Radius®

Instruction Sheet for GR400 X-Pand & GR1225 Repeaters Battery Revert Accessory HLN9455

NOTE: This unit is also used in the RKR1225 Repeater.

Overview

The battery revert accessory is available for the GR400 X-Pand and GR1225 Repeater Stations. This accessory allows you to cable your unit to a back-up battery which will engage in case of a power outage.

This sheet contains instructions for installing the battery revert unit into the repeater.

NOTE
The term "repeater" is used to cover common steps for the GR400 X-Pand and GR1225 repeater stations.

1. Remove the battery revert unit from the box.
2. Disconnect the AC line cord of the repeater power supply from the AC mains outlets.
3. Unplug the AC line cord from the power supply unit.

Installing the Battery Revert Unit into a GR1225 Repeater

1. Remove the two (2) M3.5, pan head machine screws, located at the bottom back of the housing, using a Torx® T15 driver.
2. Slide the housing cover straight back until it stops.
3. Lift the cover straight up and remove it from the housing chassis.
4. Unplug the fan DC cable from the power supply fan DC "pigtail."
5. From the back of the housing, position the battery revert unit upside down (flat side up) with the cables facing away from you.
6. Route the battery DC input cable to the left of the battery revert unit so the cable is facing toward you.
7. Route the remainder of the cables to the right of the battery revert unit so the cables are facing toward you.
8. Place the battery revert unit, flat side up, into the upper rear of the chassis and align to the screw holes.

NOTE
The battery revert unit can be mounted only in the correct alignment.

9. Secure the battery revert unit to the chassis using the four (4) TT3.0 x 10 screws furnished with your battery revert kit.

Installing the Battery Revert Unit into a GR400 X-Pand Repeater

1. Unplug the fan power cable from the power supply.
2. Remove the two (2) TT4.0 x 7.0 screws that secure the power supply "hold-down" bracket to the GR400 X-Pand housing.
3. Slide the power supply bracket assembly toward the front of the repeater housing sufficiently to allow the rear tab of the bracket to clear the slot in the housing.
4. Remove the power supply bracket assembly from the housing.
5. Remove the two (2) M5.0 x 8.0 machine screws that secure the power supply to the bracket.
6. Lift the bracket off the power supply.
7. Position the battery revert module onto the bracket with the battery revert's cables extending to the side of the bracket that corresponds to the heatsink side of the power supply.
8. Attach the battery revert module to the bracket using the four (4) TT3.0 x 10mm screws suppled with the battery revert kit.
9. Reinstall the battery revert bracket assembly onto the power supply using the two (2) M5.0 x 8.0 machine screws removed in Step 5. Tighten the screws to 1.58 N-m (14 in.-lbs.) torque.
10. Tilt the notched flange of the bracket assembly slightly upward and slide the rear flange into the slot at the back of the repeater housing.

11. Lower the bracket assembly and replace the two (2) TT4.0 screws removed in Step 2. Tighten the screws to 1.80 to 2.00 N-m (16 to 18 in.-lbs.) torque.

Connecting the Cables

1. Disconnect the DC power cable from the R1225 transceiver.
2. Connect the DC output cable of the battery revert module to the transceiver DC input connector.
3. Connect the DC input cable of the battery revert module to the DC output power cable from the power supply .
4. Connect the fan DC power cable from the revert module to the fan DC power cable of the power supply.
5. Connect the repeater DC fan cable to the DC fan cable connector on the battery revert unit.
6. **For a GR1225 Repeater:** Push the battery cable connector, from the inside to the outside of the chassis, through the vane grommet located on the back panel of the chassis.

Final Assembly

1. Check the float maintenance charger output voltage:

1A. Plug the IEC AC power cord plug into the power supply and the AC mains outlet.

CAUTION
Hands can be injured and cables can be damaged if they come into contact with the fan blade while the repeater is operating. Keep fingers and cables clear of the rotating fan blades.

