### Analog Inputs
- ±10 Vdc current reference
- Peak, continuous current & peak-time set

### Analog Outputs
- Current monitor
- Current reference

### Digital Inputs
- Amp Enable
- Fwd/Rev Enable (limit switches)
- Hi/Lo load inductance

### Digital Outputs
- Amp OK
- Regen control
- Brake control

### Feedback
- Digital Halls from brushless motors

### Dimensions
- 53.3 x 45.7 x 15.2 mm
- 2.1 x 1.8 x 0.6 in

Actual Size

| Model | Vdc | Ic | Ip |
|---|---|---|---|
| BTM-055-20 | 20~55 | 10 | 20 |
| BTM-090-10 | 20~90 | 5 | 10 |



## DESCRIPTION

*Bantam* is a compact, DC powered analog current amplifier for torque control of DC brush or brushless motors. It operates as a stand-alone driver taking a ±10V input from an external controller. Mounting to a PC board with solderless connectors facilitates low-cost, multi-axis designs.

The Amp Enable input interfaces to active LO signals up to 24 Vdc. Another digital input switches the current-loop gain from a high to low for load inductance compensation. Forward and Reverse Enable inputs are provided for limit switches.
A digital output for Amp-OK indicates the amplifier's status. There are two other digital outputs one of which can activate an external regenerative energy dissipator circuit and another for motor brake control.

Digital Hall feedback enables trapezoidal drive of DC brushless motors. For driving DC brush motors, these inputs are left unconnected and the motor connected between the U & V outputs.

Protections include I2T current limiting for peak and continuous current as well as peak time. Short circuits between outputs or to ground and amplifier over-temperature produce latching faults.

## DEVELOPMENT KIT

A Development Kit is available that provides mounting and easy connectivity for the Bantam.

## GENERAL SPECIFICATIONS

Test conditions: Load = Wye connected load: 2 mH + 2 Ω line-line. Ambient temperature = 25°C, +HV = $HV_{max}$

| MODEL | BTM-055-20 | BTM-090-10 | |
|---|---|---|---|
| **OUTPUT POWER** | | | |
| Peak Current | 20 | 10 | Adc, ±5% |
| Peak time | 1 | 1 | Sec |
| Continuous current | 10 | 5 | Adc, ±5% |
| Peak Output Power | 1045 | 855 | W |
| Continuous Output Power | 523 | 427 | W |
| Output resistance | 0.075 | 0.075 | Rout (Ω) |
| Maximum Output Voltage | Vout = HV*0.97 - Rout*Iout | | |
| **INPUT POWER** | | | |
| $HV_{min}$ to $HV_{max}$ | +20 to +55 | +20 to +90 | Vdc, Transformer-isolated |
| Ipeak | 20 | 10 | Adc (1 sec) peak |
| Icont | 10 | 5 | Adc continuous (Note 1) |
| Aux HV | +20 to +HVmax @ 500 mAdc maximum | | |
| **PWM OUTPUTS** | | | |
| Type | 3-phase MOSFET, 30 kHz | | |
| Commutation | Trapezoidal using digital Hall feedback | | |

| | |
|---|---|
| **CONTROL** | |
| Analog Reference Input | ±10 Vdc, 5 kΩ differential input impedance |
| Bandwidths | Current loop: 2.5 kHz typical, bandwidth will vary with tuning & load inductance |
| Minimum load inductance | 200 µH line-line |
| **FEEDBACK** | |
| Digital Halls | 3, non-isolated, for brushless motor commutation |
| | 10 kΩ to +5 Vdc pull-up with 33 µs RC filter to 74HC14 Schmitt trigger |
| Power | +5 Vdc @ 250 mA max. (J1-21, 22) to power Hall sensors or commutating encoder |
| **DIGITAL INPUTS** | |
| Number | 4 |
| [IN1] /Enable | Amplifier enable, LO active, HI disables |
| [FwdEn], [RevEn] | Forward and reverse direction limit switch/enable inputs: HI will disable output current in direction |
| Type | 74HC14 Schmitt trigger operating from +5 Vdc with RC filter on input |
| | Vin-LO < 1.35 Vdc, Vin-HI >3.65 Vdc, input voltage range 0 to +24 Vdc |
| | 10 kΩ to +5 Vdc pull-up, 74HC14 Schmitt trigger operating from +5 Vdc with RC filter on input |
| | 74HCT, Vil = 0.8 Vdc max, Vih = 2.0 Vdc min, input voltage range 0 to +24 Vdc |
| [LoInd] Low Inductance | HI or open: for higher inductance loads, LO or grounded: for lower inductance loads |
| **ANALOG INPUTS** | |
| Number | 5 |
| Ref(+), Ref(-) | Command input for output current demand, ±10 Vdc |
| Peak Current Limit | 0.5 to 4.80 Vdc sets peak current limit from 10~100% of rated peak current |
| Continuous Current Limit | 0.5 to 4.87 Vdc sets continuous current limit from 10~100% of rated continuous current |
| I2T Limit | 0.5 to 5.00 Vdc sets 10~100% of I2T time |
| Balance | ±2.5 Vdc from the 2.5 Vdc quiescent state will adjust output current ±1% of peak rated current |
| **DIGITAL OUTPUTS** | |
| Number, type | 3, N-channel MOSFET, open-drain, 30 Vdc max, 100 mA max for [AOK] and [OUT1], 1000 mA for [OUT2] |
| [AOK] | Amp OK: active LO when amplifier has no faults and will operate when enabled |
| [OUT1] | Configured as external regen switch controller: will be LO to turn on regen switch |
| [OUT2] | Brake control (external flyback diode required): will be LO when AOK and is enabled to release brake |
| **ANALOG OUTPUT** | |
| Current Monitor | ±3.0 Vdc @ ±Ipeak |
| Current Ref | Monitor for current-loop command: ±3.0 Vdc = ±100% of rated peak current |



