DATA SHEET

DN1220

SUBMINIATURE THERMOELECTRIC COOLER CONTROLLER

General Description

The DN1220 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 Proportional Integral (PI) control loop of the DN1220.

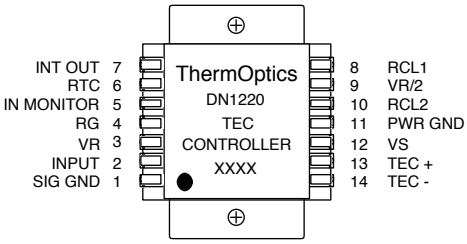
Proportional gain and integrator time constants are set independently with resistors. No external integrator capacitor is needed. These parameters can be optimized to minimize temperature overshoot and stability. In addition, the maximum cooling and heating current supplied to the TEC can be adjusted independently from 0 to 2 amperes with two resistors.

An evaluation kit is available that contains the DN1220, 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 Constants 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 DN1220 TEC Controller

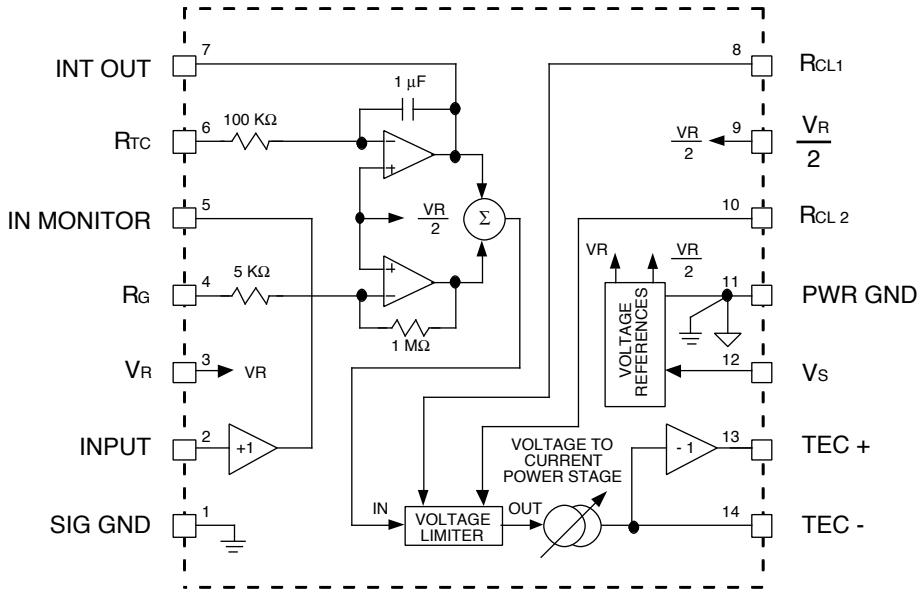


Figure 1

DN1220 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; also, the input signal to the proportional gain and the integrator stages
6	R_{TC}	A resistor between Pin 5 and Pin 6 that sets the integrator time constant
7	INT OUT	Integrator output
8	R_{CL1}	A resistor R_{CL1} between Pin 8 and Pin 9 limiting the maximum heating current
9	$V_R/2$	1.5 volt reference serving as the internal reference for the control electronics.
10	R_{CL2}	A resistor R_{CL2} between Pin 9 and Pin 10 limiting the maximum cooling current
11	PWR GND	Ground return for the power supply.
12	V_S	Positive power supply voltage
13	TEC +	Positive input into the TEC
14	TEC -	Negative input into the TEC