1B. Connect a digital multimeter to the battery power cable. If necessary, remove the protective insulator from the positive terminal of the cable (the red wire connects to this terminal).

NOTE
Do **not** discard the insulator.

1C. Adjust R70, accessible through the round hole in the cover, for 13.6 Vdc ±0.1 Vdc. This is the recommended value for a sealed, lead acid, gel cell battery. Other batteries may require a different float voltage. Consult the manufacturer's recommendation for other battery types.

NOTE
The battery revert is adjustable between 12 and 15 Vdc.

NOTE
A more accurate setting of the charge voltage will be obtained by loading the output with a resistance sufficient to draw a current equal to 0.001C, where C is the amp-hour rating of the battery.

1D. Disconnect the digital multimeter from the battery cable.

1E. Unplug the IEC power cord from the ac mains outlet.

IMPORTANT
Keep all cables clear of the fan.

2. If the positive terminal of the battery power cable is exposed, cover it with the protective insulator removed in Step 1B.
3. **For the GR1225 repeater:** replace the cover to the repeater housing.

Battery Attachment

1. Remove the protective insulator from the positive terminal of the battery power cable of the revert unit.
2. Connect the battery power cable to the power cable of an external battery.

⚠ WARNING
For safety, it is strongly recommended that BOTH the positive and negative-leads of the battery cable be fused at the battery terminals.

Battery Type

The back-up battery "bank" for the repeater consists of one or more rechargeable batteries. The most readily available batteries are the maintenance free solid gel electrolyte lead-acid and nickle-cadmium (NiCd). Whichever type you choose, the battery must be designed for a service of operation that is typically sporadic and short term and may experience deep discharging before recharging. In between discharging periods, the battery must be capable of sustaining continuous, "float maintenance" charging at less than 1% of the rated capacity. Batteries in this category are called "stationary", "general purpose float and cyclic", "deep cycle", or a similar term. Automotive batteries are not designed for this service and should be avoided.

Battery Capacity

To determine the capacity for the battery or battery bank, you must know, or at least, estimate the longest period of time that the repeater is expected to operate on this back-up power source. Also, the percentages of time the repeater is expected to transmit and receive/standby must be factored in. Personal experience or that of others may give you a close approximation. If all else fails, punt (!) and assume a standard eight (8) hour shift operating solely on the battery with an extra hour before and another one after the shift. Ten (10) hours makes the calculation easy. The transmit and receive/standby times can be set equal (50% usage).

The capacity of the battery is rated in Ampere-hours (Ah) and is called "C" or "1C". This is not to be construed as the amount of current that may be drawn from the battery in an hour of time. Typically, battery manufacturers rate battery capacity based on the current drawn over a five (5), ten (10) or twenty (20) hour period. In terms of capacity, these are referred to as 0.2C, 0.1C and 0.05C rates, respectively. They are not linearly related; doubling the current drain will most likely reduce the time available by more than half.

Ambient temperature has a profound effect on the battery capacity. At -20°C (only 4 degrees below zero Fahrenheit!), approximately half of the capacity of room temperature is available.

Example:

What "size" battery do you need? Let's assume that you customer's repeater is in a location that experiences power outages that require battery backup for no more than 5 hours. The repeater operates at a 66% transmit duty cycle. The transmitter is on the air an average of 2 minutes and the repeater is then in standby/receive for 1 minute. The total cycle time is 3 minutes. The repeater transceiver draws 14A of current during transmit and 1.5A during receive. The repeater is using an external controller. The controller and the fan of the repeater add 0.5A to the current drains of transmit and receive. Therefore, for 2 minutes the battery must supply 14.5A and for the next 1 minute the battery must supply 2A. Then, the cycle repeats for a total of 5 hours.

