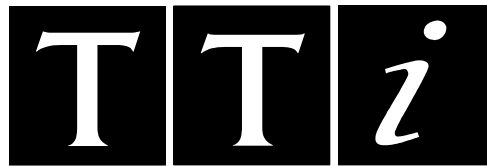


# **EX354D/T & Tv**

Dual/Triple 35V/4A  
Power Supplies  
**Service Manual**



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## Specification

### MAIN OUTPUTS

Voltage Range:	0V to 35V minimum
Current Range:	0A to 4A minimum
Output Voltage Setting:	By coarse and fine controls.
Output Current Setting:	By single logarithmic control.
Operating Mode:	Constant voltage or constant current with automatic cross-over.
Output Switch:	Electronic. Preset voltage and current displayed when off.
Output Terminals:	4mm terminals on 19mm (0.75") pitch.
Output Impedance:	Typically $<5\text{m}\Omega$ in constant voltage mode. Typically $>50\text{k}\Omega$ in constant current mode.
Output Protection:	Output will withstand up to 40V forward voltage. Reverse protection by diode clamp for reverse currents up to 3A.
Load & Line Regulation:	$<0.01\%$ of maximum output for a 90% load change or 10% line change.
Ripple & Noise (20MHz bandwidth):	Typically $<2\text{mV}_{\text{rms}}$ , $<10\text{mV}$ pk-pk, constant voltage mode.
Transient Response:	$<200\mu\text{s}$ to within 50mV of set level for 90% load change.
Temperature Coefficient:	Typically $<100\text{ppm}/^\circ\text{C}$
Status Indication:	Output on lamp. Constant current mode lamp.

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## METER SPECIFICATIONS (Main Outputs)

Meter Types:	Dual 3 digit meters with 14mm (0.56") LEDs. Reading rate 4 Hz.
Meter Resolutions:	100mV, 10mA
Meter Accuracies:	Voltage 0.3% of reading $\pm 1$ digit, Current 0.6% of reading $\pm 1$ digit

## LOGIC OUTPUT (Triple only)

Voltage:	<i>EX354T</i> : 5V or 3.3V, selectable by front panel switch. <i>EX354Tv</i> : Variable <1.5V to >5V by front panel control.
Voltage Accuracy	<i>EX354T</i> : $\pm 2\%$ <i>EX354Tv</i> : 0.3% $\pm 1$ digit.
Current Limit:	5A minimum.
Output Terminals:	4mm terminals on 19mm (0.75") pitch.
Output Protection:	Output will withstand up to 7V forward voltage. Diode clamp reverse protection for currents up to 3A.
Load Regulation:	<0.5% for a 90% load change.
Line Regulation:	<0.1% for a 10% line voltage change.
Ripple & Noise (20MHz bandwidth):	Typically <2mV, rms, <10mV pk-pk, constant voltage mode.
Transient Response:	Typically <200 $\mu$ s to within 50mV of set level for 90% load change.
Temperature Coefficient:	Typically <100ppm/ $^{\circ}$ C.
Status Indication:	Current limit lamp (EX354T) UNREG lamp (EX354Tv)

## GENERAL

AC Input:	110V - 240V AC $\pm 10\%$ , 50/60Hz. Installation Category II.
Power Consumption:	500VA max.
Operating Range:	+5 $^{\circ}$ C to +40 $^{\circ}$ C, 20% to 80% RH.
Storage Range:	-40 $^{\circ}$ C to + 70 $^{\circ}$ C.
Environmental:	Indoor use at altitudes up to 2000m, Pollution Degree 2.
Safety:	Complies with EN61010-1.
EMC:	Complies with EN61326.
Size:	260 x 160 x 320mm (WxHxD).
Weight:	4.3kg

This power supply is a Safety Class I instrument according to IEC classification and has been designed to meet the requirements of EN61010-1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use). It is an Installation Category II instrument intended for operation from a normal single phase supply.

This instrument has been tested in accordance with EN61010-1 and has been supplied in a safe condition. This instruction manual contains some information and warnings which have to be followed by the user to ensure safe operation and to retain the instrument in a safe condition.

This instrument has been designed for indoor use in a Pollution Degree 2 environment in the temperature range 5°C to 40°C, 20% - 80% RH (non-condensing). It may occasionally be subjected to temperatures between +5°C and -10°C without degradation of its safety. Do not operate while condensation is present.

Use of this instrument in a manner not specified by these instructions may impair the safety protection provided. Do not operate the instrument outside its rated supply voltages or environmental range.

## **WARNING! THIS INSTRUMENT MUST BE EARTHED**

Any interruption of the mains earth conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited. The protective action must not be negated by the use of an extension cord without a protective conductor.

When the instrument is connected to its supply, terminals may be live and opening the covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts. The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair. Capacitors inside the power supply may still be charged even if the power supply has been disconnected from all voltage sources but will be safely discharged about 10 minutes after switching off power.






Any adjustment, maintenance and repair of the opened instrument under voltage shall be avoided as far as possible and, if inevitable, shall be carried out only by a skilled person who is aware of the hazard involved.

If the instrument is clearly defective, has been subject to mechanical damage, excessive moisture or chemical corrosion the safety protection may be impaired and the apparatus should be withdrawn from use and returned for checking and repair.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders is prohibited.

Do not wet the instrument when cleaning it.

The following symbols are used on the instrument and in this manual:-

	Earth (ground) terminal.
	mains supply OFF.
	mains supply ON.
	alternating current (ac)
	direct current (dc)

## Service Handling Precautions

Service work or calibration should only be carried out by skilled engineers using high quality test equipment. If the user is in any doubt as to his competence to carry out the work, the instrument should be returned to the manufacturer or their agent overseas for the work to be carried out.

The tracks on the printed circuit boards are very fine and may lift if subjected to excessive heat. Use only a miniature temperature-controlled soldering iron and remove all solder with solder wick or suction before attempting to remove a component. On the latest version (3), many devices are also miniature surface mounted components with very fine leads on small pitches. These components must be removed and replaced with great care to avoid damage to the PCB. It is essential that only the proper tools and soldering equipment for surface mount components are used.

## Dismantling the instrument

### WARNING

Disconnect the power supply from all voltage sources before it is opened for adjustment or repair. Capacitors inside the supply may still be charged even if the supply has been disconnected from all voltage sources but will be safely discharged about 10 minutes after removing power.

If any adjustment or repair of the opened supply under voltage is inevitable it shall be carried out only by a skilled person who is aware of the hazard involved. The incoming AC supply to the unit under test should be isolated for safety by means of a 1:1 isolation transformer of at least 700VA. High voltages (up to 400V) are always present in the primary-side circuitry which lies in a clearly defined area at the rear of the main printed circuit boards.

1. Remove the 6 side screws and front handle screw to release the top cover.
2. Unplug the connector assemblies linking the main pcb to the front panel control pcb, noting their orientation (brown wire to pin 1 corner marker).
3. Unplug the mains connection at the rear of the pcb and remove the chassis safety earth connection.
4. Undo the 10 screws which secure the main pcb support pillars to the chassis (i.e. the screws accessible **underneath** the chassis) and lift out the pcb with its mounting pillars attached. On versions 3 & 4 (see below) the separate 3V/5V or 1.5V-5V variable sections can then be removed if necessary.
5. To remove the control pcb on the front panel first remove the main pcb. Pull off the 6 control knobs then undo the 5 screws which retain the pcb to the moulding and the 4 screws or nuts (6 on EX354T) which connect the pcb to the output terminals; note that the latter fixings are 4BA screws, as marked on the pcb adjacent to each screw, prior to the introduction of safety terminals at Version 4 which used M4 nuts. The control pcb can then be lifted clear.
6. Reassemble in the reverse order taking great care to ensure that all connections are exactly as before dismantling and that no insulation creepage and clearance distances have been compromised. Ensure that only the correct fastenings have been used otherwise earthing, and hence EMC and safety performance, may be impaired.

## Model Changes (as at August 2006)

The EX354 has undergone a number of changes since its inception. The three major versions of the Main pcb, summarised here, have separate Circuit Descriptions, Component Layouts and Parts Lists. The particular version can be identified by the part number printed on the Main pcb appropriate to each version, see below. In addition, for each major version, there have been a variety of minor component changes, e.g. output chokes in a different mechanical format or alternative FETs, but 'old' and 'new' parts for a particular component location are generally self-evidently interchangeable.

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In August 2006 the EX354Tv was introduced. This uses the same Main pcb as previous but had different Control and third output pcbs to realize the variable 1.5V to 5V third output.

The four main versions are as follows:

- Version 1:* From April 1997 – December 2000. 230V only operation, non-PFC, built on Main pcb part number 35515-1460 (single-sided). Control pcb 35555-2600.
- Version 2:* From December 200 – October 2005. Universal operation PFC version; built on 35515-1820 (single-sided) Main pcb until January 2003, then 35555-3710 (double-sided) Main pcb until October 2005. Control pcb unchanged from Version 1.
- Version 3:* From October 2005 onwards. Built on 3555-4550 Main pcb using surface-mount components wherever possible. At the same time the Control pcb also became surface mount (changing from pcb part no. 35555-2600 to 35555-4360) and the 3.3V/5V Output became a separate assembly built on 35555-4580.
- Version 4:* From August 2006 onwards. Built using the same Main pcb (35555-4550) but with a 1.5V to 5V variable output assembly built on pcb 35555-4790 replacing the switched 3.3V/5V assembly of version 3. At the same time the Control pcb changed (to accommodate the 1.5V to 5V control), built on pcb 35555-4780.

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# Circuit Descriptions

The main board contains all the power sections for the 2 main 35V/4A outputs, the 3.3V/5V logic output and the auxiliary supplies for the control, measurement and display functions on the front panel Control board. Pcb layouts are the same in triple and dual units but pcbs in the triple are additionally populated with the components for the 5V/3.3V output (Versions 1 & 2) or are fitted with a separate 5V/3.3V assembly (Version 3) or 1.5V-to-5V assembly (Version 4). Refer to the Model Changes section for an overview of the four main versions of this PSU.

## Main Pcb – Version 1

Component references, when output specific, are given for Channel A (the left hand main output when viewed from the front) with Channel B references shown in brackets. Where supply rail and signal names are given, these will be followed by /A, /B or /C on the schematics for Channels A, B and C respectively.

The topology employed is a double-ended forward converter with isolated secondary windings for each output which are regulated by means of a magamp pre-regulator followed by a MOSFET linear regulator.

## Mains Input, Filtering and Rectification

The AC input is direct via a pcb-mounted IEC inlet connector. X-capacitors C1, C9, C5, Y-capacitors C6, C7 and common-mode inductors L1, L2 comprise an input filter which ensures that the supply meets both conducted emission and conducted immunity EMC requirements. VDR1 'clips' mains spikes for component protection; R1 provides safety discharge for C1, C5 and C9.

Pcb-mounted fuse FS1 limits damage on switchmode failure; the front panel mains switch is connected via PJ4; RT1 reduces the mains inrush when the unit is turned on from cold. BR1 is a bridge rectifier and C13 the reservoir capacitor for the high voltage rail HT; the circuit is only configured for 230V operation. R113 provides safety discharge for C13. C11 and C12 by-pass noise signals and help to snub reverse recovery transients in the bridge rectifier.

## Startup Circuit

When AC power is applied, C94 charges via R60 and R98 and pin 1 of IC1 is low. IC1 pin 7 is also low keeping the 555 timer IC7 in a reset condition.

When the voltage on C94 reaches about 29V, IC1 pin 1 goes high via R8 (LM393 has an open collector o/p) and a regulated voltage of about 17V appears at Q1 emitter. R5 is no longer in parallel with R4 thus providing positive feedback during the switching transition and sufficient hysteresis to prevent IC1A being switched by 50Hz ripple on the supply rail. IC7 is now enabled.

## Oscillator and Feed-forward PWM

IC5A, B, C, is a 160kHz oscillator. D-type IC6A produces a squarewave at 80kHz. The Q output of the D-type is used to provide a negative trigger pulse for the 555 timer IC7. R73, C4 produce a leading edge delay to reduce the duty cycle to about 45%.

The Q output of the D-type provides a means of terminating the 555 timer pulse by charging C68.

After the 555 timer has been triggered by Q21, IC7 pin 7 goes high and allows R82, R90 to charge C68. While the HTA rail is below about 250V, the voltage on C68 will not have reached the level required at IC7 pin 6 to terminate the pulse and a maximum duty cycle pulse is generated when Q19 terminates the pulse. As the input mains voltage rises above 185V AC, the current through R82, R90 manages to charge C68 to the 555 timer threshold level and terminate the pulse before Q19 does so. From this point to maximum mains voltage the pulse width varies inversely with the mains voltage giving a degree of feed-forward regulation.

## Gate Drive to the Power MOSFETs

The pulse from IC7 pin 3 drives the complimentary emitter followers Q2, Q3 which in turn drive the gate drive transformer TX1. The transformer is AC coupled via C16.

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## Operation of the Double-ended Forward Converter

During the on-time both pairs of power MOSFETs, Q4/Q5 and Q6/Q7, are turned on by the gate drive transformer TX1. Local decoupling of the HT supply is by C14 and L12.

When the MOSFETs are turned off, the energy in the leakage and magnetising inductances is returned to the HT rail via D2, D3 and D4, D5. The snubber components C101, C17, R118, R119 and D8 control the rate of rise of voltage across the transformer at switch off. The current in the power stage is monitored by R16. When this current becomes excessive under fault conditions, the latch Q22, Q23 is fired, removing gate drive to the MOSFETs and discharging the local power rail via R122.

Power to the primary control circuit is obtained from a power-back winding on the transformer and components D6, D7, L3, C15. D39 isolates the power-back circuit from C94 during initial start-up.

## Main Outputs

The voltage on the secondary winding is rectified and filtered and fed to a linear regulator. To minimise power dissipation in the linear stage the voltage across it is maintained at about 1V by means of a magamp.

Linear regulation is performed by MOSFET Q14 (Q15) which receives gate drive from the control pcb via pin 2 of PJ1 (PJ2). The voltage across Q14 (Q15) is monitored by Q11 (Q12) which generates reset current to the magamp MA1 (MA2) whenever the voltage across Q14 (Q15) forward biases the base-emitter junction of Q11 (Q12). D24 (D26) is the main rectifier and flywheel diode. The rectified pulse is filtered by L6 (L7) and C33 (C37). Q8 (Q9) minimises parasitic reset of the magamp by bypassing it during the flyback period. D44 (D45), R111 (R110) and C76 (C77) generate a negative rail to sink the base bias current of Q11 (Q12) which would otherwise cause the output to remain slightly positive when 0V was set from the control board.

In the event of a fault where control of the magamp is lost and the voltage across the filter capacitor C33 (C37) rises above 40V, the crowbar circuit D57, D58, R99, R102, R123 (D59, D60, R100, R103, R124) fires and causes the primary current limit to interrupt gate drive to the primary MOSFETs Q4, Q5, Q6, Q7 and to discharge the primary control power rail. This is followed by a normal reset; if the fault persists the entire PSU is disabled.

## Fixed 5V/3.3V Output

The linear regulation using MOSFET Q16 and magamp pre-regulation using MA3 and associated components work exactly as described above for the main outputs with the exception that D62 sets the crowbar trip voltage to approximately 7.5V. When the crowbar fires fuse FS2 is blown and must be replaced, once the fault has been removed, to restore operation.