Electrical Specifications

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Compliance Voltage [1]	V_C	V_S = +12 VDC I_{TEC} = ±2 amperes	± 8			V
	V_C	V_S = +5 VDC I_{TEC} = ±1 amperes	± 2			V
Current Drive Capability	I_{SMAX}	V_S = +12 VDC TEC Resistance < 4Ω	± 2			A
Current Limiting Range [2]	I_{CL}	V_S = +12 VDC TEC resistance < 4Ω	0		± 2	A
Voltage Reference [3]	V_R	V_S = +5 to +12 VDC	2.940	3.000	3.060	V
Voltage Reference [3]	$V_R/2$	V_S = +5 to +12 VDC	1.470	1.500	1.530	V
Voltage Reference Drift	TC_{VR}	V_S = +5 to +12 VDC			± 100	ppm/°C
Quiescent Current (I_{TEC} = 0)	I_{SQ}	V_S = +12 VDC			100	mA
Maximum Power Dissipation[4]	P_{MAX}	V_S = +5 to +12 VDC			10	Watts
Operating Temperature Range	T	V_S = +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 1.5 mA and $V_R/2$ can supply up to 100µA of current.
4. The DN1220 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 DN1220 TEC Controller

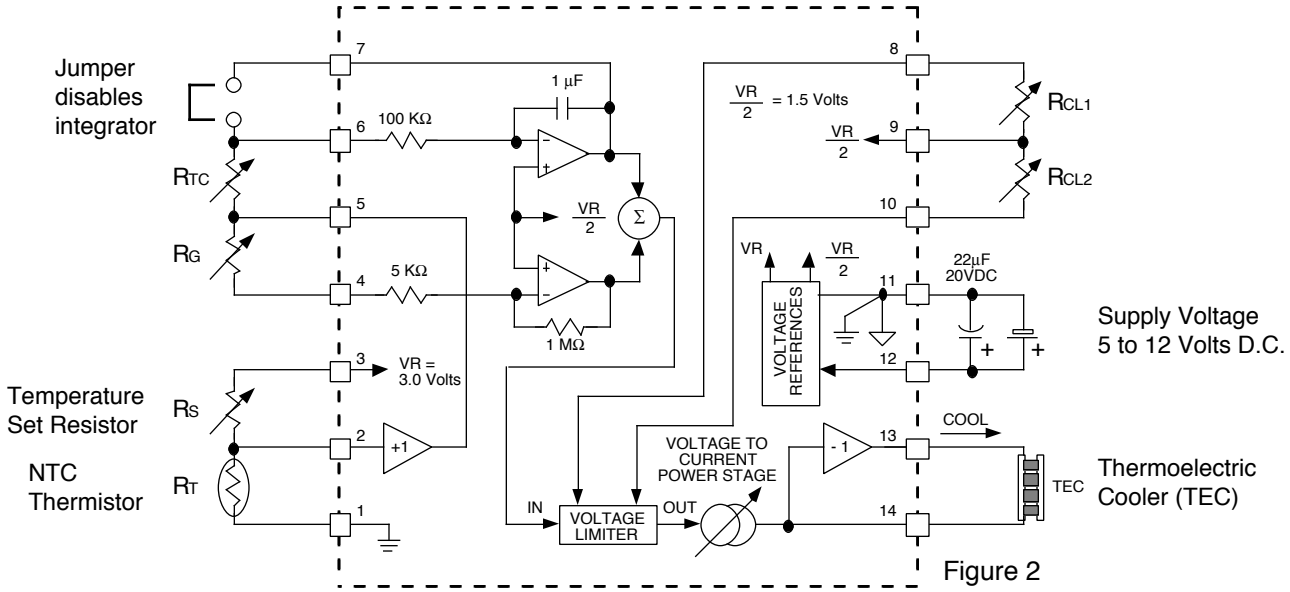


Figure 2

Setting the Temperature of the TEC

The DN1220 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 (RT) used, 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 DN1220 TEC Controller

Integrator Time Constant

Integrator Time Constant is set with resistor R_{TC} that is connected between Pin 5 and Pin 6. A 1µF integrator capacitor is internal to the DN1220. 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 1 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 DN1220 can be independently set from 0 to 2 amperes by resistors R_{CL1} and R_{CL2}. R_{CL1} is connected from Pin 8 to Pin 9 and limits the maximum current that is supplied to the TEC in the heating mode. Likewise, R_{CL2} limits the maximum heating that is supplied when cooling the TEC.

$$R_{CL} = \frac{10}{\frac{4}{I_{MAX}} - 2} \text{ K}\Omega$$

I_{CL}	R_{CL}
2.0 A	∞
1.0 A	5 KΩ
0.5 A	1.67 KΩ
0.0	0 Ω

Power Supply

The DN1220 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. This power supply is connected between Pin 11 and Pin 12 with the positve voltage applied to Pin 12. A linear power supply is recommended for the application where a high degree of temperature stability is required. However, a switch mode power supply will work for many applications.