Let the battery operating "capacity" be represented by C_{op}. This is based on the current drains during transmit and receive, the percentage of times of each and the total time required for battery operation. C_{op} may be represented by the following equation:

$$Cop = Ttotal \times \left[Itx \times \left(\sqrt{\frac{Ttx}{Tcycle}}\right) + Irx \times \left(\sqrt{\frac{Trx}{Tcycle}}\right)\right]$$

where:

Cop = Operating capacity in Ampere-hours (A-h)

Ttotal = Total time the station is on battery power (in hours) = 5 hours

Itx = Total current drain during transmit (in Amperes) = 14.5A

Irx = Total current drain during receive/standby (in Amperes) = 2A

Ttx = Transmit time during a single cycle (in minutes) = 2 minutes

Trx = Receive time during a single cycle (in minutes) = 1 minute

Tcycle = Cycle time (in minutes) = 3 minutes

Therefore:

$$Cop = 5 \times \left[14.5 \times \left(\sqrt{\frac{2}{3}}\right) + 2 \times \left(\sqrt{\frac{1}{3}}\right)\right]$$

$$Cop = 65$$

Now, how big is it? Let's consider the rated battery capacity, C, as a function of the C_{op} calculated above. An approximation to the rated battery capacity can be calculated with the following equation:

$$C \approx Cop \times \left[\left(\frac{Tcr}{Top}\right)^{0.1}\right]$$

where:

C = Rated battery capacity in Ampere hours (A-h)

Tcr = Rated battery discharge time in hours (usually 5, 10, or 20 hours)

Top = Time, in hours, that the repeater will be operating on the battery

0.1 = Raise the term *Tcr* / *Top* to the 0.1 power

A scientific calculator or the functions in a speadsheet program can be used to solve the equation.

For our example, let's consider the 65 A-h operating capacity, over 5 hours of operating on battery, and rated battery discharge times of 5 hours, 10 hours, and 20 hours.

1. *Tcr* = 5 hours

$$C \approx 65 \times \left[\left(\frac{5}{5}\right)^{0.1}\right]$$
$$C \approx 65$$

A 65 A-h (0.2C) battery would provide the required energy at room temperature environment.

2. *Tcr* = 10 hours

$$C \approx 65 \times \left[\left(\frac{10}{5}\right)^{0.1}\right]$$
$$C \approx 69.7$$

A 70 A-h (0.1C) battery would provide the required energy at room temperature environment.

3. *Tcr* = 20 hours

$$C \approx 65 \times \left[\left(\frac{20}{5}\right)^{0.1}\right]$$
$$C \approx 74.7$$

A 75 A-h (0.05C) battery would provide the required energy at room temperature environment.

Remember that the above calculations are approximate. Different discharge rates yield different "end of discharge" cell voltages which were not taken into account. The battery revert module is designed to disconnect the station from the battery if the input voltage to the module drops below 11 V dc. When in doubt, you can consult the manufacturer of the battery you intend to use to obtain "project planning data" charts. Or, you can "err" to the high side and add 10% to 25% to the calculated number. If the battery is going to experience extremes in temperature, the capacity will be affected. For cold climates, the capacity may need to be doubled or tripled.

Where to Buy the Battery?

Most of the larger electronic supply houses will carry or can obtain the type and capacity of battery required for your application. You may be able to deal directly with some of the battery manufacturers especially if you need large quantities of the same model.

CAUTION

Batteries contain a lot of energy stored in a rather small volume. To prevent injury or fire from accidental shorting:

1. both the positive and negative leads from the battery to the station should be fused as close to the battery terminals as practical.
2. insulated battery terminal covers should be installed.
3. the battery should be housed in a non-conductive box with a cover. If required, ventilation holes should be provided.

Theory of Operation

Battery Revert Circuit

A voltage reference network consisting of CR55, CR57, CR58, R66, and VR51 provides a stable voltage reference of 7.5 V dc. This reference voltage, at the anode of CR58, is applied to the negative input of the Over Voltage Detector U53B-6, to the positive input of PSU Fail Detector U53A-3, and to the positive input of the Low Battery Detector U52B-5. Operating positive supply voltage for the integrated circuits is obtained from the repeater power supply through CR57 when the repeater is operating on AC mains input power. The supply voltage is obtained through CR55 when the station is operating on the battery.

