

# INTERMIL

## ICL8073/8074 Calibrated Low-Power Temperature Transducers

### FEATURES

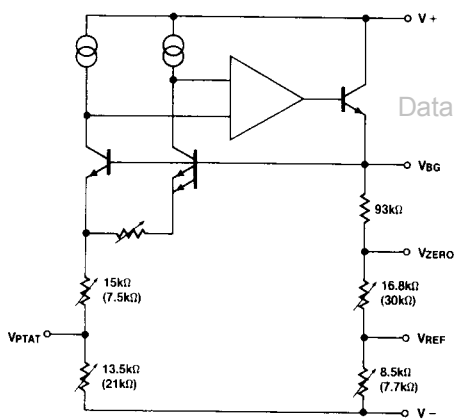
- Excellent Interchangeability Due to Laser Trimming
- Output Proportional to Absolute Temperature ( $^{\circ}\text{K}$ ) ( $V_{\text{PTAT}}$ )
- Output Directly Proportional to  $^{\circ}\text{C}$  (8073) or  $^{\circ}\text{F}$  (8074) ( $V_{\text{PTAT}} - V_{\text{ZERO}}$ )
- Reference Output for A/D Scaling in  $^{\circ}\text{C}$  or  $^{\circ}\text{F}$  ( $V_{\text{REF}}$ )
- Direct Interface to A/D Converters, for Digital Readings with No Extra Parts or Adjustments
- Constant Output for Arbitrary A/D Scaling ( $V_{\text{BG}}$ )
- Low Power-Consumption ( $50\mu\text{A}$  Typical)
- Wide Supply Range: 2.7 to 30 Volts

### GENERAL DESCRIPTION

The ICL8073/8074 single-chip temperature transducers include all necessary offset and reference voltages, pre-trimmed for direct temperature measurement in any of the normal scales. The devices utilize bandgap and thin-film techniques, and are laser-trimmed to ensure accuracy and interchangeability.

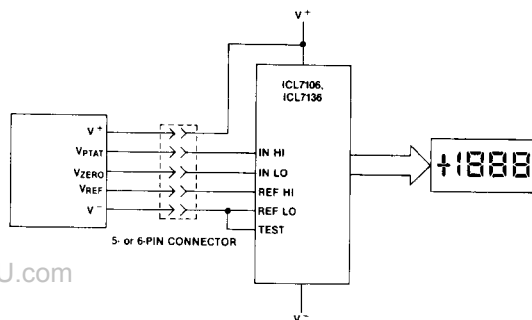
The parts come in both Celsius ( $^{\circ}\text{C}$ ) and Fahrenheit ( $^{\circ}\text{F}$ ) versions, and have three outputs: the first is proportional to absolute temperature (in degrees K); the second is a constant at the offset needed to convert to the Celsius or Fahrenheit scale; and the third is a constant at a reference voltage for A/D conversion in a ratiometric system such as the ICL7106/7 or ICL7109, giving direct-reading temperature scales. Using an ICL8073 or ICL8074 plus the ICL7136 micropower DPM chip and a standard 9V transistor radio battery forms a temperature measurement system with a battery life in excess of six months.

### BLOCK DIAGRAM

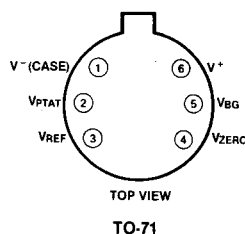


ICL8073 (8074) resistor values are nominal only

### TYPICAL APPLICATION (Full-Function Device)



### PIN CONFIGURATION



### ORDERING INFORMATION

PART TYPE	GRADE	TEMPERATURE RANGE	
		-25 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$	-55 $^{\circ}\text{C}$ to +125 $^{\circ}\text{C}$
ICL8073I	$\pm 5^{\circ}\text{C}$	ICL8073IIUT	ICL8073IMUT
ICL8074I	$\pm 9^{\circ}\text{F}$	ICL8074IIUT	ICL8074IMUT
ICL8073J	$\pm 3^{\circ}\text{C}$	ICL8073JIUT	ICL8073JMUT
ICL8074J	$\pm 5.4^{\circ}\text{F}$	ICL8074JIUT	ICL8074JMUT
ICL8073K	$\pm 1.5^{\circ}\text{C}$	ICL8073KIUT	ICL8073KMUT
ICL8074K	$\pm 2.7^{\circ}\text{F}$	ICL8074KIUT	ICL8074KMUT
ICL8073L	$\pm 1^{\circ}\text{C}$	ICL8073LIUT	ICL8073LMUT
ICL8074L	$\pm 1.8^{\circ}\text{F}$	ICL8074LIUT	ICL8074LMUT

# ICL8073/8074

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ( $V^+$ to $V^-$ )	35V
Current in Any Pin	10mA

Operating Temperature	-100°C to +150°C
Storage Temperature	-100°C to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

## OPERATING TEMPERATURE RANGES

	ICL8073	ICL8074
Grade I	-25°C to +85°C	-13°F to +185°F
M	-55°C to +125°C	-67°F to +257°F

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## OPERATING CHARACTERISTICS ( $V^+ = 5V$ , $T_A = 25^\circ\text{C}$ unless otherwise noted).