The Power Output Stage

The TEC is connected to Pin 13 and Pin 14. Current flows out of Pin 13 into the TEC when cooling. This is generally the red lead on the TEC. The TEC pin assignment is reversed if a positive coefficient thermistor is used. Care should be taken not to short Pin 13 to ground or to the power supply, Pin 12. Otherwise, damage to the DN1220 may occur.

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

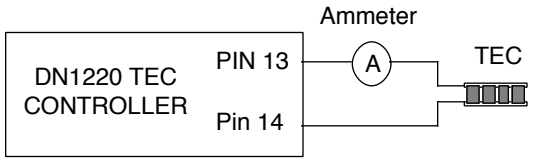


Figure 3

Setting Up The DN1220 TEC Controller

The maximum output current of the DN1220 is limited to 2 amperes by design. However, there are operating conditions that will limit the maximum current to less than 2 amperes. The compliance voltage of the DN1220, 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 DN1220, as a function of supply voltage and TEC resistance, are shown in Figure 4.

Examples: The compliance voltage of the DN1220 is typically ±8 volts for a supply voltage of 12 volts. This is the maximum voltage available to drive the TEC. If the TEC resistance is 5 ohms, the maximum TEC current will only be 1.6 amperes. Likewise, the compliance voltage is ±2 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 ampere in this case.