During normal operation under AC mains power, the negative input of the PSU Fail Detector U53A-2 is more positive than the positive input U53A-3. The output of U53A-1 is low and Q52, the driver for relay K51, and Q51, the "ON BAT" driver, are turned off. When AC mains power or the 13.8 V dc output of the PSU is lost, the voltage at U53A-2 becomes lower than the reference voltage applied to U53A-3. The output at U53A-1 then goes high and turns on both Q52, which activates relay K51, and transistor Q51, which provides a low at the output point "ON BAT." The "ON BAT" point may be used in conjunction with the accessory connector "on battery" function of the R1225 transceiver to provide an aural indication that the repeater is operating on emergency battery power.

If the battery voltage at J53 falls below approximately 10.2 Vdc, the output at U52B-7 goes high. This action turns on Q53 which shunts the base drive to Q52 through CR62 and turns off the relay. Q53 also provides a low through CR63 at output point "LO BAT." This auxiliary output might be used to key a portable radio to signal the repeater operator that the battery has exceeded the low voltage limit for the radios. Hysteresis is provided by the feedback network consisting of CR64, R57, and R80 from the output of U52B-7 to the positive input U52B-5. The reference voltage at the positive input of U52B-5 is increased such that the battery voltage must rise above 12 V dc before relay K51 reactivates and places the repeater back on battery power. This latching action is used to prevent excessively deep discharging of the battery.

The repeater remains turned off until either AC mains return or a charged battery is substituted for the discharged battery. The circuit consisting of C60, CR59, Q54, R58, R81, and R83 resets U52B-7 to low upon the return of the AC mains power.

Capacitor C59, at the negative input of U52B-6, smooths the variation in the battery voltage between the transmit radio keyed and unkeyed conditions. Capacitor C61 at U53A-2 input, in conjunction with C59 at U52B-6, ensures proper resetting of U52B with the return of the AC mains power.

The Over Voltage Detector consisting of U53B and resistors R51, R52, and R79 monitors the dc output of the repeater's power supply. If the voltage exceeds 16.4 V dc, the output of U53B-7 goes high and turns on relay driver Q52. The station switches to battery power although there is no indication at the "ON BAT" output point.

Zener diodes VR54 through VR58 protect the electronics from damage by accidental static discharge.

Fuse F51 (15A) and diode CR56 provide protection from reverse polarity if the battery is inadvertently connected "backward."

Battery Charging (Float Maintenance) Circuit

The battery charging circuit is intended for use with sealed lead acid gel cell batteries. The charging current, limited to approximately 300 mA, is used to maintain a "float" charging condition on the battery. After operating the repeater station on the battery for long periods of time, or if the battery reaches the low battery limit of the revert circuit, the battery must be recharged with an external high-current charger. Recharging with the internal trickle charger requires an extended period of time.

The trickle charging voltage is derived from U51, a 5 V dc, 500 mA, three-terminal integrated circuit regulator. The IC is self-protected from overcurrent and excessive temperature operation. The regulator is biased above ground to obtain a 14.3 V dc output by the network consisting of R69, potentiometer R70, R71, R72, and U52A. The output voltage of the charger may be set to 13.6 V dc with R70 while the repeater is operating on AC mains power.

The voltage at the rotating arm of R70 is fed to unity gain amplifier, U52A, to raise the voltage at the common terminal of the regulator to 9.3 V dc above ground. The low output impedance of the amplifier maintains the 9.3 V dc regardless of the load on the regulator. The 5 V dc of the regulator adds to the 9.3 V dc to ground to produce 14.3 V dc at the anode of isolation diode CR61. The 0.7 Vdc drop of CR61 subtracts from the regulator output to yield the 13.6 V dc float maintenance voltage. Resistors R67 and R68 limit the charging current to approximately 300 mA to a partially discharged battery (terminal voltage of 12 V dc). Once the battery is fully charged, the current decreases to 10 to 25 mA to float the battery at a terminal voltage of 13.6 V dc.

