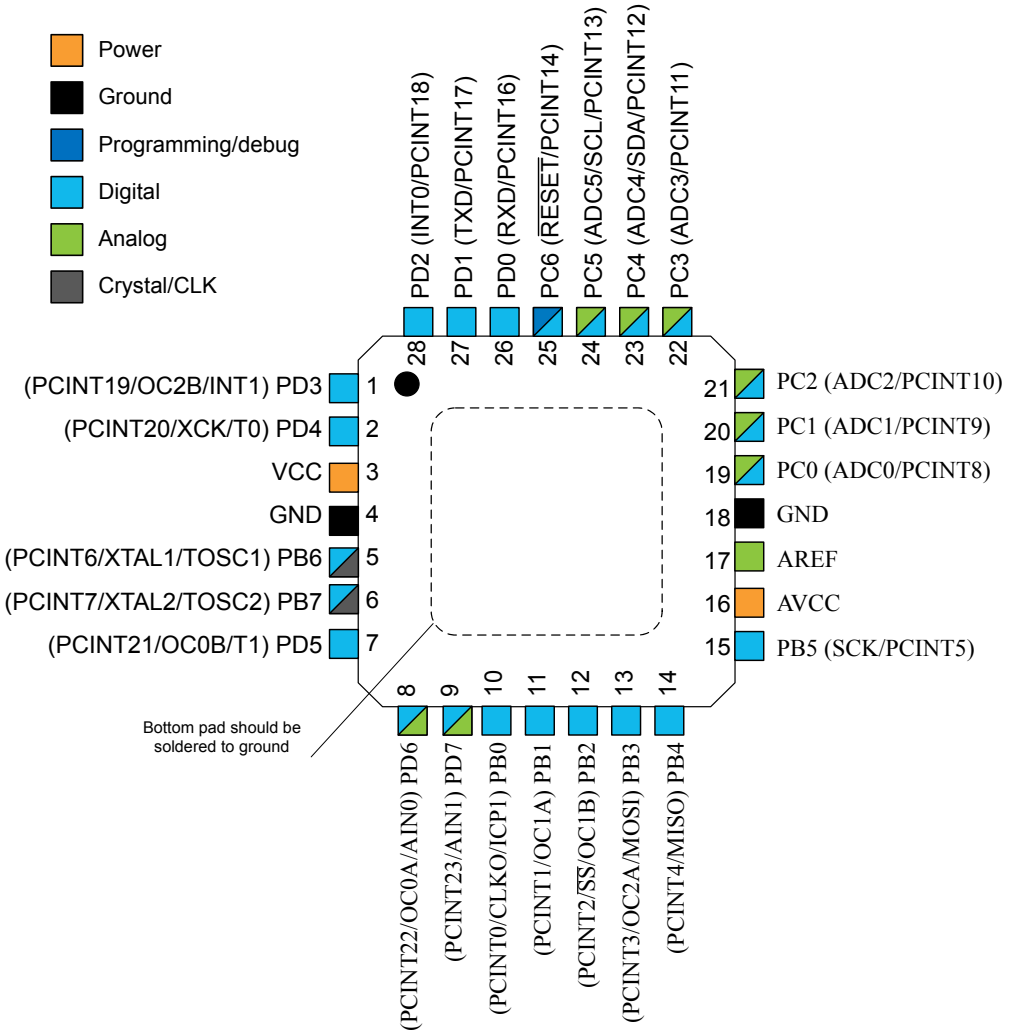


Figure 5-3. 32-pin TQFP Top View

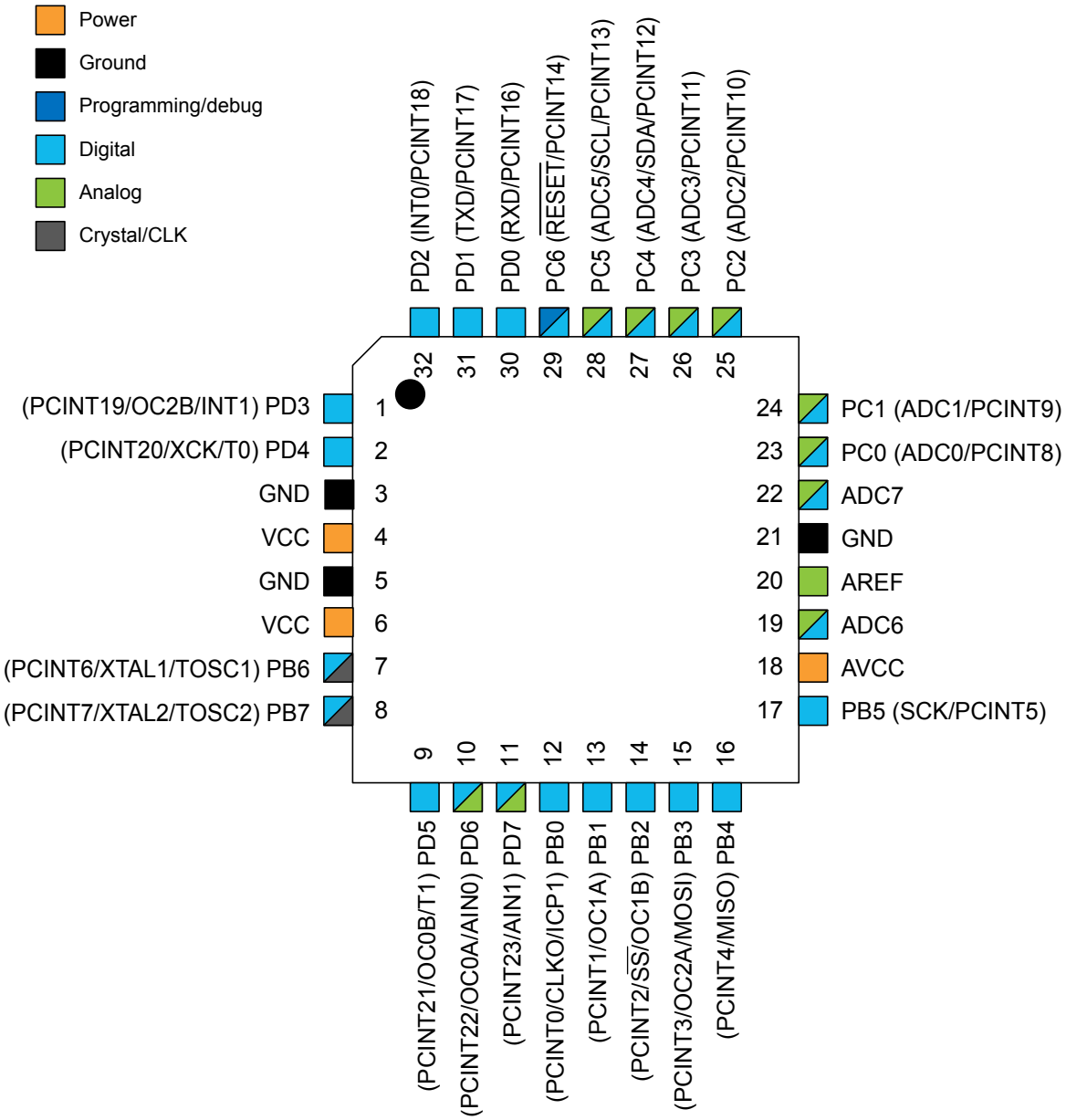
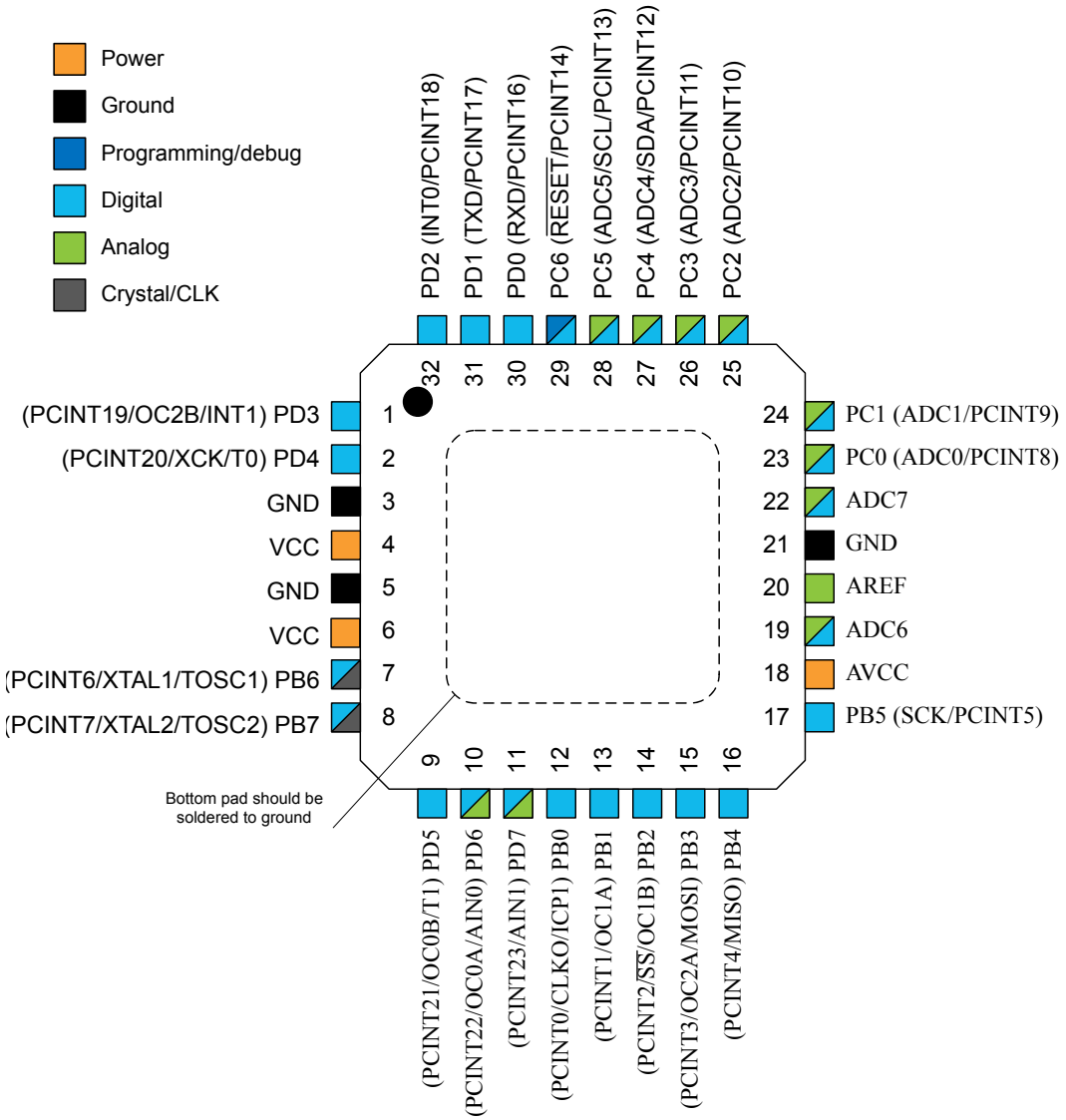