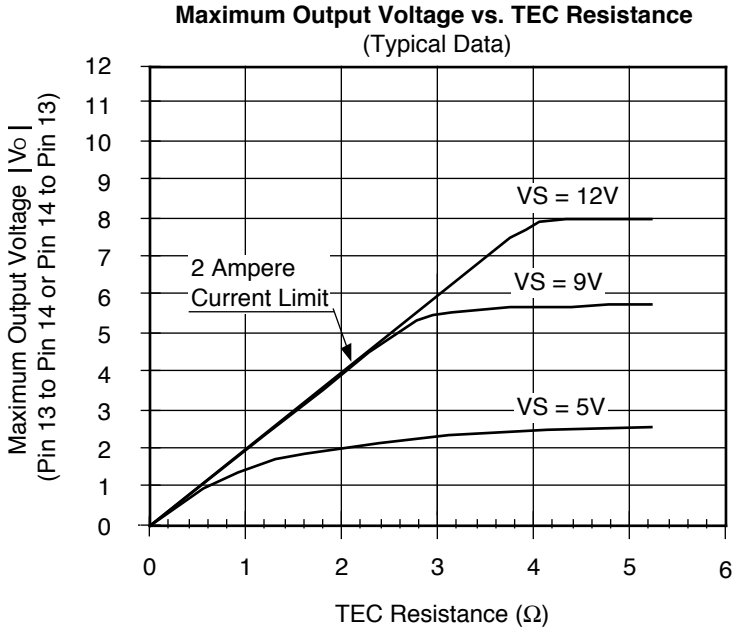


Figure 4

Mechanical Dimensions

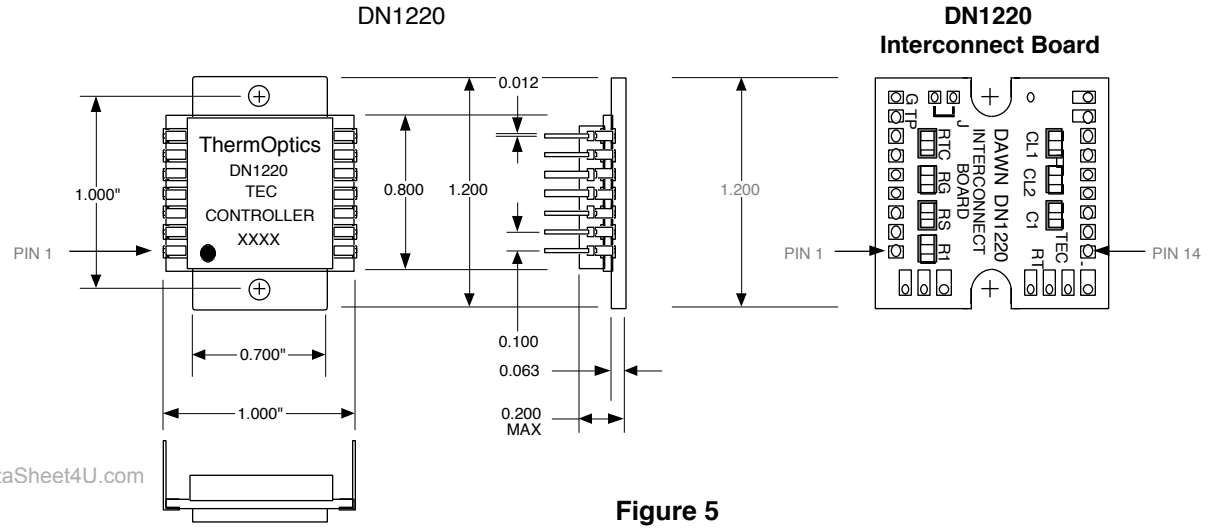


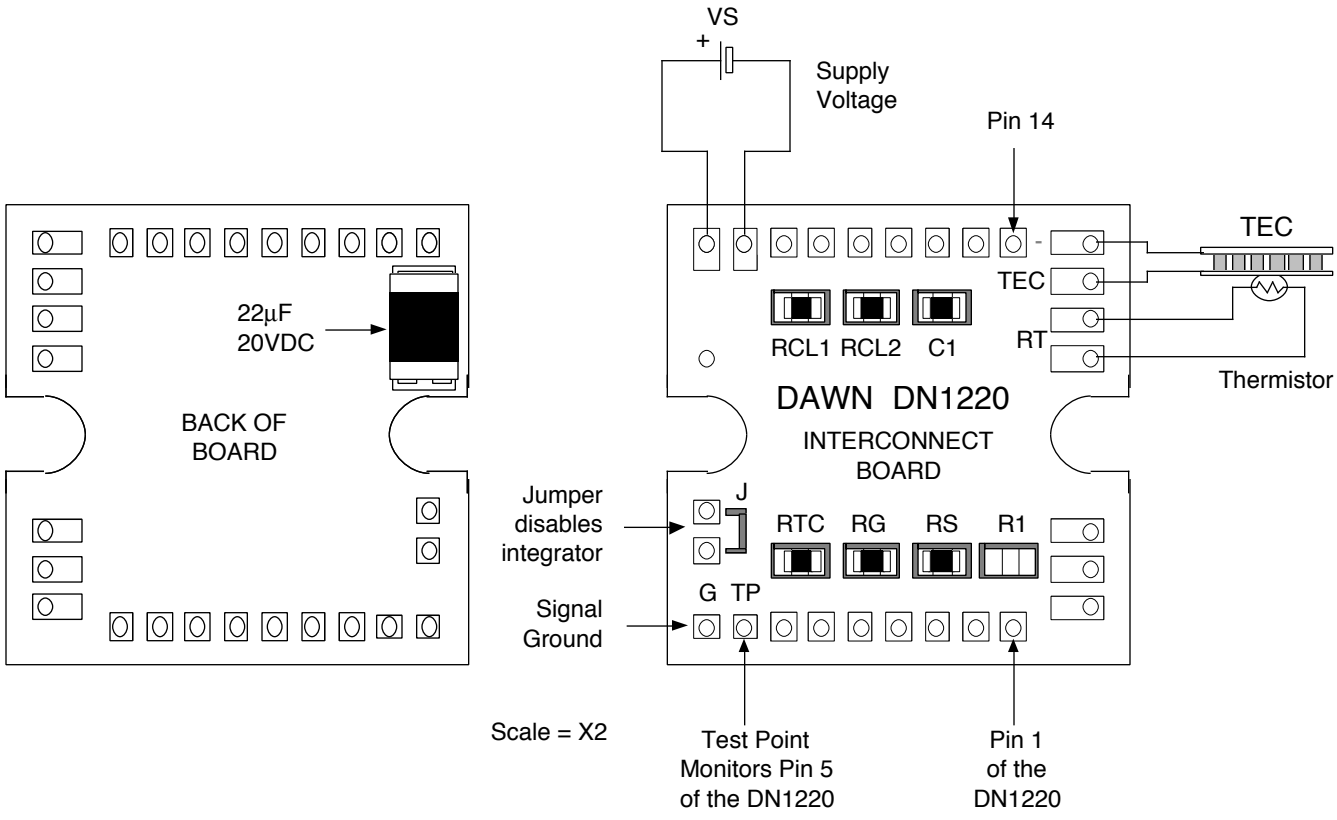
Figure 5

DN1220 Interconnect Board

The DN1220 Interconnect Board provides a quick, easy way to interface the DN1220 TEC Controller with a TEC assembly. The DN1220, the TEC assembly, along with the other associated components, are soldered to the interconnect board as illustrated in the Figure below. The board was designed for 0805 size resistors