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Si24BdTETRC1-12BSD-30V-20A

Field Programmable, 12-Bit, Bi-directional, Thermo-Electric (TE), Temperature-Range Controller with Aluminum Plate Heat Sink, Serial LCD Port, and with an RS232 Data-Logging/Programming Port

The **Si24BdTETRC1-12BSD-30V-20A** is a 30V, 20A, microprocessor based, Field Programmable, Bi-directional, Thermo-Electric, **Temperature-Range Controlle**r that heats or cools a thermal-zone (using an H-bridge and one Thermo-Electric (TE) cell) whenever the measured temperature (**MT**) is outside of the user-selectable temperature Limit Ranges (**L, l, h, H**). **The word "Bi-directional" implies that no wire reversal is required on the TE cell to accomplish the heating and cooling task.** An efficient onboard high-power H-bridge controls the current (in the 0 to +/- 20A range) to a Peltier type Thermo-Electric (TE) cell, functioning as a bi-directional heat-pump. **The temperature is measured with a 12-bit digital sensor and controlled with 0.0625^{0}C steps in the -55^{0}C to +125^{0}C range**. This controller has two operating modes: Program-Mode and Run-Mode. In the **"Program-Mode"** with Jumper **J2** pins open circuited (**J2=Open**), seven control parameters are interactively selected and saved in nonvolatile memory. In the **"Run–Mode"**, with Jumper **J2** pins short circuited (**J2=Short**), the board functions as a Bi-directional Temperature-Range Controller as directed by the seven programmed parameters. The control action is defined on **Figure1**. Note that there are 4 Field Programmable Temperature Limit Values (**L, l, h, H**) used to control the heating/cooling action of the thermo-electric (**TE**) cell. The control action includes a low-side (**L** to **l**) region and a high-side (**h** to **H**) region. These are Hysteresis regions, preventing excessive temperature-control chatter. An LCD port (with 9600 Baud RS232 Interface Standard) is provided to display the Temperature-Limit values and the Measured Temperature data. In addition, a Full-Duplex, 9600 Baud, RS232 Data Port (on **CN5**) is also provided, used in both operating modes.

Control Action of the Si24BdTETRC1-12BSD-30V-20A

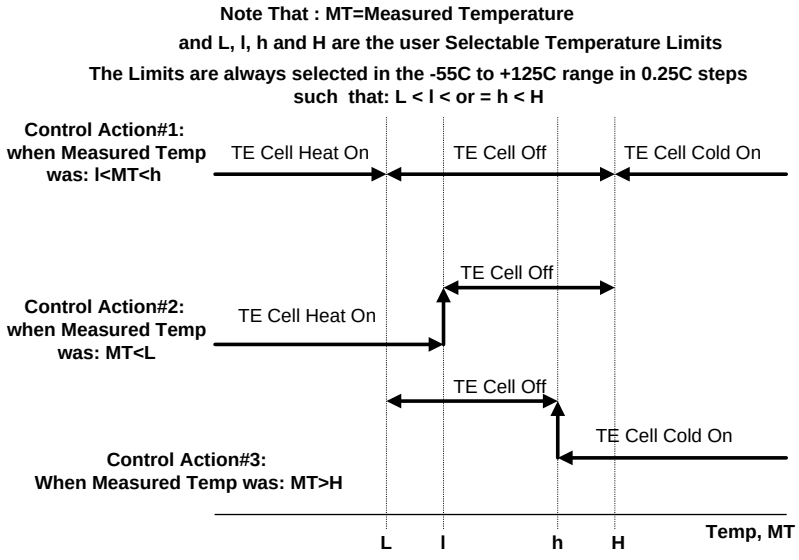

Figure 1

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Specification of the Si24BdTRC1-12BSD-30V-20A