## NOTES

1) Heatsink is required for continuous current rating.

## MOTOR CONNECTIONS

| | |
|---|---|
| Phase U, V, W | PWM outputs to 3-phase ungrounded Wye or delta wound brushless motors, or DC brush motors (U-V) |
| Hall U, V, W | Digital Hall signals, single-ended |
| Hall power | +5 Vdc ±2% @ 250 mAdc max |

## PROTECTIONS

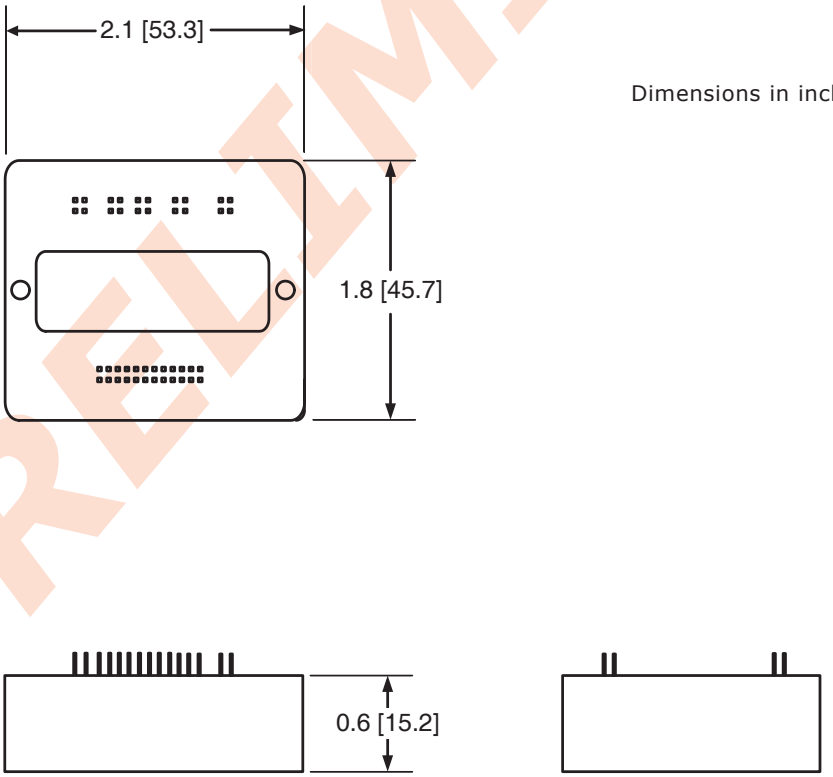
| | |
|---|---|
| HV Overvoltage | +HV > $HV_{max}$, Amplifier outputs turn off until +HV < $HV_{max}$ (See Input Power for HV) |
| HV Undervoltage | +HV < +14 Vdc, Amplifier outputs turn off until +HV > +14 Vdc |
| Amplifier over temperature | Heat plate > 70°C |
| Short circuits | Output to output, output to ground, internal PWM bridge faults |
| $I^2T$ Current limiting | Programmable: continuous current, peak current, peak time |

## MECHANICAL & ENVIRONMENTAL

| | |
|---|---|
| Size | 2.1 x 1.8 x 0.6 [53.3 x 45.7 x 15.2] in [mm] |
| Weight | |
| Ambient temperature | 0 to +45 °C operating, -40 to +85 °C storage |
| Humidity | 0 to 95%, non-condensing |
| Contaminants | Pollution degree 2 |
| Environment | IEC68-2: 1990 |
| Cooling | Conduction through heatplate on amplifier chassis, or convection |



## AMPLIFIER DIMENSIONS

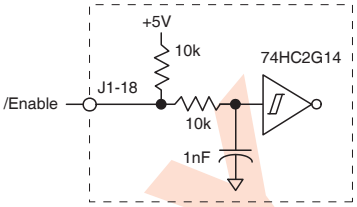



Dimensions in inches [mm]

## CONTROL INPUTS AND OUTPUTS

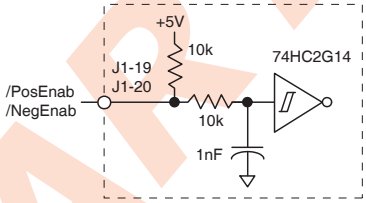
### ENABLE INPUT

The Enable input [IN1] is LO-active and pulled up to +5V by an internal 10k resistor. This provides fail-safe operation by disabling the amplifier if the Enable input is open, or a wire from the controller should break.