and capacitors. The schematic circuit diagram for the interconnect assembly is shown in Figure 2.

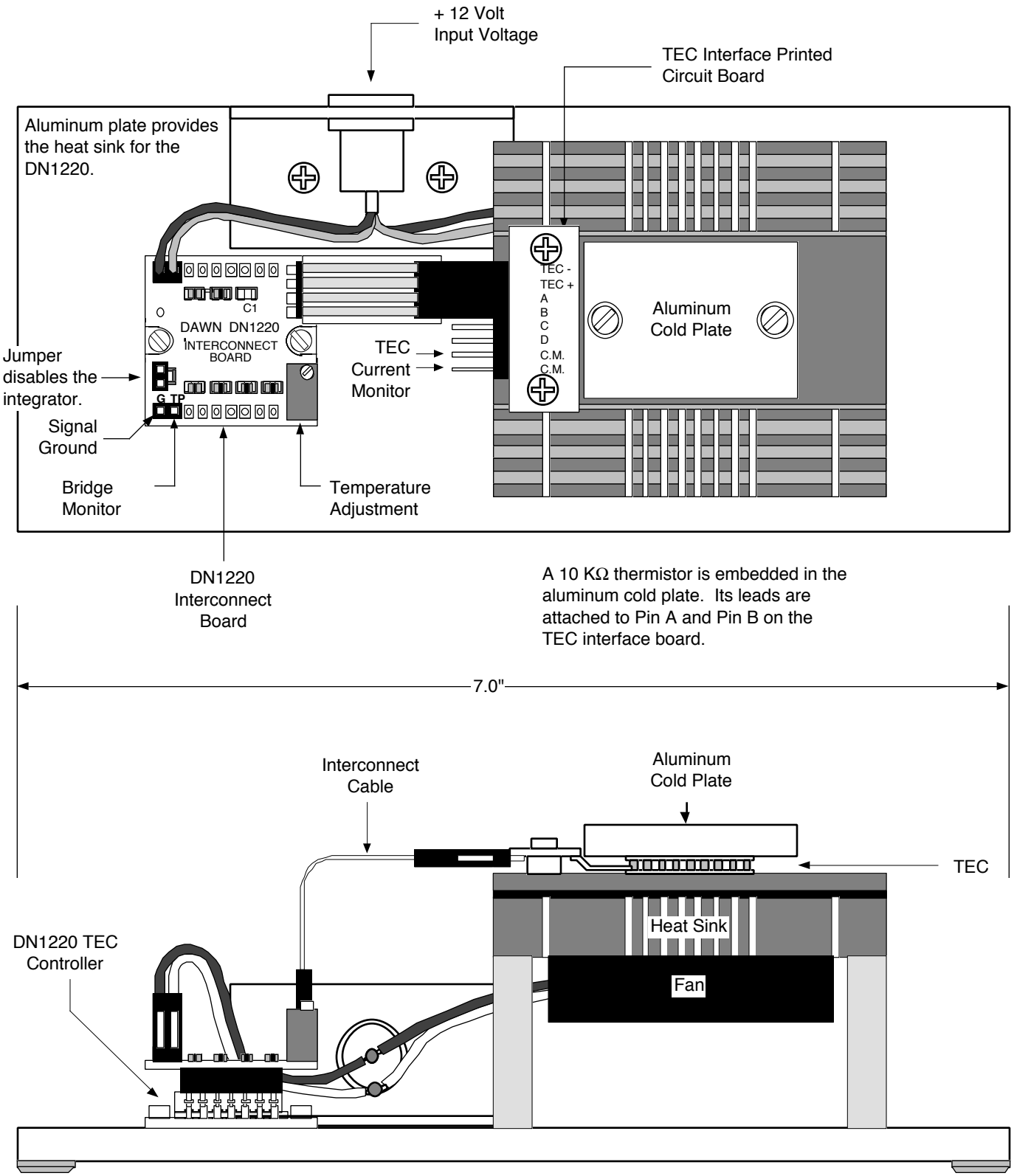
Header pins with 0.100" spacing can be soldered into the board so that the power supply, TEC, and thermistor can be interfaced through a connector. However, it is recommended that these components be soldered into the board in production applications. Upon request, the DN1220 interconnect board can be supplied with the header pins and the DN1220 soldered in place.