- **Typical Operating Temperature at 20A:** 45^{0}C with the Metal Heat-Ring Bolted to a small Aluminum Plate (3.3"x4.0"x0.065") acting as a Heat-Sink, while the plate is exposed to air at 25^{0}C (as shown on photograph).
- **Overall Dimensions:** Length=4.0", Width=3.3", Height=1.3" Inches, (L=102, W=84, H=33 mm).
- **Board Dimensions:** Length=2.9", Width=2.9", Height=1.1" Inches, (L=74, W=74, H=29 mm).
- **Source-Voltage Requirements: V_P (from pin +P to pin -P)** 8V to 30V, unregulated DC voltage.
- **Average Load Current of $i_L(t)$:** 0A at 0% Duty-Cycle and 20A max. at 100% Duty-Cycle.
- **Load Isolation:** The Load or TE cell must be isolated from the source voltage (**V_P**).
- **Load-Current Indicator and Protection:** An onboard bicolor LED is used to monitor the TE Cell (or load) voltage (red = heat, green = cold). The analog control inputs are zener-diode protected and the board is protected by a fast-acting 20A Mini Fuse (DigiKey Part#: F993-ND).
- **Power-Conversion Efficiency:** Approximately 98.5% at full-load (30V and 20A).
- **Type of Control:** Field Programmable, PWM control in 0.065^{0}C steps.
- **Load-Voltage Rise and Fall-Time:** 20 μSec (10% to 90%) at 750Hz PWM carrier frequency.
- **Load PWM Duty-Cycle:** The **Heat PWM** and **Cold PWM** parameters are selected in the **Program-Mode**. These values (ranging from +1=0.83% PWM to +120=100% PWM) control the average heating or cooling TE cell–current used in the **Run-Mode**. Higher values represent more aggressive heating or cooling action used in the temperature control process.
- **Program-Mode (with J2=Open):** The Temperature Limits (**L**, **l**, **h**, **H**), Heat PWM (**HePWM**), Cold PWM (**CoPWM**) parameter, and the Temperature Bias (**Tbias**) are interactively entered. The Programmed parameter values are saved in nonvolatile memory and used in the **Run-Mode**.
- **UP/Down Keys on Port k0:** In the **Program-Mode (with J2=Open)** the control parameters are increments or decrements by closing these keys.
- **Measured-Temperature** is determined in the -55^{0}C to +125^{0}C range, with 1^0 C accuracy and with 0.0625^0 C precision, using the Dallas Semi. DS18B20 (in TO-92 casing) Digital Thermometer.
- **Sampling Rate:** The temperature is sampled at approximately 1Hz rate; and the control-loop and display are updated with this same rate.
- **Load-Current Indicator:** An on-board bicolor LED is used to monitor the load-voltage (red = heat, green = cold).
- **Alarm Kill Switch, J1:** A normally open switch (or an Open Collector npn Transistor) can be connected to jumper **J1** pins (as shown on the diagram below), **J1** Open=Normal operation; **J1** Short=Load or TE Cell is open. The active pin on **J1** is pulled to +5V through a 4.7k Ohm resistor, while the other pin (G) is at ground.
- **Next Key and LCD Display-Mode Key, CN7:** In the Program-Mode (with J2=Open), **CN7** functions as a **Next Key**. In the Run Mode (with J2=Short), **CN7** functions as a **LCD Display-Mode Key.** Accordingly, when **CN7** is Open, then Limits **L** and **H** are displayed on LCD line1. Similarly, when **CN7** is Short, the Limits **l** and **h** are displayed on LCD line1. A normally open switch (or an Open Collector npn Transistor) can be connected to **CN7** pins (as shown on the diagram below); The active pin on **CN7-** is pulled to +5V through a 4.7k Ohm resistor, while the other pin (G) is at ground.

Program Mode (J2 Open)

In the **Program-Mode**, seven Control Parameters (four Temperature Limit Values (**L**, **l**, **h**, **H**), **Heat PWM** value, **Cold PWM** value, and the Temperature Bias (**Tbias**)) are sent to the LCD Port (pin **2** of

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CN4) and to the Data Port (pin **Tx** of **CN5**). The Control Parameter values can be interactively changed by two different ways: Using the Up/Down Keys (on Port **k0**) to Increment/ Decrement a value and a parameter change is terminated by a momentary short on port **CN7** (used as Next Key). Using this method, the LCD is used and an external PC is not required. Or, a Control Parameter can be changed by a single 9600 Baud lower-case ASCII character (**u**=Up, **d**=Down, **n**=Next) applied to **Pin Rx on Port CN5** to Increment, Decrement or to select the Next parameter. Using this method, an external PC is used and the LCD is not required.

