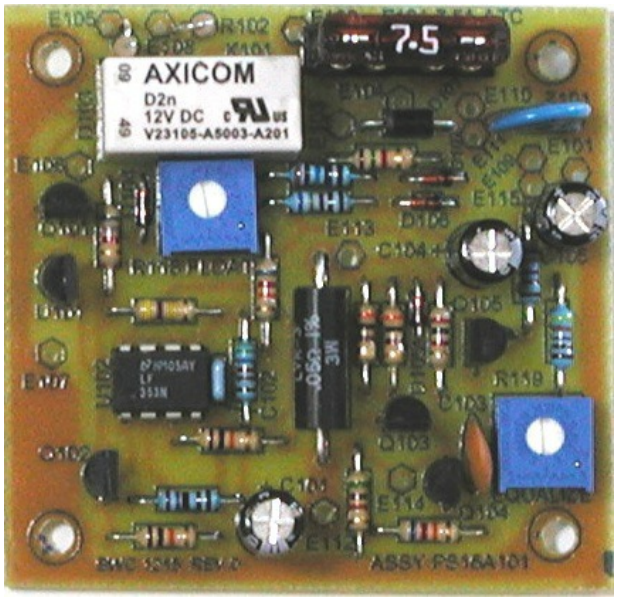
PS-16A-1 Charge Controller



PS-16A-1
Charge Controller
For
AGM VRLA Batteries

The PS-16A-1 provides concise charge control for AGM (absorbed glass mat) VRLA (valve regulated lead acid) batteries from an input of 14.5 to 19 VDC.

This multi-stage charger optimizes battery life by controlling initial current, providing temperature compensated float and equalize voltages and automatic “equalize” termination.

The PS-16A-1 operates from a lap top power supply (16VDC, 6ADC), a vehicular 12 VDC system (float charge) or from an unregulated voltage source such as the rectifier/filter of a linear 13.8 VDC power supply.

PS-16A-1 Charge Controller

Applications:

- Charge controller for VRLA AGM batteries using CCCV modes to protect, fully charge and maintain the battery.
- Operates from 14.5 to 19 VDC source capable of 6 ADC such as vehicular systems, including ATV, automotive or generator.
- Low drop out and reverse current protection allows operation from solar panels and wind/hand generators.
- Can provide float charge with only 14.5 VDC input.
- Includes manual Equalize charge for initial charge and enhanced re-charge after extended discharge.
- Provides battery isolation from input voltage source - so multiple batteries can be charged from a single source.

Features:

- Operates as CCCV battery charge controller with temperature compensated float and equalize voltages.
- Simple transistor design uses no complex IC or special components.
- Input reverse current and voltage protection.
- Fused and switched power.
- Fully adjustable float and equalize voltage.
- Input voltage and current monitoring allows precise control of charge conditions.
- Allows battery power be supplied to load in float charge condition.
- Equalize function allows quick recovery from deep discharge, provides initial charge and cell maintenance.
- Provides shut-down control to automatically disconnect battery load during equalization.

Physical Characteristics:

Size	2.28” x 2.4” Circuit Board mtg on Wakefield ½ brick heat sink
Enclosure	Open Frame
Mounting	Four 4-40 screws and hex 4-40 0.375” spacers to heat sink.

Electrical Characteristics:

Parameter	Conditions		Value	Notes
Input Voltage	Normal operation		14.5 to 19 VDC	1, 2
	Absolute maximum		22 VDC	3
Input Current	Limited by CC in Equalize		< 6 ADC	
Temperature	Free air around heat sinks		0 to +45 °C	
Float Voltage	Adjustment range at +25 °C (13.65 VDC set)		13.0 to 15.0 VDC	
Equalize Voltage	Adjustment range at +25 °C (14.35 VDC set)		13.0 to 15.0 VDC	
Float T/C	0 to +45 °C		-12 mV/°C	5
Equalize T/C	0 to +45 °C		-36 mV/°C	
Initial Current	16 VDC Input Voltage		< 6 ADC	
Power Dissipation	With 16.0 VDC input and 6.0 ADC charge current		20 Watts	
Equalize Termination	Automatically terminates (switches to Float) at battery charge current of (nominal)		350 mA	
Run Time	Fully charged battery, T_a = +25 °C and average I_o = 5.6 ADC	With Float charge	Continuous	6,7
		Battery Alone	5 Hours	
	AmpHour capacity expected from new, fully charged battery		28 AH	8
Recharge Time	Float Service	(hours)	0.42 d_r (AH)	9
	Equalize after cyclic use		0.29 d_r (AH)	

