TECHNICAL DATA

DN1221

Designers' Data Sheet

SUBMINIATURE THERMOELECTRIC COOLER CONTROLLER

General Description

The DN1221 is a subminiature Bipolar Temperature Controller for Thermoelectric Coolers (TEC) used in fixed temperature OEM applications. The device is designed to operate with a negative temperature coefficient (NTC) thermistor that senses the temperature of the object attached to the TEC. Temperature is set with a user selected resistor. Temperature stability of 0.01°C is achieved by the linear PI control loop of the DN1221.

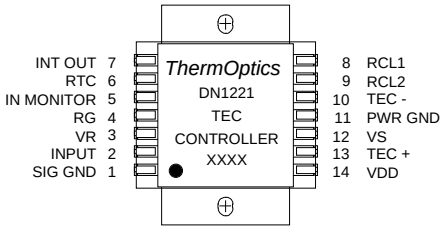
Proportional gain and integrator time constant are set independently with resistors. No external integrator capacitor is needed. These parameters can be optimized to minimize temperature overshoot and stability. In addition, the maximum cooling and heating current supplied to the TEC can be adjusted independently from 0 to 2.2 amperes with two resistors.

An evaluation kit is available that contains the DN1221, a fan cooled TEC, and an aluminum cold plate (with imbedded thermistor) that is attached to the TEC. The evaluation kit operates on a 12 VDC power supply. Temperature of the cold plate can be changed from 0 to 60 °C with a variable resistor. The TEC is mounted on a socket so that it can be easily removed.

Features

- Proportional and Integral Control
- Gain and Integrator Time Constant set with Single Resistors. ***No External Integrator Capacitor Needed***.
- Single Power Supply Operation. +5 to +12 Volts D.C.
- ± 2 Ampere Drive Capability
- Independent Cool and Heat Current Limit Adjustments
- Temperature Stability Better Than 0.01°C
- Small Size Hybrid Circuit Construction