Figure 5-4. 32-pin MLF Top View



5.2. Pin Descriptions

5.2.1. VCC

Digital supply voltage.

5.2.2. GND

Ground.

5.2.3. Port B (PB[7:0]) XTAL1/XTAL2/TOSC1/TOSC2

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.

Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier.

If the Internal Calibrated RC Oscillator is used as chip clock source, PB[7:6] is used as TOSC[2:1] input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

5.2.4. Port C (PC[5:0])

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC[5:0] 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.

5.2.5. PC6/$\overline{\text{RESET}}$

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C.

If the RSTDISBL Fuse is unprogrammed, PC6 is used as a 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. Shorter pulses are not guaranteed to generate a Reset.

The various special features of Port C are elaborated in the *Alternate Functions of Port C* section.

5.2.6. Port D (PD[7:0])

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.

5.2.7. AV_{CC}

AV_{CC} is the supply voltage pin for the A/D Converter, PC[3:0], and PE[3:2]. 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. Note that PC[6:4] use digital supply voltage, V_{CC}.

5.2.8. AREF

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

5.2.9. ADC[7:6] (TQFP and VFQFN Package Only)

In the TQFP and VFQFN package, ADC[7:6] serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

6. I/O Multiplexing

Each pin is by default controlled by the PORT as a general purpose I/O and alternatively it can be assigned to one of the peripheral functions.

The following table describes the peripheral signals multiplexed to the PORT I/O pins.

Table 6-1. PORT Function Multiplexing

(32-pin MLF/TQFP) Pin#	(28-pin MLF) Pin#	(28-pin PIPD) Pin#	PAD	EXTINT	PCINT	ADC/AC	OSC	T/C #0	T/C #1	USART 0	I2C 0	SPI 0
1	1	5	PD[3]	INT1	PCINT19			OC2B				
2	2	6	PD[4]		PCINT20			T0		XCK0		
3	3	7	VCC									
4	4	8	GND									
5	-	-	VCC									
6	-	-	GND									
7	5	9	PB[6]		PCINT6		XTAL1/ TOSC1					
8	6	10	PB[7]		PCINT7		XTAL2/ TOSC2					
9	7	11	PD[5]		PCINT21			OC0B	T1			
10	8	12	PD[6]		PCINT22	AIN0		OC0A				
11	9	13	PD[7]		PCINT23	AIN1						
12	10	14	PB[0]		PCINT0		CLKO	ICP1				
13	11	15	PB[1]		PCINT1			OC1A				
14	12	16	PB[2]		PCINT2			OC1B				$\overline{SS0}$
15	13	17	PB[3]		PCINT3			OC2A				MOSI0
16	14	18	PB[4]		PCINT4							MISO0
17	15	19	PB[5]		PCINT5							SCK0
18	16	20	AVCC									
19	-	-	ADC6			ADC6						
20	17	21	AREF									
21	18	22	GND									
22	-	-	ADC7			ADC7						
23	19	13	PC[0]		PCINT8	ADC0						
24	20	24	PC[1]		PCINT9	ADC1						
25	21	25	PC[2]		PCINT10	ADC2						
26	22	26	PC[3]		PCINT11	ADC3						
27	23	27	PC[4]		PCINT12	ADC4					SDA0	
28	24	28	PC[5]		PCINT13	ADC5					SCL0	
29	25	1	PC[6]/ $\overline{RESET}$		PCINT14							

(32-pin MLF/TQFP) Pin#	(28-pin MLF) Pin#	(28-pin PIPD) Pin#	PAD	EXTINT	PCINT	ADC/AC	OSC	T/C #0	T/C #1	USART 0	I2C 0	SPI 0
30	26	2	PD[0]		PCINT16					RXD0		
31	27	3	PD[1]		PCINT17					TXD0		
32	28	4	PD[2]	INT0	PCINT18							

7. Resources

A comprehensive set of development tools, application notes, and datasheets are available for download on http://www.atmel.com/avr.

8. Data Retention

Reliability Qualification results show that the projected data retention failure rate is much less than 1 PPM over 20 years at 85°C or 100 years at 25°C.

9. 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. Confirm with the C compiler documentation for more details.

For I/O Registers located in extended I/O map, “IN”, “OUT”, “SBIS”, “SBIC”, “CBI”, and “SBI” instructions must be replaced with instructions that allow access to extended I/O. Typically “LDS” and “STS” combined with “SBRS”, “SBRC”, “SBR”, and “CBR”.

10. Capacitive Touch Sensing

10.1. QTouch Library

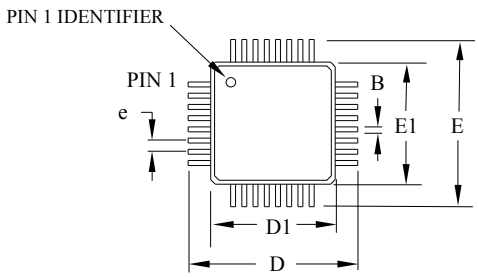
The Atmel® QTouch® Library provides a simple to use solution to realize touch sensitive interfaces on most Atmel AVR® microcontrollers. The QTouch Library includes support for the Atmel QTouch and Atmel QMatrix® acquisition methods.