The control circuit for this output is also on the main board. IC4A provides voltage control; its output is buffered by Q17 which provides gate drive to Q16. D46, VR1 and associated components provide the 3.3V reference at IC4A pin 2. With selector switch SW3 (on the control pcb) set to 3.3V R53 is open circuit and IC4A pin 3 sees the full output voltage (+SENSE/C) via R49; with SW3 set to 5V, R49 and R53 form a potential divider across the output such that the output is approximately 5V with IC4A pin 3 at 3.3V.

IC43 provides current limit control; when the voltage across the current sense resistors R44A/R44B exceeds the reference level set by R58/R59, IC4B limits the gate drive to Q16, by acting on Q17, and simultaneously drives the constant current LED (on the control pcb) via R109/Q25.

## Auxiliary Supplies for Main Outputs

Additional transformer windings TX2-D and TX2-E provide auxiliary power for Channel A and Channel B respectively.

D40 (D41), C72 (C73) and D42 (D43) rectify, smooth and zener regulate to provide +15V.

D18 (D22), L4 (L5) and C23 (C25) rectify and smooth the supply rail to linear regulator IC2 (IC3) which provides +5V.

D13 (D14), C18 (C19) and D20 (D23) rectify, smooth and zener regulate to provide -5V.



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## Main Pcb – Version 2

Component references, when output specific, are given for Channel A (the left hand main output when viewed from the front) with Channel B references shown in brackets. Where supply rail and signal names are given, these will be followed by /A, /B or /C on the schematics for Channels A, B and C respectively.

The topology employed is a double-ended forward converter with isolated secondary windings for each output which are regulated by means of a magamp pre-regulator followed by a MOSFET linear regulator.

### Mains Input, Filtering and Rectification

The AC input is via a pcb mounted IEC plug.

X-capacitors C1, C9 and C47, together with the Y-capacitors C6, C7 and common mode inductors L1 and L2 comprise an input filter which ensures that the supply meets both conducted emission and conducted immunity EMC requirements.

VDR1 clips mains spikes for component protection, while R1 discharges the X-capacitors after removal of the mains supply.

Pcb mounted fuse FS1 limits damage on boost-stage or forward converter failure. The front panel mains switch is connected via PJ4.

The bridge rectifier BR1 has C11 and C12 connected across it to bypass noise signals and to snub reverse recovery transients in the bridge rectifier.

C89 further decouples the input filter and rectifier from the boost converter, while R113 discharges C89 after removal of the mains supply.

RT1 is an NTC which limits the initial inrush current into the boost stage output capacitor C88.

### Primary Boost stage Control circuit

The primary boost stage control is by means of IC8.

This contains all the processing circuitry to shape the current taken by the power supply from the mains supply to be sinusoidal and in phase with the voltage.

For a detailed description refer to the ST 'Power Factor Corrector Applications Manual'.

Initial start-up is via R79 and R80 which charge the auxiliary storage capacitor C32 and HF bypass capacitor C13 with voltage limiting zener diode D66. When the voltage on C32 exceeds the under voltage lockout level of 16V, IC8 starts up and supplies drive pulses to the gate of the boost MOSFET Q5 via R127 and D57. The gate drive pulses to Q5 are given a slight negative offset by C94, D52, D53 and R112 to give extra noise immunity.

C117 is connected to the soft start pin of IC8 and provides a degree of soft start.

Once the boost converter is running, the supply to IC8 is derived from an auxiliary winding on the boost inductor L3 via fusible resistor R61, rectified and filtered by D7 (fitted with snubber C17, R13), C2 and C15 and also from a power back winding via fusible resistor R17 on the main converter transformer TX2, rectified and filtered by D6, C87 and C93. Diodes D68 and D56 isolate the startup current bleed from the auxiliary supplies.

R131, R132, R133, R71, C4, and C34 form a two stage RC filter to feed a voltage proportional to the mains voltage to IC8/pin 7 which, after an internal  $1/V^2$  transformation, is fed to the internal multiplier. For a universal mains input, the voltage at this pin will vary between 1.5V and 5.5V.

R135 and R136 supply a current derived from the full wave rectified mains voltage to IC8/pin 4 to be used by the internal multiplier.

Also fed to the internal multiplier is the output of the voltage error amplifier of IC8/pin 13. The input to the error amplifier at pin 14 is from potential divider R74, R75 and R93. This potential divider monitors the voltage on the boost stage output capacitor C88 and this is compared to an accurate internal reference voltage. Thus a steady voltage of about 380V is maintained across C88.

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Another potential divider R81, R82, R98 monitors the voltage across C88 and feeds into pin 3 of IC8 which is the over-voltage shutdown.

Pin 8 is the output of the multiplier and is the programming current for the internal current error amplifier. This signal is taken to the mains supply side of the current sense resistor R83 via R8. The other input of the current error amplifier is taken to the other side of R83 via R72. The current error amplifier thus compares the signal across the current sense resistor R83 with the programming current and adjusts the PWM drive to the boost MOSFET Q5 accordingly. R73 and C86 with R72 form the compensation network around the current error amplifier.

When the mains supply falls below about 85Vrms, the circuit comprising of long tail pair Q6 and Q10 and Q1 act on the soft start input of IC8 to curtail operation.

### **Boost Stage**

Q5 and boost inductor L3 raise the incoming, full wave rectified, sinusoidal mains voltage to a value some 20V higher than the peak of the maximum rms input voltage. This is achieved by storing energy in L3 when Q5 is conducting and transferring it to C88 via boost diode D54 when Q5 is turned off.

When Q5 next turns on, D54 is still conducting current. To prevent large switch on losses in Q5, a delay inductor L9 is placed in series with Q5. This ensures that the current in the boost diode D54 is reduced at a gradual rate and the reverse recovery time is minimised at the same time as Q5 drain voltage is allowed to fall rapidly.

The energy stored in L9 is transferred to C119 via D67 and dissipated in R92 and R95.

Snubber network C121, R90, D50 reduces switch off losses in Q5.

### **Oscillator and Forward Converter**

IC1-A,B,C is a 160kHz oscillator. D-type IC7-A produces a square wave at 80kHz. The square wave at the Q output of IC7-A is processed by R9, D99, C68 and IC1-D to give a pulse of about 45% duty.

The Q output of IC7-B is processed by components C10, R55, R77 and Q19 to produce a synchronisation pulse for IC8. This synchronisation signal is not used in some models.

The output from IC1-D is buffered by IC1-E and IC1-F to drive the complimentary emitter followers Q2, Q3 which in turn drive the gate drive transformer TX1.

TX1 is ac coupled via C16 and its parallel diode D1.

A 15V supply for the CMOS ICs IC1 & IC7 is derived from the primary auxiliary rail via 3-terminal regulator IC4.

R105 in series with the primary winding of TX1 is used to control the switching speed of the MOSFETs. R10 in parallel with TX1 primary dampens any ringing.

A dual ended forward converter comprising of Q4, Q7 and TX2 converts the boost voltage of C88 to provide three isolated low voltage secondaries and also the secondary auxiliary voltages.

TX2 leakage energy is returned to the high voltage supply rail via D2, D3 and D4, D5. The turnoff voltage rise is controlled by 'loss-less' snubber network C27, C28, D61, D63, D69, L10.

R20 dampens any oscillation across L10.

The current in the forward converter is monitored by R16 and, if excessive, activates latch Q22, Q23 to provide a pulse-by-pulse current limit.

### **Main outputs**

The voltage on the secondary winding is rectified and L-C filtered and fed to a linear regulator. To minimise power dissipation in the linear regulating element, the voltage across it is maintained at about 1V by means of a magamp.

Referring to output A, the linear regulation is performed by MOSFET Q14 which receives gate drive from the front panel pcb. The voltage across Q14 is monitored by Q11 which generates reset current to the magamp MA1 whenever the voltage across drain/source of Q14 forward biases the base-emitter junction of Q11.

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D24 is the main rectifier and flywheel diode . The rectified pulse is filtered by L6 and C33.

D44, R111 and C76 generate a negative rail and via R63 sink the base bias current of Q11 which would otherwise cause the output to remain slightly positive when 0V was set on the front panel.

In the event of a fault where control of the magamp is lost and the voltage across the filter capacitor C33 rises above 40V, the opto-isolator IC13 is activated via zener diode D58 and R102 and causes primary side thyristor SC1 to discharge the primary control power rail . This is followed by a normal restart. If the fault persists, the PSU will continue to 'hiccup'.

### **Fixed 5/3.3V output**

This works in an identical fashion to the main outputs with the exception that the output voltage control and current limit functions are performed by op-amp IC5. This output is fused in case of a failure in the current limit circuit .

### **Secondary auxiliary power supply**

The power rails for the control electronics of the two main outputs are generated from auxiliary windings on the main converter transformer.

Again referring to channel A, the +15V is peak rectified by D40, C72 and zener regulated by D42.

The +5V rail is rectified by D18, D19 and filtered by L4 and C23. The inductor L4 is held in continuous conduction and thus the voltage at the input to the three terminal regulator IC2 is maintained at a low value.

The -5V rail is peak rectified by D13, C18 and zener regulated by D20.

### **PCB Change**

Note that during the period of this Version 2 the pcb was changed from a single-sided layout (with zero-Ohm links fitted) to a double-sided layout, see Model Changes section. The component positions and numbering remained the same; links were simply replaced by component-side tracks. The benefit of this change was the greater mechanical security that the plated-through holes gave, particularly to the heavier components.

## **Main PCB – Versions 3 & 4**

Component references, when output specific, are given for Channel A (the left hand main output when viewed from the front) with Channel B references shown in brackets. Where supply rail and signal names are given, these will be followed by /A, /B or /C on the schematics for Channels A, B and C respectively.

The topology employed is a double-ended forward converter with isolated secondary windings for each output which are regulated by means of a magamp pre-regulator followed by a MOSFET linear regulator.

### **Mains Input, Filtering and Rectification**

The AC input is via a pcb mounted IEC plug.

X-capacitors C1, C9 and C47, together with the Y-capacitors C6, C7 and common mode inductors L1 and L2 comprise an input filter which ensures that the supply meets both conducted emission and conducted immunity EMC requirements.

VDR1 clips mains spikes for component protection, while R1 discharges the X-capacitors after removal of the mains supply.

Pcb mounted fuse FS1 limits damage on boost-stage or forward converter failure. The front panel mains switch is connected via PJ4.

The bridge rectifier BR1 has C11 and C12 connected across it to bypass noise signals and to snub reverse recovery transients in the bridge rectifier.

C89 further decouples the input filter and rectifier from the boost converter, while R113 discharges C89 after removal of the mains supply.

RT1 is an NTC which limits the initial inrush current into the boost stage output capacitor C88.

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## Primary Boost Stage Control circuit

The primary boost stage control is by means of IC8.

This contains all the processing circuitry to shape the current taken by the power supply from the mains supply to be sinusoidal and in phase with the voltage.

For a detailed description refer to the ST 'Power Factor Corrector Applications Manual'.

Initial start-up is via R79 and R80 which charge the auxiliary storage capacitor C32 and HF bypass capacitor C13 with voltage limiting zener diode D66. When the voltage on C32 exceeds the under voltage lockout level of 16V, IC8 starts up and supplies drive pulses to the gate of the boost MOSFET Q5 via R127 and D57. The gate drive pulses to Q5 are given a slight negative offset by C94, D52, D53 and R112+R112a to give extra noise immunity.

C117 is connected to the soft start pin of IC8 and provides a degree of soft start.

Once the boost converter is running, the supply to IC8 is derived from an auxiliary winding on the boost inductor L3 via fusible resistor R61, rectified and filtered by D7 (fitted with snubber C17, R13), C2 and C15 and also from a power back winding via fusible resistor R17 on the main converter transformer TX2, rectified and filtered by D6, C87 and C93. Diodes D68 and D56 isolate the startup current bleed from the auxiliary supplies.

R131+R131a, R132, R133, R71, C4, and C34 form a two stage RC filter to feed a voltage proportional to the mains voltage to IC8/pin 7 which, after an internal  $1/V^2$  transformation, is fed to the internal multiplier. For a universal mains input, the voltage at this pin will vary between 1.5V and 5.5V.

R135+R135a and R136+R136a supply a current derived from the full wave rectified mains voltage to IC8/pin 4 to be used by the internal multiplier.

Also fed to the internal multiplier is the output of the voltage error amplifier of IC8/pin 13. The input to the error amplifier at pin 14 is from potential divider R74+R74a, R75a and R93+R93a. This potential divider monitors the voltage on the boost stage output capacitor C88 and this is compared to an accurate internal reference voltage. Thus a steady voltage of about 380V is maintained across C88.

Another potential divider R81+R81a, R82+R82a, R98 monitors the voltage across C88 and feeds into pin 3 of IC8 which is the over voltage shutdown.

Pin 8 is the output of the multiplier and is the programming current for the internal current error amplifier. This signal is taken to the mains supply side of the current sense resistor R83 via R8. The other input of the current error amplifier is taken to the other side of R83 via R72. The current error amplifier thus compares the signal across the current sense resistor R83 with the programming current and adjusts the PWM drive to the boost MOSFET Q5 accordingly. R73 and C86 with R72 form the compensation network around the current error amplifier.

When the mains supply falls below about 85Vrms, the circuit comprising of long tail pair Q6 and Q10 and Q1 act on the soft start input of IC8 to curtail operation.

## Boost Stage

Q5 and boost inductor L3 raise the incoming, full wave rectified, sinusoidal mains voltage to a value some 20V higher than the peak of the maximum rms input voltage. This is achieved by storing energy in L3 when Q5 is conducting and transferring it to C88 via boost diode D54 when Q5 is turned off.

When Q5 next turns on, D54 is still conducting current. To prevent large switch on losses in Q5, a delay inductor L9 is placed in series with Q5. This ensures that the current in the boost diode D54 is reduced at a gradual rate and the reverse recovery time is minimised at the same time as Q5 drain voltage is allowed to fall rapidly.

The energy stored in L9 is transferred to C119 via D67 and dissipated in R92 and R95.

Snubber network C121,R90,D50 reduces switch off losses in Q5.

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## Oscillator and Forward Converter

IC1-A,B,C is a 160kHz oscillator. D-type IC7-A produces a square wave at 80kHz. The square wave at Q output of IC7-A is processed by R9, D99, C68 and IC1-D to give a pulse of about 45% duty.

The output from IC1-D is buffered by IC1-E and IC1-F to drive the complimentary emitter followers Q2,Q3 which in turn drive the gate drive transformer TX1.

TX1 is ac coupled via C16 and its parallel diode D1.

A 15V supply for the CMOS ICs IC1, IC7 is derived from the primary auxiliary rail via 3-terminal regulator IC4.

R105 in series with the primary winding of TX1 is used to control the switching speed of the MOSFETs. R10+R10a in parallel with TX1 primary dampen any ringing.

A dual-ended forward converter comprising of Q4, Q7 and TX2 converts the boost voltage of C88 the provide three isolated low voltage secondaries and also the secondary auxiliary voltages.

TX2 leakage energy is returned to the high voltage supply rail via D2, D3 and D4, D5. The turn-off voltage rise is controlled by 'loss-less' snubber network C27, C28, D61, D63, D69, L10 . R20 dampens any oscillation across L10.

