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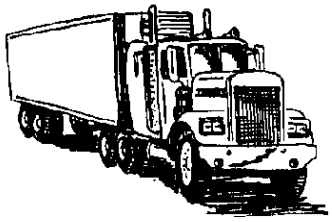
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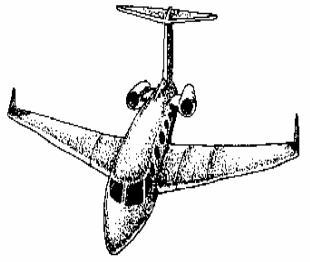
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PC/104 Vehicle Power Supply

High Efficiency & Smart Charging
Vehicle Power Supply
DC to DC Convertor

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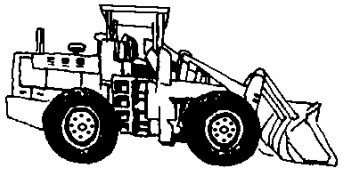


Technical Manual

P/N: HE104MAN-V8
Revision: 23 June 2005

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PREFACE

This manual is for integrators of applications of embedded systems. It contains information on hardware requirements and interconnection to other embedded electronics.

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CHAPTER 1: INTRODUCTION

1.1 GENERAL DESCRIPTION

The HE104 multiple output DC to DC 50 watt converter is a high efficiency, high performance unit that can be supplied with +5V, +12V outputs only or can include features such as, Power Management, Universal Battery Charger, AC Bus termination, -5V output, -12V output and custom output voltages from -42V to +42V. The HE104 is designed for low noise embedded PC/104 computer systems, which has a wide input range of 6 to 40V(>6:1) and is ideal for battery or unregulated input applications. The HE104 is specifically designed for vehicular applications and has heavy-duty transient suppressors (5000W) that clamp the input voltage to safe levels. Further, it is able to maintain normal power supply operation.

The HE104 is a state-of-the-art MOSFET based design that provides outstanding line and load regulation with efficiencies up to 95 percent. Organic Semiconductor Capacitors provide filtering, which reduces ripple noises below 20mV. The low noise design makes the HE104 ideal for use aboard aircraft, military applications or wherever EMI or RFI must be minimized. The +5VDC and +12VDC outputs are controlled by a constant off-time current mode architecture regulator, which provides excellent line and load transient response.

The +12VDC boost regulator uses the +5VDC as input power, so it can operate without dropout from 6 to 40V input and supply 2A. The +5VDC output is protected from output shorts by a high-speed pulse-by-pulse current limit circuit. Furthermore, +12VDC output is protected from shorts by the current limiting of the +5VDC controller.

A “plug-in” Universal Battery Charger (BC104) is available for the HE104 to charge Lead-Acid, NiCd and NiMH batteries. Charge currents can be up to1.5A and battery charging voltages range from 6 to 40V.

The Power Management controller (PM104) allows for timed on/off control of the HE104, bus interrupts on impending power failure, current limit setting and intelligent charge termination for the BC104.

The HE104 is provided in a PC/104 form factor compliant size, which includes the 8bit and 16bit PC/104 expansion bus header. All generated voltages are provided to their related power supply pins on the PC/104 expansion bus and are available for off-board use through a screw terminal block. PC/104 AC bus termination is an option that is available on the HE104,that provides the cleanest possible signals on the PC/104 bus.

The HE104 can be configured to meet almost any power supply need for embedded PC/104 applications. This could be a simple +5V application, which provides for back lighted LCD panels or a full UPS (un-interruptible power supply configuration).

1.2 Features

- DC to DC convertor for PC/104 bus equipped products.
- “Load Dump” transient suppression on input power supply.
- Operates from 6VDC to 40VDC input.
- “Stacks” onto the PC/104 bus.
- Passthrough or non-passthrough 8 bit and 16 bit versions.
- 5V, 12V standard, -12V, -5V and battery charger optional.
- Highly compact, 100 percent PC/104 conforming.
- AC bus termination available.
- Screw terminals provide off-board connection to output voltages.

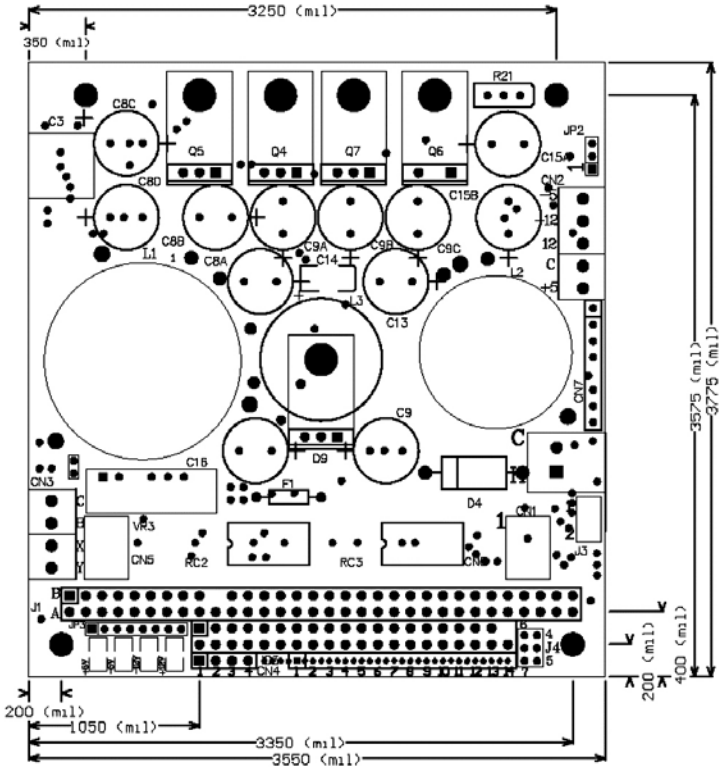


Figure 1-1, HE104 Dimensions
1000mil=1in

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1.3 Specifications

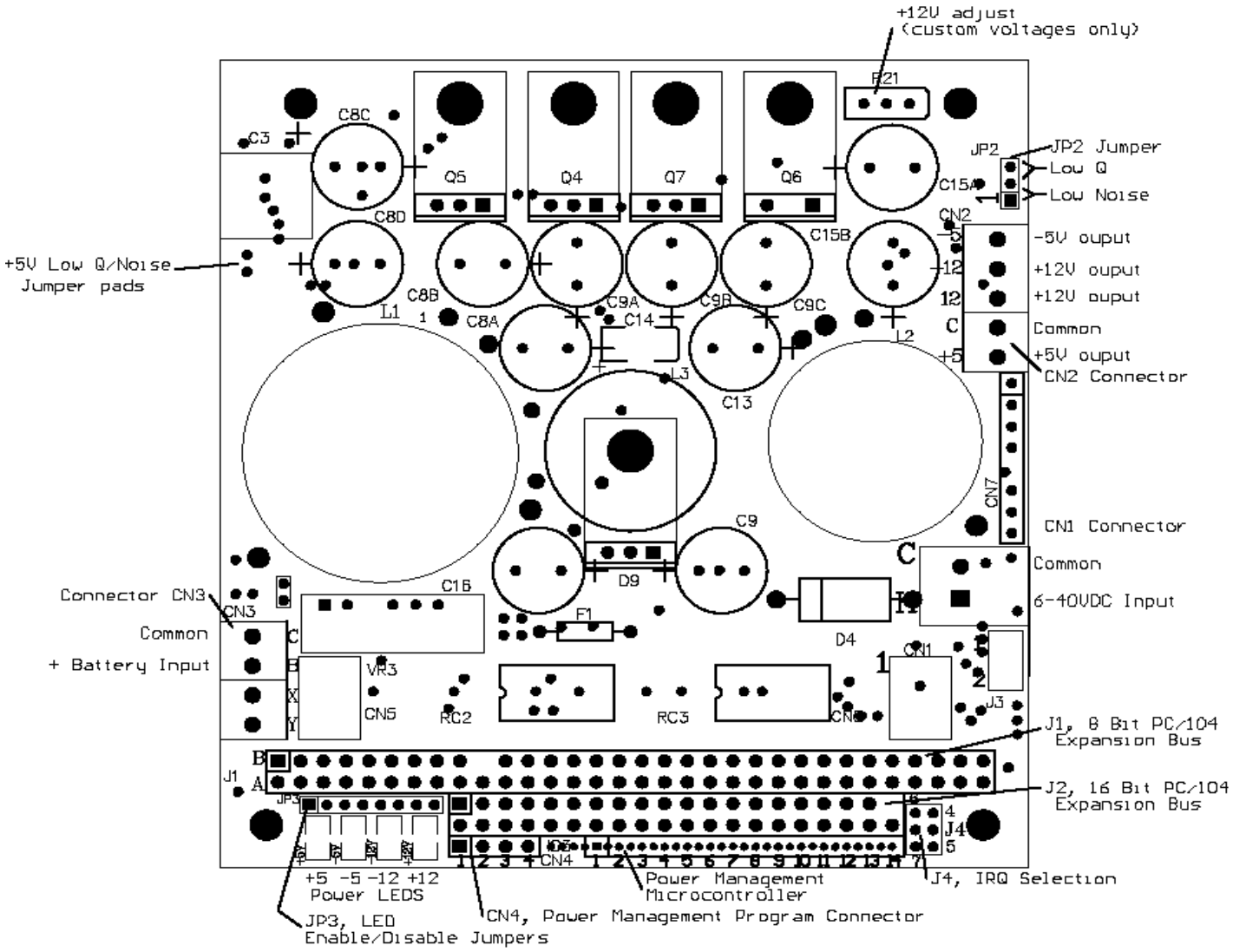
Power Supply Specifications	
Model	**HE104**
5V output*	10A
12V output	2A
-5V output	400mA
-12V output	500mA
Input Voltage Range	6 to 40V
Load Regulation **	<60mV
Line Regulation **	±40mV
Output temp.drift **	<40mV
Switching Frequency	75kHz
Max. Input Transient	125V for 100msec
Output Ripple **	<20mV
Conducted Susceptibility **	>57db
Efficiency **	up to 95%
Temp Range	-40 to 85C
Quiescent current ***	2mA
Size, PC/104 form factor compliant ****	3.55"W.x 3.75"L x 0.6" Height

