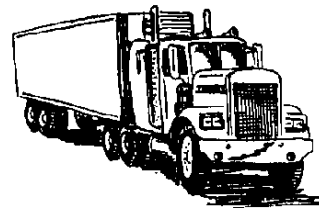
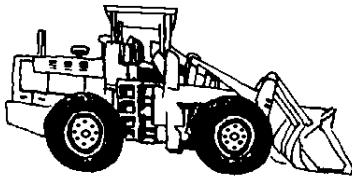


PC/104 Vehicle Power Supply

DC to DC Converter
Manufactured by
TRI-M ENGINEERING

Engineered Solutions for Embedded Applications



Technical Manual

P/N: V104MAN-V6
Revision: 18 May 2004



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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 V104 multiple output DC to DC 25 watt converter is a versatile, “bullet-proof” unit that can be supplied with as a +5V, outputs only or can include features such as Power Management, Universal Battery Charger, AC Bus termination, +12V output, -5V output, -12V output and custom output voltages from -42V to +42V. The V104, designed for embedded PC/104 computer systems, has a wide input range of 8 to 30V (>6:1) and is ideal for battery or unregulated input applications or low voltage AC inputs. The V104 is specifically designed for vehicular applications. It has heavy-duty transient suppressors (5000W) that clamp the input voltage to safe levels, while maintaining normal power operation. Battery, DC and AC input configurations from 8 to 30V are all handled by the V104 automatically.

The V104 is a “simple switcher” based design that provides outstanding line and load regulation with efficiencies up to 80 percent. Organic Semi conductor capacitors provide filtering that reduces ripple noises below 30mV. The low noise design makes the V104 ideal for applications 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 and therefore can operate without dropout from 8 to 30V input and supply 1A.

A “plug-in” Universal Battery Charger (UBC104) is available for the V104 to charge Lead-Acid, NiCd and NiMH batteries. Charge currents can be up to 1.5A and battery charging voltages from 6 to 40V.

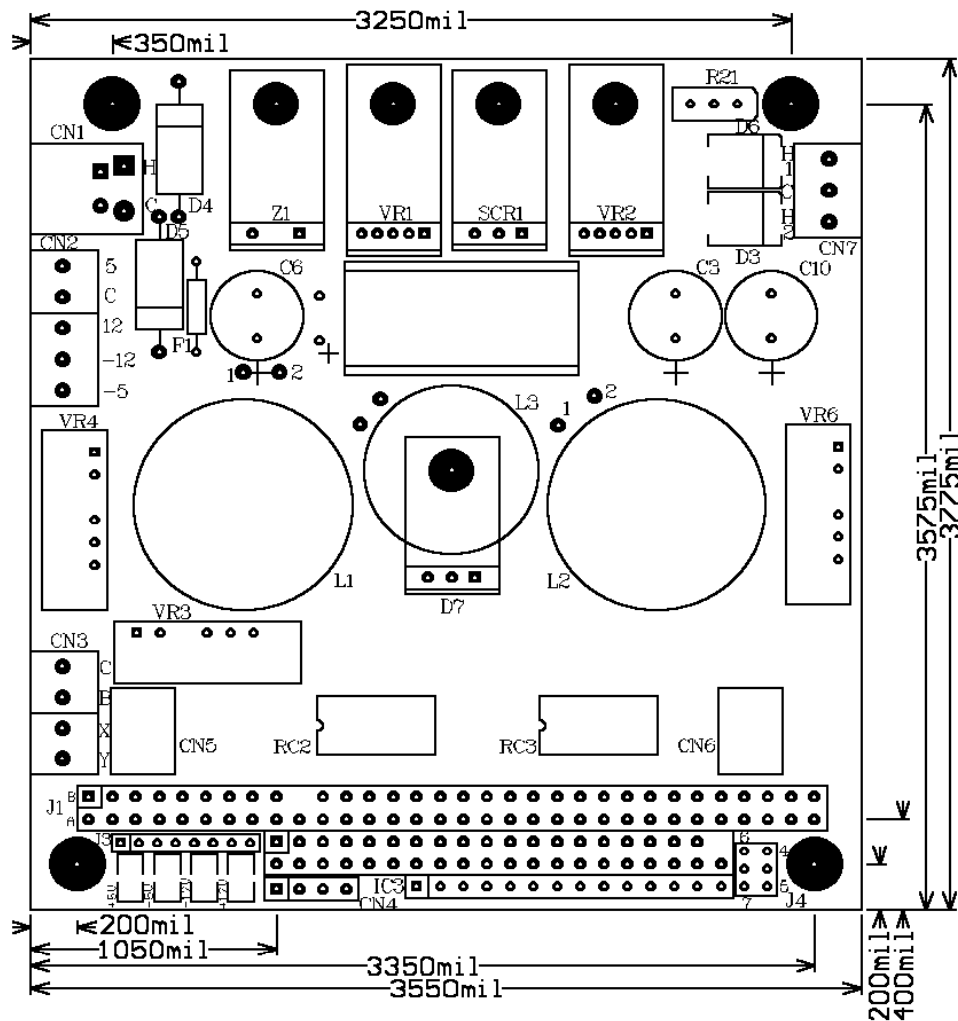
The Power Management controller (PM104) allows timed on/off control of the V104, bus interrupts on impending power failure, current limit setting and intelligent charge termination for the UBC104.