Notes:
1. Float charge down to minimum, Equalize requires 16 VDC or greater.
2. Dissipation limited at high input voltage and current.
3. Dissipation, SOA and MOV limited.
4. Adjust per Figure 2 for ambient temperatures other than +25 °C.
5. See Figure 1 for nominal Float and Equalize voltage temperature coefficient.
6. Equivalent to 100 W SSB continuous transmission. Burst Digital modes similarly supported.
7. Approximate - many factors, e.g. temperature, charge level, battery age and condition effect actual run time.
8. For 80% discharge at +25 °C and discharge current equal to or greater than 20 AH rate.
9. Approximate due to many factors effecting actual performance. d_r = discharge rate (AH), see http://www.bwcelectronics.com/projects/AP10A090.pdf

Theory of Operation.

Proper charging is one of the key requirements for battery longevity and is ensured by the PS-16A-1 linear charge controller, which accepts DC input power in the range of 14.5 to 19 VDC (16 VDC nominal) and draws 6 ADC or less. The charge controller regulates and filters the input to provide temperature compensated FLOAT and EQUALIZE charge modes.

The use of a linear design is only slightly less efficient than a SMPS, is simpler, and generates NO RFI/EMI. This supports low noise applications operating in the BATTERY mode.

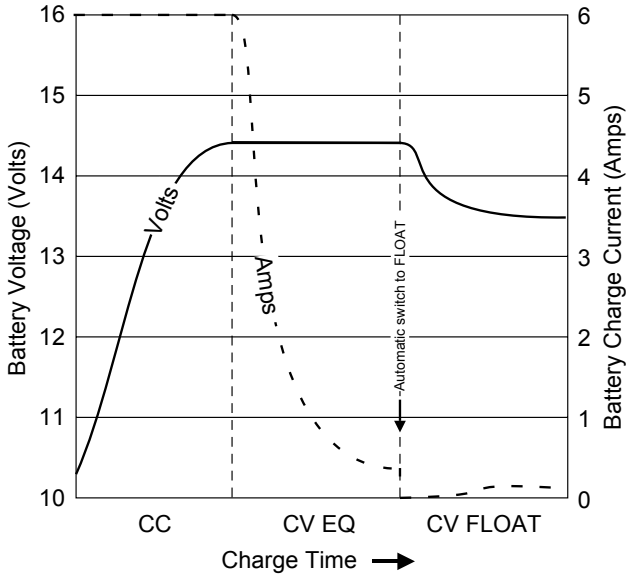


Figure 1. PS-16A-1 Charge Controller Stages.

The PS-16A-1 design is commonly called a multistage charger. Figure 1 shows three primary stages of charge. The first stage of charge is “CC”, “Constant Current” and operates in both FLOAT and EQUALIZE modes. Some marketing literature refer to these as separate stages so they can claim a “four stage” charger, but in reality they are one in the same. When charged with a constant current the voltage is controlled by the battery’s state of charge . This current must be limited to less than the “initial current” specified by the manufacturer to prevent irreversible cell damage. Normally the “initial current” is specified as a fraction of the AH capacity of the battery and in this application is set to 6 ADC.

As the battery takes on charge the terminal voltage rises until it reaches a point the compliance voltage of the charger can no longer maintain the constant current. Here, in fact, is where the stage changes. If the charger is in the EQUALIZE mode, the battery voltage is allowed to rise above the FLOAT voltage which ensures each cell will charge fully and expedites charging.

This is the entry point for the CV EQ, Constant Voltage EQUALIZE, stage. The charge voltage is held constant at a temperature compensated level, while the charge current declines, as the battery takes on charge. Because the EQUALIZE charge voltage is excessive for continuous charging, the battery is disconnected from the load during this stage, thus enabling the charge current to be accurately monitored. When the charge current drops to 0.01C, C = battery AH capacity, or 350 mA in the PS-16A-1, the charge controller automatically switches to the CV FLOAT, Constant Voltage FLOAT, stage. The battery has been charging at a higher voltage so the charge current will go to zero for a time and the DC BUSS can now be turned back ON.