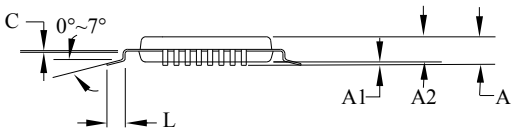
Touch sensing can be added to any application by linking the appropriate Atmel QTouch Library for the AVR Microcontroller. This is done by using a simple set of APIs to define the touch channels and sensors, and then calling the touch sensing API's to retrieve the channel information and determine the touch sensor states.

The QTouch Library is FREE and downloadable from the Atmel website at the following location: http://www.atmel.com/technologies/touch/. For implementation details and other information, refer to the Atmel QTouch Library User Guide - also available for download from the Atmel website.

11. Packaging Information

11.1. 32-pin 32A





COMMON DIMENSIONS
(Unit of measure = mm)

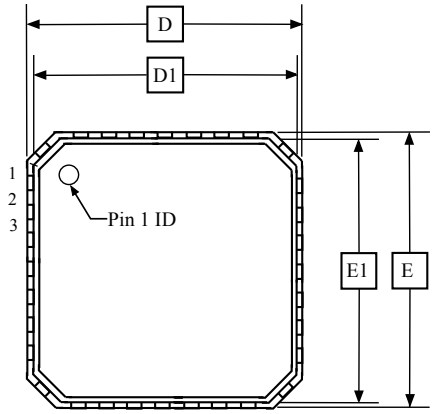
SYMBOL	MIN	NOM	MAX	NOTE
A	–	–	1.20	
A1	0.05	–	0.15	
A2	0.95	1.00	1.05	
D	8.75	9.00	9.25	
D1	6.90	7.00	7.10	Note 2
E	8.75	9.00	9.25	
E1	6.90	7.00	7.10	Note 2
B	0.30	–	0.45	
C	0.09	–	0.20	
L	0.45	–	0.75	
e	0.80 TYP			

Notes:
1. This package conforms to JEDEC reference MS-026, Variation ABA.
2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25mm per side. Dimensions D1 and E1 are maximum plastic body size dimensions including mold mismatch.
3. Lead coplanarity is 0.10mm maximum.

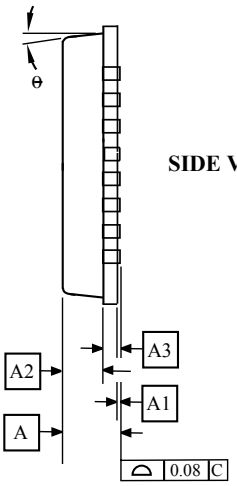
2010-10-20

	TITLE	DRAWING NO.	REV.
Atmel	**32A,** 32-lead, 7 x 7mm body size, 1.0mm body thickness, 0.8mm lead pitch, thin profile plastic quad flat package (TQFP)	32A	C

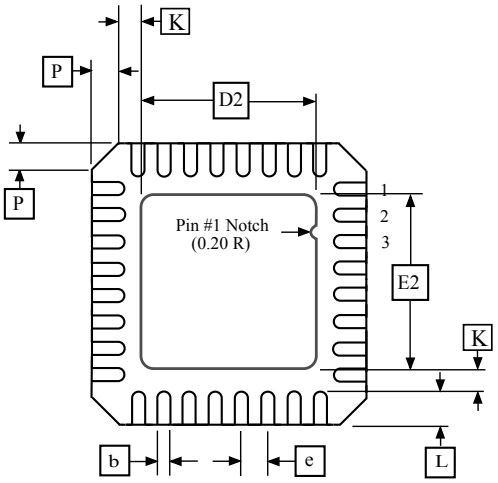
11.2. 32-pin 32M1-A



TOP VIEW



SIDE VIEW



BOTTOM VIEW

COMMON DIMENSIONS
(Unit of Measure = mm)

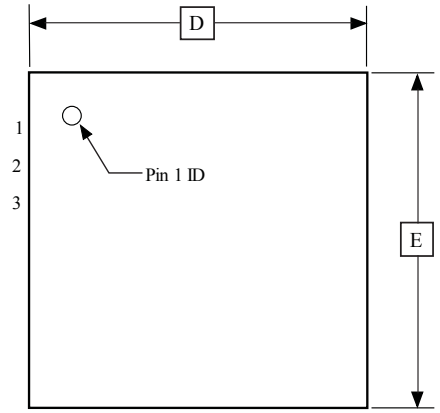
SYMBOL	MIN	NOM	MAX	NOTE
A	0.80	0.90	1.00	
A1	–	0.02	0.05	
A2	–	0.65	1.00	
A3		0.20 REF		
b	0.18	0.23	0.30	
D	4.90	5.00	5.10	
D1	4.70	4.75	4.80	
D2	2.95	3.10	3.25	
E	4.90	5.00	5.10	
E1	4.70	4.75	4.80	
E2	2.95	3.10	3.25	
e		0.50 BSC		
L	0.30	0.40	0.50	
P	–	–	0.60	
θ	–	–	12°	
K	0.20	–	–	

Note : JEDEC Standard MO-220, Fig . 2 (Anvil Singulation), VHHD-2 .

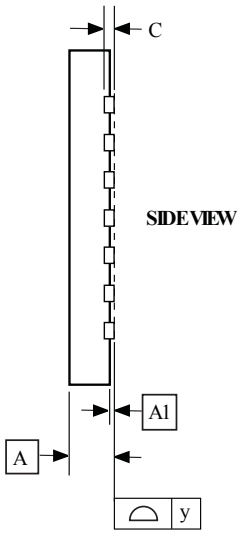
03/14/2014

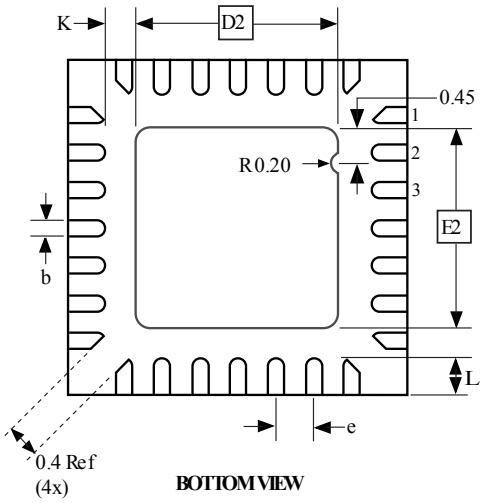
Atmel Package Drawing Contact: packagedrawings@atmel.com	TITLE	DRAWING NO.	REV.
	32M1-A , 32-pad, 5 x 5 x 1.0mm Bod y, Lead Pitch 0.50mm , 3.10mm Exposed Pad, Micro Lead Frame Package (MLF)	32M1-A	F

11.3. 28-pin 28M1



TOP VIEW





BOTTOM VIEW

Note: The terminal #1 ID is a laser-marked feature.