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	LIMITS TYP.	MAX.	UNIT
Supply Voltage (Note 1)	$V^+$		2.7		30	V
Supply Current	$I^+$			50	200	$\mu\text{A}$
Bandgap: ( $V_{BG}$ )	$V_{BG}$		1.215	1.232	1.250	V
Output Voltage Noise (Note 6)	$e_n$	0.1 to 10Hz		10	50	$\mu\text{V}$ (RMS)
Tempco (Note 6)		$0.1\mu\text{V } V_{BG} \text{ to } V^-$		20	100	$\frac{\text{ppm}}{^\circ\text{C}}$
Short-Circuit Current Limit	$I_{sc}$		5		10	mA
Load Regulation (Note 2)	$\frac{\Delta V_O}{\Delta I_O}$				2	mV/mA
$\frac{\Delta V_{BANDGAP}}{\Delta V_{SUPPLY}}$				-75	-60	dB
Long-Term Stability (Note 6)				20		$\frac{\text{ppm}}{\text{month}}$
Reference: ( $V_{REF}$ )				100		mV
Output Voltage 8073	$V_{REF}$			83.33		
8074					-60	dB
$\frac{\Delta V_{REF}}{\Delta V_{SUPPLY}}$						
Zero Base: ( $V_{ZERO}$ )				273.15		mV
Output Voltage 8073	$V_{ZERO}$			383.06		
8074					-60	dB
$\frac{\Delta V_{ZERO}}{\Delta V_{SUPPLY}}$						
Transducer ( $V_{PTAT}$ : Note 3):				1.0		mV/°K
Output Voltage 8073	$V_{PTAT}$			1.5		
8074					-60	dB
$\frac{\Delta V_{PTAT}}{\Delta V_{SUPPLY}}$						
Nonlinearity (Note 6)				0.5		°K
Long-Term Stability (Note 6)				20		$\frac{\text{ppm}}{\text{month}}$

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### NOTES:

- Devices are calibrated with a 5-volt supply.
- Load regulation is measured from no-load to 1mA.
- PTAT means "Proportional To Absolute Temperature," i.e., the voltage output at the terminal called  $V_{PTAT}$ .
- The interchangeability accuracy equals the absolute accuracy.
- Full-function refers to the use of the  $V_{PTAT}$ ,  $V_{ZERO}$ , and  $V_{REF}$  outputs together per the equation:

$$\left[ \frac{V_{PTAT} - V_{ZERO}}{V_{REF}} \right] \times 10^3 = V_{OUT}$$

The 6-pin TO-71 device is capable of 0.1° resolution in this application (typically an A/D input). Absolute accuracy refers to the grading of parts with letter codes I through L. This means that two parts from grade J, for example, will be interchangeable in a given circuit within  $\pm 3^\circ\text{C}$  or  $\pm 5^\circ\text{F}$ , in full-function operation. The device may be externally trimmed, of course, to much higher accuracy.

- These parameters are guaranteed by design, but not 100% tested.

**ICL8073/8074****INTERSiL****OPERATING CHARACTERISTICS (Continued)**

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	LIMITS TYP.	MAX.	UNIT
Self-Heating		Still Air		0.05		°C
Absolute Accuracy, Full-Function °C (Notes 4 and 5): 8073L 8073K 8073J 8073I					±1.0 ±1.5 ±3.0 ±5.0	°C
°F 8074L 8074K 8074J 8074I					±1.8 ±2.7 ±5.4 ±9.0	°F
Linearity (Full Function) (Note 5, 6) 8073L 8073K 8073J 8073I 8074L 8074K 8074J 8074I					±0.5 ±0.5 ±1.0 ±1.5 ±0.9 ±0.9 ±1.8 ±2.7	°C  °F
Time Constant (Note 6) Still Air 100 ft/min. Air Stirred Oil				60 13.5 1.4		sec
Electrical Turn-On Time	$t_{on}$			60		$\mu s$

**5****EXPLANATION OF OUTPUTS****DEFINITIONS:**

- V<sub>PTAT</sub>:** Voltage Proportional To Absolute Temperature (in K, or "degrees Kelvin").
- V<sub>ZERO</sub>:** Offset voltage, used for cancelling the sensor V<sub>PTAT</sub> at the temperature corresponding to zero °C (ICL8073) or °F (ICL8074).
- V<sub>REF</sub>:** Reference voltage, used by the input A/D section of the reading instrument to set the scale factor, e.g., 10 counts/mV, etc.
- V<sub>BG</sub>:** Bandgap voltage, from which V<sub>ZERO</sub> and V<sub>REF</sub> are derived. Since V<sub>BG</sub> has (ideally) a zero temperature coefficient, other references or offset voltages can be derived from it.