In the FLOAT mode the charge voltage is also temperature controlled and current limited to levels safe for continuous charging. This allows the battery to be maintained in a fully charged state either in a standby or operational application. Figure 2 shows the FLOAT and EQUALIZE charge voltages temperature dependence. This compensation allows the

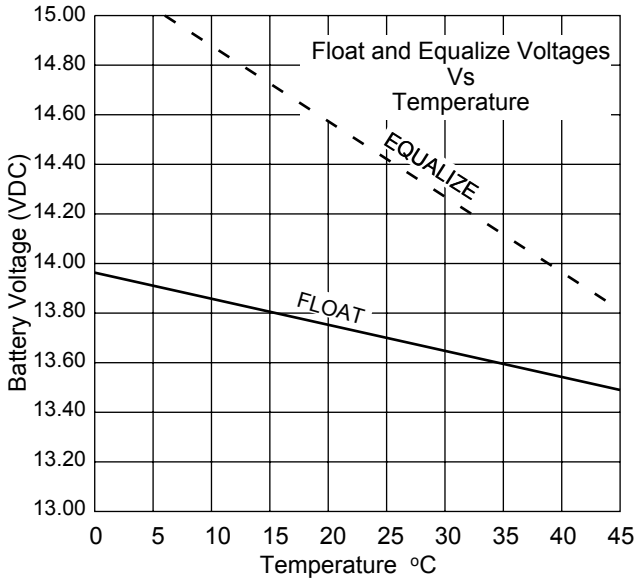


Figure 2. PS-16A-1 Equalize and Float mode temperature dependent voltages.

battery to charge effectively at low temperature but not suffer thermal run away at higher temperature.

The charger’s input is through a 7.5 Amp ATC blade fuse and is controlled by an external FLOAT-OP/OFF-RESET switch. An MOV and diode isolation provides protection for reverse or over voltage. The diode isolation also prevents

reverse current that could discharge the battery with low input voltage.

When the EQUALIZE switch is operated (momentary action) K101 energizes. K101 provides a battery disconnect contact and sets the regulator's reference voltage for equalize. K101 is held in this state until U102 and associated circuitry sense the charge current drops to 350 mA. Q102 level shifts the current sense voltage and U102B compares it to the +5 V reference to turn off K101.

The charge is controlled by Q106, a P-channel power FET. This low R_{DS} FET operates down to very low V_{DS} enabling low input voltages. Q103 provides constant current by sensing the voltage drop across R110 and reducing the bias to Q106 as needed.

Q104 and Q105 control Q106 gate voltage to regulate the output voltage by comparing the output to one of two reference voltages, as selected by K101. R119 sets the EQUALIZE voltage and is set with the EQUALIZE switch pressed. Then R118 is adjusted to set the FLOAT voltage once K101 de-energizes.

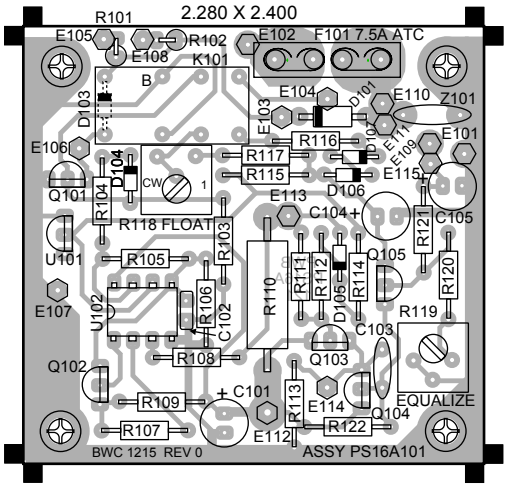


Figure 3. PS-16A-1 Component Locator.