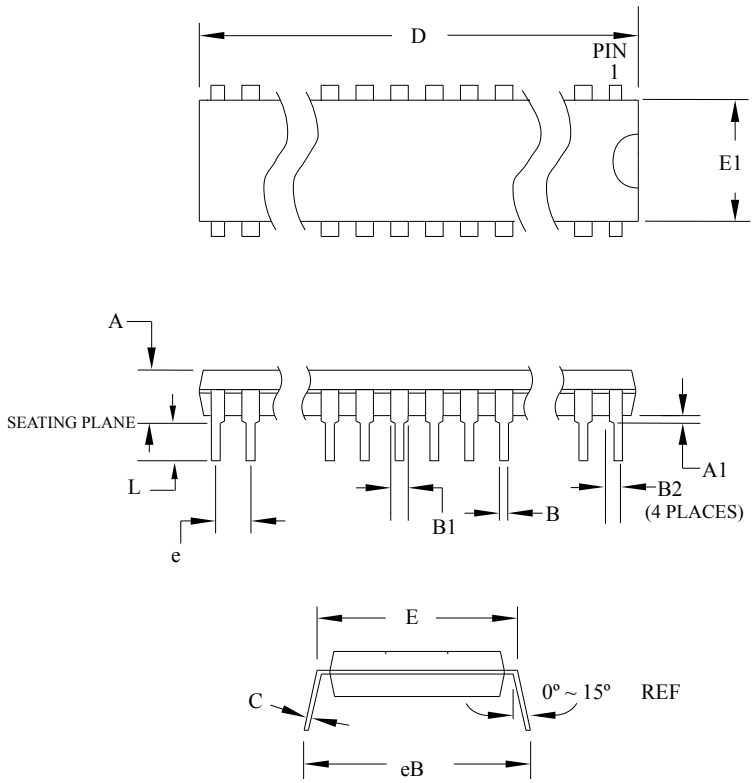
COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	0.80	0.90	1.00	
A1	0.00	0.02	0.05	
b	0.17	0.22	0.27	
C		0.20 REF		
D	3.95	4.00	4.05	
D2	2.35	2.40	2.45	
E	3.95	4.00	4.05	
E2	2.35	2.40	2.45	
e		0.45		
L	0.35	0.40	0.45	
y	0.00	–	0.08	
K	0.20	–	–	

10/24/08

Package Drawing Contact: packagedrawings@atmel.com	TITLE	GPC	DRAWING NO.	REV.
	28M1, 28-pad, 4 x 4 x 1.0mm Body, Lead Pitch 0.45mm, 2.4 x 2.4mm Exposed Pad, Thermally Enhanced Plastic Very Thin Quad Flat No Lead Package (VQFN)	ZBV	28M1	B

11.4. 28-pin 28P3



COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	–	–	4.5724	
A1	0.508	–	–	
D	34.544	–	34.798	Note 1
E	7.620	–	8.255	
E1	7.112	–	7.493	Note 1
B	0.381	–	0.533	
B1	1.143	–	1.397	
B2	0.762	–	1.143	
L	3.175	–	3.429	
C	0.203	–	0.356	
eB	–	–	10.160	
e	2.540 TYP			

Note: 1. Dimensions D and E1 do not include mold Flash or Protrusion. Mold Flash or Protrusion shall not exceed 0.25mm (0.010").

09/28/01

	TITLE	DRAWING NO.	REV.
Atmel 2325 Orchard Parkway San Jose, CA 95131	**28P3**, 28-lead (0.300"/7.62mm Wide) Plastic Dual Inline Package (PDIP)	28P3	B

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PT TEMPERATURE SENSOR – PTF FAMILY

SPECIFICATIONS

- **Conformal to standard platinum temperature sensors according DIN EN 60751**
- **R0: 100 and 1000 Ω**
- **Class F 0.1 (T = AA), F 0.15 (A), F 0.3 (B) and F 0.6 (C) accuracy**
- **Wide temperature range**
- **Different outline dimensions**
- **Global interchangeability**

The PTF-sensor family combines a group of resistance temperature detectors (RTD) using a Platinum resistor in thin film technology as sensing element. It consists of a structured platinum film on a ceramics substrate, passivated by glass coating. The connection wires are protected with glass on the welding area.
The characteristic curve of this Platinum RTD complies with DIN EN 60751. The usage of Platinum as resistive material guarantees high long term stability.
Due to small outline and low mass this RTD has a low time constant; therefore it is a suitable solution for fast and precise feedback control systems.

FEATURES

- Conformal to DIN EN 60751
- Wide temperature range: -50 … +600 °C (Ni/Au wire and Class F 0.3, Ag-Wire versions are limited to 300 °C)
- Standard nominal resistances values:
  R_0: 100 and 1000 Ω (other on request)
- Class F 0.1 (T = AA), F 0.15 (A), F 0.3 (B) and F 0.6 (C) accuracy
- Low drift over lifetime
- Fast response time because of low thermal mass
- Different outline dimensions available to fit a wide range of space requirements
- Global interchangeability

APPLICATIONS

- Temperature feedback control
- White goods
- Industrial applications
- Automotive
- Medical
- Sensing element for plug-in probes

PERFORMANCE SPECS

Parameter	Symbol	Condition	Min.	Typical	Max.	Unit
Nominal Resistance at 0 °C	R_0	Class B	99.88 998.8	100.00 1000.0	100.12 1001.2	Ω
Tolerance at 25 °C	Class B	Room temperature calibration	-0.43	0	0.43	°C
Temperature Coefficient of Resistance	TCR	0 °C, 100 °C		3850		ppm/°C
Temperature Range		Class C (F0.6) Class B (F 0.3) Class A (F 0.15) Class T (F 0.1)	-50 -50 -30 -30		600 600 300 200	°C
Self Heating Coefficient in air, flow: 1 m/s		PTFC outline PTFD outline PTFF outline PTFM outline		0.5 0.33 0.5 0.5		°C/mW
Response Time Water Flow: 0.4 m/s	$\tau_{W,0.9}$	PTFC outline PTFD outline PTFF outline PTFM outline		0.2 0.35 0.2 0.2		s
Response Time Air Flow: 1 m/s	$\tau_{A,0.9}$	PTFC outline PTFD outline PTFF outline PTFM outline		10 17 10 10		s
Measuring Current R_0: 100 Ω		PTFC outline PTFD outline PTFF outline PTFM outline			1.4 1.7 1.4 1.4	mA
Measuring Current R_0: 1000 Ω		PTFC outline PTFD outline PTFF outline PTFM outline			0.4 0.5 0.4 0.4	mA

CALCULATION FORMULAS

The calculation formulas of Pt-RTDs are defined in DIN EN 60751 as following:

For T ≥ 0 °C: $R_{(T)} = R_{(0)} * (1 + a * T + b * T^2)$

For T < 0 °C: $R_{(T)} = R_{(0)} * [1 + a * T + b * T^2 + c * (T - 100°C) * T^3]$

Coefficients:

a = 3.9083E-03
b = -5.775E-07
c = -4.183E-12

Tolerances:

Class F 0.1 (T = AA):	± (0.10+0.0017*|T/°C|) °C	(-30…+200 °C)
Class F 0.15 (A)	± (0.15+0.002*|T/°C|) °C	(-30…+300 °C)
Class F 0.3 (B):	± (0.30+0.005*|T/°C|) °C	(-50…+600 °C)
Class F 0.6 (C):	± (0.60+0.01*|T/°C|) °C	(-50…+600 °C)