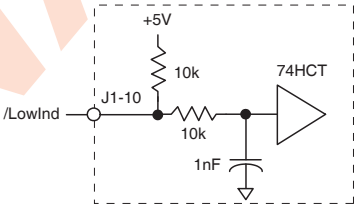

### FWD/REV ENABLE INPUTS

Two inputs are provided for limit switches.



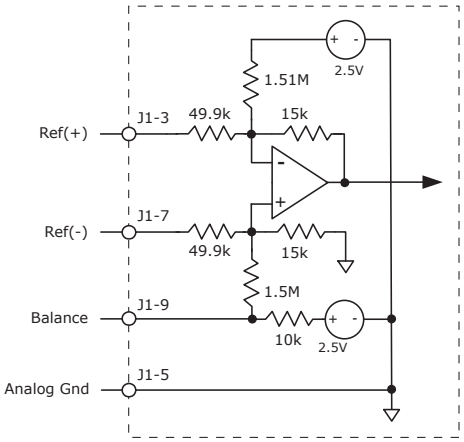

### LOAD INDUCTANCE INPUT

The [IN2] input controls the gain of the current error amplifier to compensate the amplifier for lower or higher inductance loads. Grounding the input reduces the gain of the current loop by 80% for low inductance loads.




### ANALOG REFERENCE INPUT

The amplitude and polarity of the amplifier output current is controlled by a ±10V analog signal from an external controller.



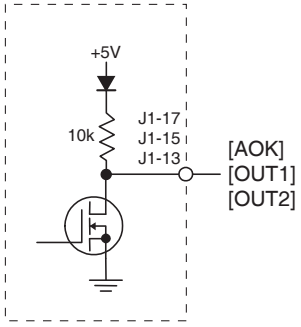

### BALANCE INPUT

The output current of the amplifier can be adjusted to 0 Adc by connecting the balance input to a potentiometer with an adjustment range of 0 to +5 Vdc. This will produce an offset adjustment range of ±0.8% of the Ipeak rating of the amplifier. The table below shows the offset adjustment range in mA.

| Model | ±Ioffset (mA) |
|---|---|
| BTM-055-20 | 160 |
| BTM-090-10 | 80 |

### DIGITAL OUTPUTS

Three N-channel MOSFETs sink current from loads connecting to +30 Vdc maximum. Outputs [AOK] and [OUT1] can sink 100 mA maximum. The brake output [OUT2] can sink 1000 mA. An external flyback diode is required with driving inductive loads like a brake, or relays.

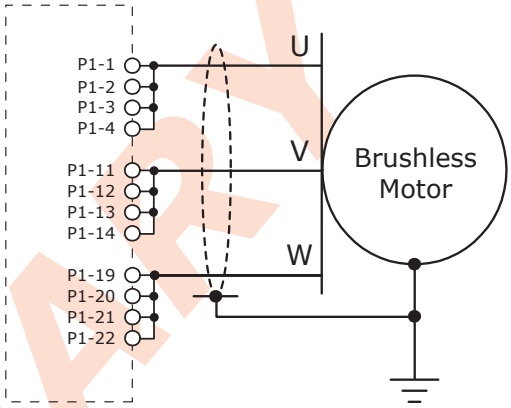


## MOTOR CONNECTIONS

Motor connections are of two types for brushless motors: phases and Halls. For brush motors, only the armature connections are needed. The phase or armature connections carry the amplifier output currents that drive the motor to produce motion. The Hall signals are three digital signals used for commutating a brushless motor. When using a brush motor the Hall inputs should be unconnected and the motor armature connections made between the U & V phase outputs.