Pin Configuration



Functional Block Diagram of the DN1221 TEC Controller

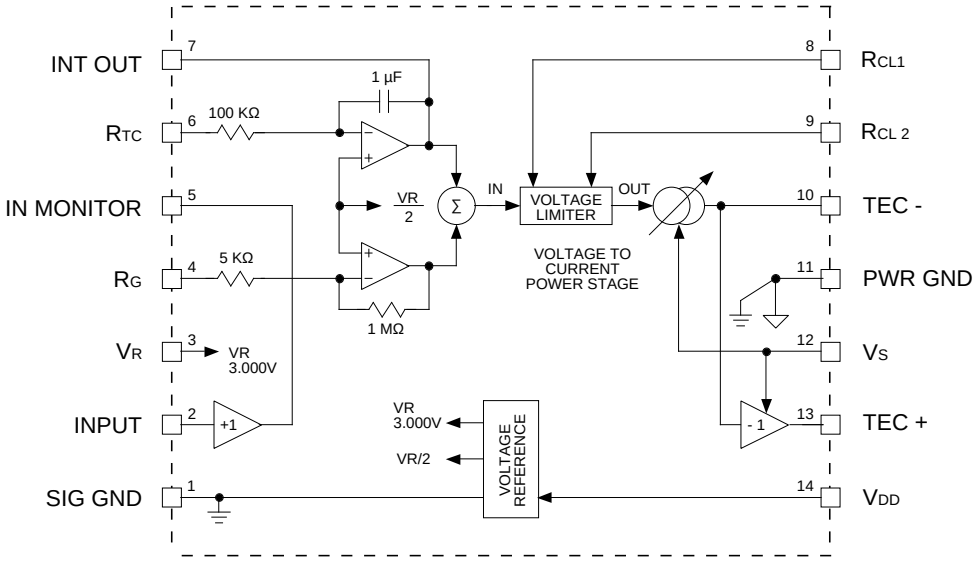


Figure 1

DN1221 Pin Designations

PIN	NAME	DESCRIPTION
1	SIG GND	Ground for the reference voltages and the input signal.
2	INPUT	Input signal from the temperature sensing bridge.
3	V_R	3.0 volt reference for the temperature sensing bridge.
4	R_G	A resistor between Pin 4 and Pin 5 that sets the proportional gain of the controller.
5	IN MONITOR	Buffered input voltage.
6	R_{TC}	A resistor between Pin 5 and Pin 6 that sets the integrator time constant.
7	INT OUT	Integrator output.
8	R_{CLC}	A resistor R_{CLC} between Pin 8 and Pin 11 limits the maximum cooling current.
9	R_{CLH}	A resistor R_{CLH} between Pin 9 and Pin 11 limits the maximum heating current.
10	TEC -	Negative input into the TEC.
11	PWR GND	Ground return for the power supply.
12	V_S	Supply voltage for the power amplifier. Pin 12 and Pin 14 are connected for most applications.
13	TEC +	Positive input into the TEC
14	V_{DD}	Supply voltage for voltage reference and the control electronics.

Electrical Specifications

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Compliance Voltage [1]	V_C	V_S = V_{DD} =+12 VDC I_{TEC} = ±2 amperes	± 8			V
	V_C	V_S = V_{DD} = +5 VDC I_{TEC} = ±1 amperes	± 2			V
Current Drive Capability	I_{SMAX}	V_S = V_{DD} = +12 VDC TEC Resistance < 4Ω	± 2			A
Current Limiting Range [2]	I_{CL}	V_S = V_{DD} = +12 VDC TEC Resistance < 4Ω	0		± 2.2	A
Voltage Reference [3]	V_R	V_S = V_{DD} = +5 to +12 VDC	2.990	3.000	3.010	V
Voltage Reference Drift	TC_{VR}	V_S = V_{DD} = +5 to +12 VDC			± 30	ppm/°C
Quiescent Current (I_{TEC} = 0)	I_{SQ}	V_S = V_{DD} = +12 VDC			100	mA
Maximum Power Dissipation[4]	P_{MAX}	V_S = V_{DD} = +5 to +12 VDC			10	Watts
Operating Temperature Range	T	V_S = V_{DD}= +5 to +12 VDC	-20		75	°C

1. Compliance voltage is the maximum voltage that can be supplied to the load and is dependent on the power supply voltage. Maximum compliance of ±8 volts is specified for a supply voltage of +12 V and ±2 volts for a power supply voltage of +5 V.
2. There are independent maximum current adjustments for both heating and cooling cycles.
3. V_R can supply a maximum of 100µA of current.
4. The DN1221 must be attached to a heat sink with a thermal compound such as Dow Corning 340 to keep the temperature of the device below 75°C.