The current in the forward converter is monitored by R16 and, if excessive, activates latch Q22, Q23 to provide a pulse-by pulse current limit.

While providing a pulse-by-pulse current limit, the latch Q22,Q23 also charges C57 which after a short delay causes Q24 to conduct and trigger SC1, the subsequent trip – restart action limiting the temperature rise in Q4,Q7 and TX2.

## Main outputs

The voltage on the secondary winding is rectified and L-C filtered and fed to a linear regulator . To minimise power dissipation in the linear regulating element, the voltage across it is maintained at about 1V by means of a magamp.

Referring to output A, the linear regulation is performed by MOSFET Q14 which receives gate drive from the front panel Control pcb. The voltage across Q14 is monitored by Q11 which generates reset current to the magamp MA1 whenever the voltage across drain/source of Q14 forward biases the base-emitter junction of Q11.

D24 is the main rectifier and flywheel diode. The rectified pulse is filtered by L6 and C33.

D44, R111 and C76 generate a negative rail and, via R63, sink the base bias current of Q11 which would otherwise cause the output to remain slightly positive when 0V was set on the front panel.

Fuse FS3 protects the primary power devices and TX2 from the damaging effects of a short circuit filter capacitor C33 or faulty linear output MOSFET Q14.

In the event of a fault where control of the magamp is lost and the voltage across the filter capacitor C33 rises above 40V, the opto isolator IC13 is activated via zener diode D58 and R102 and causes primary side thyristor SC1 to discharge the primary control power rail. This is followed by a normal restart. If the fault persists, the PSU will continue to 'hiccup'.

Resistors R96 and R130 prevent the output from 'floating' to a dangerous voltage with respect to the chassis. C108 and C51 help to reduce noise voltages on the output.

## Secondary auxiliary power supply

The power rails for the control electronics of the two main outputs are generated from auxiliary windings on the main converter transformer.

Again referring to channel A, the +15V is peak rectified by D40,C72 and zener regulated by D42.

The +5V rail is rectified by D18, D19 and filtered by L4 and C23. The inductor L4 is held in continuous conduction and thus the voltage at the input to the three terminal regulator IC2 is maintained at a low value.

The –5V rail is peak rectified by D13, C18 and zener regulated by D20.

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### **Fixed 5/3.3V output – Version 3**

For Version 3 the 5V/3.3V output is contained on a separate pcb mounted to the Main board and connected to it via a soldered header (marked PJ6 on the Main, PJ1 on the 5V/3.3V board). This works in an identical fashion to the main outputs with the exception that the output voltage control and current limit functions are performed by opamp IC5. This output is fused in case of a failure in the current limit circuit.

### **Variable 1.5V to 5V output – Version 4**

In Version 4 the 3<sup>rd</sup> output is further changed to offer a variable 1.5V to 5V AUX output in conjunction with minor changes to the Control board (described under Version 4 Control in the following section).

The AUX output is connected to the Main board via the same soldered header as for Version 3 (PJ6 on the Main, PJ1 on the AUX board). Connection to the Control board is via an 8-way connector, PJ5, and 2 way connector, PJ5A. Operation is essentially the same as for the main outputs with the exception that the output voltage control and current limit functions are performed by opamp IC5; VR11 on the Control board (see Sheet 1 of Version 4) sets the output voltage.

The voltmeter of the right-hand main output (Channel B) is used to measure the AUX output via an isolation circuit. Opto-isolator IC4 contains one LED and two matched photodiodes. One photodiode is placed in the feedback path of IC2A to linearise the output from the photodiodes. The other photodiode is connected, via PJ5A, to R63/R64 on the Control board and the right-hand voltmeter measures the voltage across R64 when the SHOW AUX PRESET switch SW2A is closed. The preset current limit (5 Amps) is displayed at the same time by measuring the voltage at the junction of R61/R65 when SW2B is closed. Calibration of the voltage measurement is achieved with VR2 on the AUX board.

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# Control Board

Component references are given for Channel A, the left-hand channel viewed from the front; Channel B components are all numbered from 100 upwards, e.g. RP3, C9 and R24 on Channel A are RP103, C109 and R124 on Channel B.

The linear regulator is in series with the positive output but, because of the way in which the control and metering works, it is convenient to consider the regulator output (OP) as 0V and to regard the negative output as the controlled output voltage (-V).

Supply rail and signal names on the schematics are followed by /A or /B for Channels A and B respectively, e.g. OP/A.

From October 2005 the Control board was changed to a mainly surface mount assembly and in August 2006 further minor changes were made with the introduction of the 1.5V to 5V variable AUX output. The 3 control variants are described in the Model Changes section (page 5) and each have their own Parts Lists, Schematics and Component Layouts. The following descriptions of the main output control apply equally to all 3 variants, however.

## Voltage Control

IC7C buffers the voltage control potentiometers VR1 and VR2; VR5 sets the maximum output voltage. D6 provides the reference ( $V_{REF}$ ) which is nominally 2.45V.

IC7A is a differential amplifier with a voltage gain of 14.7; for an output voltage of 35V the voltage at IC7C pin 8 will be 2.38V. VR9 trims differential gain to ensure good voltage regulation, see Calibration section.

The output of IC7C drives the input of IC7A when the ON-OFF switch, SW1B, is in the ON position. When SW1B is in the OFF position the input of IC7A is grounded via R50, setting the output volts to zero.

The output of IC7A provides the gate drive (GATE) to the regulating MOSFET Q14 (Q15) on the main pcb via D3.

## Current Control

IC7D is the error amplifier which compares the voltage on the wiper of VR3, the current limit control with the voltage generated across the current sense resistor R21. When the output current reaches the set limit IC7D takes control via D4, changing the supply from constant voltage to constant current mode. At the same time Q1 is turned on by IC7D, making ILIMIT go high; this is read by the microcontroller IC3 which turns on the constant current lamp, LED2.

VR4 sets the maximum output current; VR8 adjusts the output current to be the same as the preset current at low levels, see Calibration section.

## Measurement and Display

The measurement and display is controlled by a microcontroller, IC3. IC5, IC2 and associated components, together with IC3, form a dual slope A-to-D converter. Multiplexer IC4, under the control of IC3, selects the signals to be measured. The status line SW1 from the output ON/OFF switch is read by IC3 to determine which signals are measured, as follows:

Status	Voltage Measurement	Current Measurement
Output Off	Preset Volts (VPRT & ILO)	Preset Current (IPHI & ILO)
Output On	Output Volts (+SENSE & VOLO)	Output Current (IOHI & ILO)

IC3 processes the measurement and drives the two multiplexed 3-digit, 7-segment, LED displays via digit driver IC1 and segment latch IC6. Individual segment current limit is provided by RP1 and RP2. The constant current lamp, LED2, is part of this multiplexing scheme; the output on lamp, LED1, is driven directly from the +5V auxiliary rail via R2 when the dc output switch SW1-A is closed.

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## AUX Output Control (Version 4)

Refer to the Control schematic Version 4. VR11 is the front panel  $V_{\text{set}}$  control for the AUX output providing an output range of <1.5V to >5.0V. With the right-hand main output off the meters read preset volts (VPRTB) and preset current limit (IPHIB) via the open position of front panel switch SW2-A, SW2-B, (SHOW AUX PRESET) whose poles are connected to multiplexer IC104 of the ADC. When SHOW AUX PRESET is pressed, the voltages at R63/R64 and R61/R65 are read which correspond to the set output voltage and current limit (5Amps) respectively.

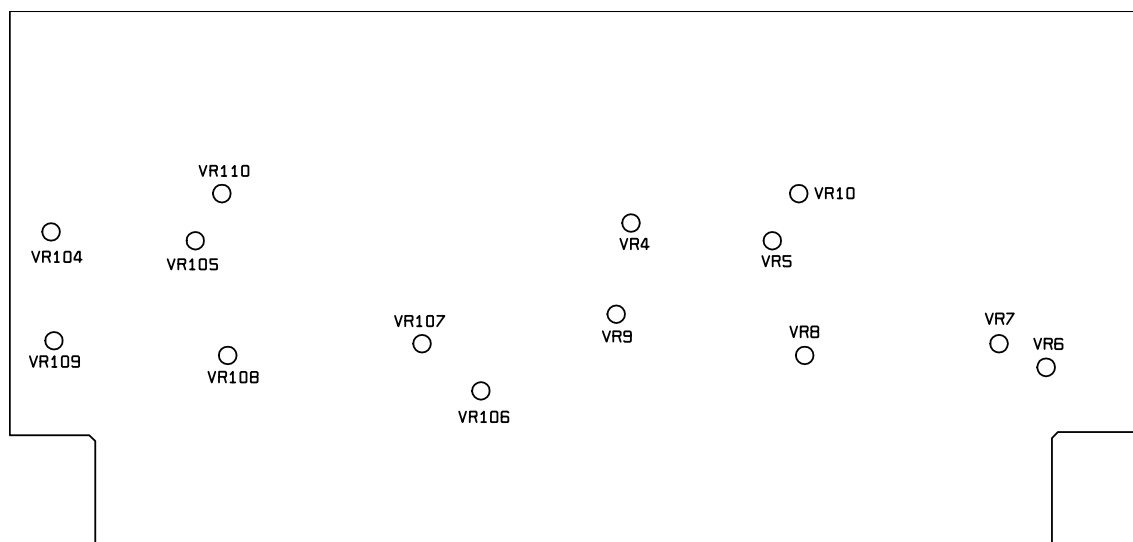


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# Calibration

Refer to the General section for dismantling instructions and safety precautions. Component adjustment references are given as Channel A/ Channel B, e.g. VR5/VR105; Channel A is the left-hand output. All adjustments are on the front panel control board unless otherwise stated.

Allow 5 minute warm-up before commencing calibration.



**Control pcb calibration points (viewed from rear)**

## Equipment Required

A 5½ digit multimeter with better than 0.05% accuracy on dc volts and better than 0.1% accuracy on dc current (to 5A); alternatively use a precision shunt for current measurement.

Rheostat or other high power load arrangement to provide up to 5A load at 35V.

## Voltage Calibration

Connect the DMM (set to volts 0) across the output. Set voltage and current controls to minimum. Switch output ON (Check LED is on) and check for a reading of  $00.0V \pm 0.1V$  on the Volts display and DMM; check the Amps display reads  $0.00 \pm 0.01A$ .

Set voltage and current controls to maximum. Adjust VR5/VR105 (maximum output volts) for a reading of 35.16V to 35.24V on the DMM. Adjust VR6/VR106 (measured output volts) until the Volts display matches the reading on the external DMM.

Switch output OFF. Adjust VR10/110 (preset volts) until the Volts display shows 35.2.

## Current Calibration

Switch output OFF. Set output voltage to nominally 2V. Set current control to minimum. Connect the DMM (set to Amps) and load in series across the output. Switch output ON.

Adjust VR8/108 (offset compensation of current control error amp) for a reading of  $0.003A \pm 0.001A$  on the DMM. Check that the CC LED is ON.

Increase voltage controls and current control to maximum. Adjust load until the DMM reads  $4.00A \pm 0.02A$ . Adjust VR7/107 (measured output current) until the Amps display matches the DMM reading.

Reduce load until the CC LED is ON. Adjust VR4/104 (maximum output current) until the Amps display shows 4.05.

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## Voltage Regulation

Connect the DMM (set to Volts) across the output, no load, output ON.

Adjust voltage controls for a reading of 18.xxxx on the DMM; note exact reading.

Connect load and adjust it to give an output current of 4.00A on the Amps display. Adjust VR8/109 (differential voltage gain) until the external DMM matches the previous reading.

## 3.3V/5V Output (Versions 1, 2 & 3)

Connect the DMM to the output. With switch set to 3.3V position adjust VR1 on the main pcb for a reading of 3.300 Volts.

Switch to the 5V position and check output is between 4.905V and 5.095V.

Connect the DMM (set to Amps) and load in series across the output. Adjust load until the C.LIMIT LED comes ON. Check that the DMM reads >5 Amps.

Connect the DMM (set to Volts) in parallel with the load across the output. Adjust load until the C.LIMIT LED just goes off. Check that the DMM reads the same as in the 5V check above,  $\pm 0.025V$ .

## Variable 1.5V to 5V AUX Output (Version 4)

Connect the DMM to the output. Adjust  $V_{SET}$  to minimum and check voltage is 1.0xxV to 1.4xxV.

Adjust  $V_{SET}$  to maximum and check voltage is 5.1xxV to 5.8xxV. Set output to 5.0xxV and note reading.

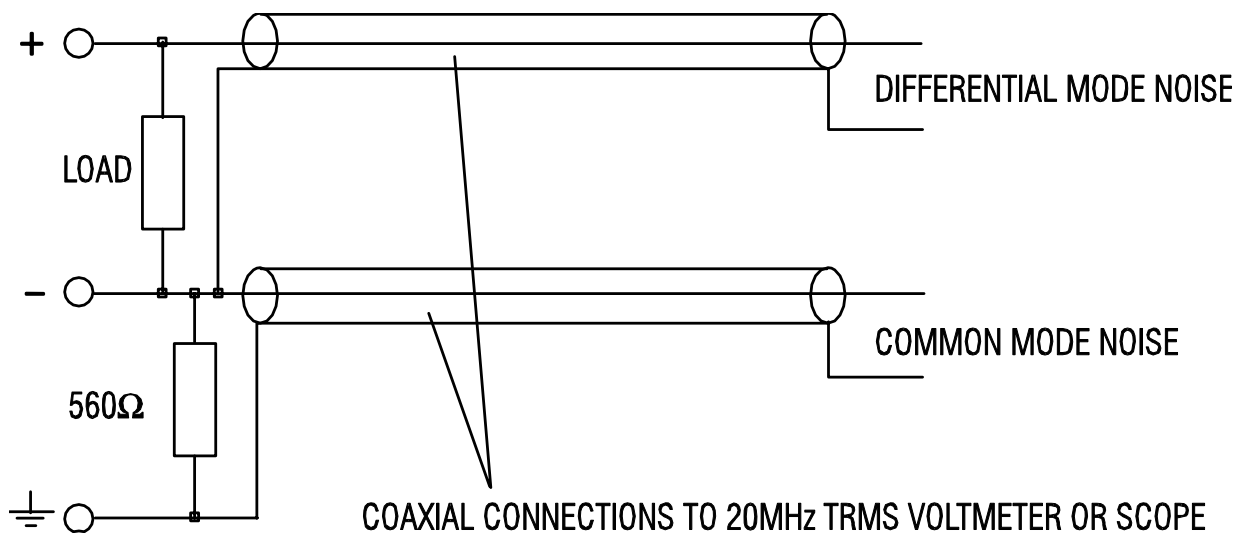
With RHS main output off, press SHOW AUX PRESET switch and adjust VR2 on AUX pcb until the RHS voltage display matches the DMM reading noted. Check RHS current display shows 5.01 to 5.07.

Connect variable load to output and adjust for an external current meter reading of 5.0x Amps. Check voltmeter reads the same as in the 5V check above,  $\pm 0.025V$ . Check UNREG LED is off.

Disconnect load. Connect S/C across output. Check UNREG LED is on. Remove S/C.