The V104 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 all also available for off-board use through a screw terminal block. PC/104 AC bus termination is optionally available on the V104, which provides the cleanest possible signals on the PC/104 bus.

The V104 can be configured to meet almost any power supply need for embedded PC/104 applications, whether that be a simple +5V application, providing power 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 8VDC to 30VDC input.
- "Stacks" onto the PC/104 bus.
- Passthrough or non-passthrough 8 bit and 16 bit versions.
- +5V standard, +12V, -12V, -5V and battery charger optional.
- Highly compact, 100 percent PC/104 conforming.
- AC bus termination available.
- Screw terminals blocks for off-board connection to outputs.
- Remote "logic level" on/off control.



1.3 SPECIFICATIONS

Power Supply Specifications	
Model	V104
5V output*	5A
12V output	1A
-5V output	400mA
-12V output	160mA
Input Voltage Range	8 to 30V
Load Regulation **	<30mV
Line Regulation **	+ 40mV
Output temp. drift **	<10mV
Switching Freq.	100kHz
Output Ripple**	<40mV
Conducted Susceptibility**	>57db
Efficiency**	Up to 85%
Temp Range	0 to 70C
Quiescent current***	22mA
Weight	150 grams
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.

****Not including passthrough pins.

CHAPTER 2 – CONFIGURATION AND INSTALLATION

2.1 Introduction

This chapter describes the configuration and installation of the V104 power supply. In addition, section 2.2 provides a formula to calculate the available +5VDC. Figure 2-1 shows the V104 connectors, jumper and other options.