*Current rating includes current supplied to 12V, -12V, & -5V regulators.
**Measured on the 5V output.
***LEDS disabled, Low Quiescent mode enabled.
****Not including passthrough pins.

CHAPTER 2: CONFIGURATION AND INSTALLATION

2.1 Introduction

This chapter describes the configuration and installation of the HE104 power supply. In addition, section 2.2 provides a formula to calculate the available +5VDC. Figure 2-1 shows the HE104 connectors, jumpers and other options.



2.2 Power Considerations

$$\text{Usable +5V output} = 10A - \frac{(I[-5] + I[-12] \bullet 2.4 + I[12] \bullet 2.4)}{0.8}$$

The +5V switching regulator is rated at 10A maximum output however, the +5V output, supplies power to the +12VDC, -5VDC and –12VDC regulators. To obtain the usable range of +5V output, "derate" according to the use of +12VDC, -5VDC and –12VDC. Use the following formulae to calculate the maximum usable output.

Where: I[-5] = -5VDC current load
I[-12] = -12VDC current load
I[12] = 12VDC current load

Assuming 90 percent convertor efficiency (actual efficiency may vary).

2.3 HE104 Connectors

2.3.1 Main Input Power Connector

Input power is connected to the "pluggable" block, CN1, which is removable from the socket connector on the circuit board. The power supply accepts DC input voltages in the range of 6VDC to 40VDC.

Unregulated vehicle power is connected as follows:

-Terminal 1: "hot" polarity
-Terminal 2: Common (0VDC)

!! CAUTION !!

To allow operation at the lowest possible input voltages (6VDC) and for the best efficiency, there is no input Reverse Polarity Diode (RPD) provided on the HE104 without a battery charger option. If input RPD is required, add RPD to the HE104 part number:

- Example HE 104-512-16-RPD

Note: Adding the RPD results in an increased power loss. For heat dissipation estimation please refer to section 2.11.

2.3.2 Output Power Connector

Output power is available for non-PC/104 use via connector CN2.

- Terminal 1: +5VDC output
- Terminal 2: Common
- Terminal 3: +12VDC
- Terminal 4: -12VDC output (optional)
- Terminal 5: -5VDC output (optional)

2.3.3 Battery Power Connector (Optional)

Batteries are connected to the screw terminal block, CN3. The HE104 accepts DC battery voltages in the range of 6.5V to 40DVC through the Battery Power Connector. Two external signals can be connected to the battery terminal block for use by add-on modules plugged into the mezzanine header connectors. Connect to the HE104 Battery Terminal Block as follows:

-Terminal 1: Common of battery
-Terminal 2: Positive Battery Terminal
-Terminal 3: External signal 1
-Terminal 4: External signal 2

Note: When Optional Plug-IN Boost regulator (VR3) is ordered, batteries or external signals cannot be connected to CN3. See section 2.3.4

2.3.4 Onboard PC "Boost" Adaption (Optional)

An optional converter Boost pump (model NMH05XXS, XX=output voltage, ± 5V, ±9V, ±12V, ±15V) can be installed in location VR3 to provide custom output voltages. The NMH charge pumps have an isolated positive and negative output and a maximum 2-watt capacity. A minimum load of 10 percent is required for proper operation. By connecting the charge pump to other voltages, the user can create more or less supplies, as well as elevated and negative voltages (i.e.: The charge pump "0V" is not connected to the HE104 common).

- Terminal 1: Common of battery
- Terminal 2: -V output
- Terminal 3: 0V
- Terminal 4: +V output

Examples of NMH0515S can generate the following voltages:

- 15V by connecting NMH “0V” to HE104 common
- -30V by connecting NMH +V to Common
- +30V by connecting NMH –V to Common
- +42V by connecting NMH –V to +12V output

Note: When batteries or external signals are connected to CN3 the Plug-IN Boost regulator (VR3) cannot be installed. See section 2.3.4

2.4 Bus Termination (Optional)

AC bus termination minimizes power consumption as it improves the reliability of the bus. The resistor/capacitor combination only conducts a current during the few nanoseconds when the bus signal is changing state. See appendix “B”.

2.5 Installation Onto PC104 Modules

The PC/104 bus on the HE104, is keyed according to the standards as set out by the PC/104 Consortium Guidelines. Pin B10, of the 8-bit bus, and pin C20, of the 16-bit bus, are removed. It is important to note that the female sockets are not plugged. Although, it is highly recommended the female sockets be plugged to prevent mis-alignment with other PC/104 modules however, this is left up to the customer.

Because of the large number of pins and sockets (104 total) in the PC/104 bus, caution must be used in separating the PC/104 modules to prevent bending of the pins or cutting the person separating the modules. Tri-M Engineering recommends the use of the PC/104 removal tool (model #5535) is available from Tri-M Engineering.

2.6 Jumper Selection

This section describes the function, the location of it, the default setting and how to change each jumper on the HE104-V8.

2.6.1 LED Jumper Enable/Disable

The jumpers that are located behind each LED, allow the LEDs to be disabled, which are most likely to be used when absolute minimum power consumption is maintained such as, when operating off a limited battery source..

Each LED is enabled by factory default. To disable any LED, remove the LED jumper (or cut the small PCB trace if no jumper is installed) associated with the LED. To re-enable any LED, re-install the associated jumper (or solder a short jumper wire between each of the jumper pads).

2.6.2 +5VDC Low Q/ Noise (Q=quiescent)

This jumper allows the +5VDC regulator IC1 to be changed from the low ripple noise mode into the low quiescent power mode. This option is most likely to be used when absolute minimum power consumption must be maintained such as, when operating off a limited battery source. It is recommended that the +12vDC Low Noise mode be selected whenever the +5VDC Low Q. mode is not required.

The PCB jumper trace is located on the bottom of the circuit board between two pads. Location of the jumper is identified on the left side of the heat sink by “Low Q/Noise”. Refer to figure 2.1 for exact location of +5VDC Low Q/Noise jumper.