Si24BdTETRC1-12BSD-30V-20A Control Parameter Format, Table 1

Parameter Name	Parameter Range	Default Value
Lower Temp Limit, L	**L Range = -55.00C to +125.00C, One Step = 0.25C**	**27.00 C**
Lower Hysteresis Limit, l	**l Range = -55.00C to +125.00C, One Step = 0.25C**	**29.00 C**
Upper Hysteresis Limit, h	**h Range = -55.00C to +125.00C, One Step = 0.25C**	**31.00 C**
Upper Temp Limit, H	**H Range = -55.00C to +125.00C, One Step = 0.25C**	**33.00 C**
Heat PWM Value, HePWM	**HePWM Range = 1 to 120, One Step = 0.83%**	**60=50%**
Cold PWM Value, CoPWM	**CoPWM Range = 1 to 120, One Step = 0.83%**	**60=50%**
Temp Bias, Tbias	**Tbias Range = -7.00C to +7.00 (1 Step=0.0626C)**	**0.00 C**

In the "**Programming-Mode**", with Jumper **J2** pins open-circuited, control parameters can be interactively changed using the following procedure:
Step1: Power Down and Pull Out jumper **J2.** **Step2**: Power ON and Increment or Decrement a **Control Value** (Displayed on the LCD and on Data Port **CN5 pin Tx**) using the Up/Down Keys (on **k0**) or apply an ASCII character "**u**" for Up and "**d**" for Down on Port **CN5 pin Rx**. Go to the NEXT value by applying a momentary short circuit to port **CN7** or apply an "**n**" character (on **CN5 pin Rx**). After the last parameter is entered, the **Programming- Mode** is terminated, (denoted by the prompt "PowerOFF ShortJ2" requesting that the unit should be placed in the Running Mode). The newly entered Control Values will be saved in nonvolatile memory after the termination prompt is displayed. **Step3:** Power OFF after the last parameter is entered and insert **J2**. **Step4:** Power ON and the unit is in the **Running Mode**.

A typical parameter list on Port **CN5** is given below.

Control Parameter List from pin Tx on Port CN5 (the unit is in Programming Mode, J2 Open)

```
Si24-BdTETRC1   -Fp12B2SP-6Y1
LT L=+027.00C
LH l=+029.00C
UH h=+031.00C
UT H=+033.00C
HePWM=00064
CoPWM=00064
Tbias=0000.00C
PowerOFF ShortJ2
```

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The first line is the Program Identifier while the other 7 lines are the Control Parameters. The **Programming**- **Mode** is terminated by the ASCII string "PowerOFF ShortJ2" requesting that the unit should be placed in the **Running Mode**.

Run Mode (J2 Short)

In the **Run-Mode**, the temperature is sampled at approximately 1Hz rate; and the control-loop/display is updated with the same rate. An optional 2 line by 16 character LCD (Signal's part number **Si14LCD2L16CH-4PC**) connected to port **CN4** is used to display the Limit and Measured Temperature Values. A small 12-bit digital sensor, Signal's part number **Si24DTsens-12B** (connected to port **CN3** that uses the Dallas Semi., DS18B20 sensor) is used to measure and control the temperature in the -55^{0}C to +125^{0}C range, with ½^0 C accuracy and 0.0625^{0}C precision. Because this sensor is digital, it is virtually immune to noise and loading; ideally suited for remote sensing. This sensor uses a unique "1-wire interface" (with parasite power mode) that requires only 2-conductors for reliable remote (typical length of 20 meters) temperature sensing.
This board requires a single 8V to 30V DC power source (unregulated and unfiltered, with 20A max. current output) to operate normally. The high-side H-Bridge FETs are optically isolated from the control pins. Snubbing circuits and filter capacitors are included to suppress inductive switching transients. An onboard bi-color LED (**Red=Heat, Green=Cold)** is used to monitor the load-voltage. A small aluminum plate (3.3"x4.0"x0.065") heat sink is recommended (with thermal grease between the four FETs and the plate) to operate at 600W power levels. Higher power-levels can be achieved with more efficient heat-sinks. Please click on this link and read the **Board Mounting Instructions and Heat Sink Selection Guide** .