Setting Up The DN1221 TEC Controller

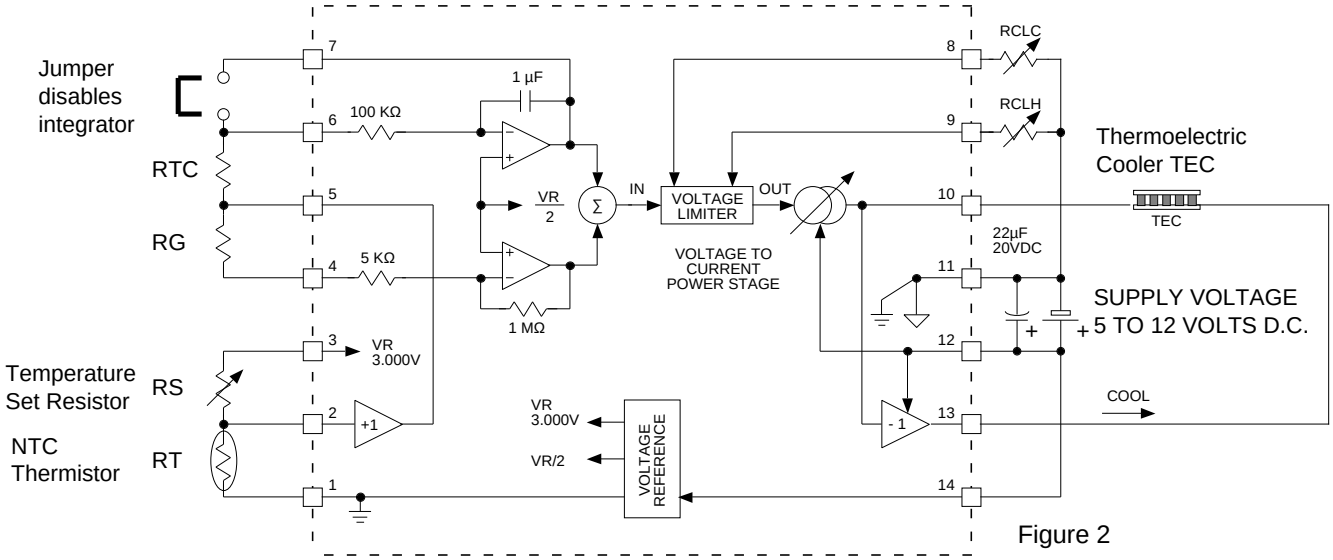


Figure 2

Setting the Temperature of the TEC

The DN1221 is designed to operate with a negative temperature coefficent (NTC) thermistor that senses the temperature of the thermoelectric cooler (TEC). The thermistor R_T is connected between Pin 1 and Pin 2 as illustrated in Figure 2. The temperature set reisistor R_S is connected between Pin 2 and Pin 3.

To set the temperature of the TEC, follow 3 simple steps:

1. Determine the operating temperature of the TEC.
2. Find the resistive value for the thermistor at this temperature from a "look-up" table.
3. Select a temperature set resistor (Rs) that is the same value.

(The control loop forces the temperature of the TEC so that R_T is equal to R_S)

Example:

- The desired operating temperature for the TEC is 15°C.
- The thermistor used, R_T, is a ***BetaTHERM*** 10 KΩ model 10K3A2 that has a value of 15.7 KΩ at 15°C.
- The temperature set resistor of 15.8 KΩ is selected because it is the nearest 1% resistor value.
- The control loop will force the TEC to 15°C.

The accuracy with which the temperature can be set is dependent on the tolerance of the thermistor used. Manufacturers of thermistors normally supply devices that have resistance tolerances at 25°C of ±1, ±2, ±5, and ±10% of the specified value. The thermistor used in this example has a negative temperature coefficient of -4.4% per °C. Therefore, the best temperature set accuracy that can be expected is approximately ±2.5% for a 10% tolerance thermistor and an accuracy of ±0.5% with a 1% tolerence thermistor.

Proportional Gain

R_G sets the proportional gain of the the control loop from 1 to 200. Proportional gain should be set as large as possible to minimize temperature overshoot. However, if the gain is too large, loop instability will result. It is recommended that the integrator be disabled when setting the proportional gain. This is done by shorting Pin 6 to Pin 7.

$$R_G = \left(\frac{1{,}000}{G} - 5 \right) K\Omega$$

Gain	R_G KΩ
200	0
50	15
1	1,000

Setting Up The DN1221 TEC Controller

Integrator Time Constant

Integrator Time Constant is set with resistor R_{TC} that is connected between Pin 5 and Pin 6. A one microfarad integrator capacitor is internal to the DN1221. The time constant can be set from 0.2 second to an excess of 10 seconds. The integrator can be disabled by shorting Pin 6 to Pin 7. A minimum R_T value of 100 kΩ is recommended if the integrator is disabled. A 1 MΩ resistor, which produces an integrator time constant of approximately one second, will be satisfactory in most applications.

$$R_{TC} = \left[T - 0.1 \right] \text{ M}\Omega$$

Where T is the integrator time constant

T (Sec.)	R_T MΩ
0.2	0.1
1	0.9
10	10.0

Output Current Limiting

Both maximum cooling and heating current supplied by the DN1221 to a TEC can be independently set from 0 to 2.2 amperes by resistors R_{CLC} and R_{CLH}. R_{CLC} (Pin 8) and R_{CLH} (Pin 9) are connected to Pin 11 which is the Power ground. The equation for calculating the value of the current limiting resistor is shown below. A look up table is also shown.

$$R_{CL} = 10 \left\{ \frac{1 + \frac{I_{CL}}{4}}{1 - \frac{I_{CL}}{4}} \right\} \text{ K}\Omega$$

Current Limit Resistor vs. Maximum TEC Current

I_{CL} (A)	R_{CL} (KΩ)	I_{CL} (A)	R_{CL} (KΩ)
2.2	34.4	1.0	16.7
2.0	30.0	0.8	15.0
1.8	26.4	0.6	13.5
1.6	23.3	0.4	12.2
1.4	20.8	0.2	11.1
1.2	18.6	0.0	10.0

The maximum TEC current should always be limited to 2.2 Amperes or less. Therefore, a value for R_{CL} of 34.4KΩ or less must be selected.