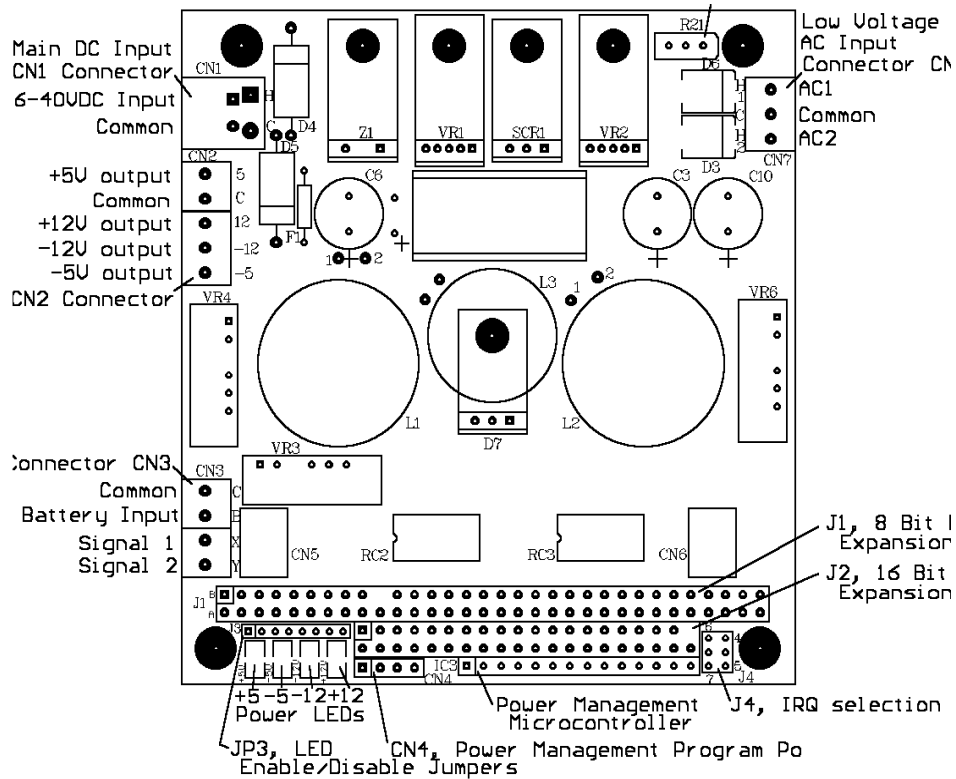


Figure 2-1, V104 Connector and Jumpers

2.2 Power Considerations

The +5V switching regulator is rated at 5A maximum output however, the +5V output supplies power to the +12, -5 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.

$$\text{Usable +5VDC output} = 5A - (I[-5] + I[12] * 2.4) / 0.80$$

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

Assuming 80 percent convertor efficiency (actual efficiency may vary).

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 8VDC to 30VDC.

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 (8VDC) and for the best efficiency, **there is NO input reverse-polarity diode provided on the V104 main DC input connector.** If reverse-polarity protection is required, connect to the AC input connector. See section 2.3.2

2.3.2 AC Input Power Connector (Optional)

Low voltage AC is connected to the V104 on screw terminal block, CN7. The V104 accepts AC power in the range of 6 to 20 volts however, 12 to 16 volts RMS is the recommended range. The input capacitor on the V104 is 1000uF and is adequate for low power applications drawing 1 amp, connect an additional 1000uF capacitor to connector CN1 (terminal 1, positive, terminal 2 negative).

2.3.3 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 output (optional)
- Terminal 4: -12VDC output (optional)
- Terminal 5: -5VDC output (optional)

2.3.4 Battery Power Connector (Optional)

The batteries are connected to the screw terminal block, CN3. The V104 accepts DC battery voltages in the range of 6.5V to 40VDC 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 V104 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 2.3.5

2.3.5 Onboard DC “Boost” Convertor (Optional)

Three optional convertor “boost” pumps (model NMH05XXS, XX = output voltage, $\pm 5V$, $\pm 9V$, $\pm 12V$, $\pm 15V$) can be installed on the V104. The NMH charge pumps have a maximum 2 watt capacity, but require a minimum load of 10 percent for proper operation.

The $-5V$ output is generated by installing a NMH0505S in location VR4 and adding capacitor C7. The $-5V$ output is available on the PC/104 bus (B-7) and on connector block CN2, terminal 4.

The third optional convertor is used for generating custom voltages, which is installed in location VR3 and adding capacitors C4 and C8. The NMH charge pumps have an isolated positive and negative output. By referencing (connecting) the charge pump to other voltages, the user can create +/- supplies, elevated and negative voltages (ie. The charge pump “0V” is not connected to the V104 common).

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

Example: NMH0515S ($\pm 15V$) can generate the following voltages:

- +15V by connecting NMH "0V" to V104 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, while improving the reliability of the bus. The resistor/ capacitor combination only conducts current during the few nanoseconds when the bus signal is changing state.

2.5 Installation onto PC/104

The PC/104 bus on the V104 is keyed according to the standards as set out by the PC/104 Consortium Guidelines. Male Pin B10 of the 8-bit bus and male pin C20 of the 16-bit bus are removed but the female sockets are not "plugged".