**NORMAL USE OF SENSORS**

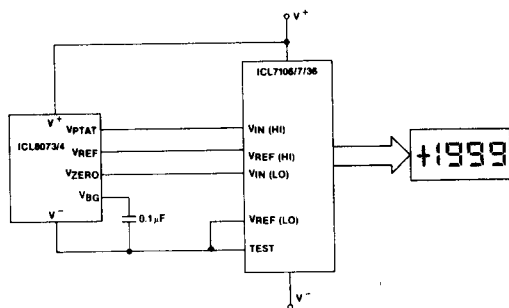
The ICL8073 V<sub>PTAT</sub> is 1mV/K, and at 0°C is 273.15mV. This is the value of V<sub>ZERO</sub>, and combined with the V<sub>REF</sub> of 100mV, may be used to make a Celsius (Centigrade) thermometer with a maximum reading of 199.9°C (using an ICL7106 family converter, as shown in Figure 1).

The ICL8074 is designed for Fahrenheit use. Its V<sub>PTAT</sub> is 1.5mV/K, which means an output of 0.8333mV/°F instead of 1mV/°F. Therefore, at 0°F (255.37K), V<sub>PTAT</sub> is 255.37 × 1.5, or 383.06mV; this is also the value of V<sub>ZERO</sub>. V<sub>REF</sub>, the scale factor, is now 83.33mV instead of 100.

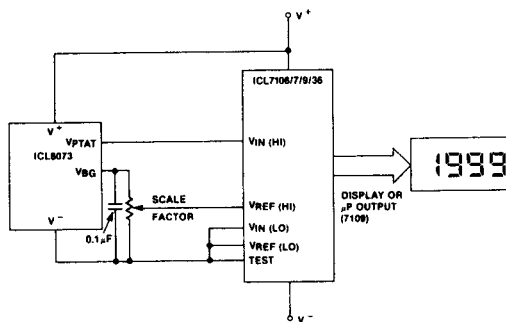
V<sub>BG</sub> for either device is 1.232V, ±0.018V.

# ICL8073/8074

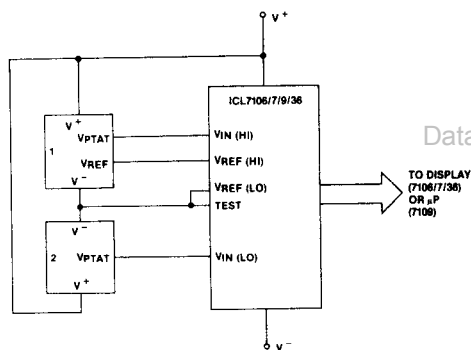
## TYPICAL APPLICATIONS



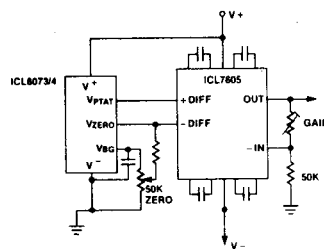
**Figure 1. Basic Digital Thermometer.** Both the 8073 (°C) and 8074 (°F) contain all necessary offset and reference (scale-factor) voltages. Just connect and read!



**Figure 2. Basic Kelvin-Scale Thermometer.** The range 0°K to 473°K (-273°C to +200°C) may be "covered" (only 173°K to 473°K is usable) in a 3-digit display. Since the maximum ICL8073 output will be 473mV,  $V_{REF}$  should be 1.000 volt (for the 2-volt scale of the ICL7106/7/9 A/D chips). This voltage is derived from  $V_{BG}$ , as shown. No  $V_{OS}$  is needed.



**Figure 3. Differential Thermometer.** Reading will be  $(T_1 - T_2) \times 1\text{mV}/^\circ\text{C}$  or  $(T_1 - T_2) \times 1.5\text{mV}/^\circ\text{F}$ . To expand the scale, a potentiometer from  $V_{BG}$  (device 1) to  $V^-$  can select a smaller voltage than  $V_{REF}$ . The potentiometer arm would then be connected to  $V_{REF}(\text{HI})$ , instead of the connection shown.



**Figure 4. Temperature measurement with adjustable temperature coefficient (slope) and scale zero.**

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