Power Supply

The DN1221 operates on a single power supply from 5 to 12 Volts. This supply should be capable of supplying a minimum of 2.5 amperes of current. Positive voltage is connected to Pins 12 and 14. The return voltage of the power supply is connected to Pin 11 which is the power ground of the DN1221. A linear power supply is recommended for application where a high degree of temperature stability is required. However, a switch mode power supply will work for most applications.

The Power Output Stage

The TEC is connected to Pin 10 and Pin 13. Current flows out of Pin 13 into the TEC when cooling. This is generally the red lead on the TEC. Check the TEC manufacture's data sheet for the polarity of the TEC if in doubt. The TEC pin assignment is reversed if a positive coefficient thermistor is used. Care should be taken not to short Pin 10 or Pin 13 to ground or to the the power supply, otherwise, damage to the DN1221 may occur.

TEC current can be monitored by placing an ameter in series with the TEC as shown in the figure below.

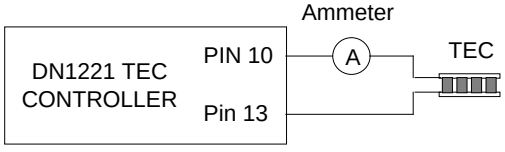


Figure 3

Setting Up The DN1221 TEC Controller

The maximum output current of the DN1221 is limited to 2.2 amperes by an external current limiting resistor. However, there are operating conditions that will limit the maximum current to something less than 2.2 amperes. The compliance voltage of the DN1221, which is dependent on the power supply voltage, limits the maximum voltage that can be supplied to the TEC. In addition, the resistance of the TEC can restrict the maximum current available. The current limiting characteristics of the DN1221 as a function of supply voltage and TEC resistance are shown in the Figure below.

Examples: The compliance voltage of the DN1221 is typically ±9 volts for a 12 volt supply voltage. This is the maximum voltage available to drive the TEC. If the TEC resistance is 5 ohms, the maximum TEC current will only be 1.8 amperes. Likewise, the compliance voltage is ±2.5 volts when the supply voltage is 5 volts and the TEC 's resistance is 2 ohms. Therefore, the maximum current will be limited to 1.2 amperes in this case.

