CHARGER

DESCRIPTION

The purpose of the Charger circuit is to recharge the batteries after Inverter operation when commercial 115vac is restored. The Charger will also charge the batteries during normal operation if it falls below 12.5 volts. The charging operation is automatic. Protection is provided to prevent both over charging and excessive discharge of the battery.

During normal operation (commercial 115vac present) there are several circuits which draw power from the batteries. To keep the batteries at a charge level sufficient to supply backup power during a commercial 115vac outage, battery voltage is monitored and charging is automatically started when battery voltage level drops to 12.5 volts.

With a loss of commercial 115vac heavy current is drawn from the battery. When commercial 115vac is restored, battery charging will be started automatically. If the battery was not drained to 11.5 volts during Inverter operation then battery recharging will begin 5 minutes after commercial 115vac is restored. The 5 minute delay is generated via the 1A1 Timing Control circuits. It is not desirable to have the Charger and the Battery supplying current to the Inverter. Therefore, when commercial 115vac is restored, the charging circuit will be disabled for the 5 minutes that the Inverter continues to operate after commercial 115vac is restored. Once the Main Relay de-energizes (disconnecting the battery from the Inverter) the Charge Relay will energize and begin the battery charging operation.

If battery charge was drained to 11.5 volts during Inverter operation the Low Battery Disconnect circuits will have shut the Power Backup System down and disconnected the battery from the Inverter. When commercial 115vac is restored after a shutdown condition, battery charging will start immediately, there will be no 5 minute delay.

Maximum charge current capability is 8 Amps, internally limited by the regulator. As battery charge level increases, the decreasing charge current level is monitored by the Charger circuits. When the charge current has dropped to a level less than 150ma and battery terminal voltage is at 13.7 volts, charging will automatically be turned off. Blower 1BL1 is provided to cool the Charge Regulator Assemble and blower 1BL2 is provided to vent the battery compartment during charging operation. The blowers are only active during charging and are turned off whenever charging stops.

Charging voltage and charge current can be monitored from Front Panel meters. A Front Panel amber indicator is also illuminated anytime charging is taking place. Charging may be manually started at anytime via both a Front Panel mounted push button switch and/or a 1A5 PCB mounted push button switch.

DETAILED THEORY OF OPERATION

Circuit Description

The Charger can be broken into 3 major sections:

1). The Charge Regulator Assembly
2). The Charger Circuits
3). The Turn-On Control Circuits

Charge Regulator Assembly.

All components in this block are mounted on the Regulator heat sink. The entire Charger is designed around 1IC1, a 3-Terminal, adjustable, 5 Amp, IC Regulator. The IC is internally current limited. While the IC is rated for 5 Amps, high supply voltage combined with heavy heat sinking and blower cooling will allow 8 Amps of charge current for a deeply discharged battery. 1C1, 1C2, and 1C3 are all filter/bypass/decoupling capacitors.

Charger Circuits:

R1, R2, R3, & R4 set the output voltage of the regulator IC 1IC1. Output voltage is set for 13.7 volts by R2. IC1 is a comparator, D2 is a steering/isolation diode, and R5 is a regulator output voltage determining component. Q1 is a transistor switch, R6 is Q1 emitter resistor. C2 is an IC1 compensation capacitor. S1 and 1S1 are manual Charge Start pushbutton switches. D1 protects Regulator 1IC1 from capacitor discharges through

the IC. 1R6, 1R7, 1R11, & 1R12 are charge current sense resistors. D3 is a coupling zener, Q2 is a switch, R7 is a Q2 collector load resistor. D4 and D5 are steering/isolation diodes, R8 is a base current limiter for Q3, Q3 is a switch, R9 is a Q3 collector load resistor. Q4 is a relay drive transistor. 1RY2 is the Charge Relay, 1D2 dampens inductive kick back from the Charge Relay when it de-energizes. 1BL1 is a blower which cools the Charge Regulator Assembly and 1BL2 is a blower to vent the battery compartment when charging is active. 1NE2 is an Amber neon indicator the indicates charging is taking place. F1 fuses the power Supply +19 volts on the board, C1 is a filter capacitor. 1M4 is a Front Panel mounted Charge Voltage meter, 1M5 is a Front Panel mounted Charge Current meter. 1R8 is the charge current meter shunt resistor, 1R9 is a voltmeter series dropping resistor. The Charge voltmeter is calibrated with 1R2.

Turn-On Control Circuits:
Q10 and Q11 sense commercial 115vac restoration and Inverter on/off status. Q7, Q8, and Q9 form the battery 12.5 volt level detection circuits. Q11 is a switch, R22 is a Q11 base current limiter, R21 is a Q11 collector load resistor. C7 is a coupling capacitor, D8 provides a discharge path for C7. Q10 is a switch, R20 is a Q10 collector load resistor and Q6 base current limiter. F2 fuses the battery line on the Charger PCB, R14 is a Q7 base current limiter, and 1R4 forms a voltage divider which senses the battery voltage level. 1R4 is adjusted to trigger the circuit when battery voltage drops to 12.5 volts. Q7 is a comparator. It compares a zener referenced voltage on it's emitter with the battery sensed voltage from the battery voltage sense divider on its base. R17 sets D6 zener static conduction level. R16 is a Q7 collector load resistor. D7 is a coupling zener. Q8 provides isolation and prevents loading of the Q7 comparator circuit. R18 is an emitter load resistor. R19 is a base current limiter for Q9. Q9 is a switch.