Header and Data Logging Response to ASCII Queries (on Port CN5), while the unit is in the Run Mode (J2 is Short)

```
Si24-BdTETRC1   -Fp12B2SP-6Y1
LT L=+027.00C
LH l=+029.00C
UH h=+031.00C
UT H=+033.00C
HePWM=00064
CoPWM=00064
Tbias=0000.00C

MT=+023.18C h064
MT=+038.75C c064
MT=+030.25C o000
MT=+024.93C Boff
MT=-367.62C Boff
```

The header (Program Identifier line and 7 lines of control values) is displayed only once (at Power ON) but the Measured Temperature (**MT**) data line requires an ASCII query. A query can be any single 9600 Baud ASCII character applied to Pin **Rx of Port CN5,** and the 9600 Baud ASCII-String (a line) response is observed on Pin **Tx of Port CN5.**

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The Measured Temperature (**MT**) data format is: A ASCII line (string) is always 18 characters long (including a Carriage-Return (CR) and a Line-Feed (LF) at the end, used as line termination characters). The data fields are separated by a Space (blank) character. The Measured-Temperature**, "MT= "** field is in Centigrade (**C**); and the last field (4-characters) describes the controller status. The 1st status character can have 3 different values: **h**=the unit is in Heat Mode**, c**=the unit is in Cooling Mode**, o**=the unit is in Open Mode**.** The next 3 decimal status characters denote the **PWM** duty-cycle used in the control loop: 000=0% duty-cycle, while 120=100% duty-cycle. Higher duty-cycle values denote more power is used in the control process. A valid Measured-Temperature reading followed by the Status Characters changing to **Boff** indicates that controller's H-Bridge is forced into an open-circuit mode by an **alarm condition on J1** or **J1** is Short (i.e. MT=+021.12C **Boff**). Similarly, an invalid Measured-Temperature reading of **-367.62C** followed by the Status Characters changing to **Boff** indicates that the controller's H-Bridge is forced into an open-circuit mode by **a broken Temperature Sensor on port CN3** (i.e. **MT=-367.62C Boff**).

2-Line by 16-Character LCD Display Format:

An optional 2-Line by 16-Character serial LCD (**Si14LCD2L16CH-4PC**) can be connected to port **CN4**. This +5V, RS232 serial LCD operates at 9600 Baud rate with:1 Start-bit, 8 Data-bits, 1 Stop-bit, and No Parity-bit. A typical LCD display is given below:

Line 1: **L**=+025.00 **H**=+031.00 when **CN7** is Open, or **l**=+027.00 **h**=+029.00 when **CN7** is Short

Line 2: **MT**=+025.00C **Bddd**

Where: **L, l, h, H** are the current Temperature Limit Values, **MT**=Measured-Temperature, **B** denotes the H-Bridge mode: **B**=**h**=Heat-Mode, **B**=**c**=Cold-Mode, **B**=**o**=Open-Mode and **ddd** represents the **Heat PWM** and **Cold PWM** parameters (**ddd**=00=00% PWM, **ddd**=120=100% PWM, as entered in the Program-Mode).

Application Drawing of the Si24BdTETRC1-12BSD-30V-20A

In this 12-bit, temperature-range control application (diagram shown below), this controller heats or cools a thermal-zone (using one Thermo-Electric (TE) cell) whenever the measured temperature (MT) is outside of a user-selectable temperature Limit Range (specified by **L,.. H**). The Peltier type Thermo-Electric (TE) cell is functioning as a bi-directional heat-pump. It can be purchased from: **www.customthermoelectric.com/**. The temperature of the enclosed and insolated Hot/Cold Environment is measured with the Dallas Semi. DS18B20 Digital Thermometer (in TO-92 casing). This sensor can be purchased from Signal Consulting, LLC as **Si24DTsens-12B** (DS18B20 with 12" leads and connector). The optional LCD module can be ordered from Signal using the part number of **Si14LCD2L16CH-4PC** (2-Line by16-Character display with 16" cable and 4-pin connectors, and with back-light). A wide variety of unregulated linear and switching power supplies can also be used with this controller. Consult the most recent catalog on **www.mpja.com** to purchase these power supplies. **Warning: The connecting wires to the Load and the Power Supply must be heavy gauge copper wire (#12 AWG or heavier) to handle the rated current level. In addition, these heavy gauge wires act as a heat sink, protecting the board from overheating.**

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