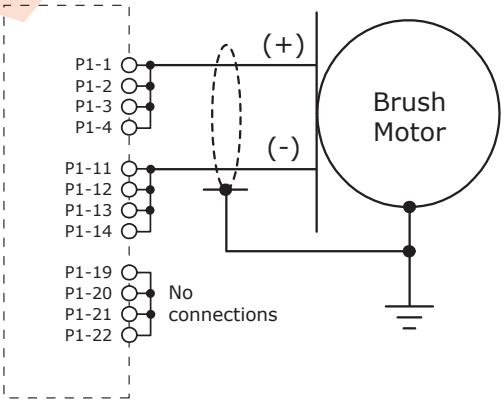
## MOTOR PHASE CONNECTIONS: BRUSHLESS

The amplifier output is a three-phase PWM inverter that converts the DC buss voltage (+HV) into DC voltage waveforms that drive two motor phase-coils at a time (trapezoidal commutation). Cable should be sized for the continuous current rating of the amplifier. Motor cabling should use twisted, shielded conductors for CE compliance, and to minimize PWM noise coupling into other circuits. The motor cable shield should connect to motor frame and the equipment frame ground for best results.



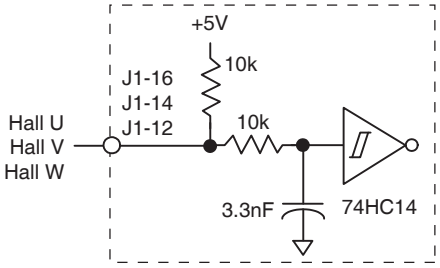

## MOTOR PHASE CONNECTIONS: BRUSH

The amplifier output is an H-bridge PWM inverter that converts the DC bus voltage (+HV) into a DC voltage waveform that drives the motor armature. Cable should be sized for the continuous current rating of the amplifier. Motor cabling should use twisted, shielded conductors for CE compliance, and to minimize PWM noise coupling into other circuits. The motor cable shield should connect to motor frame and the equipment frame ground for best results.




## MOTOR HALL SIGNALS

Hall signals are single-ended signals that provide absolute feedback within one electrical cycle of the motor. There are three of them (U, V, & W) and they may be sourced by magnetic sensors in the motor, or by encoders that have Hall tracks as part of the encoder disc. They typically operate at much lower frequencies than the motor encoder signals, and are used for commutation. When driving DC brush motors, the Hall inputs should be left unconnected.



## CURRENT LIMITING INPUTS

### CURRENT LIMIT INPUTS

Two inputs are provided for setting the peak and continuous current limits. The I-Peak and I-Cont inputs each have equivalent circuits shown below. Limits can be set either by applying a voltage (Vset) to the input or by connecting a resistor (Rset) between input and signal ground. The tables below show values for Rset and Vset that give 5~95% of the rated peak and continuous current ratings.

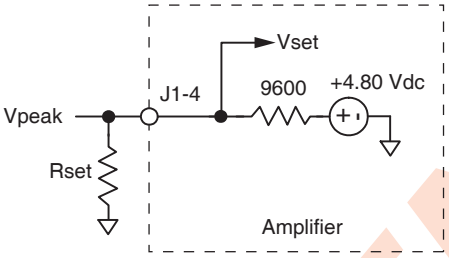
#### AMPLIFIER MODELS AND RATINGS

| Model | I-Peak | I-Cont | T-Peak |
|---|---|---|---|
| BTM-055-20 | 20 | 10 | 1 |
| BTM-090-10 | 10 | 5 | |

#### PEAK CURRENT LIMIT SETTINGS

| % | Rset | Vset |
|---|---|---|
| 90 | 86400 | 4.32 |
| 80 | 38400 | 3.84 |
| 70 | 22400 | 3.36 |
| 60 | 14400 | 2.88 |
| 50 | 9600 | 2.4 |
| 40 | 6400 | 1.92 |
| 30 | 4114 | 1.44 |
| 20 | 2400 | 0.96 |
| 10 | 1067 | 0.48 |

#### EQUIVALENT CIRCUIT




#### EXAMPLE Ipeak SETTING

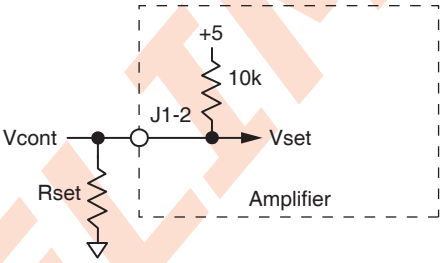
Set Ipeak to 15 A for the model BTM-055-20:

1) Find % of Ipeak = 15 / 20 = 0.75 = 75%
2) Using a resistor, find the closest standard value to
   28800 ohms: 28.7k, 1%.
3) Using a voltage at the input, apply 3.60 Vdc

#### CONTINUOUS CURRENT LIMIT SETTINGS

| % | Rset | Vset |
|---|---|---|
| 90 | 88189 | 4.38 |
| 80 | 39195 | 3.90 |
| 70 | 22864 | 3.41 |
| 60 | 14698 | 2.92 |
| 50 | 9799 | 2.44 |
| 40 | 6533 | 1.95 |
| 30 | 4199 | 1.46 |
| 20 | 2450 | 0.97 |
| 10 | 1089 | 0.49 |