The factory default setting for Low Q/Noise is for low ripple noise. To change the factory default setting to Low Q operation, the small PCB jumper trace must be cut using the tip of a sharp knife. To return to Low Noise operation, solder a jumper connecting the jumper pads.

2.6.3 +12VDC Low Q/ Noise

This jumper allows the +12VDC regulator IC1 to be changed from low ripple noise mode into the low quiescent power mode. This option is most likely to be used when absolute minimum power consumption must be maintained such as, when operating off a limited battery source.

The PCB jumper trace is located on the bottom of the circuit board, between two pads of jumper block JP2. Location of the jumper is identified on the right side of the heat sink by “Low Q” with “Low Noise” directly below it. Refer to figure 2.1 for exact location of +12VDC Low Q, Low Noise jumper.

The factory default setting for Low Q, Low Noise is for low ripple noise. To change the factory default setting to Low Q operation, the small jumper connecting JP2-1 to JP2-2 must be cut using the tip of a sharp knife and solder a jumper across the pads JP2-2 to JP-3. To return to Low Noise operation, remove the jumper between JP1-2 and JP2-3 and re-install the jumper connecting JP2-1 to JP2-2.

2.6.4 Mezzanine Expansion Headers

The mezzanine expansion headers are used for installation of the optional battery charger. The mezzanine expansion headers can also be used for custom output voltages such as, Vee for LCD panels. If custom output voltages are required please contact Tri-M Engineering.

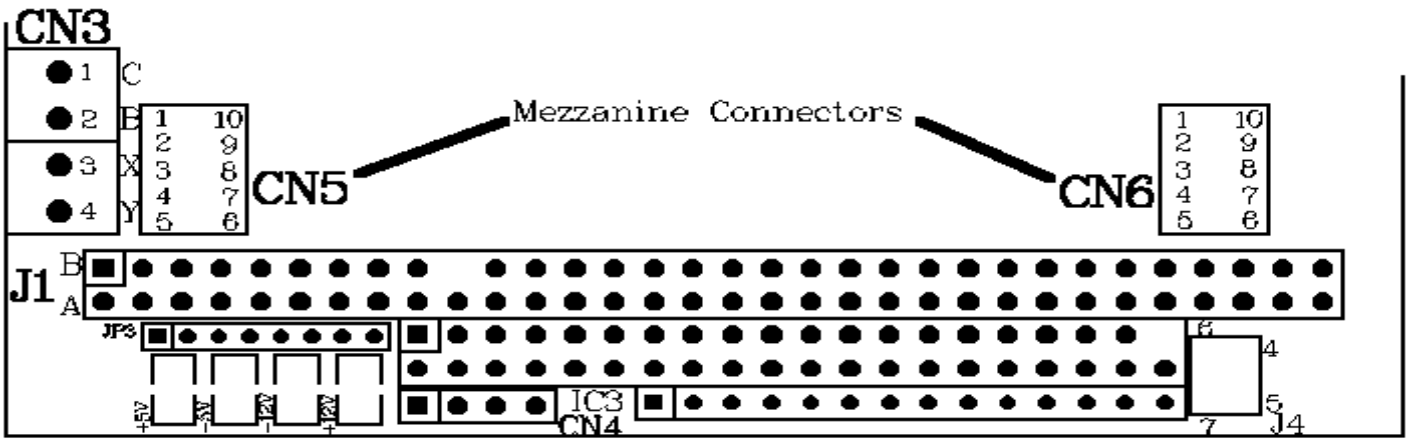


Figure 2.3, HE104 Mezzanine Connectors

Connector CN5 Pinout		Connector CN6 Pinout	
1. +5V	10. +5V	1. PM104-P1	10. Main Pwr. Input
2. Common	9. Common	2. Common	9. Common
3. +Battery Input	8. Main Pwr Input	3. PM104-P7	8. PM104-P2
4. Ext. Signal 1	7. +12V	4. PM104-P6	7. PM104-P3
5. Ext. Signal 2	6. -5V	5. PM104-P5	6. PM104-P4

2.7 PC/104 Bus Interrupts (Optional)

Interrupts to the PC/104 bus require the installation of the optional power management mircrocontroller (PM104). The PM104 can be programmed to provide indication of loss of input power, low battery voltage or to provide indication to the PC/104 CPU to begin an orderly shutdown of program operation.

Two separate interrupt requests can be generated and each interrupt request will remain active until the cause of the interrupt request returns to normal. Interrupt Int1 can be set to IRQ6 or IRQ7, while interrupt Int2 can be set to IRQ4 or IRQ5 by installing an appropriate jumper on jumper selections block J4. Jumper block J4 is located adjacent to the PC/104 bus on the opposite side where the power LEDs are located.

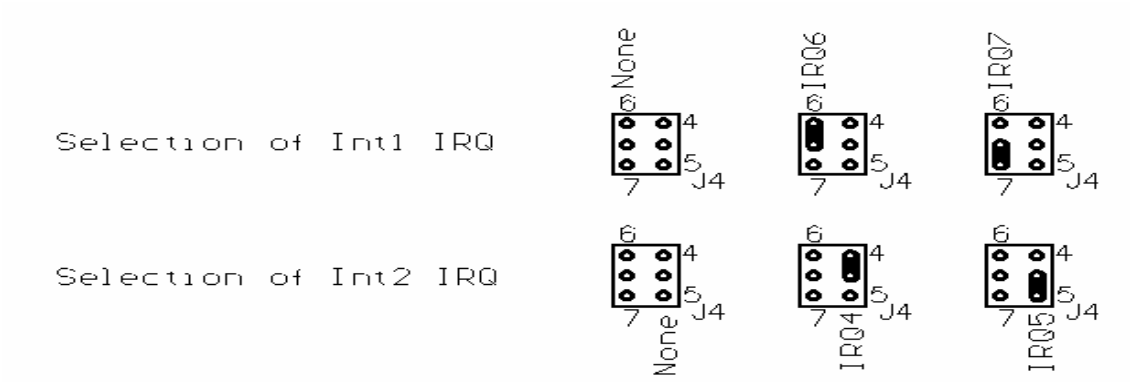


Figure 2-2, Interrupt IRQ Selection

2.8 Power Management Controller PM104 (optional)

The Power Management Controller (PM104) is a microcontroller "plug-in" module for timed on-off control of the HE104, control of the optional battery charger and generation of interrupts to the PC/104 host CPU. The PM104 is programmed in a high level "controller basic language" called Pbasic. To program the PM104, connect the program cable (PM104-Cable) to connector CN4 on the HE104 and to the parallel port of any PC compatible computer. PM104 programs can be directly downloaded or updated using the PM104 utility software.

Connector CN4 Pinout, PM104 Program Connector:

-Terminal 1: PM104 Power (leave disconnected if HE104 powered)
-Terminal 2: Common, connect to pin 25 of PC parallel port.
-Terminal 3: PC0, connect to pin 11 (busy) of PC parallel port.
-Terminal 4: PCI, connect to pin 2 (DO) of PC parallel port.

Table 2.1 PM104 Pin Number and I/O Functions

IC3 PIN#	PM104 Microcontroller Description (IC3)	HE104 Function or Connection	Battery Charger Function
1	PM104 Supply Voltage	HE104 Supply Voltage	
2	Common	Common	
3	PC0 (PC out)	Connector CN4-3	
4	PCI (Pc in)	Connector CN4-4	
5	plus5V input/output	No connection	
6	Reset	No connection	
7	P0 (Input/Output Pin 0)	Input Voltage Status	
8	P1 (Input/Output Pin 1)	HE104 On/Off Control	HE104 On/Off control
9	P2 (Input/Output Pin 2)	Connector CN6-8	Analog/Digital Chip Select
10	P3 (Input/Output Pin 3)*	Int2, Connector CN6-7*	Spare* Input/Output
11	P4 (Input/Output Pin 4)	Connector CN6-6	Data Input/Output Line
12	P5 (Input/Output Pin 5)	Connector CN605	Data Clock
13	P6 (Input/Output Pin 6)*	Int1, Connector CN6-4*	Spare* Input/Output
14	P7 (Input/Output Pin 7)	Connector CN6-3	Analog Current Limit

*If Interrupt function is not used, this PM104 line can be used for general purpose Input/Output.