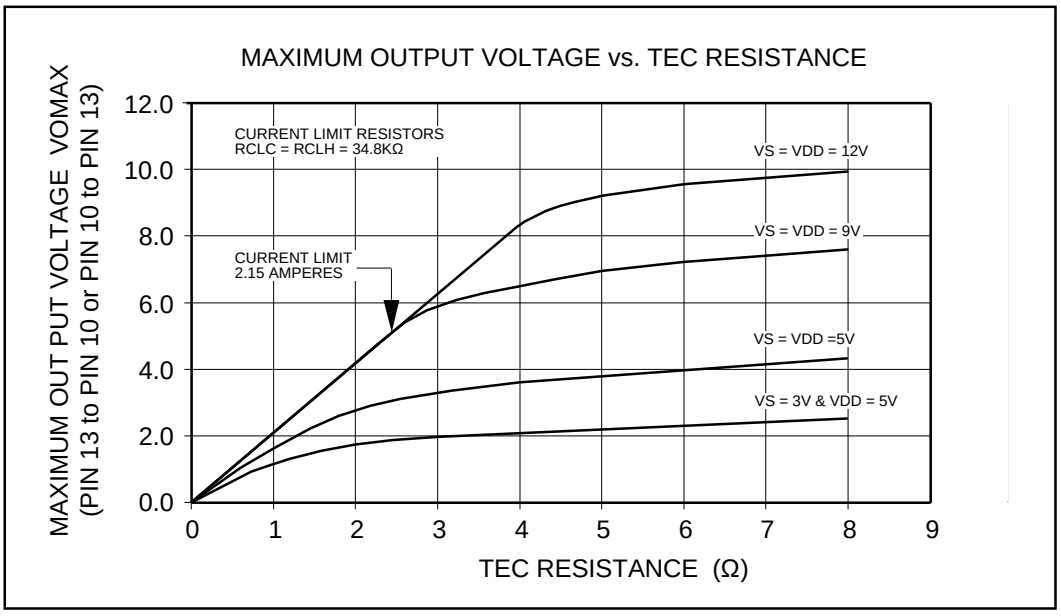


Figure 4

Mechanical Dimensions

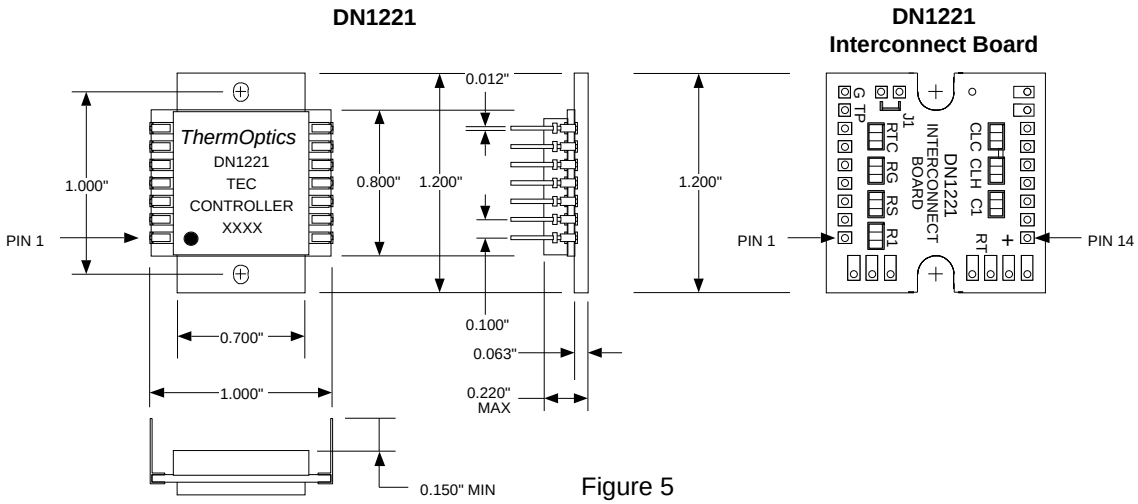


Figure 5

DN1221 Interconnect Board

The DN1221 Interconnect Board provides a quick, easy way to interface the DN1221 TEC Controller with a TEC assembly. The DN1221, the TEC assembly, along with the other associated components, are soldered to the interconnect board as illustrated in Figure 7. The board was designed for 0805 size resistors and capacitors. The schematic circuit diagram for the interconnect assembly is shown in Figure 2.

Header pins with 0.100" spacing can be soldered into the board so that the power supply, TEC, and thermistor can be interfaced through a connector. However, it is recommended that these components be soldered into the board in production applications. Upon request, the DN1221 interconnect board can be supplied with the header pins and the DN1221 soldered in place.