TYPICAL PERFORMANCE CURVES

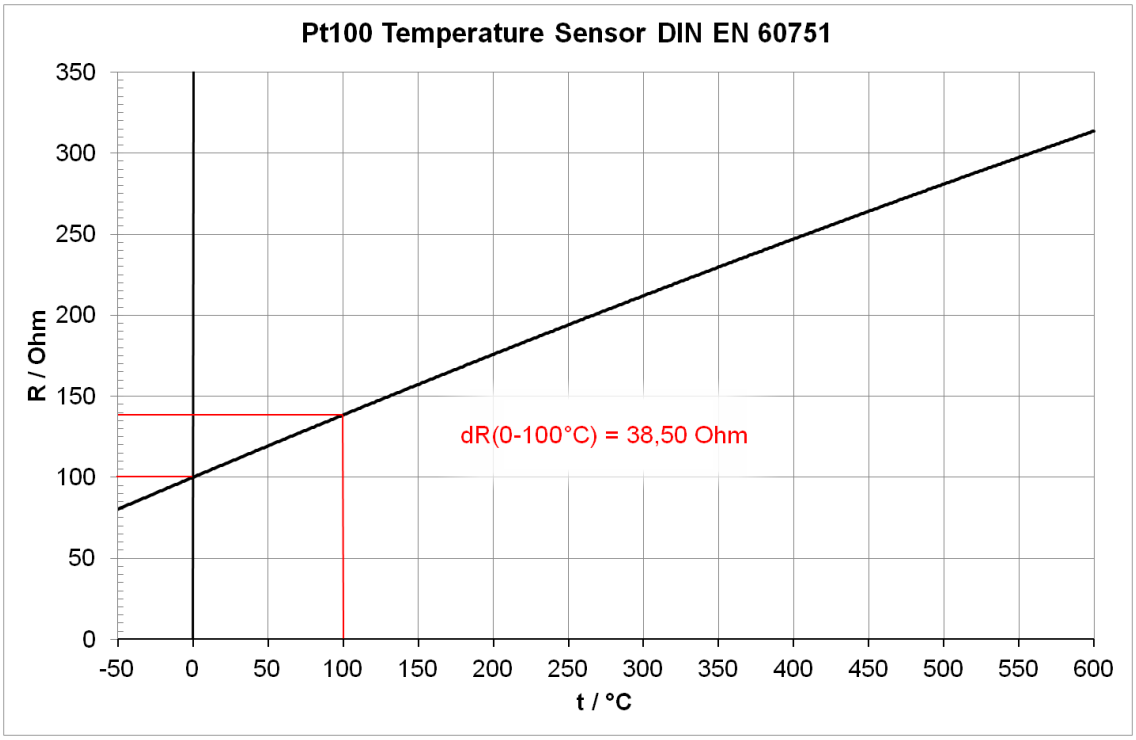


Figure 1: Resistance characteristics

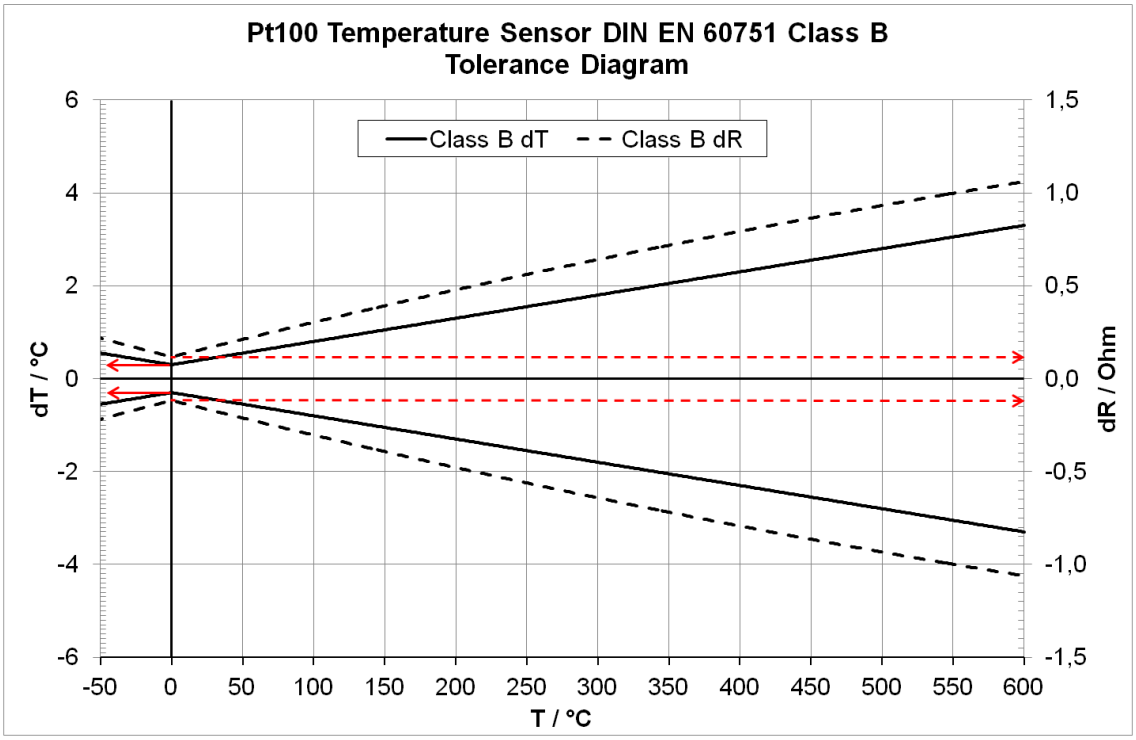


Figure 2: Tolerance chart

DIMENSIONAL DRAWING - PTFC OUTLINE

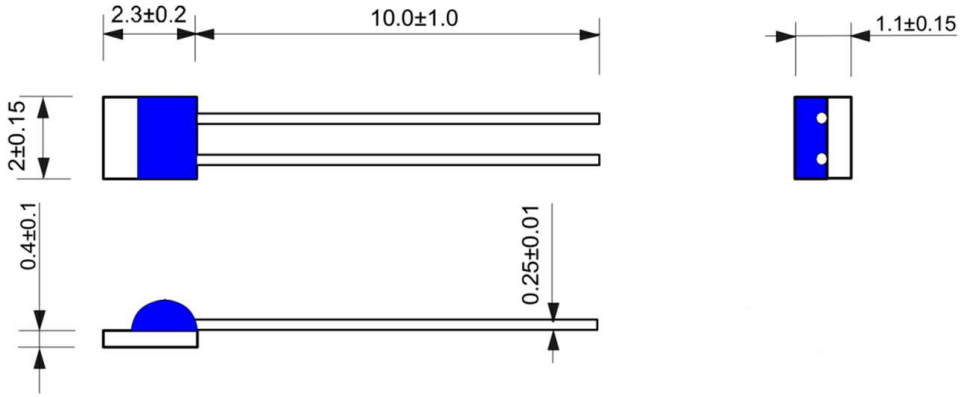


Figure 3: PTFC outline dimensions (mm)

DIMENSIONAL DRAWING - PTFD OUTLINE

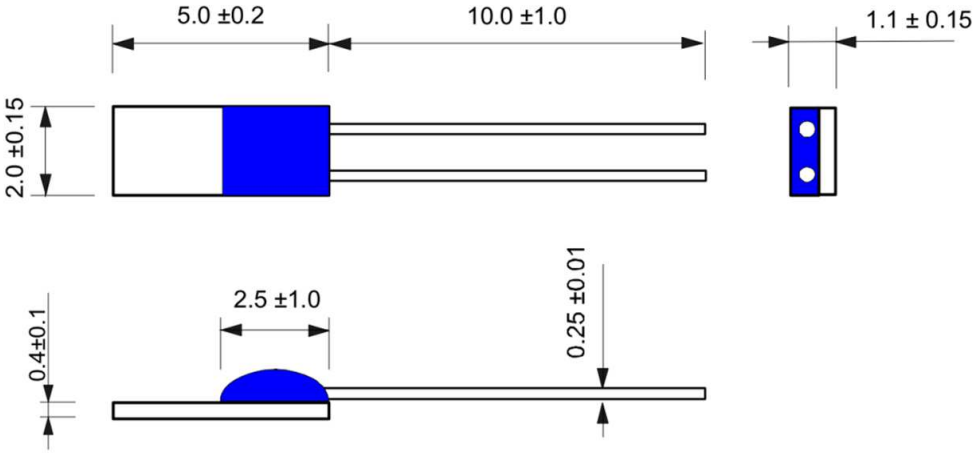


Figure 4: PTFD outline dimensions (mm)

DIMENSIONAL DRAWING - PTFF OUTLINE

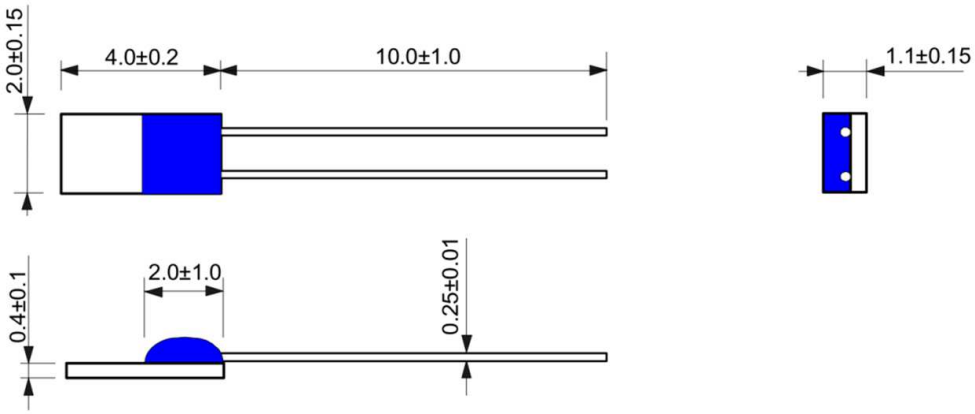


Figure 5: PTFF outline dimensions (mm)