Q6 is a switch which acts as a NOR gate, R15 is a Q6 collector load resistor. IC2 is a 555 timer used as an astable, R12, R13, and C4 form the frequency determining components of 555 astable operation. R11 is a base current limiter for Q5, Q5 is a relay driver. RY1 is a DPDT 10 volt Charger On relay (only one set of contacts is used), R10 is a relay dropping resistor, and D9 dampens inductive kickback when RY1 de-energizes. C3 and C6 are filter capacitors.

Circuit Operation

Regulator 1IC1:

The regulator output is determined by components R3, R4, R1, and R2. The output leg of the regulator will always be 2.5 volts greater than the adjustment leg. Therefore varying R2 will set the output voltage of the regulator. R2 is adjusted for 13.7 volts when the charger is charging the battery.

There are 3 modes of Charger circuit operation.

1). Commercial 115vac Present, Battery Above 12.5 volts.
2). Commercial 115vac Present, Battery Below 12.5 volts.
3). Commercial 115vac Restored

Commercial 115vac Present, Battery Above 12.5 volts

With the battery charged there is no current flow through 1R6, 1R7, 1R11, and 1R12. The voltage input to IC1 pin 2 is higher than pin 3, therefore the output at pin 6 is low. D2 is forward biased effectively putting a ground on R5. R5 now parallels R1 and R2 reducing it's total resistance thus dropping the output voltage from the regulator slightly. The low output from pin 6 is also felt on Q1 base, turning Q1 on and pulling it's collector low. The low on Q1 collector is felt on Q2 base, Q2 is off, Q2 collector is high, D5 is forward biased, Q3 base is high and Q3 is turned on. D4 prevents Q2 high collector from being felt back to the input of the Inverter. With Q3 on, it's collector is low, Q4 base is low holding Q4 off. Thus Charge Relay 1RY1 is de-energized and no charging is taking place.

Commercial 115vac Present, Battery Below 12.5 volts

During normal operation current is drawn from the battery for circuits the require power even when commercial 115vac is absent. This the battery will slowly discharge over a period of time. To ensure the battery is always at a reasonable high level of charge, battery voltage is monitored. If battery voltage drops to less than 12.5 volts, charging will automatically take place.

Battery voltage is monitored by the voltage divider formed by 1R4. Q7 compares a reference voltage on its emitter with battery terminal voltage on its base. With battery voltage above 12.5 volts, Q7 base is positive enough to maintain conduction of Q7.

As battery terminal voltage drops, Q7 base voltage also drops. Low Batt Charge set pot 1R4 is adjusted

to cause Q7 to cutoff when battery terminal voltage drops to 12.5 volts.

When Q7 cuts off, its collector voltage goes high. The high on Q7 collector is sufficient to drive zener D7 past its zener knee and D7 begins to conduct current through Q8 base-emitter junction. Q8 turns on and its emitter rises high. This high, through R19 base current limiter, turns Q9 on causing its collector to pull low. The low on Q9 collector is felt on Q6 base and Q6 turns off, and Q6 collector goes high. This high enables IC2 555 astable operation. IC2 will produce a 1 second pulse every 2 seconds. The positive output pulse on IC2 pin3 is felt on Q5 base, Q5 turns on for 1 second, energizing RY1 for 1 second. When RY1 energizes a low is put on IC1 pin 1 and the output of IC1 pin 6 goes high. This high reverse biases D2, Q1 turns off, Q1 collector goes high, Q2 turns on, Q2 collector goes low, D5 is reversed biased, therefore Q3 has no base bias and Q3 turns off, Q3 collector goes high turning Q4 on and energizing the Charge Relay 1RY2.

When 1RY2 energizes the charger connects to the battery and charge current begins to flow through 1R6, 1R7, 1R11, and 1R12. The voltage drop across 1R6, 1R7, 1R11, and 1R12 will be such that IC1 inverting input pin 2 will be less positive than non-inverting input pin 3 thus holding the output on pin 6 high, thus holding Charge Relay 1RY2 energized.

Also, with the Charge Relay energized, 1RY2 normally closed secondary contacts are now open removing 9.6 volts from astable IC2. IC2 is now disabled and stops generating output pulses. IC2 is made to astable to ensure the charger will keep trying to turn on if battery voltage drops below 12.5 volts. The charger will keep trying to turn on every 1 second. Feedback that the charger has turned on is provided by opening of the normally closed contacts on the Charge Relay and then astabling is stopped.

In addition, when the Charge Relay energizes, it's normally open secondary contacts now close connecting 115vac to blowers 1BL1 and 1BL2. 1BL1 provides cooling airflow over the Charge Regulator Assemble heatsink and 1BL2 vents the battery compartment. The Front Panel amber Charger indicator parallels the blowers and illuminates, indicating charging is taking place.