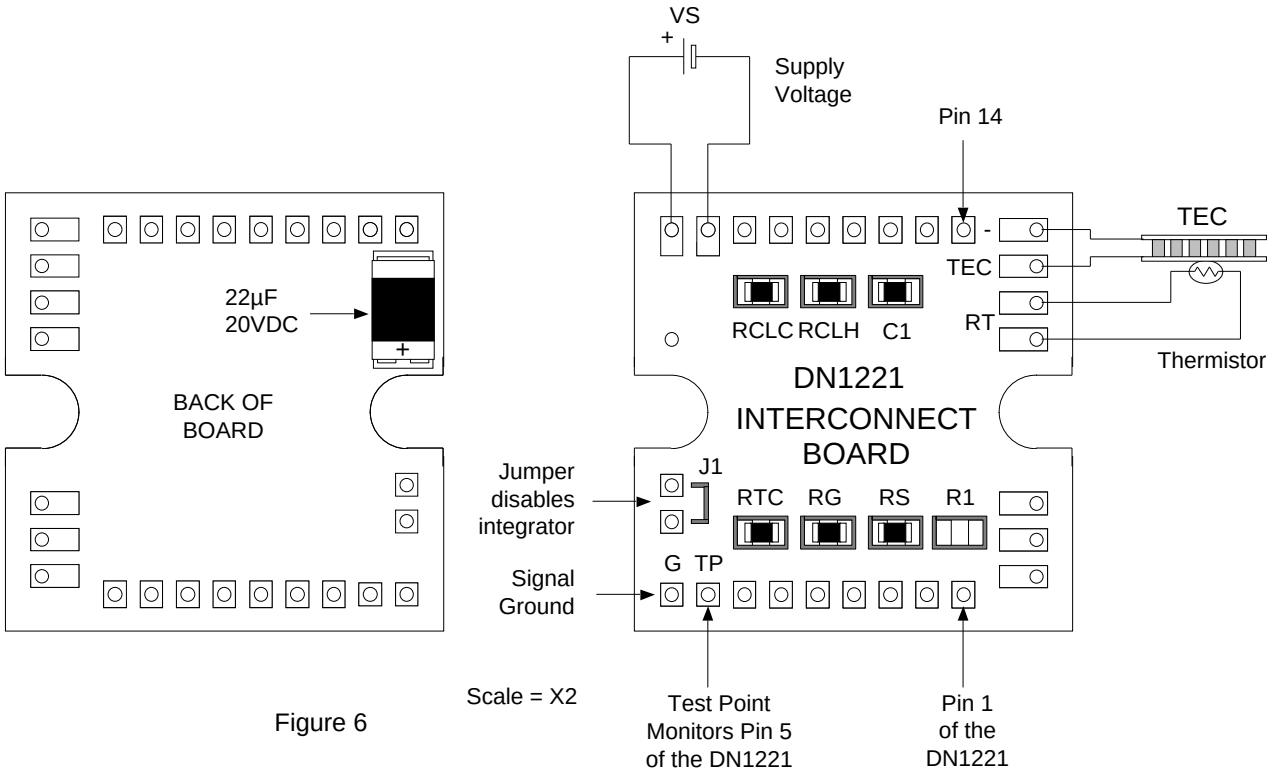


Figure 6

RS —— Temperature Set Resistor
RG —— Proportional Gain Set Resistor
RTC —— Integrator Time Constant Resistor
RCLH —— Heating Current Limit Resistor
RCLC —— Cooling Current Limit Resistor
C1 —— Filter Capacitor (Optional)