DIMENSIONAL DRAWING - PTFM OUTLINE

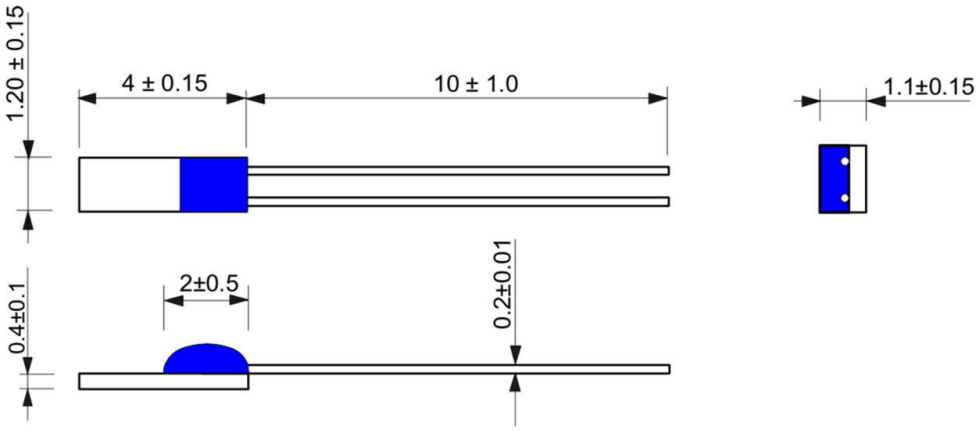


Figure 6: PTFM outline dimensions (mm)

TYPE CONFIGURATION MATRIX

Sensor family	Type	Outline dimensions	Nominal resistance		Tolerance class DIN EN 60751				Connection wire	
			100 Ω	1000 Ω					Ag wire	Ni/Au wire
PTF	C	2.0 x 2.3	101	102	T	A	B	C	1A0	1G0
PTF	D	2.0 x 5.0	101	102	T	A	B	C	1A0	1G0
PTF	F	2.0 x 4.0	101	102	T	A	B	C	1A0	1G0
PTF	M	1.2 x 4.0	101	102	T	A	B	C	1A0	1G0

PACKING AND MINIMUM ORDER QUANTITY

Packing	PCS per Packing unit	MOQ
Transparent Blister Box 80(120)mm x 50(60)mm x 20mm	500 (bulk)	500 per Type

ORDERING INFORMATION I

Product Number	Type	Description
Platinum Thin Film Sensors PTFC-Type (2 mm x 2.3 mm)		
NB-PTCO-005	PTFC101C1G0	100 Ohms, 2.0 mm x 2.3 mm, F 0.6 (C), Ni/Au-wire
NB-PTCO-002	PTFC101B1G0	100 Ohms, 2.0 mm x 2.3 mm, F 0.3 (B), Ni/Au-wire
NB-PTCO-011	PTFC101A1G0	100 Ohms, 2.0 mm x 2.3 mm, F 0.15 (A), Ni/Au-wire
NB-PTCO-058	PTFC101T1G0	100 Ohms, 2.0 mm x 2.3 mm, F 0.1 (T = AA), Ni/Au-wire
NB-PTCO-159	PTFC101C1A0	100 Ohms, 2.0 mm x 2.3 mm, F 0.6 (C), Ag-wire
NB-PTCO-160	PTFC101B1A0	100 Ohms, 2.0 mm x 2.3 mm, F 0.3 (B), Ag-wire
NB-PTCO-161	PTFC101A1A0	100 Ohms, 2.0 mm x 2.3 mm, F 0.15 (A), Ag-wire
NB-PTCO-162	PTFC101T1A0	100 Ohms, 2.0 mm x 2.3 mm, F 0.1 (T = AA), Ag-wire
NB-PTCO-046	PTFC102C1G0	1000 Ohms, 2.0 mm x 2.3 mm, F 0.6 (C), Ni/Au-wire
NB-PTCO-006	PTFC102B1G0	1000 Ohms, 2.0 mm x 2.3 mm, F 0.3 (B), Ni/Au-wire
NB-PTCO-029	PTFC102A1G0	1000 Ohms, 2.0 mm x 2.3 mm, F 0.15 (A), Ni/Au-wire
NB-PTCO-154	PTFC102T1G0	1000 Ohms, 2.0 mm x 2.3 mm, F 0.1 (T = AA), Ni/Au-wire
NB-PTCO-163	PTFC102C1A0	1000 Ohms, 2.0 mm x 2.3 mm, F 0.6 (C), Ag-wire
NB-PTCO-157	PTFC102B1A0	1000 Ohms, 2.0 mm x 2.3 mm, F 0.3 (B), Ag-wire
NB-PTCO-164	PTFC102A1A0	1000 Ohms, 2.0 mm x 2.3 mm, F 0.15 (A), Ag-wire
NB-PTCO-165	PTFC102T1A0	1000 Ohms, 2.0 mm x 2.3 mm, F 0.1 (T = AA), Ag-wire
Platinum Thin Film Sensors PTFD-Type (2 mm x 5 mm)		
NB-PTCO-013	PTFD101C1G0	100 Ohms, 2.0 mm x 5.0 mm, F 0.6 (C), Ni/Au-wire
NB-PTCO-024	PTFD101B1G0	100 Ohms, 2.0 mm x 5.0 mm, F 0.3 (B), Ni/Au-wire
NB-PTCO-037	PTFD101A1G0	100 Ohms, 2.0 mm x 5.0 mm, F 0.15 (A), Ni/Au-wire
NB-PTCO-155	PTFD101T1G0	100 Ohms, 2.0 mm x 5.0 mm, F 0.1 (T = AA), Ni/Au-wire
NB-PTCO-166	PTFD101C1A0	100 Ohms, 2.0 mm x 5.0 mm, F 0.6 (C), Ag-wire
NB-PTCO-053	PTFD101B1A0	100 Ohms, 2.0 mm x 5.0 mm, F 0.3 (B), Ag-wire
NB-PTCO-158	PTFD101A1A0	100 Ohms, 2.0 mm x 5.0 mm, F 0.15 (A), Ag-wire
NB-PTCO-152	PTFD101T1A0	100 Ohms, 2.0 mm x 5.0 mm, F 0.1 (T = AA), Ag-wire
NB-PTCO-167	PTFD102C1G0	1000 Ohms, 2.0 mm x 5.0 mm, F 0.6 (C), Ni/Au-wire
NB-PTCO-126	PTFD102B1G0	1000 Ohms, 2.0 mm x 5.0 mm, F 0.3 (B), Ni/Au-wire
NB-PTCO-168	PTFD102A1G0	1000 Ohms, 2.0 mm x 5.0 mm, F 0.15 (A), Ni/Au-wire
NB-PTCO-150	PTFD102T1G0	1000 Ohms, 2.0 mm x 5.0 mm, F 0.1 (T = AA), Ni/Au-wire
NB-PTCO-169	PTFD102C1A0	1000 Ohms, 2.0 mm x 5.0 mm, F 0.6 (C), Ag-wire
NB-PTCO-035	PTFD102B1A0	1000 Ohms, 2.0 mm x 5.0 mm, F 0.3 (B), Ag-wire
NB-PTCO-170	PTFD102A1A0	1000 Ohms, 2.0 mm x 5.0 mm, F 0.15 (A), Ag-wire
NB-PTCO-151	PTFD102T1A0	1000 Ohms, 2.0 mm x 5.0 mm, F 0.1 (T = AA), Ag-wire