#### EQUIVALENT CIRCUIT




#### EXAMPLE Icont SETTING

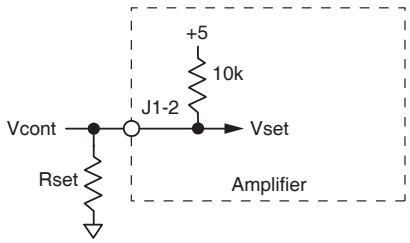
Set Icont to 3.0 A for the model BTM-090-10:

1) Find % of Icont = 3 / 5 = 0.60 = 60%
2) Using a resistor, find the closest standard value to
   14698 ohms: 15.0k, 1%.
3) Using a voltage at the input, apply 2.92 Vdc

#### I2T LIMIT SETTINGS

| % | Rset | Vset |
|---|---|---|
| 90 | 90000 | 4.50 |
| 80 | 40000 | 4.00 |
| 70 | 23333 | 3.50 |
| 60 | 15000 | 3.00 |
| 50 | 10000 | 2.50 |
| 40 | 6667 | 2.00 |
| 30 | 4286 | 1.50 |
| 20 | 2500 | 1.00 |
| 10 | 1111 | 0.50 |

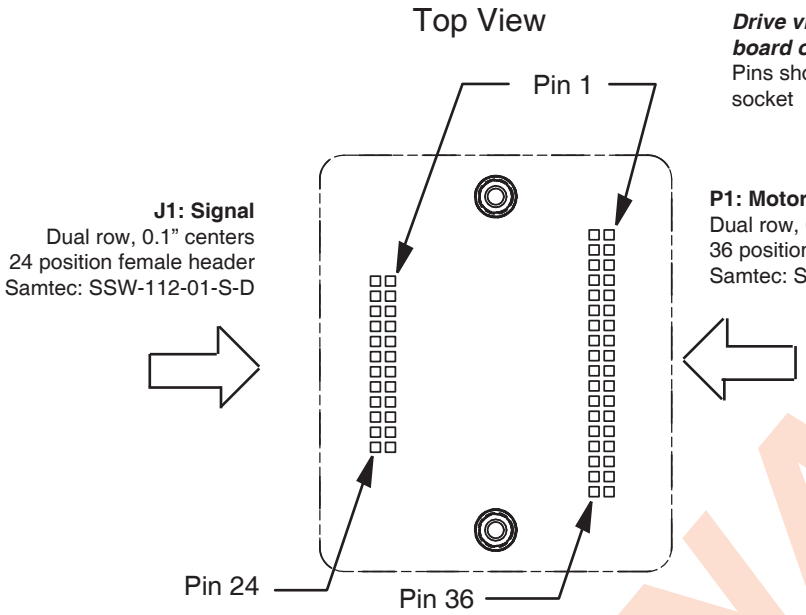
#### EQUIVALENT CIRCUIT




#### EXAMPLE I2T SETTING

Set I2T to 60%:

1) Rset = 10k * (% / (100 - %))
   where % is the percent of the I2T maximum
2) Solve for Rset:
   Rset = 10k * (60 / (100 - 60)) = 15k




***Drive viewed from above looking down on the pc board on which it is mounted.***
Pins shown in grey are unused locations in PC board socket

**J1: Signal**
Dual row, 0.1" centers
24 position female header
Samtec: SSW-112-01-S-D

**P1: Motor & HV**
Dual row, 0.1" centers
36 position female header
Samtec: SSW-118-01-S-D

J1 SIGNALS & PINS

| Signal | Pin | | Signal |
|---|---|---|---|
| I2T Time | 2 | 1 | Current Ref |
| Peak Curr Limit | 4 | 3 | Ref(+) |
| Cont Curr Limit | 6 | 5 | Agnd |
| N.C. | 8 | 7 | Ref(-) |
| /LowInd | 10 | 9 | Balance |
| Hall W | 12 | 11 | Current Monitor |
| Hall V | 14 | 13 | [OUT2] |
| Hall U | 16 | 15 | [OUT1] |
| /Enable | 18 | 17 | [AOK] |
| /Neg Enable | 20 | 19 | /Pos Enable |
| Hall +5V | 22 | 21 | Hall +5V |
| Pgnd | 24 | 23 | Pgnd |

P1 SIGNALS & PINS

| Signal | Pin | | Signal |
|---|---|---|---|
| Motor U | 2 | 1 | Motor U |
| Motor U | 4 | 3 | Motor U |
| N/C | 6 | 5 | N/C |
| N/C | 8 | 7 | N/C |
| N/C | 10 | 9 | N/C |
| Motor V | 12 | 11 | Motor V |
| Motor V | 14 | 13 | Motor V |
| N/C | 16 | 15 | N/C |
| N/C | 18 | 17 | N/C |
| Motor W | 20 | 19 | Motor W |
| Motor W | 22 | 21 | Motor W |
| N/C | 24 | 23 | N/C |
| Pgnd | 26 | 25 | Pgnd |
| Pgnd | 28 | 27 | Pgnd |
| N/C | 30 | 29 | N/C |
| N/C | 32 | 31 | N/C |
| +HV | 34 | 33 | +HV |
| +HV | 36 | 35 | +HV |