As the batteries charge, charge current decreases, therefore voltage drop across 1R6, 1R7, 1R11, and 1R12 also decreases, and the input voltage to IC1 pin 2 is rising. When the battery gets to 100% of charge (13.7v), charge current will be less than 150ma, the inverting input to IC1 pin 2 will be higher than pin 3, IC1 pin 6 output will go low, regulated output will drop in voltage slightly, Q1 will turn on, Q2 will turn off, Q3 will turn on, Q4 will turn on, and Charge Relay 1RY2 will de-energize. Thus charging will cease and over charging of the battery will be prevented.

With the Charge Relay de-energized, 9.6 volts is again reapplied to the IC2 astable thus providing it operating power again. However, with battery voltage now above 12.5 volts Q7 is on, Q8 is off, Q9 is off, therefore Q6 base is high, Q6 is on and it's collector is low. The low on Q6 collector now holds the astable in a reset condition so it does not astable.

Commercial 115vac Restored

After the Inverter has been operating due to a loss of commercial 115vac it is desirable to automatically start battery charging once commercial 115vac is restored. This is accomplished through the Q11/Q10 circuits of the Turn On control circuits. However, due to Timing Control, the Inverter will remain operating for 5 minutes after commercial 115vac has been restored and it is not desirable to have the Charge Relay energize while the Main Relay is energized. This would connect the charger to the Inverter in parallel with the battery and possible damage could be caused to the Charger. Therefore, charging will be inhibited for the first 5 minutes after commercial 115vac is restored. Once the Main Relay de-energizes ending Inverter operation and disconnecting the battery from the Inverter, charging will begin.

Q11 base is connected to the Inverter side of the Main Relay and thus has 12 volts on it when the Main Relay is energized. This positive voltage turns Q11 on, pulling it's collector low, C7 discharges down through D8 and Q10 is turned off. Once C7 finishes discharge, Q10 has no bias and remains off, it's collector is high, Q6 is on, it's collector is low, holding IC2 astable in a reset condition, thus inhibiting the charger from turning on.

Once the 5 minute timeout has completed, the Main Relay de-energizes, the 12 volts on Q11 collector is removed, Q11 turns off and it's collector goes high.. This high is felt on Q10 base for approximately 1 second until C7 charges. Once C7 charges, Q10 will turn back off. For the 1 second Q10 is on, it's collector is low, Q6 turns off for 1 second, enabling the astable to produce 1 output pulse to turn the Charger on. Operation from this point then the same as explained above.

In the event the power backup system went into a low battery shutdown mode due to excessive discharge of the battery, once commercial 115vac is restored, charging will begin immediately. This is because there will be no Inverter on 12 volts inhibiting operation upon power restoration.

CHARGE VOLTAGE LEVEL SET

Charge voltage level adjustment should be made with the charger running and charging nearly completed. This is because during high charge currents, charge voltage will be lower than the final set point. As charge current decreases charge voltage will increase. Therefore, charge voltage must be set when charging is nearly completed and charge current is very low.

1). Connect a voltmeter to 1A1TB1-4 to monitor battery voltage.
2). Adjustment should be done with the charger on and charge current approximately half an amp (500ma).
3). Adjust 1A5R2 until the voltmeter reads 13.7 volts. Note that as voltage goes up, charge current will increase as the battery attempts to charge to the new level. If voltage decreases, charge current will decrease and may actually trigger the charger off.
4). This adjustment may need to be made several times to get the exact setting.
5). Once the setting is made, continue monitoring the battery voltage as the charger cycles through several charging operations. Adjust 1A5R2 as required to get the final 13.7 volt setting.

LOW BATTERY CHARGE LEVEL SET

Method 1

1). On the 1A7 Battery Fuse/Filter Assembly disconnect the wire from 1A7TB2-5.
2). Connect a 12.5 volt power supply to the wire removed from 1A7TB2-5 in the previous step.
3). Adjust the Low Batt Charge pot 1R4 until Charge Relay 1A5RY1 energizes. Charge Relay 1RY2 should also energize at this time.

Note: May need to turn the 1A8 Power Supply off to stop charging, then turn it back on again.

4). Test the circuit reaction several times by raising, then dropping power supply voltage to 12.5 volts. Readjust 1R4 as necessary.
5). Remove the 12.5 volt power supply.
6). Reconnect the wire removed in step 1 to 1A7TB2-5.

Method 2

This adjustment should be made after charging has completed.

1). Monitor the battery voltage at 1A1TB4-1.
2). When the battery voltage drops to 12.5 volts adjust 1R4 until the charger kicks on.
3). This setting may need to be repeated several times to get the set point exact.

CHARGE VOLTAGE METER CALIBRATION

1). Disconnect the lead on TB1-1 of the Charge Current Meter Shunt Assy.
2). Connect a substitute 12 volt supply to TB1-1 of the Charge Current Meter Shunt Assy.
3). Adjust the front panel Charge Voltmeter Calibration Pot (1R2) until the front panel Charge Voltage Meter reads 12 volts.
4). Disconnect the substitute power supply.
5). Reconnect the lead removed in step 1.