2.9 Low Input Alarm

This output signals the Power Management circuit (PM104) or external circuitry that main input power has failed. The Low Input Alarm signal has a 100K current limiting resistor in a series.

If the PM104 is not installed, then external circuitry can access the Low Input Alarm output on connector IC3-7.

2.10 HE104 Efficiency and Heat Dissipation Calculation

The average efficiency for the +5V output of the HE104 is 90 percent. The efficiency, however, at any specific input voltage, output load and ambient temperature many be higher or lower. Typical efficiency is between 88 and 94 percent. Best efficiency occurs at mid input voltage ranging from16 to 18V, mid output loads are from 20 to 30 watts and a low heat sink temperature. The input voltage and output load is determined by the system application. This leaves only the heat sink temperature that System Intergrators adjust to maximize efficiency. Either the forced flow fans, which thermally couples the HE104 heat sink to enclosures or external heat sinks can improve the efficiency of the HE104. An improvement of 3 to 4 percent, can be obtained by good thermal management in which the results are 35 percent less heat dissipated.

A. Heat Dissipated (HD) = Input Power – Actual Load

   Where Input Power = Input Voltage * Input Current and Actual Load = +5V load +(+12V load) +(-5V load) + (-12V load) (Load measured in watts)

B. Estimated Heat Dissipated (ESD) can be calculated based on 90 percent efficiency:

   EHD = {+5V load + [(+12V load) +(-12V load)]/0.9} * 0.1

C. If the Battery Input option is installed or the Reverse Diode Protection (RDP) option installed additional heat will be dissipated.

   RDPD = Total Load/Input Voltage *0.7V (diode drop)

D. If the Battery Charger Option is installed the heat dissipated from it will vary according to the current charge current. Maximum heat dissipation will occur when charging at maximum current and can be estimated by:

   BCD= Maximum Charge Current * Charge Voltage * 0.2
   (Based on 80 percent efficiency)

CHAPTER 3: THEORY OF OPERATION

3.1 Input power protection

Input power is connected to the screw terminal block, CN1, which is removable from the socket connector on the circuit board. A 10 ampere "pico" fuse F1 limits the current draw from the power source. A series of devices, (toroid coil L3, transorb D4 and filter capacitors, C8A,C8B and C8D) filters and clamps the input power.

Transorb D4 is a 5KVA, heavy-duty, transient suppressor. Transorb D4 provides "zener" type protection and has an avalanche voltage of 43V. It is electrically located before fuse F1 to prevent activation of the fuse during a "load dump" or large transient. Sustained voltages greater than the avalanche voltage must not be applied or transorb D4 will fail.

3.2 Switching Regulator, +5VDC

A switching regulator IC1, generates the +5VDC output, which operates in a "buck" mode synchronous switching regulator configuration. It does this by using inductor coil L1, upper mosfet Q4, lower mosfet Q5, schottky diode D8, input filter capacitors C8A, C8B, C8C, C8D and output filter capacitors C2, C3, C9A, C9B and C9C. Regulator IC1, is a current mode controller that adjusts the "switching cycle" by the sensed current, instead of directly by the output voltage sensing error amplifier, in regulator IC1. This further sets the current trip level. Operating frequency is set by capacitor C5.

A total of 15 amperes can be supplied to the connected +5VDC load and +12VDC regulator, the –5VDC, -12VDC charge pumps and the invertors. The +5VDC power is available on the PC/104 expansion bus and screw terminal connector CN2.

At start-up, a low dropout 4.5V source located in regulator IC1, provides the operating voltage Vcc for the mosfets and control circuitry. After start-up, regulator IC1, is in a sleep mode whenever the output level is within the burst mode voltage limits. As soon as the +5VDC output drops below the burst low-level voltage, normal switching regulator operation begins and continues until the +5VDC output reaches the upper burst level voltage. Then regulator IC1 is put into sleep mode again. When low quiescent power mode is enabled, regulator IC1 burst mode operation will begin at approximately 1.5 ampere output. The output ripple when regulator IC1 is operating in burst mode, is 50millivolts.

The +5VDC regulator functions fully down to 6VDC input. Below 6VDC input, the +5VDC output will track the input and have a drop proportional to the resistive losses on the HE104. The HE104 operates up to 40VDC input.

3.3 Switching regulator, +12VDC

A switching regulator IC2, generates the +12VDC output and operates in a "Boost" mode switching regulator configuration which uses inductor coil L2, mosfet Q7, schottky diode Q6, input filter capacitors C9A, C9B, C9C and output filter capacitors C15A and C15B. Capacitors C9A, C9B and C9C work as an output filter for the +5VDC and as an input filter for the +12VDC regulator IC2. Regulator IC2 is a current mode controller and adjusts the "switching cycle" by the sensed current, rather than directly by the output voltage. Using the output of a voltage sensing error amplifier in regulator IC2 does control the output voltage, which is sensed by resistors R18 and R19. This further sets the current trip level. If a custom output voltage is ordered, variable resistor R21 (in series with R19) will adjust the feedback voltage. Operating frequency is set by capacitor C22.

A total of 2 amperes can be supplied to the connected +12VDC load and the –12VDC invertor. The +12VDC power is available on the PC/104 expansion bus and screw terminal connector CN2.

A low quiescent power mode uses the built-in "Burst" mode feature of the regulator IC2. Low quiescent power mode reduces power by placing regulator IC2 in a sleep mode whenever the output level is within the "Burst" mode voltage limits. As soon as the +12VDC output drops below the burst low-level voltage, normal switching regulator operation begins and continues until the +12VDC output reaches the upper burst level voltage. Then regulator IC2 is put into sleep mode again. When low quiescent power mode is enabled, regulator IC2 "Burst" mode operation will begin at approximately 0.3 ampere output.

Note: Low quiescent power mode should only be selected if absolute minimum current consumption is required. At output currents about 0.3 amperes, low quiescent power mode will not increase efficiency and may result in regulator IC2 jumping into "Burst" mode resulting from noise on the +12VDC output. No harm to IC2 will occur from this, but increased ripple on the +12VDC output will occur.

3.4 Charge Pumps

The –12VDC is generated by first charging capacitor C13 to +12VDC when mosfet Q7 is turned off. Diode, D6, provides a path to common for the charge current. When mosfet, Q7, is turned on, the charge on C13 is transferred to the –12VDC output capacitor, C9, through mosfet, Q10. Mosfet Q10 is synchronized with mosfet, Q7, through a level shifter (C19, D13 and R26)

The –5VDC is generated by a secondary coil on inductor L1. By design, the inductor in a buck regulator will maintain the output voltage across it. The secondary winding, having the same number of turns as the primary, will also have the same output voltage across it. By referencing the positive end of the secondary coil to common, -5V is created. Diode D3 and capacitor C14 improve the regulation. Capacitor C16 provides output filtering. The –5V is rated at 500mA, however for best regulation, the –5V load should be limited to 10 percent of the +5V load.

3.5 Filter Capacitors

At 10kHz and above, the impedance of filter capacitors is essentially their effective series resistance (ESR) and this parasitic resistance limits the filtering effectiveness of the capacitors. The filter capacitors absorb the "switching ripple" current with their 100m0hm ESR that absorbs a 5A ripple current and will dissipate 2.5W of heat.

The capacitors used for filtering in the HE104 are organic semiconductor (OS-CON) capacitors. The OS-CON is an aluminium solid capacitor with organic semi-conductive electrolyte used as cathode conductive materials. The OS-CON has many advantages over the conventional electrolytic:

- Very low ESR values, less than 8 times lower for same package.
- High ripple current rating, over 4 times higher for same package.
- No degrade in operation at extended low temperatures. (ESR value of conventional electrolytics can increase 25 fold at –40C).