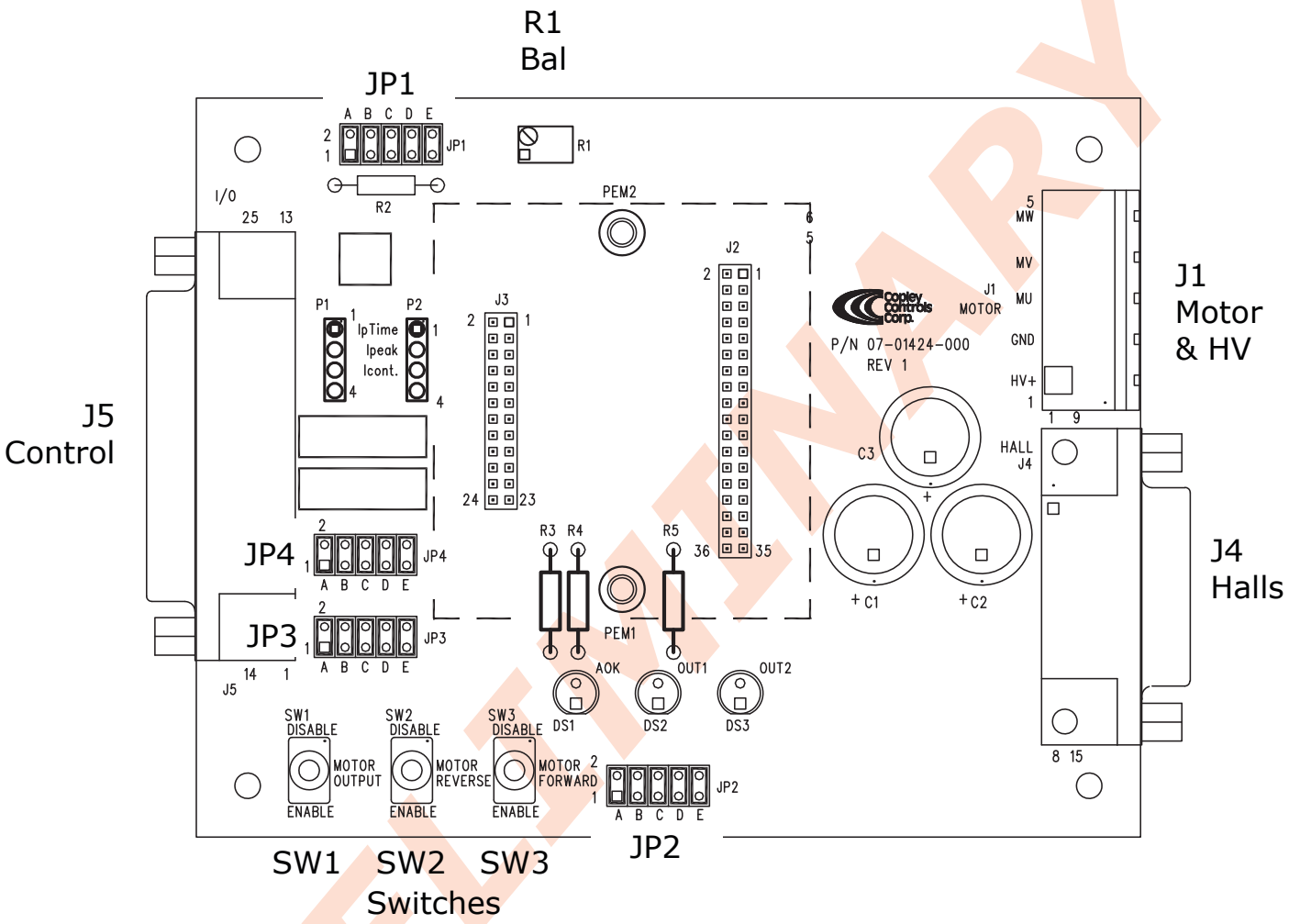


NOTES

1. Grey-shaded signal are N.C. (No Connection)
2. Signals are grouped for current-sharing on the power connector. When laying out pc board art-works, all pins in groups having the same signal name must be connected.
3. The total current current from J1-21 and J1-22 cannot exceed 250 mA.