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 the pins or hurting the person separating the modules. Tri-M Engineering recommends the use of the PC/104 removal tool (model #5535), available from Tri-M Engineering.

2.6.1 LED Jumper Enable/Disable

These jumpers allow the LEDs to be disabled. This is most likely to be used when absolute minimum power consumption must be maintained, such as when operating off a limited battery source.

The location of each LED jumper is immediately behind each LED.

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 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.

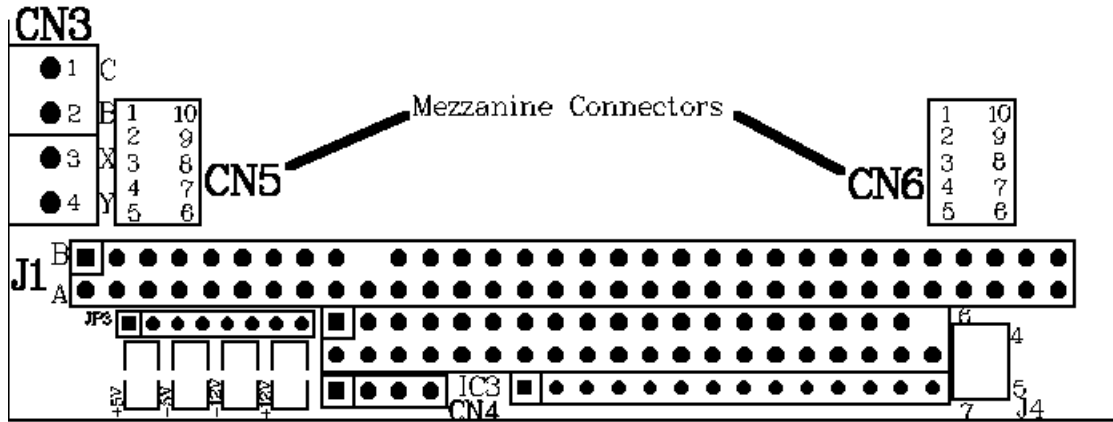


Figure 2.3, V104 Mezzanine Connectors

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	8. PM104-P4

2.6.3 PC/104 Bus Interrupts (Optional)

Interrupts to the PC/104 bus require the installation of the optional power management microcontroller (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 Int2 can be set to IRQ4 or IRQ5 by installing a appropriate jumper on jumper selections block J4. Jumper block J4 is located adjacent to the PC/104 bus, on the opposite end where the power LEDs are located.

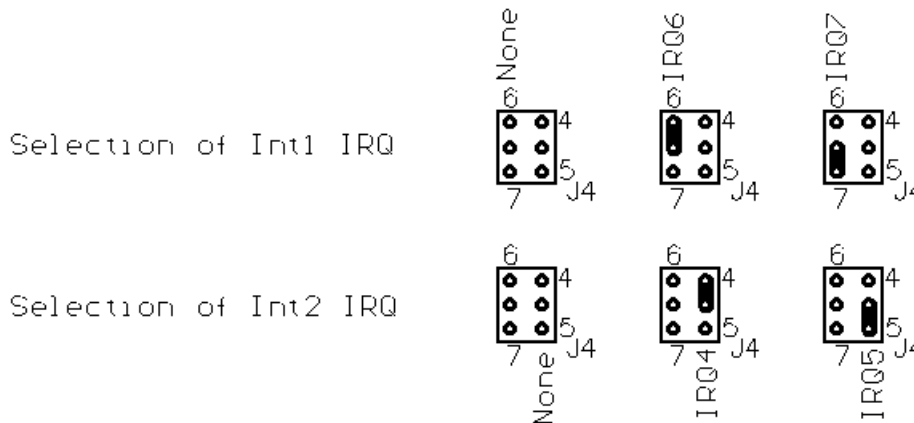


Figure 2-2, Interrupt IRQ Selection

2.7 Remote On/Off (Optional)

This input allows the V104 to be remotely turned on or off by a low power logic level signal. An ideal use of this feature is allow the PC/104 host computer to shutdown before power is removed. A simple timer triggered when the ignition is turned off tells the V104 to turn off but only after timing is out. In the meantime, the ignition signal (which is buffered) connected to the PC/104 host computer would give it time to properly shut down any programs that were running.