Ordering INFORMATION II

Product Number	Type	Description
Platinum Thin Film Sensors PTFF-Type (2 mm x 4 mm)		
NB-PTCO-171	PTFF101C1G0	100 Ohms, 2.0 mm x 4.0 mm, F 0.6 (C), Ni/Au-wire
NB-PTCO-172	PTFF101B1G0	100 Ohms, 2.0 mm x 4.0 mm, F 0.3 (B), Ni/Au-wire
NB-PTCO-173	PTFF101A1G0	100 Ohms, 2.0 mm x 4.0 mm, F 0.15 (A), Ni/Au-wire
NB-PTCO-174	PTFF101T1G0	100 Ohms, 2.0 mm x 4.0 mm, F 0.1 (T = AA), Ni/Au-wire
NB-PTCO-175	PTFF101C1A0	100 Ohms, 2.0 mm x 4.0 mm, F 0.6 (C), Ag-wire
NB-PTCO-176	PTFF101B1A0	100 Ohms, 2.0 mm x 4.0 mm, F 0.3 (B), Ag-wire
NB-PTCO-177	PTFF101A1A0	100 Ohms, 2.0 mm x 4.0 mm, F 0.15 (A), Ag-wire
NB-PTCO-178	PTFF101T1A0	100 Ohms, 2.0 mm x 4.0 mm, F 0.1 (T = AA), Ag-wire
NB-PTCO-149	PTFF102C1G0	1000 Ohms, 2.0 mm x 4.0 mm, F 0.6 (C), Ni/Au-wire
NB-PTCO-101	PTFF102B1G0	1000 Ohms, 2.0 mm x 4.0 mm, F 0.3 (B), Ni/Au-wire
NB-PTCO-179	PTFF102A1G0	1000 Ohms, 2.0 mm x 4.0 mm, F 0.15 (A), Ni/Au-wire
NB-PTCO-180	PTFF102T1G0	1000 Ohms, 2.0 mm x 4.0 mm, F 0.1 (T = AA), Ni/Au-wire
NB-PTCO-181	PTFF102C1A0	1000 Ohms, 2.0 mm x 4.0 mm, F 0.6 (C), Ag-wire
NB-PTCO-182	PTFF102B1A0	1000 Ohms, 2.0 mm x 4.0 mm, F 0.3 (B), Ag-wire
NB-PTCO-183	PTFF102A1A0	1000 Ohms, 2.0 mm x 4.0 mm, F 0.15 (A), Ag-wire
NB-PTCO-184	PTFF102T1A0	1000 Ohms, 2.0 mm x 4.0 mm, F 0.1 (T = AA), Ag-wire
Platinum Thin Film Sensors PTFM-Type (1.2 mm x 4 mm)		
NB-PTCO-148	PTFM101C1G0	100 Ohms, 1.2 mm x 4.0 mm, F 0.6 (C), Ni/Au-wire
NB-PTCO-032	PTFM101B1G0	100 Ohms, 1.2 mm x 4.0 mm, F 0.3 (B), Ni/Au-wire
NB-PTCO-142	PTFM101A1G0	100 Ohms, 1.2 mm x 4.0 mm, F 0.15 (A), Ni/Au-wire
NB-PTCO-156	PTFM101T1G0	100 Ohms, 1.2 mm x 4.0 mm, F 0.1 (T = AA), Ni/Au-wire
NB-PTCO-185	PTFM101C1A0	100 Ohms, 1.2 mm x 4.0 mm, F 0.6 (C), Ag-wire
NB-PTCO-186	PTFM101B1A0	100 Ohms, 1.2 mm x 4.0 mm, F 0.3 (B), Ag-wire
NB-PTCO-187	PTFM101A1A0	100 Ohms, 1.2 mm x 4.0 mm, F 0.15 (A), Ag-wire
NB-PTCO-188	PTFM101T1A0	100 Ohms, 1.2 mm x 4.0 mm, F 0.1 (T = AA), Ag-wire
NB-PTCO-189	PTFM102C1G0	1000 Ohms, 1.2 mm x 4.0 mm, F 0.6 (C), Ni/Au-wire
NB-PTCO-012	PTFM102B1G0	1000 Ohms, 1.2 mm x 4.0 mm, F 0.3 (B), Ni/Au-wire
NB-PTCO-050	PTFM102A1G0	1000 Ohms, 1.2 mm x 4.0 mm, F 0.15 (A), Ni/Au-wire
NB-PTCO-153	PTFM102T1G0	1000 Ohms, 1.2 mm x 4.0 mm, F 0.1 (T = AA), Ni/Au-wire
NB-PTCO-190	PTFM102C1A0	1000 Ohms, 1.2 mm x 4.0 mm, F 0.6 (C), Ag-wire
NB-PTCO-191	PTFM102B1A0	1000 Ohms, 1.2 mm x 4.0 mm, F 0.3 (B), Ag-wire
NB-PTCO-192	PTFM102A1A0	1000 Ohms, 1.2 mm x 4.0 mm, F 0.15 (A), Ag-wire
NB-PTCO-193	PTFM102T1A0	1000 Ohms, 1.2 mm x 4.0 mm, F 0.1 (T = AA), Ag-wire

NORTH AMERICA

Measurement Specialties, Inc.,
a TE Connectivity Company
910 Turnpike Road
Shrewsbury, MA 01545
United States
Phone: +1-508-842-0516
Fax: +1-508-842-0342
Email: temperature.sales.amer@meas-spec.com
Web: www.meas-spec.com

EUROPE

Measurement Specialties (Europe), Ltd.,
a TE Connectivity Company
Deutschland GmbH
Hauert 13
D-44227 Dortmund
Germany
Phone: +49-(0)231-9740-0
Fax: +49-(0)231-9740-20
Email: info.de@meas-spec.com
Web: www.meas-spec.com

ASIA

Measurement Specialties (China), Ltd.,
a TE Connectivity Company
No. 26 Langshan Road
Shenzhen High-Tech Park (North)
Nanshan District, Shenzhen 518057
China
Tel: +86 755 3330 5088
Fax: +86 755 3330 5099
Email: temperature.sales.asia@meas-spec.com
Web: www.meas-spec.com