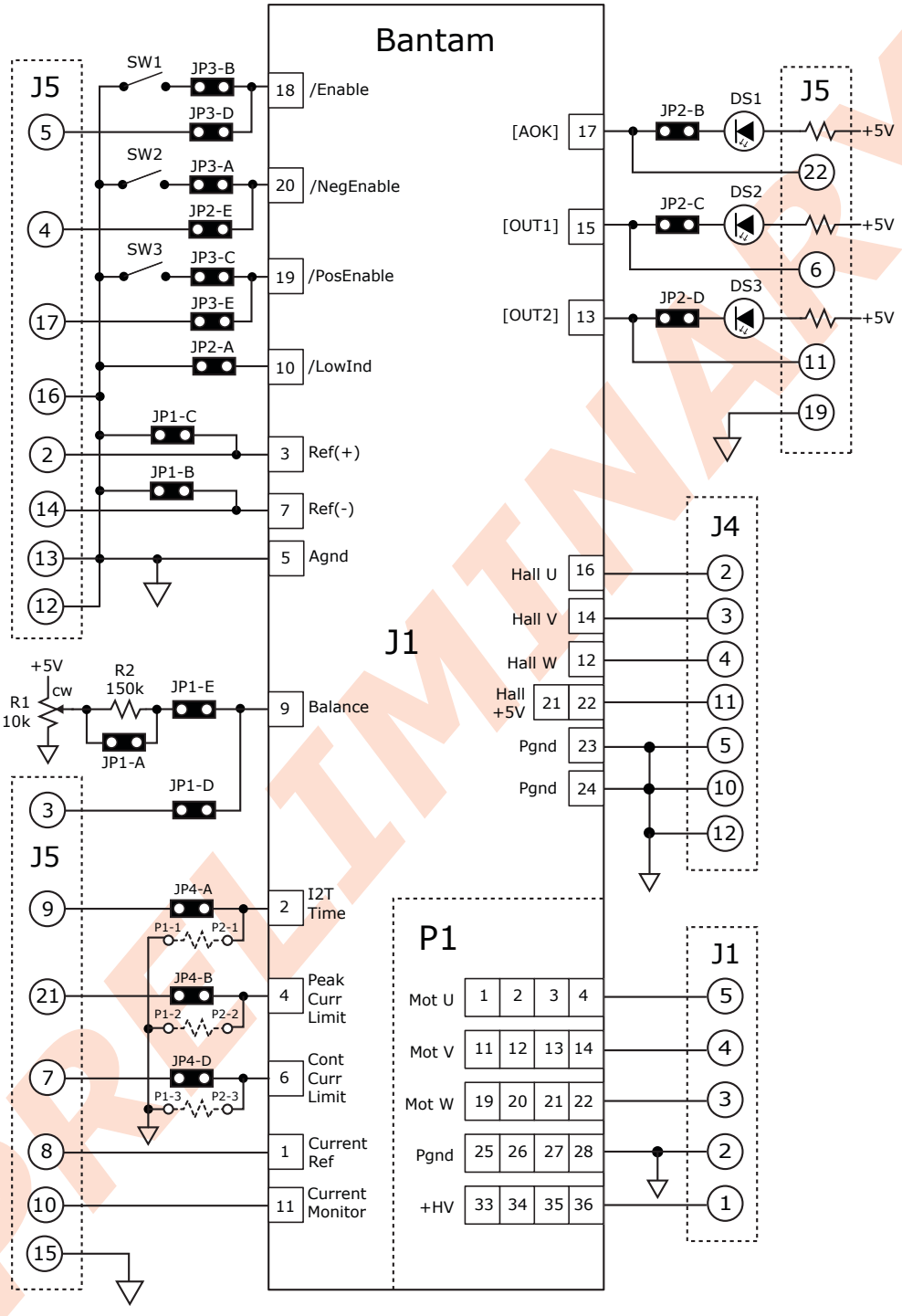
## DEVELOPMENT KIT TOP VIEW

The graphic below shows the placement of components and connectors on the Development Kit PC board.
The Bantam amplifier is not shown, but mounts in the outline that contains connectors J3 & J2.



## CONNECTIONS

In the diagram below, connectors inside the Bantam outline are the amplifier connectors, their signal names, and pin numbers. All connectors and components outside of the Bantam are on the Development Kit.






## NOTES

1) The combined current from J4-11 and J5-23 cannot exceed 250 mA.

## JUMPER FUNCTIONS

The functions shown in the tables below are in effect when the jumper is in place.
When a jumper is removed, the stated function is disabled.
J5 connects to an external controller

### JP1

| JP1 | Remarks |
|---|---|
| A | Shorts 150k balance scaler |
| B | Ref(-) input is grounded |
| C | Ref(+) input is grounded |
| D | Connects J5-3 to Amp: Balance |
| E | R1 controls Amp: Balance |

### JP2

| JP2 | Remarks |
|---|---|
| A | Gain Select to Sgnd |
| B | Amp: [AOK] drives DS1 |
| C | Amp: [OUT1] drives DS2 |
| D | Amp: [OUT2] drives DS3 |
| E | Connects J5-4 to Amp: /Neg Enable |