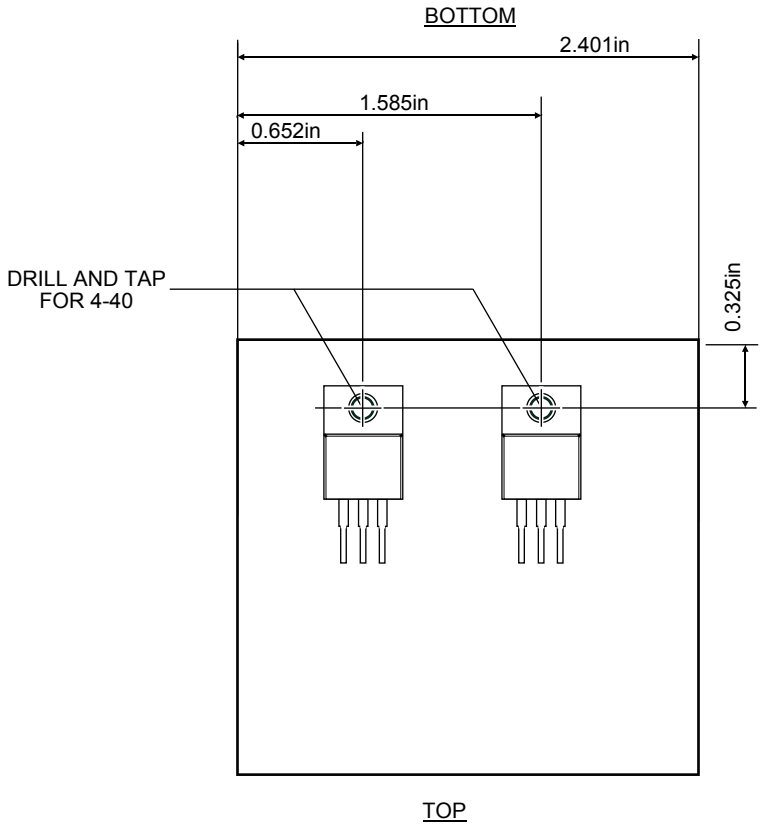


Figure 4. PS-16A-1 Heat sink drill and tap pattern. See PS17A141 for details.

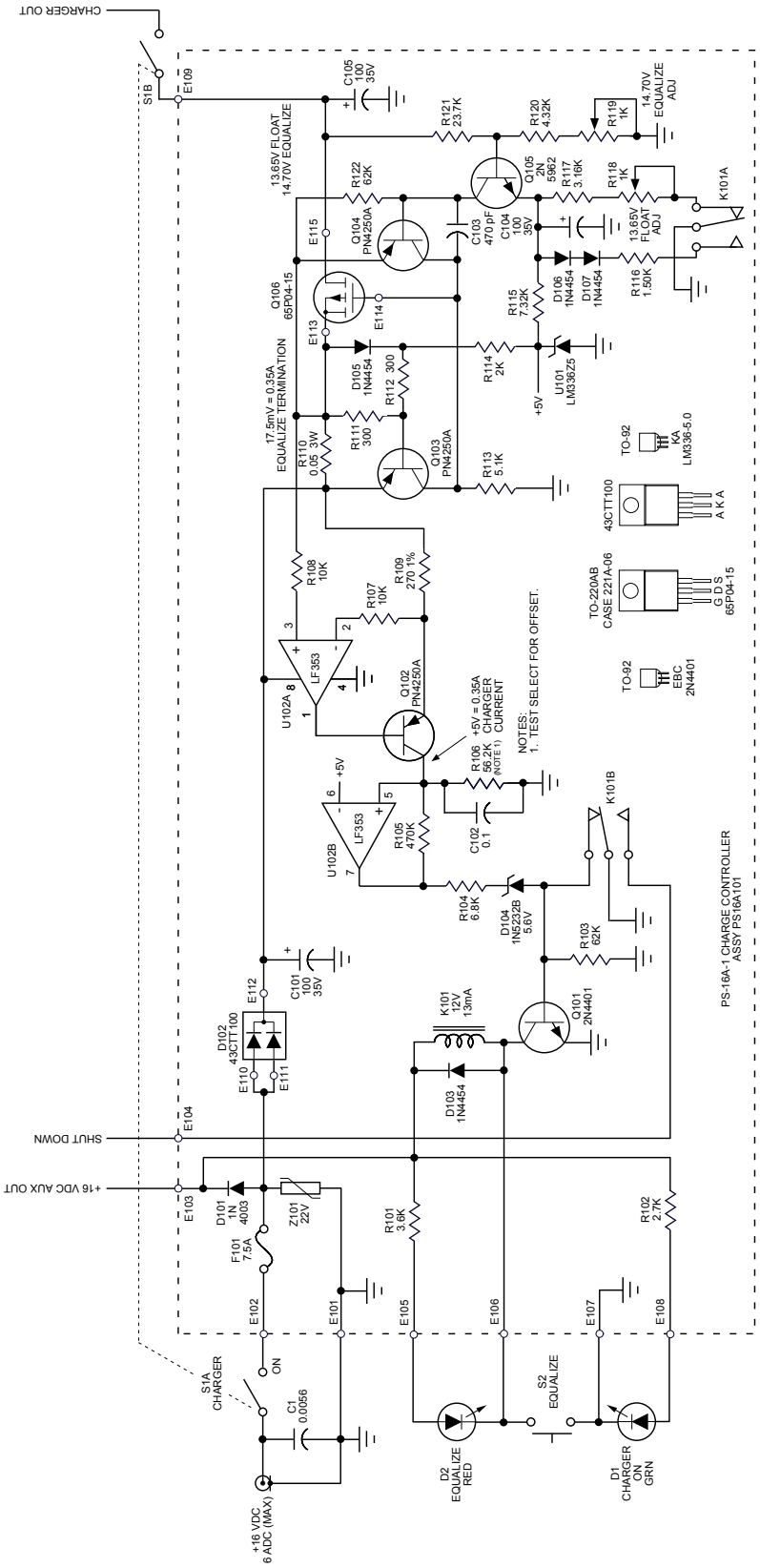


Figure 5. PS-16A-1 Schematic.