## Noise Measurements

Differential and common-mode noise checks can be made using the arrangement below. Keep all unscreened connections as short as possible.



Make measurements with the output fully loaded. Measure differential and common-mode noise one at a time on a 20MHz TRMS voltmeter or use a 20MHz bandwidth-limited scope for peak-to-peak measurements.

# Parts List

## PCB ASSEMBLY - MAIN - EX354T Version 1 (44115-0850)

Parts not fitted on PCB ASSY-MAIN-EX354D Version 1 (44115-0870) shown in **bold**.

Part Number	Description	Position
20030-0263	WASHER M3 ZPST	SPACERS
20037-0301	WASHER M3 SHK/PROOF I/T ZPST	SPACERS TO UNDERSIDE OF PCB
20038-9501	WASHER M3 SPRING	SPACERS
20234-0027	SCREW M3 X 6 PNHDPZ ZPST	SPACERS
20613-0006	SIL-PAD TO220 PLAIN	SK1, 2, 4, 5, 7-10, <b>3, 6</b>
20661-0225	SPACER HEX M3 x 12 ZPST	PCB
20670-0135	CLIP GP02 FOR PCB MTG H/SINKS	SK1, 2, 4, 5, 7-10, <b>3, 6</b>
20670-0300	HEATSINK PCB MTG 63MM PLAIN	SK1, 2, 4, 5, 7-10, <b>3, 6</b>
20670-0340	HEATSINK TO220 CLIP-ON 20°C/W	FOR D57,D59,IC2,IC3
22040-0901	BEAD FERRITE FX1115	FB2, 3, 5 – 8, <b>1, 4</b>
22109-0120	TRANSFORMER HF POWER	TX2
22109-0130	TRANSFORMER GATE DRIVE	TX1
22154-0130	CHOKES 22uH RADIAL 54 MILLIOHMS	L12
22154-0160	CHOKES 1mH AXIAL 1.3 OHMS	L3, 4, 5
22154-0180	CHOKES 350uH/4A	L6, 7
22154-0190	CHOKES 200uH/5A	<b>L8</b>
22154-0220	CHOKES 3.3mH/4A COMMON MODE	L1, 2
22154-0500	MAGAMP (4A)	MA1, 2
22154-0510	MAGAMP (5A)	<b>MA3</b>
22300-0211	FUSEHOLDER PCB MOUNTING	
22315-0240	FUSE 6.3A 20MM FB GLASS	<b>FS2</b>
22315-0248	FUSE 10A ANTISURGE (T) HBC CER	FS1
22520-0190	AC MAINS RECEPT 10AMP SOLDER MTG	PJ3
22573-0207	HEADER 7 WAY STRAIGHT .156P	PJ4, <b>PJ5</b>
22573-0209	HEADER 9 WAY STRAIGHT .156P	PJ1, 2
23185-0000	RES ZERO OHM	LK2-17, <b>1, 18, 19</b>
23202-0100	RES 10R0F W60 MF 50PPM	<b>R94, 95</b>
23202-0150	RES 15R0F W60 MF 50PPM	R11,12,14,15
23202-0220	RES 22R0F W60 MF 50PPM	R67, 68, 69, 70, 91, 92
23202-0470	RES 47R0F W60 MF 50PPM	R122
23202-0680	RES 68R0F W60 MF 50PPM	R105
23202-1100	RES 100RF W60 MF 50PPM	R44,106, 102, 103

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**PCB ASSEMBLY - MAIN - EX354T Version 1 (44115-0850) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23202-1220	RES 220RF W60 MF 50PPM	R74, 78, 83, 84, 93, <b>104</b>
23202-1470	RES 470RF W60 MF 50PPM	R10, 85
23202-1536	RES 536RF W60 MF 50PM	<b>R59</b>
23202-2100	RES 1K00F W60 MF 50PPM	R73, 89, <b>13, 47, 51</b>
23202-2220	RES 2K20F W60 MF 50PPM	R40, 41, 72, 55, 114, <b>42, 52, 57, 108</b>
23202-2470	RES 4K70F W60 MF 50PPM	<b>R50,107</b>
23202-3100	RES 10K0F W60 MF 50PPM	R6, 43, 45, 75, 81, <b>46, 48, 58, 109, 121</b>
23202-3220	RES 22K0F W60 MF 50PPM	R65, 66, 71, <b>49</b>
23202-3430	RES 43K0F W25 MF 50PPM	<b>R53</b>
23202-4100	RES 100KF W60 MF 50PPM	R8, 61
23202-4220	RES 220KF W60 MF 50PPM	R5
23202-4470	RES 470KF W60 MF 50PPM	R3
23202-4560	RES 560KF W60 MF 50PPM	R4
23206-1270	RES 270RF W60 MF 50PPM	R29, 32, <b>36</b>
23206-2100	RES 1K00F W60 MF 50PPM	R25, 26
23206-4220	RES 220KF W60 MF 50PPM	R90
23206-4270	RES 270KF W60 MF 50PPM	R2, 82
23206-5680	RES 6M80F W60 MF 50PPM	R96, 97, <b>117</b>
23207-1470	RES 470RJ 1W MF 250PPM	R56, 62
23207-2220	RES 2K20J 1W MF 250PPM	R9
23207-3330	RES 33K0J 1W MF 250PPM	R60, 63, 64, 98
23209-4220	RES 220KF W75 MF 100PPM	R1,113
23210-0470	RES 47R0J 2W MF 250PPM	R28, 31, <b>35</b>
23222-0047	RES 4R70J W33 MF FUSIBLE	R7, 21, 23, 24, 54, 22, <b>33</b>
23222-0220	RES 22R0J W33 MF FUSIBLE	R17, 37, 38, 39,110,111,112
23222-1100	RES 100RJ W33 MF FUSIBLE	R79, 80
23222-1220	RES 220RJ W33 MF FUSIBLE	R99,100, <b>101</b>
23274-0005	RES 0R22K 2W5 WW	R16
23274-0020	RES 0R10K 2W5 WW	<b>R44A, 44B</b>
23274-0130	RES 0R1J 4W WW	R123,124
23274-0200	RES 680RJ 7W MF	R120
23377-2220	RES PS/H 2K2 CF10MM	<b>VR1</b>
23386-0010	VARISTOR V275LA20A	VDR1
23386-0030	THERMISTOR - INRUSH LIMITER 4A	RT1
23424-0459	CAP 4N7 250V AC CER Y	C6, 7,11,12
23424-0466	CAP 1N0K 1KV CER P5	C82, 83, 84, 85, 92, 93, 101

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**PCB ASSEMBLY - MAIN - EX354T Version 1 (44115-0850) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23424-0468	CAP 470PK 1KV CER P5	C20, 21, 58, 59, <b>22</b>
23427-0388	CAP 220PK 100V CER P2.5	C68
23427-9211	CAP 470PK 100V CER MED K P2.5	C4
23428-1100	CAP 100PG 100V CER NPO P2.5	C10, 87
23557-0661	CAP 470U 25V ELEC RE2 P5	C23, 25
23557-0663	CAP 220U 63V ELEC RE2 P5	C70, 71, <b>64</b>
23557-0678	CAP 22U 50V ELEC RE2 P2	C94
23557-0816	CAP 1000U 50V ELEC RSH P7.5	C33, 37
23557-0818	CAP 2U2 50V ELEC LOW ESR P2	C15, <b>29</b>
23557-0820	CAP 10U 50V ELEC LOW ESR P2	C72, 73
23557-0822	CAP 1000U 10V ELEC LOW ESR P5	<b>C41</b>
23557-0950	CAP 470U 385/400V ELEC S/I P10	C13
23620-0246	CAP 100NK 63V P/E P5	C2,18,19, 24, 26, 31, 35, 44, 45, 61, 62, 69, 74, 75, 80, 81, 88, 89, 91, 98, 99, 102,107-110, <b>39, 42, 63, 67, 97</b>
23620-0252	CAP 2N2K 63V P/E 95	<b>C65</b>
23620-0264	CAP 100NK 400V P/E 368 SER P15	C51, 54, 76, 77, <b>104</b>
23620-9007	CAP 10NK 100V P/E P5	C86, 90, 98, 99, <b>66, 100, 103</b>
23621-0314	CAP 1U 400V P/E P27.5	C14
23646-0017	CAP 1N0F 63V P/S EXFS/HR	C3
23684-0010	CAP 470NK 250VAC X2 P/P P27.5	C1, 5, 9
23685-0013	CAP 330NK 160V P/P P15	C16
25021-0901	DIO 1N4148 B/R	D13,14, 25, 27, 48, 50, 51, 53-55, 64, <b>29, 32, 36, 63</b>
25021-0910	DIO BAV21	D15,16, 30, 31, 40, 41, <b>17</b>
25031-0060	DIO BYV27	D6, 7,18,19,21, 22, <b>11</b>
25031-0080	DIO BYV32E	D24, 26, <b>28</b>
25031-0100	DIO BAX12A	D1
25031-0110	DIO BYV26C	D8, 44, 45
25031-0120	DIO BYM26C	D2, 3, 4, 5
25115-0910	DIO 1N4007 B/R	D38, 39
25130-0207	DIO ZEN 15V W4	D42, 43
25130-0229	DIO ZEN 5V6 W4	<b>D46</b>
25130-0245	DIO ZEN 36V W4	D56
25130-0903	DIO ZEN 5V1 W4	D20, 23
25130-0913	DIO ZEN 6V8 W4	<b>D62</b>
25130-0914	DIO ZEN 39V W4	D58, 60

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**PCB ASSEMBLY - MAIN - EX354T Version 1 (44115-0850) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
25130-9208	DIO ZEN 7V5 W4	D47
25130-9210	DIO ZEN 18V W4	D33, 34, 49, <b>35, 37</b>
25210-0040	THYRISTOR TIC126D	D57, 59, <b>61</b>
25211-0302	BRIDGE RECTIFIER D5SB60	BR1
25349-3500	TRAN PNP MJE350	Q11,12, <b>13</b>
25349-5560	TRAN PNP BC556	Q23
25384-9001	TRAN PNP ZTX751	Q3
25383-0507	TRAN NPN BC546	Q1,19, 21, 22, 24, <b>25</b>
25388-0211	TRAN NPN ZTX651	Q2
25388-0212	TRAN NPN BF422	<b>Q17, 18</b>
25601-0480	TRAN MOSFET N CHAN IRF740	Q4, 5, 6, 7
25601-0490	TRAN MOSFET N CHAN BUZ11A	Q14, 15, <b>16</b>
27103-0003	IC LM393	IC1
27106-0513	IC LM358N	<b>IC4</b>
27155-0100	IC ICM7555IPA	IC7
27160-0009	IC V/REG 7805	IC2, 3
27226-0130	IC 4013B	IC6
27226-0690	IC 4069UB	IC5
29212-0160	COVER - 20MM PCB FUSEHOLDER	FOR FS1
35515-1460	PCB - MAIN	

**PCB ASSEMBLY – MAIN – EX354T Version 2 (44115-1210)**

Parts not fitted on PCB ASSY – MAIN – EX354D Version 2 (44115-1230) shown in **bold**.

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
20030-0263	WASHER M3 ZPST	SPACERS, FOR BR1
20037-0301	WASHER M3 SHK/PROOF I/T ZPST	SPACERS TO UNDERSIDE OF PCB
20038-9501	WASHER M3 SPRING	SPACERS, FOR BR1
20210-0101	NUT M3 ZPST	FOR BR1
20234-0011	SCREW M3 x 10 PNHDPZ ZPST	FOR BR1
20234-0027	SCREW M3 x 6 PNHDPZ ZPST	SPACERS
20613-0007	SIL-PAD TO220 PLAIN	SKD24, SKD26, SKD28, SKD54, SKQ4, SKQ7, SKQ14-16
20613-0018	SIL-PAD TO-3P/247 PLAIN	SKQ5
20661-0225	SPACER HEX M3 x 12 NPBR	PCB
20670-0135	CLIP GP02 FOR PCB MTG H/SINKS	SKD24, SKD26, SKD28, SKD54, SKQ4, SKQ7, SKQ14-16
20670-0300	HEATSINK PCB MTG 63MM PLAIN	SKD24, SKD26, SKD28, SKD54, SKQ4, SKQ7, SKQ14-16

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**PCB ASSEMBLY – MAIN – EX354T Version 2 (44115-1210) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
20670-0340	HEATSINK TO220 CLIP-ON 29DEG/W	SKIC2, 3
20670-0400	HEATSINK PCB MTG 3.7DEG C/W	SKQ5
20670-0401	CLIP FOR 20670-0400	FOR SKQ5
20670-0410	HEATSINK - BOLT ON - 7DEG C/W	HSBR1
22040-0940	BEAD (DOUBLE) - FERRITE	FB1, 5, <b>6, 7, 8</b>
22109-0130	TRANSFORMER GATE DRIVE - EX	TX1
22109-0210	TRANSFORMER HF PWR EX354 UL	TX2
22154-0160	CHOKE 1mH AXIAL 1.3 OHMS	L4, 5
22154-0230	CHOKE 1.8mH/6A COMMON MODE UL	L1, 2
22154-0240	INDUCTOR BOOST - EX SERIES UL	L3
22154-0460	CHOKE 1mH (EF16) - EX	L10
22154-0470	CHOKE 140uH AT 4A (EF25) - EX	L6, 7
22154-0500	MAGAMP 35V/4A - EX354	MA1, 2
22154-0510	MAGAMP 5V/5A - EX354	<b>MA3</b>
22154-0600	CHOKE 110uH AT 5A (EF25) - EX	<b>L8</b>
22154-0610	CHOKE 3.6uH (EF16) - EX	L9
22312-0242	FUSE CLIPS PCB MTG	FS1
22315-0248	FUSE 10A ANTISURGE (T) HBC CER	FS1
22315-0460	FUSE 5.0AT SUBMIN PCB MTG UL	<b>FS2</b>
22455-0040	TAB 4.8MAX 0.8MM STR PCB MTG	PJ4
22520-0190	AC RECEP 10AMP R/A SOLDER UL	PJ3
22573-0041	HEADER 2WAY STR SIL STD/GOLD	TP1, 2, <b>3</b>
22573-0207	HEADER 7 WAY STRAIGHT .156P	<b>PJ5</b>
22573-0209	HEADER 9 WAY STRAIGHT .156P	PJ1, 2
23202-0100	RES 10R0F W60 MF 50PPM	<b>R87, 104</b>
23202-0220	RES 22R0F W60 MF 50PPM	R13, 37, 38, <b>58</b> , 67-70, 105, 120, 121
23202-0330	RES 33R0F W60 MF 50PPM	R127
23202-0470	RES 47R0F W60 MF 50PPM	R11, 15, 122
23202-1100	RES 100RF W60 MF 50PPM	R44, 106
23202-1220	RES 220RF W60 MF 50PPM	R84
23202-1270	RES 270RF W60 MF 50PPM	R29, 32, <b>34</b>
23202-1330	RES 330RF W60 MF 50PPM	R89
23202-1470	RES 470RF W60 MF 50PPM	R2, 10, 85, 123
23202-1536	RES 536RF W60 MF 50PPM	<b>R124</b>
23202-2100	RES 1K00F W60 MF 50PPM	R25, 26, <b>91, 101, 109</b> , 112, <b>126</b>
23202-2220	RES 2K20F W60 MF 50PPM	R14, 42, 46, <b>115, 117</b>