TE.com/sensorsolutions

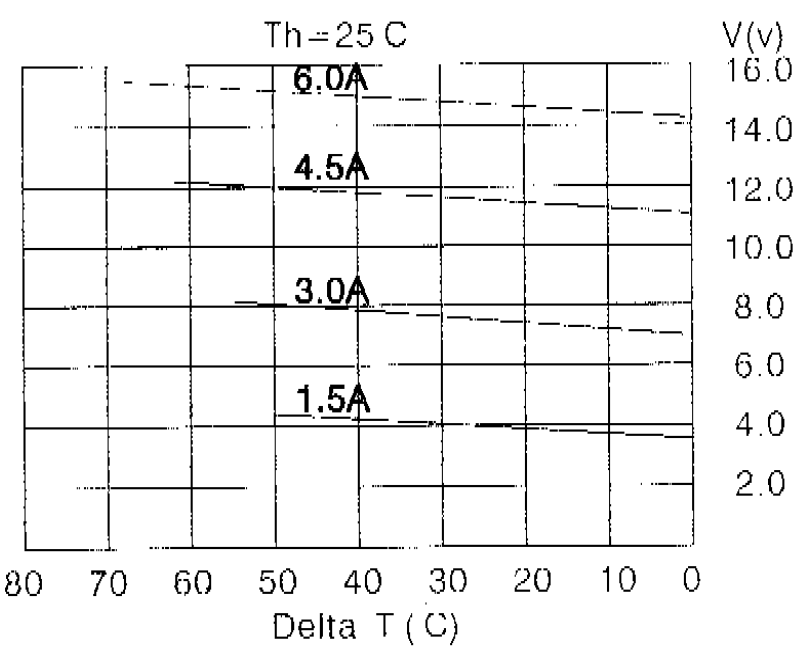
TEC1-12706

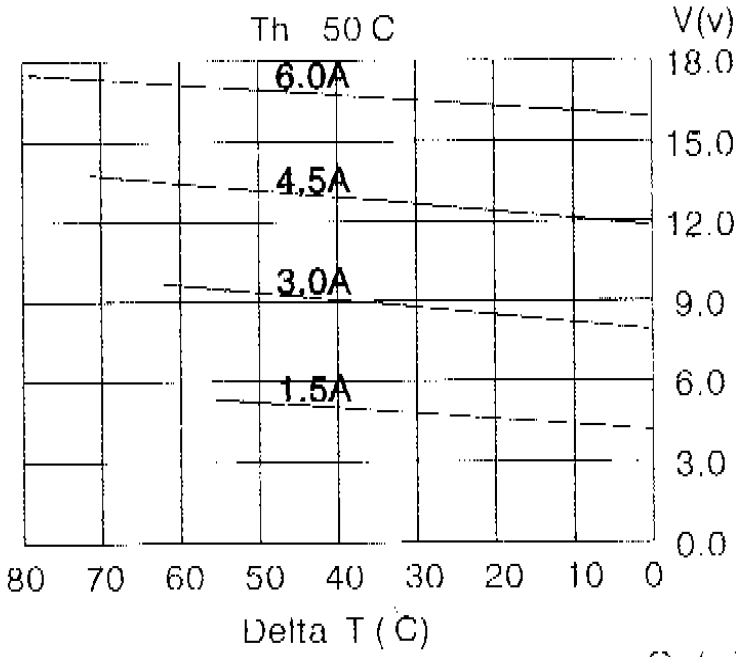
Performance Specifications

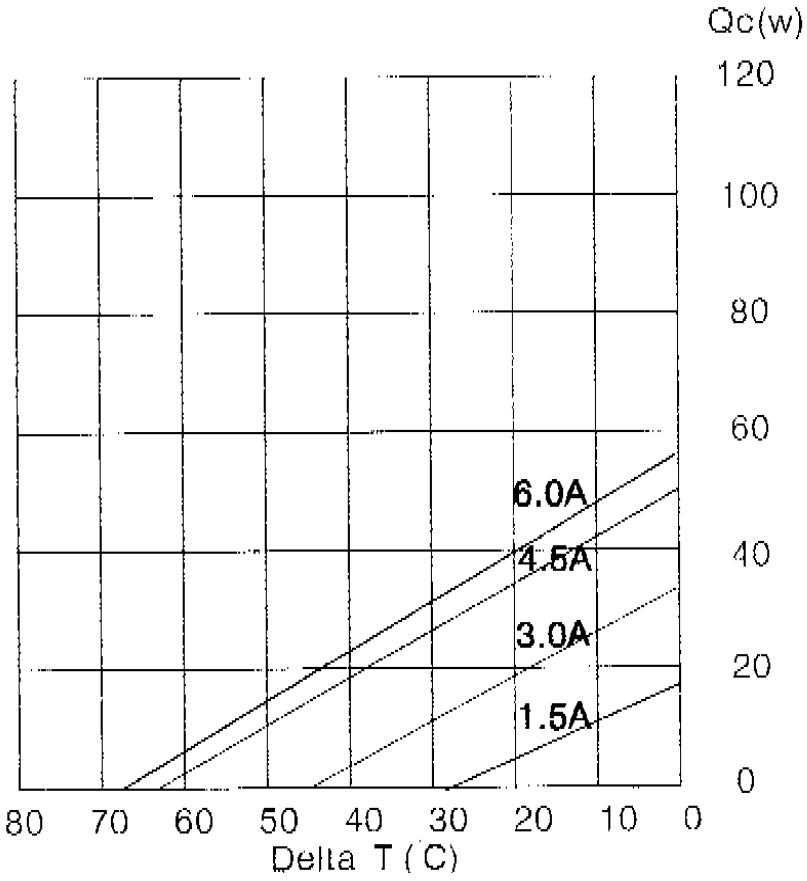
Hot Side Temperature (º C)	25º C	50º C
Qmax (Watts)	50	57
Delta Tmax (º C)	66	75
Imax (Amps)	6.4	6.4
Vmax (Volts)	14.4	16.4
Module Resistance (Ohms)	1.98	2.30

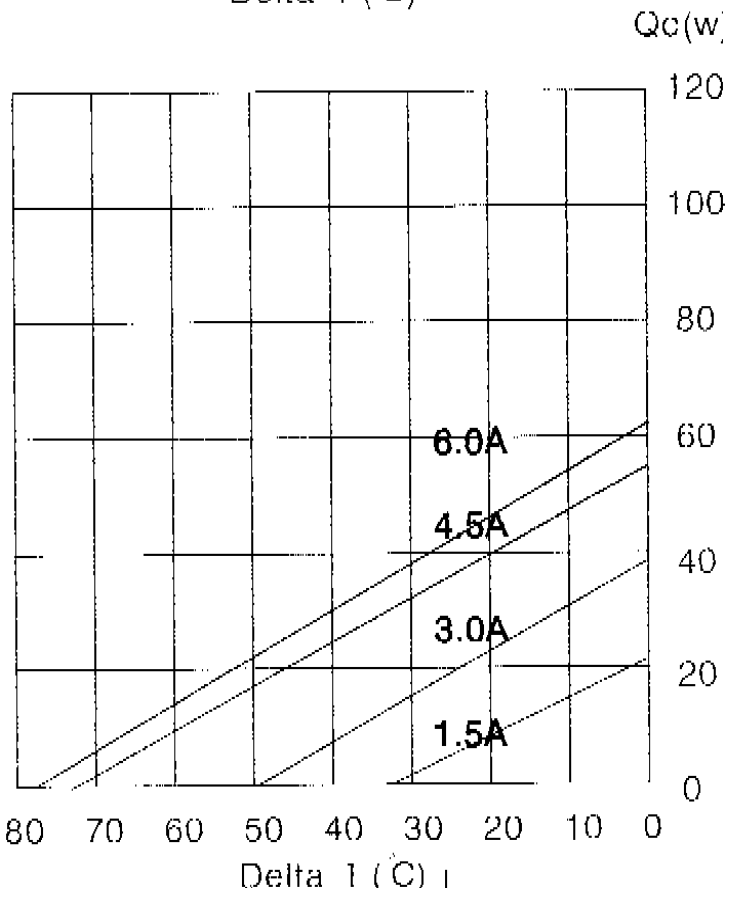
TEC1-12706

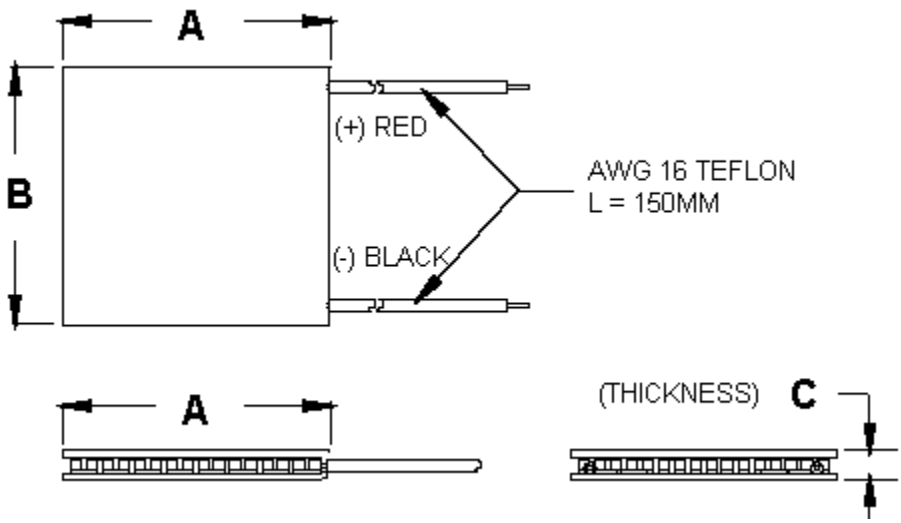
Performance curves:











Ceramic Material: Alumina (Al_2O_3)
Solder Construction: 138°C, Bismuth Tin (BiSn)

Size table:

A	B	C			
40	40	3.9			

Operating Tips

- Max. Operating Temperature: 138°C
- Do not exceed Imax or Vmax when operating module.
- Life expectancy: 200,000 hours
- Please consult HB for moisture protection options (seeling).
- Failure rate based on long time testings: 0.2%.