The life expectation for a filter capacitor is typically 2,000 to 6,000 hours @ 105C. For a conventional electrolytic capacitor the temperature acceleration coefficient = 2 for a 10C increase, while the OS-CON has a temperature acceleration coefficient = 10 for a 20C increase. For example, a capacitor rated for 2,000 hours @ 105C would have an expected life of:

For conventional electrolytic capacitor
32,000 hours (3.6 years) @ 65C
128,000 hours (14.6 years) @ 45C
For OS-CON capacitor
200,000 hours (22 years) @ 65C
2,000,000 hours (220 years) @ 45C

This means that the OS-CON has extremely longer life in practical use, even under the same warranty of 2,000 hours @ 105C.

In a buck convertor, output ripple voltage is determined by both the inductor value and the output filter capacitor (for continuous mode).

$$Vp\text{–}p = \frac{ESR \bullet Vout \bullet \left(1 - \frac{(Vout)}{Vin}\right)}{L1 \bullet frequency}$$

Note: that only the ESR of the output capacitor is used in the formula. It is assumed that the capacitor is purely resistive at the frequencies about 20kHz. Worst case output ripple is at highest input voltage. Ripple voltage is independent of load (for continuous mode).

Example

Vout = 5V, Vin = 28V, L1 = 55uH, frequency = 50kNz and three 330uF capacitor with 27 mohm ESR in parallel.

$$Vp\text{–}p = \frac{0.009 \bullet 5 \bullet (1 - (\frac{5}{28}))}{55 \bullet 10E6 \bullet 0.5 \bullet 10E5}$$

3.6 Bus Termination (Optional)

AC bus termination is provided by 5 “RC” SOIC packages (3 only for 8-bit PC/104 bus HE 104s), RC1 to RC5 and discrete components C20 and C27. Each RC package contains 16 resistor/capacitor combinations of 47R and 47PF with a common bus connected to the signal ground.

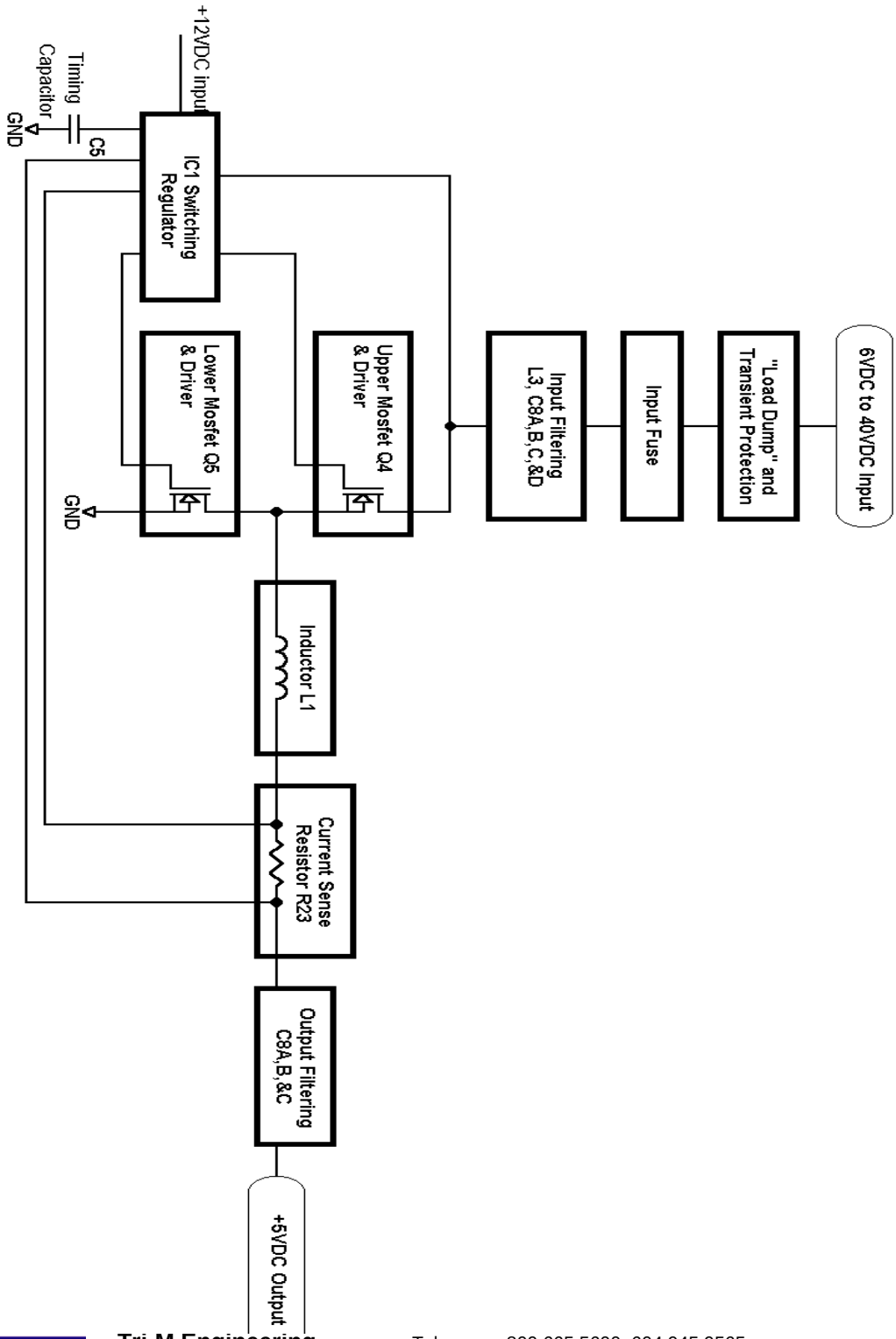
	RC1	RC2	RC3	RC4	RC5
1	GND	GND	GND	GND	GND
2	*SMEMW	IRQ10	*BACK6	SA11	SA3
3	AEN	LA22	SD9	*Refresh	BALE
4	IOCHRDY	IRQ11	DRQ6	SA12	SA4
5	SD0	LA21	*DACK7	DRQ1	IRQ3
6	SD1	LA20	SD11	SA13	SA5
7	SRDY	IRQ15	DRQ7	*DACK1	*DACK2
8	SD2	LA19	SD12	SA14	SA6
9	SD3	LA18	-----	SA15	SA7
10	GND	GND	GND	GND	GND
11	GND	GND	GND	GND	GND
12	SD7	*MEMR	SD15	*IOW	IRQ6
13	SD6	LA17	SD14	SA17	SA9
14	SD5	LA18	SD13	*IOR	IRQ5
15	SD4	IRQ12	SD10	SA16	SA8
16	DRQ2	LA23	SD8	*DACK3	IRQ4
17	SA19	*IOCS16	DRQ5	DRQ3	DA2
18	*SMEMR	*SBHE	*MEMW	IRQ7	SA1
19	SA18	*MEMCS16	*DACK5	SA10	SA0
20	GND	GND	GND	GND	GND