An alternative DN1220 interface board is available that provides voltage programing of the temperature of the DN1220. This board will interfaces with a 100Ω platinum RTD. This linearized 4 wire system provides ± 0.5˚C accuracy and better than 0.01˚C temperature stability.



RS — Temperature Set Resistor
RG — Proportional Gain Set Resistor
RTC — Integrator Time Constant Resistor
RCL1 — Heating Current Limit Resistor
RCL2 — Cooling Current Limit Resistor
C1 — Filter Capacitor (Optional)

DN1220 Evaluation Kit



DN1220

The DN1220 Evaluation Kit

The DN1220 evaluation kit contains the DN1220 TEC controller, the DN1220 interconnect board, and a Thermoelectric Cooler (TEC) 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).

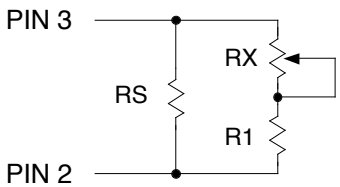
The temperature set resistor is made up of three resistors including a 12-turn potentiometer that has been configured and a variable resistor (RX) . This enables the TEC temperature to be set to approximately -2°C when RX is rotated counter clockwise to the stop. The temperature can be varied from this 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. The 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/A of TEC current.

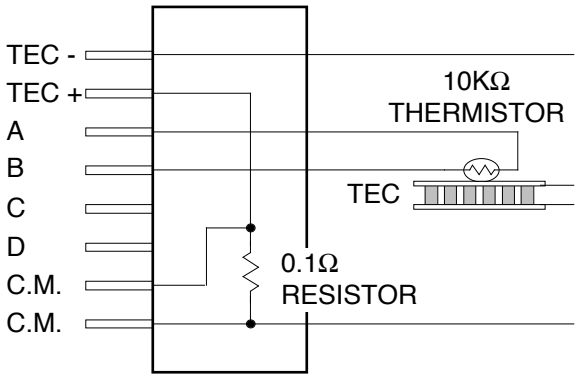
KIT RESISTOR VALUES

RS =100 KΩ
R1 = 3.01 KΩ
RX = 50 KΩ
RTC = 237 KΩ
RG = 20 KΩ
RCL1 = 4.99 KΩ
RCL2 = ∞
C1 -- Omitted

TEMPERATURE SET RESISTOR CIRCUIT



TEC ASSEMBLY P.C. BOARD



VOLTAGE PROGRAMMING THE DN1220 TECC USING A THERMISTOR TEMPERATURE SENSOR