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**PCB ASSEMBLY – MAIN – EX354T Version 2 (44115-1210) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23202-2270	RES 2K70F W60 MF 50PPM	R9
23202-2330	RES 3K30F W60 MF 50PPM	R8, <b>60</b> , 72
23202-2390	RES 3K90F W60 MF 50PPM	R5
23202-2470	RES 4K70F W60 MF 50PPM	<b>R118</b>
23202-3100	RES 10K0F W60 MF 50PPM	R43, 45, <b>107</b> , <b>108</b> , <b>114</b> , <b>119</b>
23202-3110	RES 11K0F W60 MF 50PPM	R93
23202-3220	RES 22K0F W60 MF 50PPM	<b>R3</b> , 35, 65, 66, 73, <b>88</b> , 98
23202-3270	RES 27K0F W60 MF 50PPM	R12
23202-3330	RES 33K0F W60 MF 50PPM	R71
23202-3430	RES 43K0F W60 MF 50PPM	<b>R116</b>
23202-3470	RES 47K0F W60 MF 50PPM	R6, 18, 19
23202-4100	RES 100KF W60 MF 50PPM	R36, 48-52, 57, 78
23202-4360	RES 360KF W60 MF 50PPM	R133
23202-4390	RES 390KF W60 MF 50PPM	R74, 75
23202-4470	RES 470KF W60 MF 50PPM	R53
23202-4620	RES 620KF W60 MF 50PPM	R131, 132, 135, 136
23202-4820	RES 820KF W60 MF 50PPM	R81
23202-4910	RES 910KF W60 MF 50PPM	R82
23202-5680	RES 6M80F W60 MF 50PPM	R96, 97, <b>128</b> , 130, 134, <b>137</b>
23207-3330	RES 33K0J 1W MF 250PPM	R63, 64
23209-4220	RES 220KF W75 MF 100PPM	R1, 113
23210-0470	RES 47R0J 2W MF 250PPM	<b>R27</b> , 28, 31
23210-1100	RES 100RJ 2W MF 250PPM	R90, 129
23210-1470	RES 470RJ 2W MF 250PPM	R56, 62, 92, 95
23210-3330	RES 33K0J 2W MF 250PPM	R79, 80
23210-3390	RES 39K0J 2W MF 250PPM	R39, 94
23222-0047	RES 4R70J W33 MF FUSIBLE NFR25	<b>R4</b> , 7, 21, 22, 23, 24, 54
23222-0100	RES 10R0J W33 MF FUSIBLE NFR25	R61
23222-0220	RES 22R0J W33 MF FUSIBLE NRF25	R17, 110, 111
23222-1220	RES 220RJ W33 MF FUSIBLE NFR25	<b>R30</b> , <b>33</b> , 99, 100, 102, 103
23222-2220	RES 2K20J W33 MF FUSIBLE NFR25	<b>R125</b>
23271-0020	RES 0R047J 2W MR	<b>R76</b> , 83
23274-0005	RES 0R22K 2W5 WW	R16
23274-0310	RES 10K0J 4W WW	R20
23377-2220	RES PS/H 2K2 CF 10MM	<b>VR1</b>
23386-0010	VARISTOR V275LA20A UL	VDR1



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**PCB ASSEMBLY – MAIN – EX354T Version 2 (44115-1210) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23386-0060	THERMISTOR INRUSH LIMIT 6A UL	RT1
23424-0443	CAP 10NZ 1KV CER D10 P5	C5
23424-0459	CAP 4N7 250V AC CER Y UL SP	C6, 7, 11, 12
23424-0466	CAP 1N0K 1KV CER P5	C82-85
23424-0468	CAP 470PK 1KV CER P5	C20, 21, <b>22</b> , 58, 59
23424-0469	CAP 220PK 1KV CER P5	C118, 121
23424-0472	CAP 2N2K 1KV CER P5/P7.5	C27, 28
23427-0388	CAP 220PK 100V CER P2.5	C68
23427-0389	CAP 2N2K 100V CER MED K P2.5	C17
23427-9211	CAP 470PK 100V CER MED K P2.5	C8, 49
23557-0610	CAP 100U 50V ELEC RE2 P3.5	C32
23557-0661	CAP 470U 25V ELEC RE2 P5	C23, 25
23557-0663	CAP 220U 63V ELEC RE2 P5	C70, 71
23557-0673	CAP 22U 35V ELEC RE2 P2	C18, 19
23557-0693	CAP 2U2 160V ELEC P2.5	C30
23557-0816	CAP 1000U 50V ELEC RSH P7.5	C33, 37
23557-0818	CAP 2U2 50V ELEC LOW ESR P2	<b>C29</b>
23557-0820	CAP 10U 50V ELEC LOW ESR P2	C15, 72, 73, 93
23557-0822	CAP 1000U 10V ELEC LOW ESR P5	<b>C36, 78</b>
23557-0950	CAP 470U 400V ELEC S/I P10	C88
23620-0236	CAP 1N0K 100V P/E P5	C3, 86
23620-0246	CAP 100NK 63V P/E P5	C2,13,24, 26, 31, 35, <b>39, 40, 43, 52</b> , 61, 62, 69, 74, 75, 80, 81, 87, 92,102, 107-110,115, 117,120, 41, 42, 44, 45
23620-0247	CAP 220NK 63V P/E P5	C4, 34
23620-0252	CAP 2N2K 63V P/E P5	<b>C46</b> , 48
23620-0264	CAP 100NK 400V P/E 368 SER P15	C76, 77
23620-0268	CAP 220NK 400V P/E 468 SER P15	C51, <b>53</b> , 54
23620-9007	CAP 10NK 100V P/E P5	<b>C38, 50</b> , 90, 91,101
23621-0314	CAP 1U0K 400V P/E P27.5	C14
23684-0016	CAP 220NM 250VAC X2 P22.5 UL	C89
23684-0020	CAP 1UM 250VAC X2 P/P P27.5 UL	C1, 9, 47
23685-0013	CAP 330NK 160V/250V P/P P15	C16, 94, 119
25021-0901	DIO 1N4148 B/R	<b>D9, 11</b> , 13, 14, 25, 27, <b>29, 32</b> , 37, 38
25021-0910	DIO BAV21	D15,16, <b>17</b> ,30,31,39-41,53, 56, 57, 68, 77
25031-0060	DIO BYW100-200	D6, 7, <b>8</b> , 18, 19, 21, 22
25031-0080	DIO BYV32E TO220AB	D24, 26, <b>28</b>

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**PCB ASSEMBLY – MAIN – EX354T Version 2 (44115-1210) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
25031-0100	DIO BAX12A	D1
25031-0110	DIO BYV26C	D2-5, 44, 45, 50, 61, 63, 69
25031-0140	DIO DUAL MURH860CT TO220AB	D54, 67
25115-0910	DIO 1N4007 B/R	D78
25130-0207	DIO ZEN 15V W4	D42, 43
25130-0229	DIO ZEN 5V6 W4	<b>D12</b> , 55, 65, <b>70</b>
25130-0246	DIO ZEN 22V W4	D66
25130-0903	DIO ZEN 5V1 W4	D20, 23
25130-0913	DIO ZEN 6V8 W4	<b>D10</b>
25130-0914	DIO ZEN 39V W4	D58, 60
25130-0916	DIO ZEN 3V3 W4	D52
25130-9210	DIO ZEN 18V W4	D33, 34, <b>35</b> , <b>36</b> , 59
25210-0050	THYRISTOR 2N5064	SC1
25211-0301	RECTIFIER BRIDGE D20XB60	BR1
25349-3500	TRAN PNP MJE350	Q11, 12, <b>13</b>
25349-5560	TRAN PNP BC556	Q23
25349-7580	TRAN PNP ZTX758	Q6, 10
25383-0506	TRAN NPN BC337	Q22
25383-0507	TRAN NPN BC546	Q1, <b>8</b>
25384-9001	TRAN PNP ZTX751	Q3
25388-0211	TRAN NPN ZTX651	Q2
25388-0212	TRAN NPN BF422	<b>Q18</b> , <b>20</b>
25601-0490	TRAN MOSFET N CHAN 50V/60V	Q14, 15
25601-0510	TRAN MOSFET N-CHAN 500V 20A	Q5
25601-0610	TRAN MOSFET N CHAN IRFB11N50A	Q4, 7
25601-0660	TRAN MOSFET N CHAN 60V TO-220	<b>Q16</b>
27001-0060	OPTO-COUPLER SFH615A-3 UL	IC12, 13, <b>14</b>
27106-0513	IC LM358N 8 PIN	<b>IC5</b>
27160-0009	IC V/REG 7805 TO220	IC2, 3
27160-0013	IC V/REG 7815 TO220	IC4
27168-0040	IC L4981A 20 PIN	IC8
27226-0130	IC 4013B 14 PIN	IC7
27226-0690	IC 4069UB 14 PIN	IC1
35555-3710	PCB - MAIN - EX354 PFC	

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**PCB ASSEMBLY - MAIN - EX354 Versions 3 & 4 (44115-3040)**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
20030-0263	WASHER M3 ZPST	SPACERS, FOR BR1
20037-0301	WASHER M3 SHK/PROOF I/T ZPST	SPACERS TO UNDERSIDE OF PCB
20038-9501	WASHER M3 SPRING	SPACERS, FOR BR1
20210-0101	NUT M3 ZPST	FOR BR1
20234-0011	SCREW M3 X 10 PNHDPZ ZPST	FOR BR1
20234-0100	SCREW M3x6 PNHDPZ C/W EXT SH/P	FOR PCB SPACERS
20613-0007	SIL-PAD TO220 PLAIN	FOR SKD24, SKD26, SKD54, SKQ4, SKQ7, SKQ14-15
20613-0018	SIL-PAD TO-3P/247 PLAIN	FOR SKQ5
20661-0225	SPACER HEX M3 x 12 NPBR	PCB
20661-0280	SPACER HEX STUD M3 x 8 NPBR	MAIN/5V PCB
20670-0135	CLIP GP02 FOR PCB MTG H/SINKS	FOR SKD24, SKD26, SKD54, SKQ4, SKQ7, SKQ14-15
20670-0300	HEATSINK PCB MTG 63MM PLAIN	SKD24, SKD26, SKD54, SKQ4, SKQ7, SKQ14-15
20670-0340	HEATSINK TO220 CLIP-ON 29DEG/W	SKIC2-3
20670-0400	HEATSINK PCB MTG 3.7DEG C/W	SKQ5
20670-0401	CLIP FOR 20670-0400	FOR SKQ5
20670-0410	HEATSINK - BOLT ON - 7DEG C/W	SKBR1
22040-0940	BEAD (DOUBLE) - FERRITE	FB1-5,FB8
22109-0130	TRANSFORMER GATE DRIVE - EX	TX1
22109-0210	TRANSFORMER HF PWR EX354 UL	TX2
22154-0160	CHOKE 1mH AXIAL 1.3 OHMS	L4-5
22154-0230	CHOKE 1.8mH/6A COMMON MODE UL	L1-2
22154-0240	INDUCTOR BOOST - EX SERIES UL	L3
22154-0460	CHOKE 1mH (EF16) - EX	L10
22154-0470	CHOKE 140uH AT 4A (EF25) - EX	L6-7
22154-0500	MAGAMP 35V/4A - EX354	MA1-2
22154-0610	CHOKE 3.6uH (EF16) - EX	L9
22312-0242	FUSE CLIPS PCB MTG	FS1
22315-0310	FUSE 10A ANTISURGE (T) HBC UL	FOR FS1
22315-0460	FUSE 5.0AT SUBMIN PCB MTG UL	FS3, 5
22455-0040	TAB 4.8MAX 0.8MM STR PCB MTG	H40-43
22520-0190	AC RECEP 10AMP R/A SOLDER UL	PJ3
22573-0041	HEADER 2WAY STR SIL STD/GOLD	TP1-2
22573-0206	HEADER 6 WAY STRAIGHT .156P	PJ6 (BREAK IN HALF)
22573-0209	HEADER 9 WAY STRAIGHT .156P	PJ1-2

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**PCB ASSEMBLY - MAIN - EX354 Versions 3 & 4 (44115-3040) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23185-0000	RES ZERO OHM	LK1,2
23202-0220	RES 22R0F W60 MF 50PPM	R37-38
23202-3100	RES 10K0F W60 MF 50PPM	R43, R45
23202-2100	RES 1K00F W60 MF 50PPM	R25-26
23202-2220	RES 2K20F W60 MF 50PPM	R42, R46
23202-5680	RES 6M80F W60 MF 50PPM	R96-97, R130, R134
23207-3330	RES 33K0J 1W MF 250PPM	R63-64
23209-4220	RES 220KF W75 MF 100PPM	R1, R113
23210-0470	RES 47R0J 2W MF 250PPM	R28, R31
23210-1100	RES 100RJ 2W MF 250PPM	R90, R129
23210-1470	RES 470RJ 2W MF 250PPM	R56, R62, R92, R95
23210-3330	RES 33K0J 2W MF 250PPM	R79-80
23210-3390	RES 39K0J 2W MF 250PPM	R39, R94
23222-0047	RES 4R70J W33 MF FUSIBLE NFR25	R7, R21-24, R54
23222-0100	RES 10R0J W33 MF FUSIBLE NFR25	R61
23222-0220	RES 22R0J W33 MF FUSIBLE NRF25	R17, R110-111
23222-0470	RES 47R0J W33 MF FUSIBLE NFR25	R11, R15
23222-1220	RES 220RJ W33 MF FUSIBLE NFR25	R29, R32, R99-100, R102-103
23271-0020	RES 0R047J 2W MR	R83
23274-0005	RES 0R22K 2W5 WW	R16
23274-0310	RES 10K0J 4W WW	R20
23386-0010	VARISTOR V275LA20A UL	VDR1
23386-0060	THERMISTOR INRUSH LIMIT 6A UL	RT1
23424-0443	CAP 10NZ 1KV CER D10 P5	C5
23424-0459	CAP 4N7 250V AC CER Y UL SP	C6-7, C11-12
23424-0468	CAP 470PK 1KV CER P5	C20-21, C58-59
23424-0469	CAP 220PK 1KV CER P5	C118, C121
23424-0472	CAP 2N2K 1KV CER P5/P7.5	C27-28
23427-0388	CAP 220PK 100V CER P2.5	C68
23427-0389	CAP 2N2K 100V CER MED K P2.5	C17
23427-9211	CAP 470PK 100V CER MED K P2.5	C49
23557-0610	CAP 100U 50V ELEC RE2 P3.5	C32
23557-0661	CAP 470U 25V ELEC RE2 P5	C23, C25
23557-0663	CAP 220U 63V ELEC RE2 P5	C70-71
23557-0673	CAP 22U 35V ELEC RE2 P2	C18-19, C57