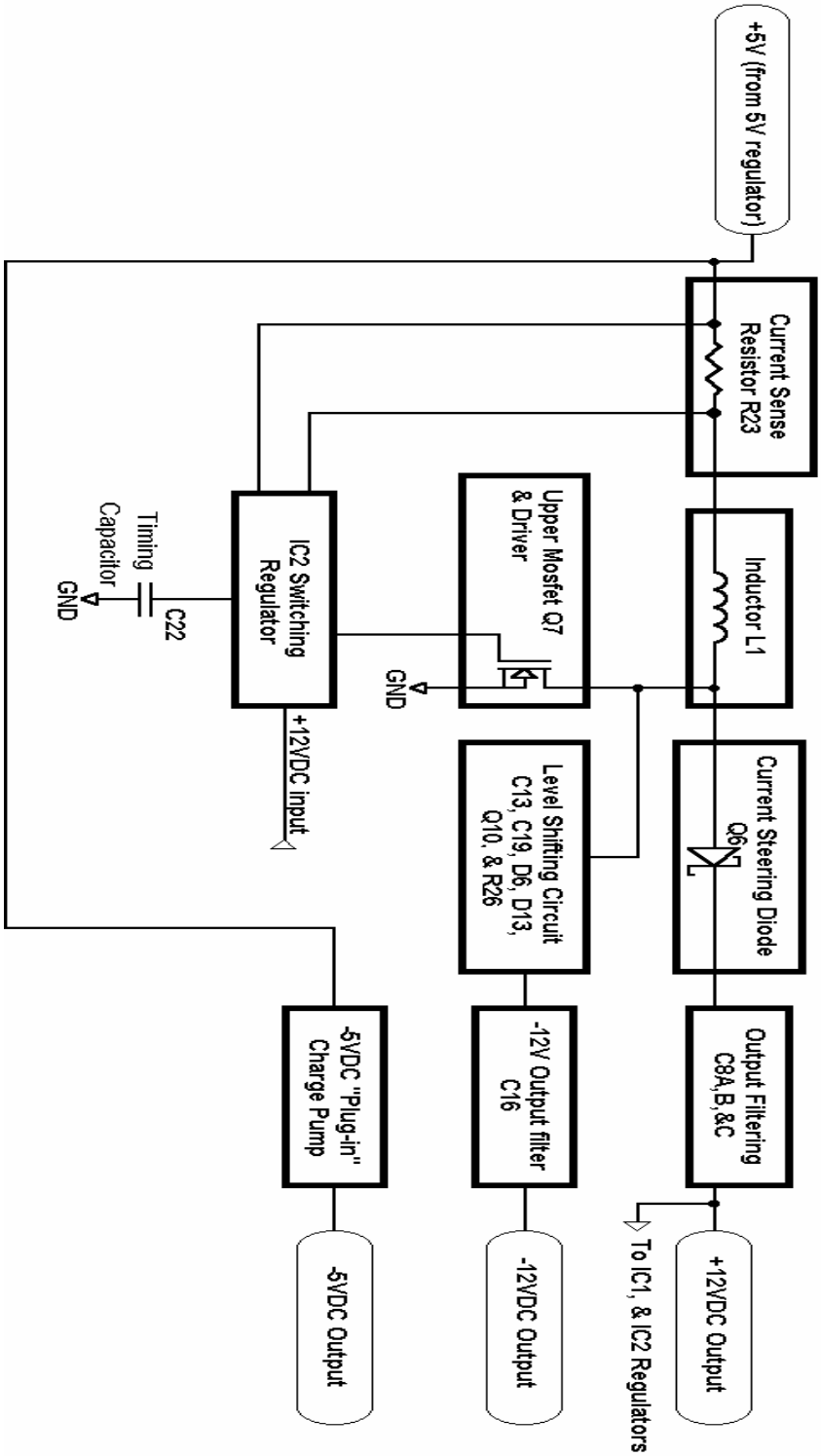
In addition, the following signals are terminated with discrete components.

- TC C1 (330pF)
- Reset C20 (330pF)

APPENDIX 1: HE104, +5V Regulator Block Diagram:

1.1 HE104, +12V, -12V, &-5V Regulator Block Diagram





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APPENDIX 2: ADVANTAGES OF USING AC TERMINATION:

One of the requirements of embedded electronics is low power consumption. One method of reducing power is to reduce the drive current available to power the expansion bus. With over 80 signal lines, any reduction in current load would have a large impact on overall requirements. The PC/104 Consortium Guidelines for the expansion bus specify drive current can be as low as 4mA. Compared with the 24mA for the standard desktop computer, this is an 84 percent reduction in the drive current available.

This disadvantage to reducing drive current is the increasing possibility for noise to infiltrate the bus. The symptoms of noise-induced problems are often flaky or unreliable operation. Systems suffering from noisy busses are often difficult to diagnose and solve. Programmers blame the hardware engineers and the hardware engineers blame the software programmers.

With reduced drive currents, more attention must be paid to reducing the noise levels on the PC/104 bus. One frequently used method is bus terminators. Testing has proven the best way to terminate the PC/104 bus is to use AC terminators instead of resistive terminators. This is the recommended termination method for Ampro CPU products. The IEEE P996 PC Bus Standard recommends the AC bus terminating technique.

The use of AC terminators had several advantages over DC terminators:

- **Reduced power consumption:** DC terminators are typically in the 330 ohm to 1K ohm range and draw heavy currents. This is significant when terminating the over 80 signals on the PC/104 bus. AC terminators draw current only during the few nanoseconds when the bus signal is changing state, resulting in negligible current drain.
- **Improved bus reliability:** DC terminators invariably increase the voltage level of the logic zero state. This decreases noise immunity, making it more likely that a zero will be seen as a one. AC terminators do not cause this shift, resulting in a more reliable bus.
- **Reduced crosstalk:** AC terminators roll off the signal transitions on the bus. The result is a quieter bus, which has fewer high frequency effects such as crosstalk to other bus lines.
- **Reduced EMI:** Busses with AC termination tend to generate less EMI than resistively terminated buses due to the reduction in high frequency components of signal transitions.

APPENDIX 3: Installation Hints for the HE104 Power Supply:

1. To minimize noise induced into the power supply, connect the HE104 power supply direct to the power supply source (battery) with “dedicated” wires. This makes use of the vehicle battery as a filter.

2. Always use large gauge hook-up wires to connect the HE104 power supply to the vehicle power source (battery). This minimizes any voltage drop caused by the resistance of the wire. Use minimum of AWG #16 for lengths less than 10 feet and AWG #14 for longer lengths.

3. Wherever possible, install the HE104 power supply on to the top of the HE104 card stack. This will allow better dissipation of heat from the heat sink. If additional cooling is required, use either forced air ventilation or mount the PC/104 power supply so that the heat sink can dissipate heat to the enclosure.

APPENDIX 4: Vehicles Are An Electronics Nightmare:

Under the hood of a vehicle is an electronics nightmare. EMI spraying and RFI sparking is everywhere and electrical transients run amuck, zapping the embedded electronics. Electronics located in that environment must withstand 600V transients and “load dump” situations. Although the automotive market is growing about 2 percent yearly, the amount of electronics being introduced into vehicles is much higher. The electronics on a vehicle are no longer just the radio and engine computer, but cellular phones, portable computers, faxes, smart navigation with Global Positioning Receiver and car alarm systems.

The infamous “load dump” is an energy surge resulting from disconnecting the battery while being charged. The alternator, with a finite response time of 40msec to 400msec, generates power with nowhere to go. Thus an energy surge is formed; much like a tidal wave that builds to an enormous height as it crashes the beach. The resultant over voltage is the most formidable transient encountered in the automotive environment and is an exponentially decaying positive voltage. The actual amplitude depends on alternator speed, the level of alternator field excitation and can exceed 100V.

Each electronic component had its own power supply and it is the power supplies that must absorb the transients and energy surges. What makes one transient more dangerous than another transient is not the voltage level, but the amount of energy it carries. A600V, 1msec transient had much less energy than a 100V, 400msec surge. Regardless of the source, all over voltages must be clamped and prevented from passing through to the rest of the electronics.

There are a number of methods for clamping over voltages, but the most efficient and cost effective is to shunt the current to ground using a surge suppressor. The surge suppressor relies on the vehicle’s wiring and alternator impedance as the current limit and it remains in a high impedance state until an over voltage condition occurs. Standard devices such as transorbs

(P6KE or 1.5KE) will not survive the high-energy discharge of a "load dump". Special automotive suppressors must be used to use up the 20A to 30A peak currents being shunted. Several manufacturers, such as Motorola, Harris and Seimens, manufacture suppressors specifically for automotive applications. Some devices provide "zener diode" style protection, while others provide "back to back zener diode" bidirectional protection. Each type has advantages, but unless they are used correctly, they will fail to protect the electronics. Ratings on the transient suppressors can be confusing. A suppressor with an avalanche voltage of 24V to 32V will have a clamp off voltage of over 40V. In addition, ambient temperature can vary from –40C to 70C and can result in the avalanche voltage being several volts lower at –40C and a clampoff several volts higher at 70C.