NOTE

This trickle charger is intended to maintain the battery for long periods of time between power failures and is not intended for charging a fully discharged battery. If the battery is completely discharged, it must be removed and charged via a battery charger with higher current capability.

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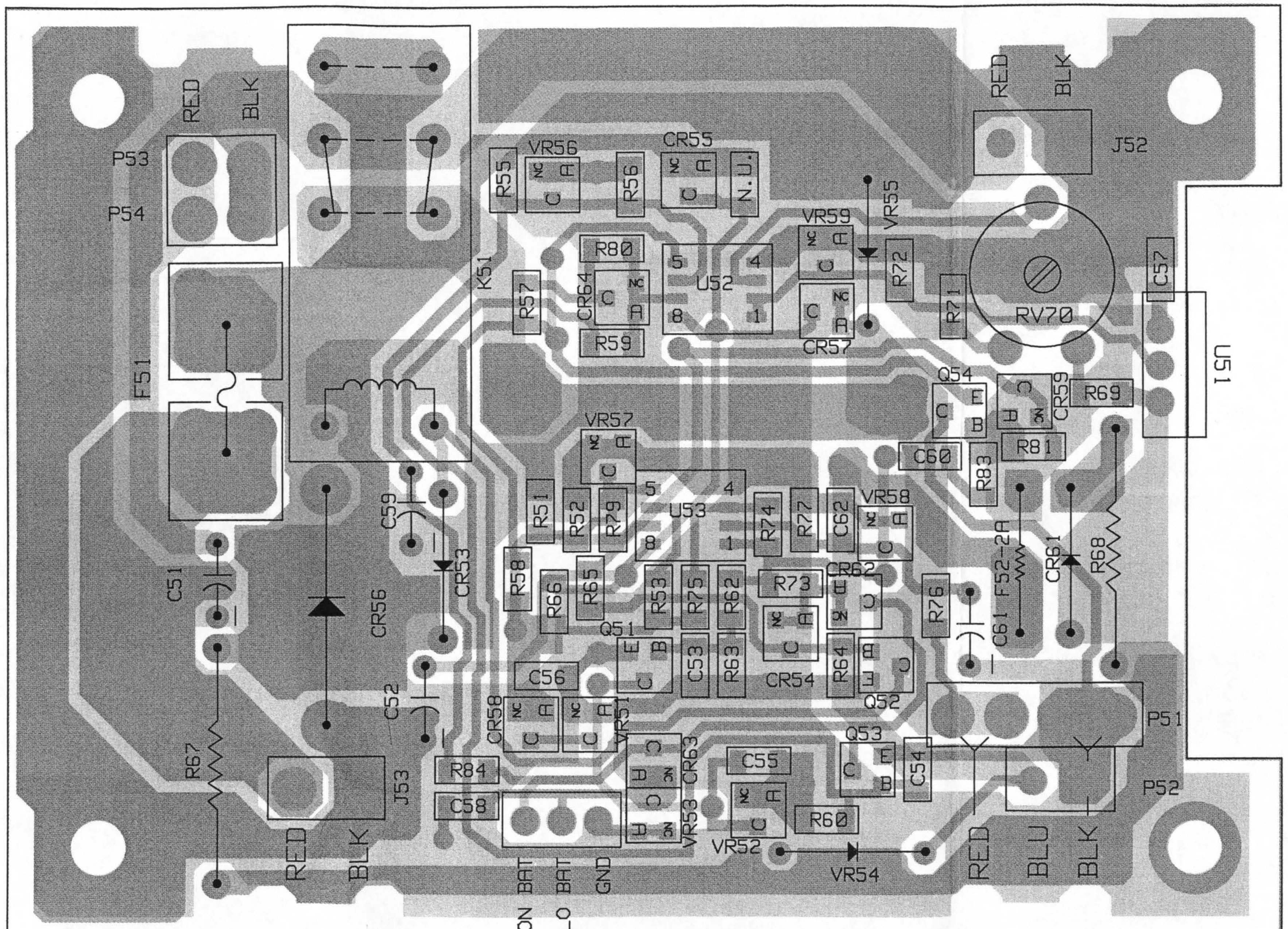
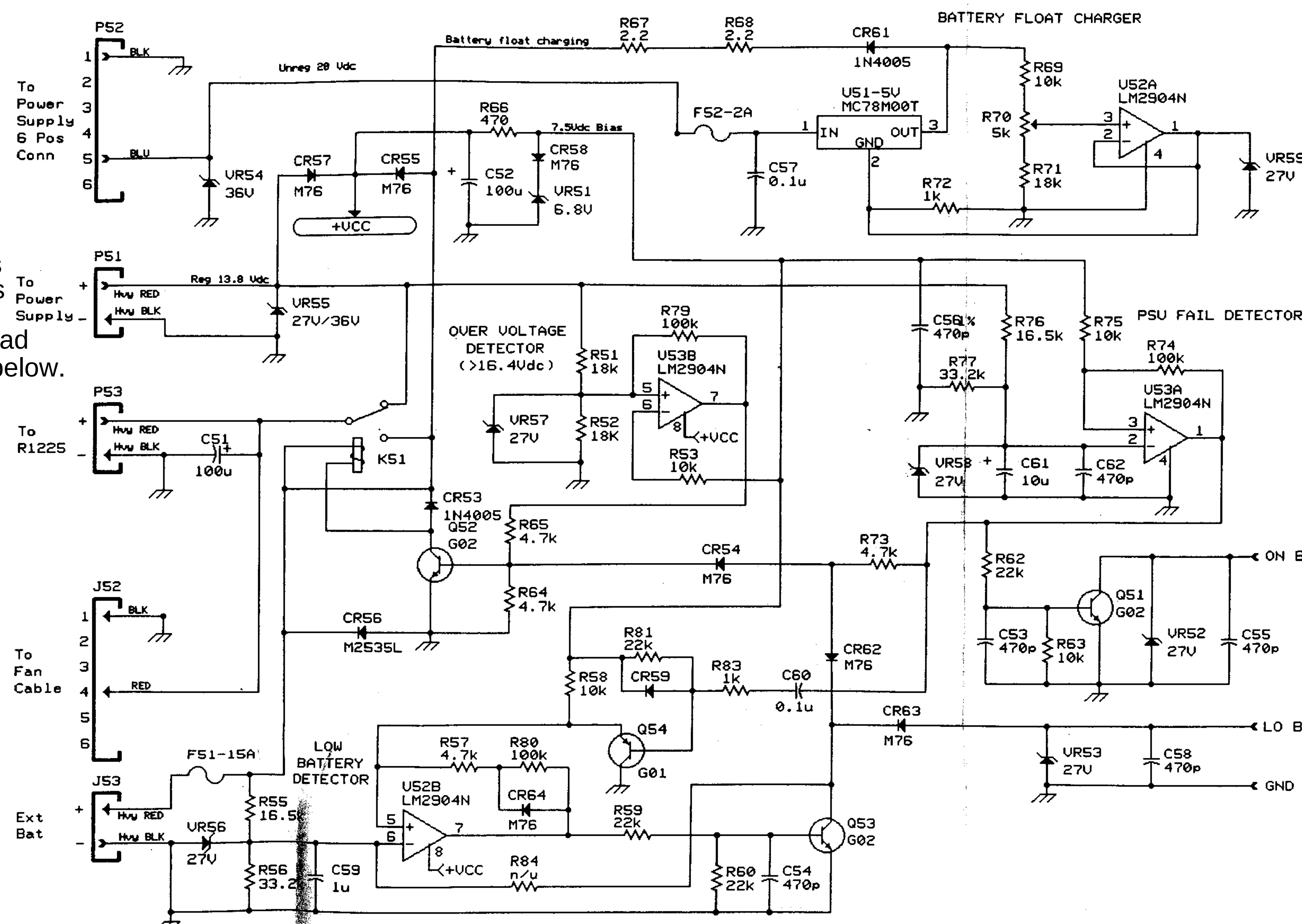