### JP3

| JP3 | Remarks |
|---|---|
| A | Connects SW2 to Amp: /Neg Enable |
| B | Connects SW1 to Amp: /Enable |
| C | Connects SW3 to Amp: /Pos Enable |
| D | Connects J5-5 to Amp: /Enable |
| E | Connects J5-17 to Amp: /Pos Enable |

### JP4

| JP4 | Remarks |
|---|---|
| A | Connects J5-9 to Amp: I2T Time |
| B | Connects J5-21 to Amp: Current Peak Limit |
| C | No connections |
| D | Connects J5-7 to Amp: Current Cont Limit |
| E | Connects J5-18 to Amp: Gain Select |

## SOCKETED COMPONENTS

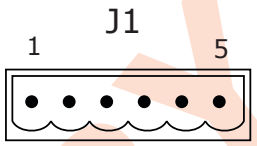
| P1/P2 | Remarks |
|---|---|
| 1 | I2T Time setting resistor |
| 2 | Ipeak setting resistor |
| 3 | Icont setting resistor |
| 4 | No function |

## CONNECTORS

These charts show the pins and signals for the Development Kit connectors.

### J1 MOTOR AND HV POWER

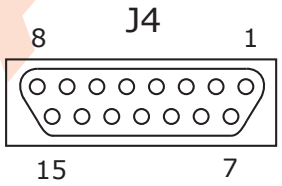
| Pin | Signal |
|---|---|
| 5 | Mot U |
| 4 | Mot V |
| 3 | Mot W |
| 2 | HV Gnd |
| 1 | +HV Input |



Euro 5 position

### J4 HALLS

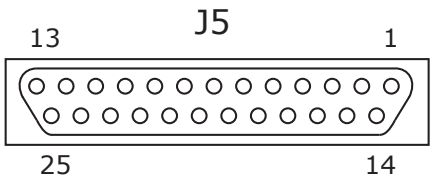
| Signal | Pin | | Signal |
|---|---|---|---|
| Sgnd | 1 | 9 | n.c. |
| Hall U | 2 | 10 | Sgnd |
| Hall V | 3 | 11 | +5 Vdc output |
| Hall W | 4 | 12 | Sgnd |
| Sgnd | 5 | 13 | n.c. |
| n.c. | 6 | 14 | n.c. |
| n.c. | 7 | 15 | n.c. |
| n.c. | 8 | | |



D-Sub 15 female

### J5 CONTROL

| Signal | Pin | | Signal |
|---|---|---|---|
| Sgnd | 1 | 14 | Ref(-) |
| Ref(+) | 2 | 15 | Sgnd |
| Ext Balance | 3 | 16 | Sgnd |
| /Neg Enable | 4 | 17 | /Pos Enable |
| /Enable | 5 | 18 | Gain Select |
| [OUT1] | 6 | 19 | Sgnd |
| Current Cont Limit | 7 | 20 | n.c. |
| Current Ref | 8 | 21 | Curr Peak Limit |
| I2T Time | 9 | 22 | [AOK] |
| Current Monitor | 10 | 23 | +5 Vdc Output |
| [OUT2] | 11 | 24 | n.c. |
| Sgnd | 12 | 25 | n.c. |
| Sgnd | 13 | | |



D-Sub 25 female



## NOTES

1) The combined current from J4-11 and J5-23 cannot exceed 250 mA.

## MASTER ORDERING GUIDE

| | |
|---|---|
| BTM-055-20 | *Bantam* analog current amplifier, 10/20 Adc |
| BTM-090-10 | *Bantam* analog current amplifier, 5/10 Adc |
| BDK-090-01 | Development kit |
| BDK-CK | Connector Kit for Development Kit |

## ORDERING EXAMPLE

Example: Order 1 BTM-055-20 current amplifier and development kit:

| Qty | Item | Remarks |
|---|---|---|
| 1 | BTM-055-20 | *Bantam* current amplifier |
| 1 | BDK-090-01 | Development Kit for Bantam amplifier |
| 1 | BDK-CK | Connector Kit for Development Kit |

## ACCESSORIES

| ORDER NUMBER | Qty | Ref | DESCRIPTION |
|---|---|---|---|
| BDK-CK Connector kit for BDK-090-01 Development Kit (includes next 5 items shown below) | | | |
| | 1 | J1 | Connector, RoHS, Euro style plug, 5 position, Tyco (AMP) 796635-5 |
| | 1 | J4 | Connector, D-Sub, 15-position, male, RoHS, Tyco (AMP) 5-747908-2 |
| | 1 | J4 | Backshell, D-Sub, RoHS, metallized, 15-position, Norcomp 979-015-020R121 |
| | 1 | J5 | Connector, D-Sub, 25-position, male, RoHS, Tyco (AMP) 5-747912-2 |
| | 1 | J5 | Backshell, D-Sub, RoHS, metallized, 25-position, Norcomp 979-025-020R121 |