If the power management microcontroller PM104 is installed, it can be used to generate a PC/104 bus interrupt the PC/104 CPU to shut down running programs, power down the V104 after a preset time.

Example:

- Connect the ignition signal (through a 10K resistor with a transient 24V suppressors to ground) to CN6 pin 8. Use of Int2 is not permitted if CN6 pin 8. Use of Int2 is not permitted if CN6 pin 8 is used as an I/O pin.
- Set Int1 to either IRQ6 or IRQ7 to shut down program operation when activated.
- Program PM104 to initiate bus interrupt when alarm situation detected.

The maximum voltage input level for the Remote On/Off input is 7VDC. No transient protection is provided on this input to the V104, therefore ensure adequate signal level clamping is provided on the connected signal. The Remote On/Off threshold voltage is 2VDC.

The Remote On/Off input can be accessed on connector CN6-1 or IC3-9 if PM104 is not installed.

2.8 V104 Efficiency and Heat Dissipation Calculation

The typical efficiency of the V104 is 80 percent for the +5V output, but efficiency at any specific input voltage, output load and ambient temperature may be higher or lower. Typical efficiency is between 70 and 85 percent. Best efficiency occurs at mid input voltage (16 to 18V), mid output loads (10 to 18 watts) and low heat sink temperature. As the input voltage and output load is determined by the system application, this leaves only the heat sink temperature that System Integrators adjust to maximize efficiency. Either forced flow fans or thermally coupling the V104 heat sink to enclosures or external heat sinks can improve the efficiency of the V104. Good thermal management can obtain an improvement of 3 to 4 percent. The results are that 35 percent less heat is dissipated.

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

Where Input Power = Input Voltage * Input Current

And Actual Load = +5V +(12V load) + (-5V load) + (-12V load)
(load measured in watts).

B) Estimated Heat Dissipated (ESD) can be calculated based on 80 percent efficiency:

$$EHD = \{+ 5V \text{ load} + [(+12V \text{ load}) + (-5V \text{ load}) + (-12V \text{ load})]/0.8\} * 0.2$$

C) If the Battery Input option is installed additional heat will be dissipated.

$$BID = \text{Total Load} / \text{Battery Voltage} * 0.7V \text{ (diode drop)}$$

D) If the AC Input option (full bridge) is used additional heat will be dissipated.

$$ACID = \text{Total Load} / \text{Voltage} * 1.4 V \text{ (2 diode drop)}$$

E) If the Battery Charger Option is installed the heat dissipated from it will vary according to the current charge current and can be estimated by:

$$BCD = \text{Maximum Charge Current} * \text{charge Voltage} * 0/1$$

(based on 90 percent efficiency).

2.9 Power Management Controller PM104 (optional)

The Power Management Controller (PM104) is a microcontroller “plug-in” module for timed on-off control of the V104, 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 V104 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 V104 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)	V104 Function or Connection	Battery Charger Function
1	PM104 Supply Voltage	V104 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)	V104 On/Off Control	V104 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 CN6-5	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.

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 5 ampere 'pico' fuse F1 limits the current draw from the power source. A series of devices, (toroid coil L3, transorb D4 and filter capacitor, C12) filters and clamps the input power.

Transorb D4 is a 5KVA, heavy duty transient suppressor that provides "zener" type protection and has an avalanche voltage of 33V. 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 simple switcher regulator VR1, generates the +5VDC output, operating in a "buck" mode switching regulator configuration using inductor coil L1, schottky diode Z1, input filter capacitors C12 and output filters capacitors C6. Regulator VR1 is a current mode controller and adjusts the "switching cycle" by the sensed current rather than directly by the output voltage. Control of the output voltage is obtained by using the output of a voltage sensing error amplifier in regulator VR1 to set the current trip level.