Not all vehicles have 12V battery systems. Some trucks use 24V batteries, aircraft use 28V and trains from 45V to 85V. Transient suppressors for aircraft cannot use the 12V system automotive components. Instead, a suppressor with an avalanche rating of 35V is needed to allow for low ambient temperature compensation, but this results in clamp off of over 70V. Tri-M Engineering's High Efficiency PC/104 Vehicle Power Supply, employs a Diode Inc. (part#5KP43A), allowing an input voltage range of 6V to 40V. If a high clamp off voltage cannot be tolerated, other techniques must be used. A series device such as a MOSFET can act as a pre-regulator, but it also must be selected to withstand transients. In addition a series device adds to in-efficiency and creates a heat dissipation problem, especially at high ambients.

"Load dumps" occur infrequently in a vehicle's lifetime, but any electronics wishing to survive in this environment must be designed to withstand the assaults. "Load dumps" co-operate slightly through, their worst-case voltage does not typically occur with worst-case source impedance. In fact, although the total energy of a "load dump" may be 500 joules, a transient suppressor capable of 70 joules typically will be adequate because of the distributed electronics in the vehicles. That is, provided the suppressor ratings are the same or larger than other suppressors throughout the vehicle. A quick thinking engineer can take advantage of this and design his power supply to withstand higher voltages and thus let others' transient suppressors do the work.

APPENDIX 5

BC104 Battery Charger and PM104 Power Management Units

1) Description

When the BC104 and PM104 units are both installed on either the V104 or HE104 (hereafter referred to as PSU), as universal battery charger can be setup and the PSU unit made into an UPS (uninterruptible power supply).

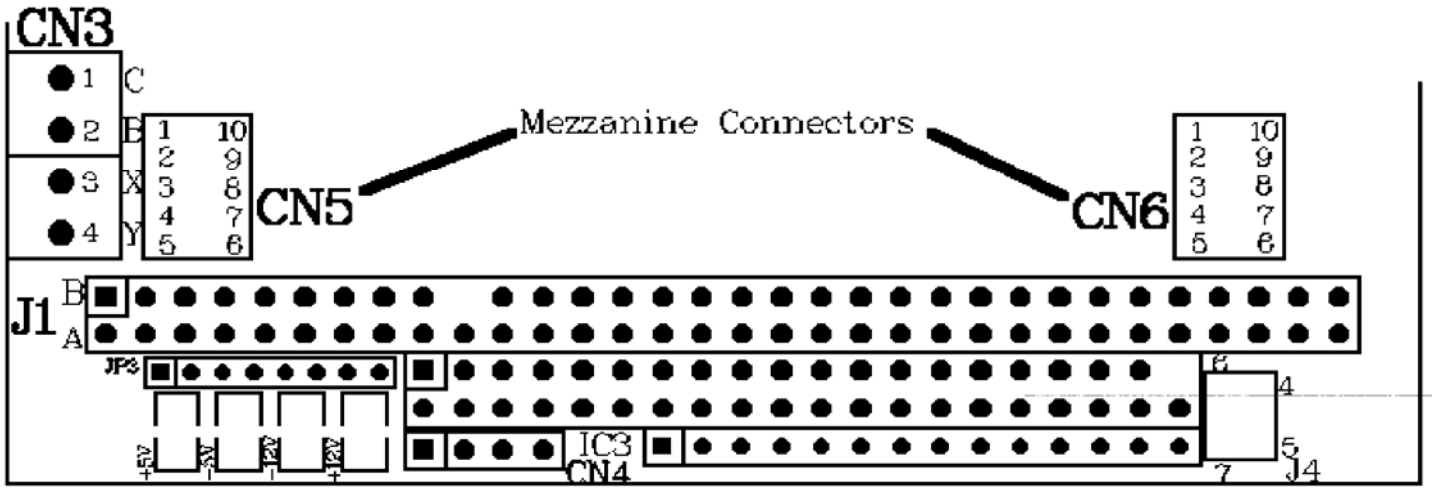
The BC104 is a constant current "buck" switching regulator with an adjustable "float" voltage. The float voltage is adjusted via a potentiometer. The PM104 is programmed by the user using a "control basic" called Pbasic. A sample program is supplied to show a typical NiCd charging control. Before using the BC104 and the PM104 the battery charging program must be set up for the intended battery pack. The sample program has separate settings for normal charge current and trickle charge current. In addition, the charge termination methods should be set, including

maximum charge time, negative delta V. The user must set these for the type and size of battery to be charged. Typically charge currents will be 1/3 to 1/6 of battery capacity and trickly charge current 1/20 to 1/30 of battery capacity. Addition of a battery temperature sensor will allow charge termination when elevated battery temperatures (which indicates battery is fully charged).

The PM104 can be programmed for many additional features not included in the sample program. Features such as setting a PC/104 bus interrupt when main power fails, stopping the PSU after running on battery backup power for a set time, tracking power consumption so that backup battery charging can be terminated when same amount restored to the battery. These features are left to the OEM integrate into their design.

2. Connections:

The BC104 is mounted on two connectors under the PSU heatsink, CN5 and CN6. The PM104 is factory installed directly in front of the PC/104 bus, location IC3. Connector CN4 is for connection to a PC parallel port for programming. Batteries are connected to the screw terminal block, CN3. The PSU accepts DC battery voltages



in the range of 6.5 to 20VDC through the Battery Power Connector CN3. Two external signals can be connected to the battery terminal block for use by add-on modules plugged into the mezzanine header connectors. Connect to the HE104 Battery Terminal Block as follows:

- Terminal 1: Common of battery
- Terminal 2: Positive Battery Terminal
- Terminal 3: External signal 1, normally connected to terminal 2
- Terminal 4: External signal 2, 0 to 40V input

The two external signals are fed into the 12 bit analog to digital convertor and will accept voltages up to 40V. The sample program requires the External signal 1 (Terminal 3) be connected to Positive Battery voltage (Terminal 2) for battery voltage sensing.

A variety of temperature sensors can be connected including thermistors and conditioned sensors such as LM35s. The LM35 series is particularly nice because their output voltage is directly proportional to temperature (ie 10mV/C or 10mV/F). In any case, the OEM can "experiment" to determine what works best in their application.

3. Programming Cable:

The programming cable is plugged into the connector CN4 on the PSU and the other end into the 25pin DB parallel port connector on a PC. The programming cable has the following connections:

CN4-1	No connection
CN4-2	Connect to pin 25 on parallel port
CN4-3	Connect to pin 11 parallel port
CN4-4	Connect to pin 2 parallel port

4. Download and Edit Software:

All programs for the PM104 are written in a "Control Basic" program language and are saved into an ASCII file with a "BAS" extension. Any text editor can be used to create, edit and save these programs. The Download program called "Stamp.exe" also has simple editing capabilities.

After the program cable is connected between the PSU and the parallel port, the PSU unit can be turned on, thus providing power to the PM104 unit. The Download program Stamp. Exe is started by typing from DOS, STAMP.EXE. The program to be downloaded is opened by pressing the keys "ALT" and "L" simultaneously. Using the arrow keys select the desired file and press ENTER key. To download the program press the keys "ALT" and "R" simultaneously. If the cable is properly connected and power applied the screen will show a horizontal bar graph indicating the percent of program downloaded. The red area of the bar graph is the portion used and the remainder is program space available.

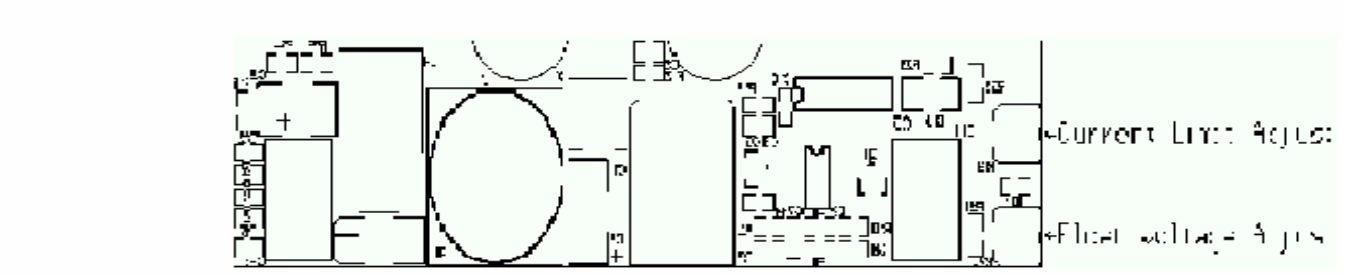
5. Program Command and Syntax:

Please refer to the Adobe files BSBOOK1.PDF and BSBOOK2.PDF.