COMPONENT SIDE (GRAY) RCB-97184-O
SOLDER SIDE (PINK) RCB-97185-O
OVERLAY ----- RCB-97186-O

COMPONENT SIDE VIEW

Note: This connector is shown with the contacts reversed. The red lead is male and the black lead is female, just like J53 below.



ON BAT (This PCB connection must be added by the user)

LO BAT (This PCB connection must be added by the user)

Schematic Diagram for
Battery Revert Accessory HLN9455

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitor, fixed: +/-5%; 100 V: unless otherwise stated
C51, 52	2313748G22	aluminum; 100 uF, ±20%, 25 V
C53 thru 56	2113740B65	chip; 470 pF
C57	2113741B69	chip; 0.1 uF, 50 V
C58	2113740B65	chip; 470 pF
C59	2311048B05	aluminum; 1 uF, ±20%, 50 V
C60	2113741B69	chip; 0.1 uF, 50 V
C61	2311048B13	aluminum; 10 uF, ±20%, 16 V
C62	2113740B65	chip; 470 pF
		connector, plug:
P51		power cable, Battery Revert to PSU
P52		power cable, Battery Revert to PSU Fan
P53		power cable, Battery Revert to transceiver
		connector, receptacle:
J52		power cable, Battery Revert to fan
J53		power cable, Battery Revert to external battery
		diode: (see note)
CR53	4880008E01	silicon, 1N4005
CR54, 55	4805129M76	SOT MMBD914
CR56	4880236E07	transorb, MR2535L
CR57 thru 59	4805129M76	SOT MMBD914
CR61	4880008E01	silicon, 1N4005
CR62 thru 64	4805129M76	SOT MMBD914
		fuse:
F51	6500139768	bladed, 15A
F52	6505214E04	2A
		integrated circuit: (see note)
U51	5184621K96	regulator, 5 V/0.5 A, 78M05CT
U52, 53	5180932W01	op-amp, dual, LM2904
		relay:
K51		SPDT 20A 12V 50mA (Potter & Brumfield RKS-5DW-12)
		resistor, fixed: +/-5%; 1/8 W:
R51, 52	0611077B05	18k
R53	0611077A98	10k
R55	0611077G13	16.5k, ±1%
R56	0611077G42	33.2k, ±1%
R57	0611077A90	4.7k
R58	0611077A98	10k
R59, 60	0611077B07	22k
R62	0611077B07	22k
R63	0611077A98	10k
R64, 65	0611077A90	4.7k
R66	0611077A66	470 Ω
R67, 68	0611086C04	met film, 2.2 Ω, 2W
R69	0611077A98	10k
R70	1884944C12	potentiometer, 5k, ±20%
R71	0611077B07	22k
R72	0611077A74	1.0k
R73	0611077A90	4.7k
R74	0611077B23	100k
R75	0611077A98	10k
R76	0611077G13	16.5k, ±1%
R77	0611077G42	18k, ±1%
R79, 80	0611077B23	100k
R81	0611077B07	22k
R83	0611077A74	1.0k
		transistor: (see note)
Q51 thru 53	4880214G02	NPN
Q54	4880214G01	PNP
		voltage regulator: (see note)
VR51	4813830A18	Zener, SOT, 6.8 V
VR52, 53	4880948V01	Zener, SOT, 27 V
VR54	48813830D41	Zener, 36 V
VR55	4813830D37	Zener, 27 V
	or 4813830D41	Zener, 36 V
VR56 thru 59	4880948V01	Zener, SOT, 27 V

note: For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.