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**PCB ASSEMBLY - MAIN - EX354 Versions 3 & 4 (44115-3040) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23557-0693	CAP 2U2 160V ELEC P2.5	C30
23557-0816	CAP 1000U 50V ELEC RSH P7.5	C33, C37
23557-0820	CAP 10U 50V ELEC LOW ESR P2	C15, C72-73, C93
23557-0950	CAP 470U 400V ELEC S/I P10	C88
23620-0236	CAP 1N0K 100V P/E P5	C3
23620-0247	CAP 220NK 63V P/E P5	C34
23620-0263	CAP 220NK 250V P/E 368 SER P15	C4
23620-0264	CAP 100NK 400V P/E 368 SER P15	C76-77
23620-0268	CAP 220NK 400V P/E 468 SER P15	C51, C54
23621-0314	CAP 1U0K 400V P/E P27.5	C14
23662-0207	CAP 470PK 100V P/C P5	C8
23684-0016	CAP 220NM 250VAC X2 P22.5 UL	C89
23684-0020	CAP 1UM 250VAC X2 P/P P27.5 UL	C1, C9, C47
23685-0013	CAP 330NK 160V/250V P/P P15	C16, C94, C119
25031-0060	DIO BYW100-200	D6-7, D18-19, D21-22
25031-0080	DIO BYV32E	D24, D26
25031-0100	DIO BAX12A	D1
25031-0110	DIO BYV26C	D2-5, D44-45, D50, D61, D63, D69
25031-0140	DIO DUAL MURH860CT	D54, D67
25115-0910	DIO 1N4007 B/R	D78
25130-0207	DIO ZEN 15V W4	D42-43
25130-0914	DIO ZEN 39V W4	D58, D60
25130-0916	DIO ZEN 3V3 W4	D52, D71
25210-0050	THYRISTOR 2N5064	SC1
25211-0301	RECTIFIER BRIDGE D20XB60	BR1
25349-3500	TRAN PNP MJE350	Q11-12
25349-7580	TRAN PNP ZTX758	Q6, Q10
25384-9001	TRAN PNP ZTX751	Q3
25388-0211	TRAN NPN ZTX651	Q2
25601-0490	TRAN MOSFET N CHAN 50V/60V	Q14-15
25601-0510	TRAN MOSFET N-CHAN 500V 20A	Q5
25601-0610	TRAN MOSFET N CHAN IRFB11N50A	Q4, Q7
27001-0060	OPTO-COUPLER SFH615A-3 UL	IC12-14
27160-0009	IC V/REG 7805 TO220	IC2-3
27160-0013	IC V/REG 7815 TO220	IC4
27168-0040	IC L4981A 20 PIN	IC8
44115-3041	PCB ASSY SM MAIN	

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**PCB ASSEMBLY – MAIN - EX354 Versions 3 & 4 - SM Stage (44115-3041)**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23105-0022	RES SM0805 2R20F W1	R121
23105-0047	RES SM0805 4R70F W1	R105
23105-0056	RES SM0805 5R60F W1	R127
23105-0220	RES SM0805 22R0F W1	R13, R67-70, R120
23105-0470	RES SM0805 47R0F W1	R122
23105-1100	RES SM0805 100RF W1	R44, R106
23105-1220	RES SM0805 220RF W1	R10, R10A
23105-1270	RES SM0805 270RF W1	R93A
23105-1330	RES SM0805 330RF W1	R84, R85, R89
23105-1470	RES SM0805 470RF W1	R2, R112, R123, R112A
23105-2220	RES SM0805 2K20F W1	R14
23105-2270	RES SM0805 2K70F W1	R9
23105-2330	RES SM0805 3K30F W1	R8, R72
23105-2390	RES SM0805 3K90F W1	R5
23105-3100	RES SM0805 10K0F W1	R41, 59, 65, 66, 65A, R66A, 86
23105-3110	RES SM0805 11K0F W1	R93
23105-3220	RES SM0805 22K0F W1	R35, R73, R98
23105-3270	RES SM0805 27K0F W1	R12
23105-3330	RES SM0805 33K0F W1	R71
23105-3560	RES SM0805 56K0F W1	R6
23105-4100	RES SM0805 100KF W1	R36, R48-52, R57, R78
23105-4180	RES SM0805 180KF W1	R133, R138
23105-4200	RES SM0805 200KF W1	R74-75, R74A, R75A
23105-4220	RES SM0805 220KF W1	R47
23105-4270	RES SM0805 270KF W1	R135-136
23105-4330	RES SM0805 330KF W1	R135A, R136A
23105-4390	RES SM0805 390KF W1	R131-132, R131A
23105-4430	RES SM0805 430KF W1	R81-82, R81A, R82A
23105-4470	RES SM0805 470KF W1	R53
23461-0015	CAP SM0805 10NK 50V CER X7R	C101
23461-0020	CAP SM0805 100NZ 50V CER Y5V	C2, C13, C24, C26, C31, C35, C41-42, C44-45, C61-62, C69, C74-75, C80-81, C87, C92, C102, C107-110, C115, C117, C120, C69A
23461-0040	CAP SM0805 1N0K 50V CER X7R	C82-C86
23461-0200	CAP SM0805 2N2J 50V CER X7R	C48, C90-91
25021-1010	DIO SM BAS21	D13-16, D30-31, D37-41, D46, D53, D56-57, D68, D77

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**PCB ASSEMBLY - MAIN - EX354 Versions 3 & 4 - SM Stage (44115-3041)**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
25132-0010	DIO SM ZEN 5V6 W5	D55, D65
25132-0230	DIO SM ZEN 5V1 W35	D20, D23
25132-0290	DIO SM ZEN 18V W35	D33-34, D59
25132-0300	DIO SM ZEN 22V W35	D66
25340-1000	TRAN SM PNP BC859C	Q23-24
25377-1000	TRAN SM NPN BC849C	Q1, Q22
27227-0130	IC SM 4013	IC7
27227-0690	IC SM 4069	IC1
35555-4550	PCB - MAIN	

**PCB ASSEMBLY - CONTROL - EX354T Versions 1 & 2 (44115-0860)**

Parts not fitted on PCB ASSY – CONTROL – EX354D Versions 1 & 2 (44115-0880) shown in **bold**.

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
20661-0851	SPACER .56 INCH 7-SEG LED 3.5H	DIS1, 2, 101, 102
22218-0213	SWITCH SLIDE 2P2W	<b>SW3</b>
22225-0220	SWITCH PUSH/PUSH SPPH11470B	SW1, 101
22573-0207	HEADER 7 WAY STRAIGHT .156P	<b>PJ2</b>
22573-0209	HEADER 9 WAY STRAIGHT .156P	PJ1, PJ101
22574-0122	SKT DIL 28 PIN	IC3, 103
23202-0100	RES 10R0F W60 MF 50PPM	R50, 150
23202-0220	RES 22R0F W60 MF 50PPM	R25, 125
23202-1100	RES 100RF W60 MF 50PPM	R40, 140
23202-1220	RES 220RF W60 MF 50PPM	R10, 110
23202-1330	RES 330RF W60 MF 50PPM	R22, 122
23202-1470	RES 470RF W60 MF 50PPM	R45, 145
23202-1680	RES 680RF W60 MF 50PPM	R2, 102
23202-2100	RES 1K00F W60 MF 50PPM	R11, 12, 23, 48, 111, 112, 123, 148
23202-2360	RES 3K60F W60 MF 50PPM	R47, 147
23202-2390	RES 3K90F W60 MF 50PPM	R46, 146
23202-2470	RES 4K70F W60 MF 50PPM	R38, 39, 138, 139
23202-2499	RES 4K99F W60 MF 50PPM	R34, 134
23202-2820	RES 8K20F W60 MF 50PPM	R18, 118
23202-3100	RES 10K0F W60 MF 50PPM	R4, 5, 14, 15, 17, 24, 30, 32, 41, 43, 44, 49, 51, 104, 105, 114, 115, 117, 124, 130, 132, 141, 143, 144, 149, 151
23202-3110	RES 11K0F W60 MF 50PPM	R28, 128
23202-3143	RES 14K3F W60 MF 50PPM	R35, 135
23202-3150	RES 15K0F W60 MF 50PPM	R33, 133

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**PCB ASSEMBLY - CONTROL - EX354T Versions 1 & 2 (44115-0860)**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23202-3270	RES 27K0F W60 MF 50PPM	R27, 127
23202-3330	RES 33K0F W60 MF 50PPM	R6, 7, 8, 106, 107, 108
23202-3560	RES 56K0F W60 MF 50PPM	R31, 131
23202-3750	RES 75K0F W60 MF 50PPM	R3, 103
23202-4180	RES 180KF W60 MF 50PPM	R1, 101
23202-4220	RES 220KF W60 MF 50PPM	R36, 37, 42, 136, 137, 142
23202-4470	RES 470KF W60 MF 50PPM	R29, 129
23202-5100	RES 1M00F W60 MF 50PPM	R19, 119
23202-6100	RES 10M0F W60 MF 50PPM	R13, 26, 113, 126
23301-0415	RES NETWK SIL 1K0 X 4S	RP3, 103
23301-0464	RES NETWK SIL 56R X 4S	RP1, 2, 101, 102
23320-0003	RES R10 - FERRYALLOY	R21, 121
23347-0330	POT 10K LIN SPLINE SHAFT 25MM	VR1, 2, 101, 102
23347-0340	POT 10K LOG SPLINE SHAFT 25MM	VR3, 103
23377-2220	RES PS/H 2K2 CF 10MM	VR4, 6, 9, 10, 104, 106, 109, 110
23377-2470	RES PS/H 4K7 CF 10MM	VR5, 105
23377-4100	RES PS/H 100K CF 10MM	VR8, 108
23379-1100	RES PS/H 100R CERMET 10MM SKEL	VR7, 107
23424-0443	CAP 10NZ 1KV CER D10 P5	C30, <b>34</b> , 130
23427-0323	CAP 22PJ 100V CER NPO P5	C4, 5, 104, 105
23427-0329	CAP 47PG 63V CER N150 P5	C15,17, 29, 42, 115, 117, 129, 142
23427-0353	CAP 220PG 100V CER N750 P5T	C19, 24, 119, 124
23427-9211	CAP 470PK 100V CER MED K P2.5	C43, 143
23557-0501	CAP 2U2 63V ELEC RC2 P1.5	C16, 116
23557-0511	CAP 47U 10V ELEC RC2 P2	C7, 107
23557-0612	CAP 1U0 100V/50V ELEC RE2 P2	C18, 23, 118, 123
23557-0647	CAP 10U 35V ELEC RE2 P2	C25, 26, 125, 126
23557-0668	CAP 220U 10V ELEC RE2 P2.5	C21, 121
23557-0685	CAP 100U 25V ELEC LOW ESR P2.5	<b>C138</b>
23557-0825	CAP 100U 50V LOW ESR P3.5	C20, 120
23620-0246	CAP 100NK 63V P/E P5	C3, 6, 8, 9, 12, 27, 28, 31, <b>33</b> , 103, 106, 108, 109, 112, 127, 128, 131
23620-0247	CAP 220NK 63V P/E P5	C1, 101
23620-0249	CAP 330NK 63V P/E P5	C10, 11, 110, 111
23620-0264	CAP 100NK 400V P/E 368 SER P15	C36, 136
23620-9007	CAP 10NK 100V P/E P5	C13, 14, 35, 113, 114, 135



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**PCB ASSEMBLY - CONTROL - EX354T Versions 1 & 2 (44115-0860) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23685-0007	CAP 100NK 250V P/P MKP4 P10	C2,102
25021-0901	DIO 1N4148 B/R	D1, 2, 3, 4, 5, 7, 8, 9, 101, 102, 103, 104, 105, 107, 108, 109
25061-0200	LED - T1 ROUND (3mm) - RED	LED1, 2, 101, 102, <b>103</b>
25061-0519	DISPLAY 3 DIG .56 LED 9MM LEG	DIS1, 2, 101, 102
25117-0020	DIO 1N5401	D10, 110
25336-5590	TRAN PNP BC559C	Q1, 101
25377-5490	TRAN NPN BC549C	Q2, 102
27106-0508	IC LM324N (NATIONAL) 14 PIN	IC7, 107
27106-0646	IC LF347 BI-FET OP AMP 14 PIN	IC5, 105
27161-0130	IC V/REF ZRC250 2.5V 3PIN	D6, 106
27164-0507	IC ULN-2003A 16 PIN	IC1, 101
27226-0520	IC 4052B 16 PIN	IC4, 104
27226-0530	IC 4053B 16 PIN	IC2, 102
27231-5740	IC 74HC574 20 PIN	IC6, 106
27250-2001	IC MCU8 PIC16C55A-04/P 28P	IC3, 103
28502-0010	RESONATOR CER 4MHZ CSA4.00MG	XTAL1, 101
35555-2600	PCB - CONTROL	

**PCB ASSEMBLY - CONTROL - EX354 Version 3 (44115-3010)**

Parts shown in **bold** are removed on EX354D Version 3

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
20661-0851	SPACER .56 INCH 7-SEG LED 3.5H	FOR DISP1, 2, 101, 102
22218-0213	SWITCH SLIDE 2P2W	<b>SW3</b>
22225-0220	SWITCH PUSH/PUSH SPPH11470B	SW1, SW101
22573-0048	HEADER 3WAY STR SIL STD/GOLD	PJ2-3, PJ102-103
22573-0207	HEADER 7 WAY STRAIGHT .156P	PJ4
22573-0209	HEADER 9 WAY STRAIGHT .156P	PJ1, PJ101
22574-0120	SKT DIL 16 PIN	FOR IC1, IC101
23202-1330	RES 330RF W60 MF 50PPM	R22, R122
23202-4180	RES 180KF W60 MF 50PPM	R1, R101
23320-0003	RES R10 - FERRYALLOY	R21, R121
23347-0330	POT 10K LIN SPLINE SHAFT 25MM	VR1-2, VR101-102
23347-0340	POT 10K LOG SPLINE SHAFT 25MM	VR3, VR103
23377-2220	RES PS/H 2K2 CF 10MM	VR4, VR6, VR9, VR10, VR104, VR106, VR109, VR110
23377-2470	RES PS/H 4K7 CF 10MM	VR5, VR105

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**PCB ASSEMBLY - CONTROL - EX354 Version 3 (44115-3010) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23377-4100	RES PS/H 100K CF 10MM	VR8, VR108
23379-1100	RES PS/H 100R CERMET 10MM SKEL	VR7, VR107
23424-0443	CAP 10NZ 1KV CER D10 P5	C30, C34 ,C130
23557-0500	CAP 1U0 50V ELEC RC2 P1.5	C18, C23, C118 ,C123
23557-0512	CAP 220U 10V ELEC 7MM P2.5	C21, C121
23557-0513	CAP 10U 35V ELEC 7MM P2	C7, C107
23557-0612	CAP 1U0 100V/50V ELEC RE2 P2	C16, C37, C116,C137
23557-0647	CAP 10U 35V ELEC RE2 P2	C25-26, C125-126
23557-0825	CAP 100U 50V LOW ESR P3.5	C20, C22, C120, C122
23557-0837	CAP 470U 10V ELEC LOW ESR P3.5	C138
23620-0246	CAP 100NK 63V P/E P5	C3, C8-9, C12, C31, C33, C103, C108-109, C112, C131
23620-0247	CAP 220NK 63V P/E P5	C1, C101
23620-0249	CAP 330NK 63V P/E P5	C10-11, C110-111
23620-0264	CAP 100NK 400V P/E 368 SER P15	C36, C136
23620-9007	CAP 10NK 100V P/E P5	C13-14, C113-114
23685-0007	CAP 100NK 250V P/P MKP4 P10	C2, C102
25061-0200	LED - T1 ROUND (3mm) - RED	LED1-2, LED101, 102, <b>103</b>
25061-0519	DISPLAY 3 DIG .56 LED 9MM LEG	DISP1-2, DISP101-102
25117-0020	DIO 1N5401	D10, D110
27164-0507	IC ULN-2003A 16 PIN	IC1, IC101
44115-3011	PCB ASSY SM CNTL - EX354	