PS-16A-1 List of Material

Qty	Designator	Value/Type	Description	Part Number	Supplier(1)
3	C101, 104, 105	100 µF, 35V	Radial Al	647-UVR1V101MED	
1	C102	0.1 µF, 50V	MLC ceramic	581-SR205E104MAR	
1	C103	470 pF, 50V	COG Disk Ceramic	140-50S5-471J-RC	
1	D101	1N4007	1 Amp, 1 kV Si Rect	512-1N4007	
1	D102	43CTT100	40 Amp, 100 V Schottky	844-43CTT100	
1	D104	1N5232B	5.6 V, 0.5 W Zener	512-1N5232B	
4	D103, 105, 106, 107	1N4454	Si Switching	512-1N4454	
1	F101	7.5 Amp	ATO Blade	576-025707.5PXPV	
1	K101	DPDT 1 Amp Relay	12 v, 13 mA Coil	653-G5LE-14-DC12	
1	Q101	2N4401	NPN Si Small Signal	512-2N4401TA	
3	Q102, 103, 104	PN4250A	PNP Si High Gain	512-PN4250A	
1	Q105	2N5962	NPN Si High Gain	512-2N5962	
1	Q106	65P04-15	40 V, 65 A, 120 W MOSFET	781-SUP65P04-15-E3	
1	R101	3.6 kΩ, 5%, ¼ W	Carbon film	291-3.6K-RC	
1	R102	2.7 kΩ, 5%, ¼ W	Carbon film	291-2.7K-RC	
2	R103, 122	62k Ω, 5%, ¼ W	Carbon film	291-62K-RC	
1	R104	6.8 kΩ, 5%, ¼ W	Carbon film	291-6.8K-RC	
1	R105	470 kΩ, 5%, ¼ W	Carbon film	291-470K-RC	
1	R106	56.2 kΩ, 1%, ¼ W	Metal film	271-56.2K-RC	
2	R107, 108	10 k Ω, 5%, ¼ W	Carbon film	291-10K-RC	
1	R109	270 Ω, 1%, ¼ W	Metal film	271-270-RC	
1	R110	0.05 Ω, 1%, 3 W	Metal film	71-LVR3-0.05	
2	R111, 112	300 Ω, 5%, ¼ W	Carbon film	291-300-RC	
1	R113	5.1 kΩ, 5%, ¼ W	Carbon film	291-5.1K-RC	
1	R114	2.0 kΩ, 5%, ¼ W	Carbon film	291-2K-RC	
1	R115	7.32 kΩ, 1%, ¼ W	Metal film	271-7.32K-RC	
1	R116	1.5 kΩ, 5%, ¼ W	Carbon film	291-1.5K-RC	
1	R117	3.16 kΩ, 1%, ¼ W	Metal film	271-3.16K-RC	
2	R118, 119	1 kΩ, 5%, ¼ W Trimmer	Top Adjust	271-7.32K-RC	
1	R120	4.32 kΩ, 1%, ¼ W	Metal film	271-4.32K-RC	
1	R121	23.7 kΩ, 1%, ¼ W	Metal film	271-23.7K-RC	
1	U101	LM336Z5	5 V Prec. Voltage Reference	512-LM336Z5	
1	U102	LF353	Dual FET Op Amp	512-LF353N	
1	XF101	30 Amp Fuse Holder	ATO Blade	534-3522-2	
1	Z101	22 V MOV	Disk	652-MOV-10D220K	
1		PWB	FR-4 Thru Hole	PS16A121	3
1		Heat Sink, ½ Brick	Wakefield	567-517-95AB	2
4		4-40 Screw	0.375” Pan Head	87913315	4
4		4-40 Screw	0.25” Pan Head	67413641	4
4		4-40, 0.25” Hex Stand Off	0.375” Threaded	67730200	4
2		TO-220 Insulator Kit		532-4880SG	

Notes:
1. Supplier is Mouser Electronics (http://www.mouser.com) unless otherwise specified.
2. Two holes drilled and threaded for 4-40 per PS17A141.
3. BWC items shop built - details available at http://www.bwcelectronics.com
4. MSC Industrial Supply Co. (http://www.mscdirect.com)