DN1221 Evaluation Kit

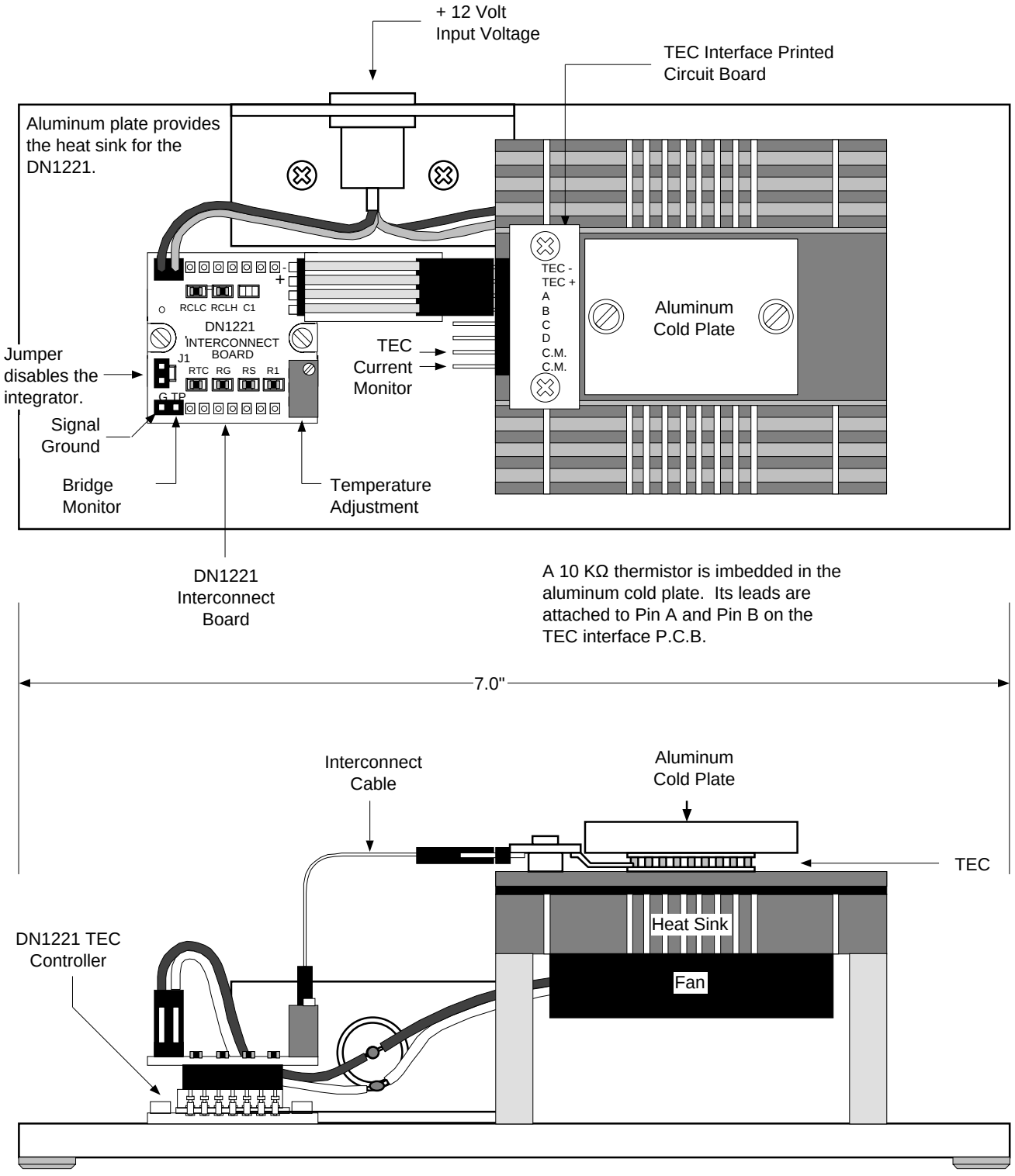


Figure 7

The DN1221 Evaluation Kit

The DN1221 evaluation kit contains the DN1221 TEC controller, the DN1221 interconnect P.C. board, and a Thermoelectric Cooler Module. These components are mounted on an aluminum block as shown on page 7 of the data sheet. The resistor values that set the gain, the integrator time constant, and the current limits are shown below. The TEC Module contains a 4Ω thermoelectric cooler, a cooling fan, a heat sink, and a cold plate with a Betatherm 10K3A2, 10kΩ thermistor embedded in it. A look up table for this thermistor is included (Curve #3).

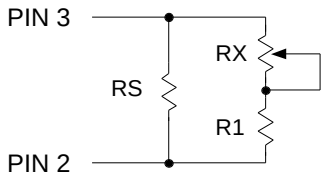
The temperature set resistor is made up of three resistors including a 12 turn potentiometer that has been configured and a variable resistor (RX) . This enables the TEC temperature to be set to approximately -2°C when RX is rotated counter clockwise to the stop. The temperature can be varied from this temperature to about 60°C when the RX is rotated clockwise to its stop. RX and R1 can be removed from the interconnect board. Then RS can be replaced with a fixed resistor value (obtained from the look-up table) in order to set the temperature to a specific value.

The TEC current flows through a 0.1Ω resistor that is mounted on TEC Assembly P.C. Board. TEC current can be measured by placing a voltmeter across the two pins labled C.M. that are connected to this resistor. The voltage sensivity is 100mV per ampere of TEC current

KIT RESISTOR VALUES

RS =100 KΩ
R1 = 3.01 KΩ
RX = 50 KΩ
RTC = 237 KΩ
RG = 20 KΩ
RCLC = 34.8KΩ KΩ
RCLH = 34.8KΩ
C1 -- Omitted

TEMPERATURE SET RESISTOR CIRCUIT



TEC ASSEMBLY P.C. BOARD