A total of 5 amperes can be supplied to the connected +5VDC load, to the inputs of the +12VDC regulator and the -5VDC and -12VDC charge pumps and invertors. The +5VDC power is available on the PC/104 expansion bus (B3, B29 and D16) and screw terminal connector CN2. LED2 provides indication of +5V operation.

3.3 Switching regulator, +12VDC

A switching regulator VR2, generates the +12VDC output, operating in a "boost" mode switching regulator configuration using inductor coil L2, schottky diode D11, input filter capacitor C6 and output filters capacitor C3. Capacitor C6 works as an output filter for the +5VDC and as an input filter for the +12VDC regulator VR2. Regulator VR2 is a current mode controller and adjusts the "switching cycle" by the sensed current rather than directly by the output voltage. Control of the output voltage, sensed by resistors R5 and R6 is obtained by using the output of a voltage sensing error amplifier in regular VR2 to set the current trip level. If a custom output voltage is ordered variable resistor R21 (in series with R5) will adjust the feedback voltage.

A total of 1 amp can be supplied to the connected +12VDC load and the -12VDC invertor. The +12VDC power is available on the PC/104 expansion bus (B9) and screw terminal connector CN2. LED1 provides indication of +12VDC operation.

3.4 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. Since the filter capacitors must absorb the “switching ripple” current, capacitors with high ESR values will quickly overheat. For example, a capacitor with a 100mOhm ESR which is absorbing a 5A ripple current, will dissipate 2.5W 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 a 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).

$$V_{p-p} = \frac{ESR * V_{out} (V_{out}/V_{in})}{L1 * frequency}$$

EXAMPLE

Vout = 5V, Vin = 16V, L1 = 55uH, frequency = 100kHz and 330uF capacitor with 27mohm ESR.

$$V_{p-p} = \frac{0.027 * 5 (1 - (2/16))}{55 * 10E-6 * 10E5} \approx 17mV \text{ ripple}$$

Note: only the ESR of the output capacitor is used in the formula. It is assumed that the capacitor is purely resistive at frequencies above 20kHz. Worst case output ripple is at highest input voltage and is independent of load.

3.5 Bus Termination (Optional)

AC bus termination is provided by 5 “RC” SOIC packages (3 only for 8-bit PC/104 bus), 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

Advantages of Using AC Termination

One of the requirements of embedded electronics is for 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.

The 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 has 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 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 busses due to the reduction in high frequency components of signal transitions.

APPENDIX 2

Installation Hints for the V104 Power Supply

1. To minimize noise induced into the power supply, connect the V104 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 V104 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 V104 power supply on to the top of the V104 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 3

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 -40°C to 70°C and can result in the avalanche voltage being several volts lower at -40°C and a clampoff several volts higher at 70°C .

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 4

BC104 Battery Charger and PM104 Power Management Units

1) Description

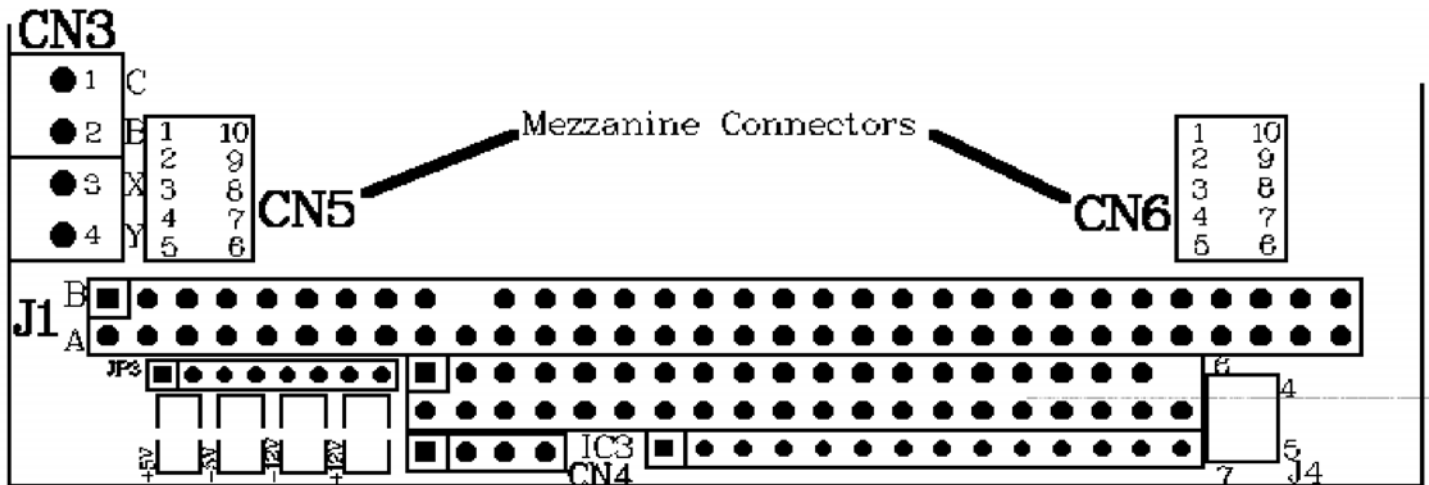
When the BC104 and PM104 units are both installed on either the V104 or HE104 (hereafter referred to as PSU), as universal battery charger can be setup and the PSU unit made into an UPS (uninterruptible power supply).