**PCB ASSEMBLY - CONTROL - EX354 Version 3 - SM Stage (44115-3011)**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23105-0000	RES SM0805 ZERO OHM	R9, R16, R20, R109, R116, R120
23105-0100	RES SM0805 10R0F W1	R50, R150
23105-0220	RES SM0805 22R0F W1	R25, R125
23105-0560	RES SM0805 56R0F W1	R53-60, R153-160
23105-1100	RES SM0805 100RF W1	R40, R140
23105-1220	RES SM0805 220RF W1	R10, R110
23105-1470	RES SM0805 470RF W1	R45, R145
23105-1680	RES SM0805 680RF W1	R2, R102
23105-2100	RES SM0805 1K00F W1	R11-12, R23, R48, R70-73, R111-112, R123, R148, R170-173
23105-2240	RES SM0805 2K40F W1	R35A, R135A
23105-2360	RES SM0805 3K60F W1	R47, R147
23105-2390	RES SM0805 3K90F W1	R34, R46, R134, R146

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**PCB ASSEMBLY - CONTROL - EX354 Version 3 - SM Stage (44115-3011) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23105-2470	RES SM0805 4K70F W1	R38-39, R138-139
23105-2820	RES SM0805 8K20F W1	R18, R118
23105-3100	RES SM0805 10K0F W1	R24, R41, R44, R124, R141, R144
23105-3110	RES SM0805 11K0F W1	R51, R151
23105-3120	RES SM0805 12K0F W1	R35, R135
23105-3150	RES SM0805 15K0F W1	R33, R133
23105-3270	RES SM0805 27K0F W1	R27, R127
23105-3330	RES SM0805 33K0F W1	R6-8, R106-108
23105-3560	RES SM0805 56K0F W1	R31, R131
23105-3750	RES SM0805 75K0F W1	R3, R103
23105-4220	RES SM0805 220KF W1	R36-37, R136-137
23105-4470	RES SM0805 470KF W1	R29, R42, R129, R142
23105-5100	RES SM0805 1M00F W1	R19, R119
23105-6100	RES SM0805 10M0F W1	R13, R26, R113, R126
23106-3100	RES SM0805 10K0D W1 25PPM	R4-5, R14-15, R17, R30, R32, R43, R104-105, R114-115, R117, R130, R132, R143
23106-3110	RES SM0805 11K0D W1 25PPM	R28, R128
23405-0221	CAP SM0805 220P CER COG	C19, C24, C119, C124
23405-0470	CAP SM0805 47P CER COG	C15, C17, C29, C42,C68,C115,C117,C129
23405-0471	CAP SM0805 470P CER COG	C43, C143
23461-0020	CAP SM0805 100NZ 50V CER Y5V	C6, C27-28, C35, C106, C127-128, C135
25021-0010	DIO SM LL4148 SWITCHING	D1-5, D7-9, D101-105, D107-109
25340-1000	TRAN SM PNP BC859C	Q1, Q101
25377-1000	TRAN SM NPN BC849C	Q2, Q102
27106-1160	IC SM LM324M OP AMP	IC7, IC107
27106-1460	IC SM LF347M BIFET OP AMP	IC5, IC105
27161-2030	IC SM V/REF ZRC250 2.5V 2%	D6, D106
27227-0520	IC SM 4052	IC4, IC104
27227-0530	IC SM 4053	C2, IC102
27239-5740	IC SM 74HC574	IC6, IC106
27250-2150	IC SM PIC16C55A-04/SO	IC3, IC103
28502-1000	RESONATOR SM CSTCR4M00G53-R0	XTL1, XTL101
35555-4360	PCB - CONTROL - EX354D/T	

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**PCB ASSEMBLY - CONTROL - EX354 Version 4 (44115-3120)**Parts shown in **bold** are removed on EX354D Version 4

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
20661-0851	SPACER .56 IN.7-SEG LED 3.5H	FOR DISPLAYS
20661-0870	SPACER TOWER RND 4.8ODx9L BLK	FOR LED2, 102
20661-0871	SPACER TOWER RND4.8ODx12L BLK	FOR LED1, 101, <b>103</b>
22219-0500	SWITCH 2 POLE MOMENTARY	<b>SW2</b>
22225-0220	SWITCH PUSH/PUSH SPPH11470B	SW1, SW101
22573-0048	HEADER 3WAY STR SIL STD/GOLD	PJ2-3, PJ102-103
22573-0208	HEADER 8 WAY STRAIGHT .156P	PJ5
22573-0209	HEADER 9 WAY STRAIGHT .156P	PJ1, PJ101
22573-0247	HEADER 2 WAY STR .1P F/LOCK	PJ5A (FIT ON REVERSE)
23202-1330	RES 330RF W60 MF 50PPM	R22, R122
23202-4180	RES 180KF W60 MF 50PPM	R1, R101
23320-0003	RES R10 - FERRYALLOY	R21, R121
23347-0330	POT 10K LIN SPLINESHAFT 25MM	VR1-2, VR101-102
23347-0340	POT 10K LOG SPLINESHAFT 25MM	VR3, VR103
23377-2220	RES PS/H 2K2 CF 10MM	VR4, VR6, VR9-10, VR104, VR106, VR109-110
23377-2470	RES PS/H 4K7 CF 10MM	VR5, VR105
23377-3221	RES PS/H 22K CF 10MM HEX ADJ	VR11
23377-4100	RES PS/H 100K CF 10MM	VR8 ,VR108
23379-1100	RES PS/H 100R CERM 10MM SKEL	VR7, VR107
23424-0443	CAP 10NZ 1KV CER D10 P5	C30, C34, C130
23557-0500	CAP 1U0 50V ELEC RC2 P1.5	C18, C23, C118, C123
23557-0512	CAP 220U 10V ELEC 7MM P2.5	C21, C121
23557-0513	CAP 10U 35V ELEC 7MM P2	C7, C107
23557-0612	CAP 1U0 100V/50V ELEC RE2 P2	C16, C37, C116, C137
23557-0647	CAP 10U 35V ELEC RE2 P2	C25-26, C125-126, C138
23557-0825	CAP 100U 50V LOW ESR P3.5	C20, C22, C120, C122
23620-0246	CAP 100NK 63V P/E P5	C3 ,C8-9, C12, C31, C33, C103, C108-109, C112, C131
23620-0247	CAP 220NK 63V P/E P5	C1, C101
23620-0249	CAP 330NK 63V P/E P5	C10-11, C110-111
23620-0264	CAP 100NK400VP/E 368 SER P15	C36, C136
23620-9007	CAP 10NK 100V P/E P5	C13-14, C113-114
23685-0007	CAP 100NK 250V P/P MKP4 P10	C2, C102
25061-0201	LED - T1 R'ND(3mm) RED L/LEG	LED1-2, LED101, LED102, <b>LED103</b>
25061-0519	DISPLAY 3 DIG .56LED 9MM LEG	DISP1-2, DISP101-102
25117-0020	DIO 1N5401	D10, D110
44115-3121	PCB ASSY SM CNTL EX354TV	

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**PCB ASSEMBLY CONTROL - EX354 Version 4 SM Stage (44115-3121)**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23105-0000	RES SM0805 ZERO OHM	R9-10, R16, R20, R109-110, R116, R120
23105-0100	RES SM0805 10R0F W1	R50, R150
23105-0220	RES SM0805 22R0F W1	R25, R125
23105-1100	RES SM0805 100RF W1	R40, R140
23105-1270	RES SM0805 270RF W1	R53-60, R153-R160
23105-1430	RES SM0805 430RF W1	R66
23105-1470	RES SM0805 470RF W1	R45, R145
23105-1560	RES SM0805 560RF W1	R62, R64
23105-1680	RES SM0805 680RF W1	R2, R102
23105-2100	RES SM0805 1K00F W1	R11-12, R23, R48, R70-73, R111-112, R123, R148, R170-173
23105-2240	RES SM0805 2K40F W1	R52, R135A, R35A
23105-2360	RES SM0805 3K60F W1	R47, R147
23105-2390	RES SM0805 3K90F W1	R34, R46, R134, R146
23105-2470	RES SM0805 4K70F W1	R38-39, R138-139
23105-2560	RES SM0805 5K60F W1	R65
23105-2820	RES SM0805 8K20F W1	R18, R118
23105-3100	RES SM0805 10K0F W1	R24, R41, R44, R124, R141, R144
23105-3110	RES SM0805 11K0F W1	R51, R151
23105-3120	RES SM0805 12K0F W1	R35, R135
23105-3150	RES SM0805 15K0F W1	R33, R133
23105-3270	RES SM0805 27K0F W1	R27, R61, R63, R127
23105-3330	RES SM0805 33K0F W1	R6-8, R106-108
23105-3560	RES SM0805 56K0F W1	R31, R131
23105-3750	RES SM0805 75K0F W1	R3, R103
23105-4220	RES SM0805 220KF W1	R36-37, R136-137
23105-4470	RES SM0805 470KF W1	R29, R42, R129, R142
23105-5100	RES SM0805 1M00F W1	R19, R119
23105-6100	RES SM0805 10M0F W1	R13, R26, R113, R126
23106-3100	RES SM0805 10K0D W1 25PPM	R4-5, R14-15, R17, R30, R32, R43, R104-105, R114-115, R117, R130, R132, R143
23106-3110	RES SM0805 11K0D W1 25PPM	R28, R128
23407-0221	CAP SM0805 220P CER NPO	C19, C24, C119, C124
23407-0470	CAP SM0805 47P CER NPO	C15, C17, C29, C42, C68, C115, C117, C129
23407-0471	CAP SM0805 470P CER NPO	C43, C143
23461-0020	CAP SM0805 100NZ 50V CER Y5V	C6, C27-28, C35, C106, C127-128, C135
25021-0010	DIO SM LL4148 SWITCHING MM	D1-5, D7-9, D101-105, D107-109

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**PCB ASSEMBLY CONTROL - EX354 Version 4 SM Stage (44115-3121) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
25340-1000	TRAN SM PNP BC859C	Q1, Q101
25377-1000	TRAN SM NPN BC849C	Q2, Q102
27106-1160	IC SM LM324M OP AMP	IC7, IC107
27106-1460	IC SM LF347M BIFET OPAMP	IC5, IC105
27161-2030	IC SM V/REF ZRC250 2.5V 2%	D6, D106
27164-1070	IC SM ULN2003AD	IC1, IC101
27227-0520	IC SM 4052	IC4, IC104
27227-0530	IC SM 4053	IC2, IC102
27239-5740	IC SM 74HC574	IC6, IC106
27250-2150	IC SM PIC16C55A-04/SO	IC3, IC103
28502-1000	RESONATOR SM CSTCR4M00G53-R0	XTL1, XTL101
35555-4780	PCB - CONTROL - EX354D/TV UL	

**5V/3.3V OUTPUT - EX354T Version 3 (44115-3050)**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
20613-0007	SIL-PAD TO220 PLAIN	FOR SKD28, SKQ16
20670-0135	CLIP GP02 FOR PCB MTG H/SINKS	FOR SKD28, SKQ16
20670-0300	HEATSINK PCB MTG 63MM PLAIN	SKD28, SKQ16
22040-0940	BEAD (DOUBLE) - FERRITE	FB6-7
22154-0510	MAGAMP 5V/5A - EX354	MA3
22154-0600	CHOKE 110uH AT 5A (EF25)	L8
22315-0459	FUSE 4.0AT SUBMIN PCB MTG UL	FS2
22573-0041	HEADER 2WAY STR SIL STD/GOLD	TP3
23202-0220	RES 22R0F W60 MF 50PPM	R58
23202-1536	RES 536RF W60 MF 50PPM	R124
23202-5680	RES 6M80F W60 MF 50PPM	R128, R137
23210-0470	RES 47R0J 2W MF 250PPM	R27
23222-0047	RES 4R70J W33 MF FUSIBLE NFR25	R4
23222-1220	RES 220RJ W33 MF FUSIBLE NFR25	R30, R33, R34
23222-2220	RES 2K20J W33 MF FUSIBLE NFR25	R125
23271-0020	RES 0R047J 2W MR	R76
23377-2220	RES PS/H 2K2 CF 10MM	VR1
23424-0468	CAP 470PK 1KV CER P5	C22
23557-0818	CAP 2U2 50V ELEC LOW ESR P2	C29
23557-0822	CAP 1000U 10V ELEC LOW ESR P5	C36, C78
23620-0268	CAP 220NK 400V P/E 468 SER P15	C53
25031-0060	DIO BYW100-200	D8

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**5V/3.3V OUTPUT - EX354T Version 3 (44115-3050) /continued...**

Part Number	Description	Position
25031-0080	DIO BYV32E	D28
25349-3500	TRAN PNP MJE350	Q13
25388-0212	TRAN NPN BF422	Q18
25601-0660	TRAN MOSFET N CHAN 60V	Q16
44115-3051	PCB ASSY SM - 5V	

**5V/3.3V OUTPUT - EX354T Version 3 - SM Stage (44115-3051)**

Part Number	Description	Position
23105-0100	RES SM0805 10R0F W1	R87, R104
23105-1470	RES SM0805 470RF W1	R126
23105-2100	RES SM0805 1K00F W1	R91, R101, R109
23105-2220	RES SM0805 2K20F W1	R115, R117
23105-2330	RES SM0805 3K30F W1	R60
23105-2470	RES SM0805 4K70F W1	R118
23105-3100	RES SM0805 10K0F W1	R107-108, R114, R119
23105-3220	RES SM0805 22K0F W1	R88
23105-3430	RES SM0805 43K0F W1	R116
23461-0015	CAP SM0805 10NK 50V CER X7R	C38, C50
23461-0020	CAP SM0805 100NZ 50V CER Y5V	C39-40, C43, C52
23461-0200	CAP SM0805 2N2J 50V CER X7R	C46
25021-1010	DIO SM BAS21	D9, D11, D17, D32
25132-0010	DIO SM ZEN 5V6 W5	D12, D70
25132-0210	DIO SM ZEN 6V8 W35	D10
25132-0290	DIO SM ZEN 18V W35	D35-36
25377-1000	TRAN SM NPN BC849C	Q8, Q20
27106-1110	IC SM LM358M DUAL OP AMP	IC5
35555-4580	PCB 5V OUTPUT	

**1.5V/5V AUX OUTPUT - EX354Tv Version 4 (44115-3130)**

Part Number	Description	Position
20613-0007	SIL-PAD TO220 PLAIN	FOR SKD28, SKQ16
20670-0135	CLIP GP02 FOR PCB MTG H/SINKS	FOR SKD28, SKQ16
20670-0300	HEATSINK PCB MTG 63MM PLAIN	SKD28 ,SKQ16
22040-0030	FERRITE SLEEVE APPX 8/16/14L	
22040-0940	BEAD (DOUBLE) - FERRITE	FB6-7
22154-0510	MAGAMP 5V/5A - EX354	MA3
22154-0600	CHOKE 110uH AT 5A (EF25) -EX	L8
22315-0459	FUSE 4.0AT SUBMIN PCB MTG UL	FS2