6. Adjusting the BC104 Float Limits:

When a PC/104 power supply is equipped with a BC104 and a PM104 the BC104 has a Float Voltage Adjust potentiometer. However, the Current Limit Adjust potentiometer is not installed and is controlled via the PM104.

Using a small screwdriver (flexible nylon works best), turn the potentiometer until the desired float voltage is obtained. No load should be present when adjusting.



7. Sample Battery Charging Program Listing

The following program listing is intended for use as a guide to customizing the BC104 and PM104 operation. Additional functions and features can be added including temperature monitoring are left up to the OEM to implement.

BC104, Battery Charger Sample program code

```
SYMBOL  Pwr_Status = 0                  ' Status of input power
SYMBOL  Pwrp_Status =pin0               ' Pin number of status of input power
SYMBOL  PSU_On/Off = 1                  'OnOff control of power supply
SYMBOL  PSUp_OnOff = pin1
SYMBOL  CS1 = 2                         ' Chip select A/D on Battery Charger; 0=active
SYMBOL  CS1p = pin2
SYMBOL  Int2 = 3                        ' PC/104 bus interrupt
SYMBOL  Int2p = pin3
SYMBOL  DIO = 4                         ' Pin_number_of data input/output.
SYMBOL  DIOp = pin4                     ' Variable_name_of date input/output.
SYMBOL  CLK = 5                         ' Clock to ADC; out on rising, in on falling edge.
SYMBOL  CLKp = pin5
SYMBOL  Int1 = 6                        ' PC/104 bus interrupt
SYMBOL  Intp = pin6
SYMBOL  Chrg_Limit = 7                  ' PWM output for current limit
SYMBOL  Chrgp_Limit = pin7

SYMBOL Bat_Set = bit1
SYMBOL Adbits = b1                      ' Counter variable for serial bit reception.
SYMBOL Bat1_Chrg = bit1
SYMBOL D0 = bit2                        ' LSB of ADC channel selection
SYMBOL D1 = bit3                        ' second bit of ADC channel selection
```

```
‘D1 = 0, D0 = 0 channel 0 input, pin3 of connector CN3
‘D1 = 0, D0 = 1 channel 1 input, pin4 of connector CN3

                                        ‘1. on max cell voltage
                                        ‘2. on time
                                        ‘3. –ve delta V
                                        ‘4. cell temperature

next TCnt
let D1 = 0
let D0 = 0
gosub Convert                           ‘Get battery charging voltage
let Batt_V =AD
‘debud “charge”
if AD> BattV_Max then Batt_Chrg_Term
Chrg_Time = Chrg_Time + 1
If Chrg_Time > Chrg_Time_Max then Batt_Chrg_Term  ‘Used maximum charge time
If AD < Batt_Peak then Batt_DeltaV
Let AD =AD +Neg_DeltaV
If AD <Batt_Peak then Batt_Chrg_Term    ‘Detected negative deltaV in battery pack
**Insert battery pack temperature code here**
goto Chrg_Lp                            ‘Continue until charging terminated

Batt_Chrg_Term:
PWM Chrg_ Limit, 0.50                   ‘turn off charge current
Let Bat1_Chrg = 1                       ‘Indicate battery has been charged
Goto Main_Batt1
```

Convert:

ADC Interface Pins

-The LTC 1594 uses a four-pin interface, consisting of chip-select, clock data input and data output. In this application, we tie the data lines together and connect to the PM104 pin designated DIO. Here’s where the conversion occurs. The PM104 first sends the setup bits to the LTC1594, then clocks in two bits followed by (sample time), one null bit (a dummy bit that always reads 0, followed by the conversion data.

```
High CS1                    ‘ Deactivate the ADC to begin
High CLK                    ‘ Clock data on rising edge, so start with CLK high
High Dio
Pulsout CLK.2
Low DIO
Pulsout CLK.2
Let DIOp = D1               ‘next bit of command
Pulseout CLK.2
```

```
Let DIOp =D0                    'next bit of command
Pulsout CLK.2                   'Activate the LTC1594
Low CS1                         'Get ready for input from LTC 1594

Input DIO

Pulsout CLK.2                   'Dummy statement for delay
Input DIO                           'Sampling requires two clocks
Pulsout CLK.2
Let AD = 0                          'Clear old ADC result.
For Adbits = 1 to 13                'Get null bit + 12 data bits.
Pulsout CLK.2                       'Clock next data bit in.
Let AD = AD*2 +DIOp                 'Shift AD left, add new data bit.
Next Adbits                         'Get next data bit.
High CS1                            'Turn off the ADC
Return                              'Return to program.
```

'D1 = 1, D0 = 0 channel 2 input, monitors input voltage of battery regulator
'D1 = 1, D0 =1 channel 3 input, monitors battery charging current

'Note: channel 0 is usually jumpered to CN3 term2 for monitoring battery voltage
'Note: channel 2 tracks main power input when greater than battery voltage
'Note: channel 2 approx. 0.6V less than battery voltage when main input less than battery voltage.

```
SYMBOL AD = w1                  '12-bit ADC conversion result
SYMBOL  Chrg Time = w2          '16-bit timer
SYMBOL  Batt_Peak = w3           'Peak voltage detected
SYMBOL TCnt =b8
SYMBOL Batt_V = w5
SYMBOL sglDif = 1               'Single-ended, two-channel mode.
SYMBOL msbf = 1                 'Output 0s after data transfer is complete.
SYMBOL AO1_LVL = 5              'Maximum current level (50 = 1A 75 = 1.5A)
SYMBOL BattV_Max = 1100         'Maximum battery pack charge voltage
SYMBOL Chrg_Time_Max =10800     'Maximum battery charging time (10,800 = 3hr.)

SYMBOL Neg_DeltaV = 8           'AD convertor points for –deltaV (74pt/V IE
                                '0.2V=18pts).
SYMBOL Trickle_LVL = 0          'Trickle Charge Level (12 =.25A) See below:
SYMBOL  BattV_Min = 740          'Minimum battery voltage (10V)
```

Main Loop

Init:

```
Low PSU_OnOff                   'Turn PSU on
```

```
Let Bat1_chrg = 0
Main_Batt1:
Low PSU_OnOff                    'Just making sure PSU stays on!
If Bat1_Chrg = 1 then Batt_Trickle   'is battery already charged?
Goto Bat_Chrg


Batt_Trickle:
'debug "trickle"
gosub Chk_Pwr
let D1 = 0
let D0 =0
gosub Convert                    'Get battery charging voltage
let Batt_V =AD
PWM Chrg_Limit, Trickle_LVL, 1000   'Turn on Trickle current
Low Chrg_Limit                   'Trickle to minimum current
Goto Main_Batt1

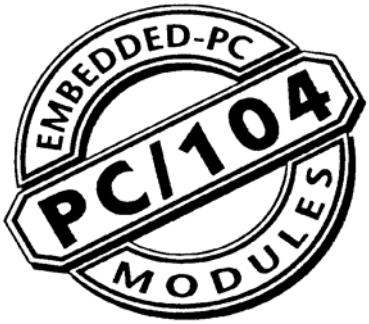
Chk_Pwr:
Let D1 = 1
Let D0 = 0
Gosub Convert
'debug AD, Batt_V                'Get battery charging voltage
if AD < Batt_V then No_ Power
return


No_Power:
'debug "no_pwr"
pause 50
let Bat1_Chrg = 0                'Indicate battery has been discharged
PWM Chrg_Limit, 0.50             'turn off charge current
Goto Main_Batt1

Battery Charger Program

Batt_Chrg:
Let Chrg_Time = 0                'Initialize charge timer (counts in sec.)
Chrg_Lp:
Gosub Chk_Pwr
For TCnt= 0 to 1
PWM Chrg_Limit,A01_LVL,1000      'first apply charge current then
                                 'check for charge termination
```

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