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.

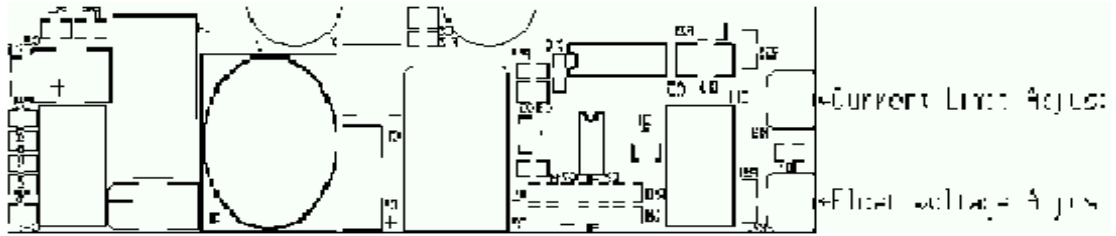
5. Program Command and Syntax:

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
'debug "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	<i>'Clear old ADC result.</i>
For Adbits = 1 to 13	<i>'Get null bit + 12 data bits.</i>
Pulsout CLK.2	<i>'Clock next data bit in.</i>
Let AD = AD*2 +DIOp	<i>'Shift AD left, add new data bit.</i>
Next Adbits	<i>'Get next data bit.</i>
High CS1	<i>'Turn off the ADC</i>
Return	<i>'Return to program.</i>

'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	<i>12-bit ADC conversion result</i>
SYMBOL Chrg Time = w2	<i>16-bit timer</i>
SYMBOL Batt_Peak = w3	<i>Peak voltage detected</i>
SYMBOL TCnt =b8	
SYMBOL Batt_V = w5	
SYMBOL sglDif = 1	<i>Single-ended, two-channel mode.</i>
SYMBOL msbf = 1	<i>Output 0s after data transfer is complete.</i>
SYMBOL AO1_LVL = 5	<i>Maximum current level (50 = 1A 75 = 1.5A)</i>
SYMBOL BattV_Max = 1100	<i>Maximum battery pack charge voltage</i>
SYMBOL Chrg_Time_Max =10800	<i>Maximum battery charging time (10,800 = 3hr.)</i>
SYMBOL Neg_DeltaV = 8	<i>AD convertor points for -deltaV (74pt/V IE 0.2V=18pts).</i>
SYMBOL Trickle_LVL = 0	<i>Trickle Charge Level (12 =.25A) See below:</i>
SYMBOL BattV_Min = 740	<i>Minimum battery voltage (10V)</i>

Main Loop

Init:

Low PSU_OnOff	<i>'Turn PSU on</i>
Let Bat1_chrg = 0	
Main_Batt1:	
Low PSU_OnOff	<i>'Just making sure PSU stays on!</i>
If Bat1_Chrg = 1 then Batt_Trickle	<i>'is battery already charged?</i>
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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