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**1.5V/5V AUX OUTPUT - EX354Tv Version 4 (44115-3130) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
22573-0041	HEADER 2WAY STR SIL STD/GOLD	TP3
22575-0077	SKT 2 WAY IDT .1P	
22575-0208	SKT 8W .156 20AWG Yellow IDT	
23202-0220	RES 22R0F W60 MF 50PPM	R58
23202-1536	RES 536RF W60 MF 50PPM	R124
23202-5680	RES 6M80F W60 MF 50PPM	R128, R137
23210-0470	RES 47R0J 2W MF 250PPM	R27
23222-0047	RES 4R70J W33 MF FUS'L NFR25	R4
23222-1220	RES 220RJ W33 MF FUS'L NFR25	R30, R33-34
23222-2220	RES 2K20J W33 MF FUSLE NFR25	R125
23271-0020	RES 0R047J 2W MR	R76
23377-4100	RES PS/H 100K CF 10MM	VR2
23424-0468	CAP 470PK 1KV CER P5	C22
23557-0818	CAP 2U2 50V ELEC LOW ESR P2	C29
23557-0822	CAP 1000U 10V ELEC LOW ESR P5	C36, C78
23620-0268	CAP 220NK400VP/E 468 SER P15	C53
25031-0060	DIO BYW100-200	D8
25031-0080	DIO BYV32E TO220AB	D28
25117-0020	DIO 1N5401	D1
25349-3500	TRAN PNP MJE350	Q13
25388-0212	TRAN NPN BF422	Q18
25601-0660	TRAN MOSFET NCHAN 60V TO-220	Q16
27001-0120	OPTO-COUPLER LINEAR IL300	IC2
43187-1780	WIRE SET CUT 1.5/5V EX354TV	
44115-3131	PCBASSY SM 1.5/5V EX354TV *4S	

**1.5/5V AUX OUTPUT - EX354Tv Version 4 SM Stage (44115-3131)**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23105-0100	RES SM0805 10R0F W1	R87, R104
23105-1330	RES SM0805 330RF W1	R6
23105-1470	RES SM0805 470RF W1	R126
23105-2100	RES SM0805 1K00F W1	R91, R101, R109
23105-2220	RES SM0805 2K20F W1	R115, R118
23105-2470	RES SM0805 4K70F W1	R1-2, R88
23105-3100	RES SM0805 10K0F W1	R60, R107-108, R114, R119
23105-3110	RES SM0805 11K0F W1	R3
23105-3220	RES SM0805 22K0F W1	R7



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**1.5/5V AUX OUTPUT - EX354Tv Version 4 SM Stage (44115-3131) /continued...**

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
23105-3270	RES SM0805 27K0F W1	R5
23105-3430	RES SM0805 43K0F W1	R116
23407-0101	CAP SM0805 100P CER NPO	C1
23461-0015	CAP SM0805 10NK 50V CER X7R	C38, C50
23461-0020	CAP SM0805 100NZ 50V CER Y5V	C39-40, C43, C52
23461-0040	CAP SM0805 1N0K 50V CER X7R	C46
25021-1010	DIO SM BAS21	D9, D11, D17, D32
25132-0210	DIO SM ZEN 6V8 W35	D10
25132-0230	DIO SM ZEN 5V1 W35	D12
25132-0290	DIO SM ZEN 18V W35	D35-36
25132-0310	DIO SM ZEN 5V6 W35	D70
25377-1000	TRAN SM NPN BC849C	Q8, Q20
27106-1110	IC SM LM358M DUAL OP AMP	IC1, IC5
35555-4790	PCB 1.5/5V VARIABLE EX354TV UL	

**MECHANICAL PARTS - EX354D, EX354T & EX354Tv**

† These parts change with the introduction of the EX354Tv to replace the EX354T and subsequently on the EX354D too. Refer to next Parts List.

\* Parts marked with \* change with the introduction of the revised 'safety' terminals, see last Parts List.

<b>Part Number</b>	<b>Description</b>	<b>Position</b>
20030-0240*	WASHER 4BA ZPST	CONTROL PCB TO SPACER, EARTH TERMINAL
20030-0263	WASHER M3 ZPST	CONTROL PCB TO GROUND STANDOFFS, BRACKET TO MOULDING
20030-0264	WASHER M2.5 ZPST	CONTROL PCB
20030-0266	WASHER M4 ZPST	EARTH
20037-0247*	WASHER 4BA SHK/PROOF I/T ZPST	TERMINAL SPACERS TO CONTROL PCB, EARTH TERMINAL
20037-0301	WASHER M3 SHK/PROOF I/T ZPST	CHASSIS TO MAIN PCB SPACERS, GROUND STANDOFFS
20037-0305*	WASHER 5/16 SHK/PRF I/T ZPST	GREY TERMINAL
20037-0401	SOLDER TAG SHAKEPROOF - 4BA	EARTH
20038-9502	WASHER M4 SPRING	EARTH
20038-9503	WASHER M3.5 SPRING	CONTROL TO OUTPUT TERMINALS
20062-9501	SCREW No.6 X 3/4 RAISED CKHDPZ	HANDLE TO COVER, HANDLE TO L BRACKET
20063-0010	SCREW No.6 X 3/8 NIB HDPZ ST/AB	COVER TO CHASSIS
20065-0020	SCREW 2-28 X 5/16 PLAS PNHDPZ	CONTROL PCB & L BRACKET TO MOULDING
20134-9005*	SCREW 4BA X 1/4 PNHDPZ ZPST	CONTROL TO OUTPUT TERMINALS

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**MECHANICAL PARTS - EX354D, EX354T & EX354Tv /continued...**

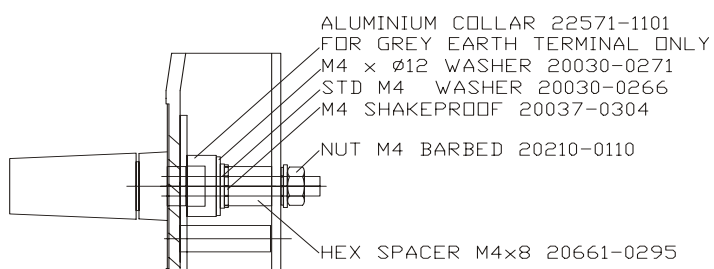
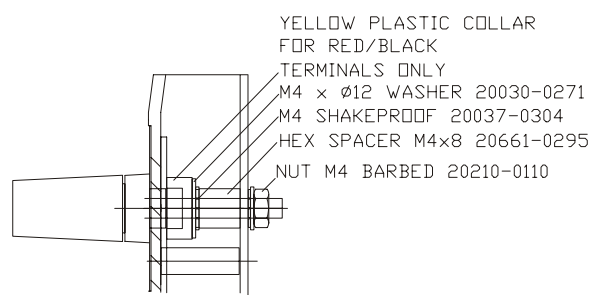
<b>Part Number</b>	<b>Description</b>	<b>Position</b>
20210-0102	NUT M4 ZPST	EARTH
20213-0040	CAPTIVE NUT SPIRE NO.6	COVER TO CHASSIS, HANDLE TO COVER, HANDLE TO L BRACKET
20234-0024	SCREW M3 X 16 PNHDPZ ZPST	
20234-0027	SCREW M3 X 6 PNHDPZ ZPST	MAIN PCB SPACERS
20236-0010	SCREW M4 X 12 TAMPERPROOF	EARTH
20611-0050	WASHER NYLON M2.5	CONTROL PCB
20653-0204	CABLE TIE 75 X 2.5MM	MAINS HARNESS TO CHASSIS
20661-0282*	SPACER RND 3.7 ID X 3.2 L NYL	FOR TERMINALS
20661-0278*	SPACER HEX 4BA X 9.53 NPBR	TERMINALS TO PCB
20662-0580	FOOT RUBBER BLACK	
22040-0030	FERRITE SLEEVE APPROX 7/14/15L	OUTPUT A, OUTPUT B, OUTPUT C, MAINS SWITCH
22219-0090	SWITCH ROCKER DPST GREY 12	
22225-0222†	PUSHBUTTON BLACK	
22491-0120	MAINS LD 2M ST IEC SKT/UK PL	FOR UK
22491-0270	MAINS LD 2M ST IEC SKT/EURO PL	FOR EUROPE
22571-0675*	TERMINAL TP/2 RED/GREY 12	
22571-0685*	TERMINAL TP/2 BLACK/GREY 12	
22571-0696*	TERMINAL TP/2 GREY/GREY 12	
22571-0691*	WASHER ALUMINIUM FOR TP2E TERM	EARTH TERMINAL
22575-0207*	SKT 7W .156 20AWG (YELLOW)	MAIN TO CONTROL (5V O/P)
22575-0209	SKT 9W .156 20AWG (YELLOW)	MAIN TO CONTROL (MAIN O/Ps)
29211-0110	HANDLE EC254-OZ 6in BLACK/NICK	
31512-0680†	BRACKET F/PANEL EL/EX D/T	
33111-0220	BRACKET HANDLE SUPPORT (OBSOLETE)	
33111-0280	BRACKET HANDLE SUPPORT (UNIVERSAL)	
33147-0120†	FRONT MOULDING	
33331-4860†	OVERLAY NAME & LOGO	EX354T ONLY
33331-4880	OVERLAY NAME & LOGO	EX354D ONLY
33331-4870†	OVERLAY TERMINAL AREA	EX354T ONLY
33331-4890†	OVERLAY TERMINAL AREA	EX354D ONLY
33533-0370	OVERLAY DISPLAY WINDOW	
33536-4090	CHASSIS	
33536-4220	COVER	
37151-0470	KNOB	
48511-0310†	INSTRUCTION BOOK	

## † MECHANICAL PARTS CHANGES FOR EX354Tv and revised EX354D (grey ON-OFF buttons)

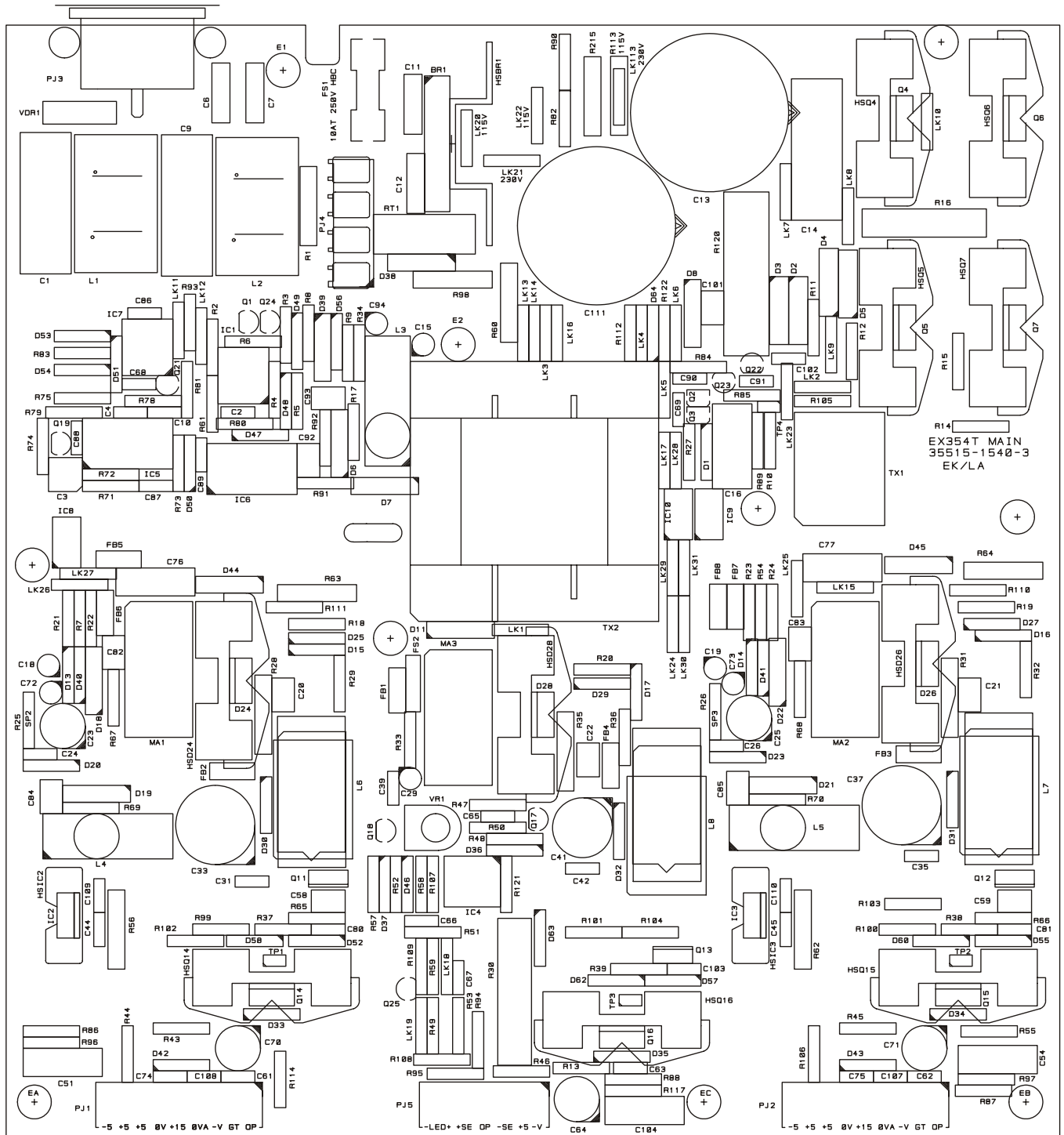
23377-7010	SPINDLE	For AUX V <sub>SET</sub>
31512-0990	BRACKET FRONT PANEL	Replaces 31512-0680
33147-0300	FRONT MOULDING	Replaces 33147-0120
33331-8900	OVERLAY NAME & LOGO	EX354Tv only
33331-8910	OVERLAY TERMINAL AREA	EX354Tv only
33331-8930	OVERLAY TERMINAL AREA – EX354D	Replaces 33331-4890
37113-2110	PUSH-BUTTON (GREY) 6.5 DIAMETER	Replaces 22225-0222
48511-0970	INSTRUCTION BOOK EX354D/Tv	Replaces 48511-0310

## \* MECHANICAL PARTS CHANGES for SAFETY TERMINALS (from mid 2006)

22571-1080	TERMINAL PSU SAFETY RED/GREY	replaces 22571-0675
22571-1090	TERMINAL PSU SAFETY BLACK/GREY	replaces 22571-0685
22571-1100	TERMINAL PSU SAFETY GREY/GREY	replaces 22571-0696
22571-1101	WASHER ALUMINIUM – SAFETY TERMINALS	replaces 22571-0691
20661-0295	SPACER HEX M4 x 8	replaces 20661-0278
20037-0271	WASHER M4 x 12	replaces 4BA fasteners, see diagrams
20037-0304	WASHER M4 SHAKEPROOF	replaces 4BA fasteners, see diagrams
20030-0266	WASHER M4 PLAIN	replaces 4BA fasteners, see diagrams
20210-0110	NUT M4 BARBED	replaces 4BA fasteners, see diagrams

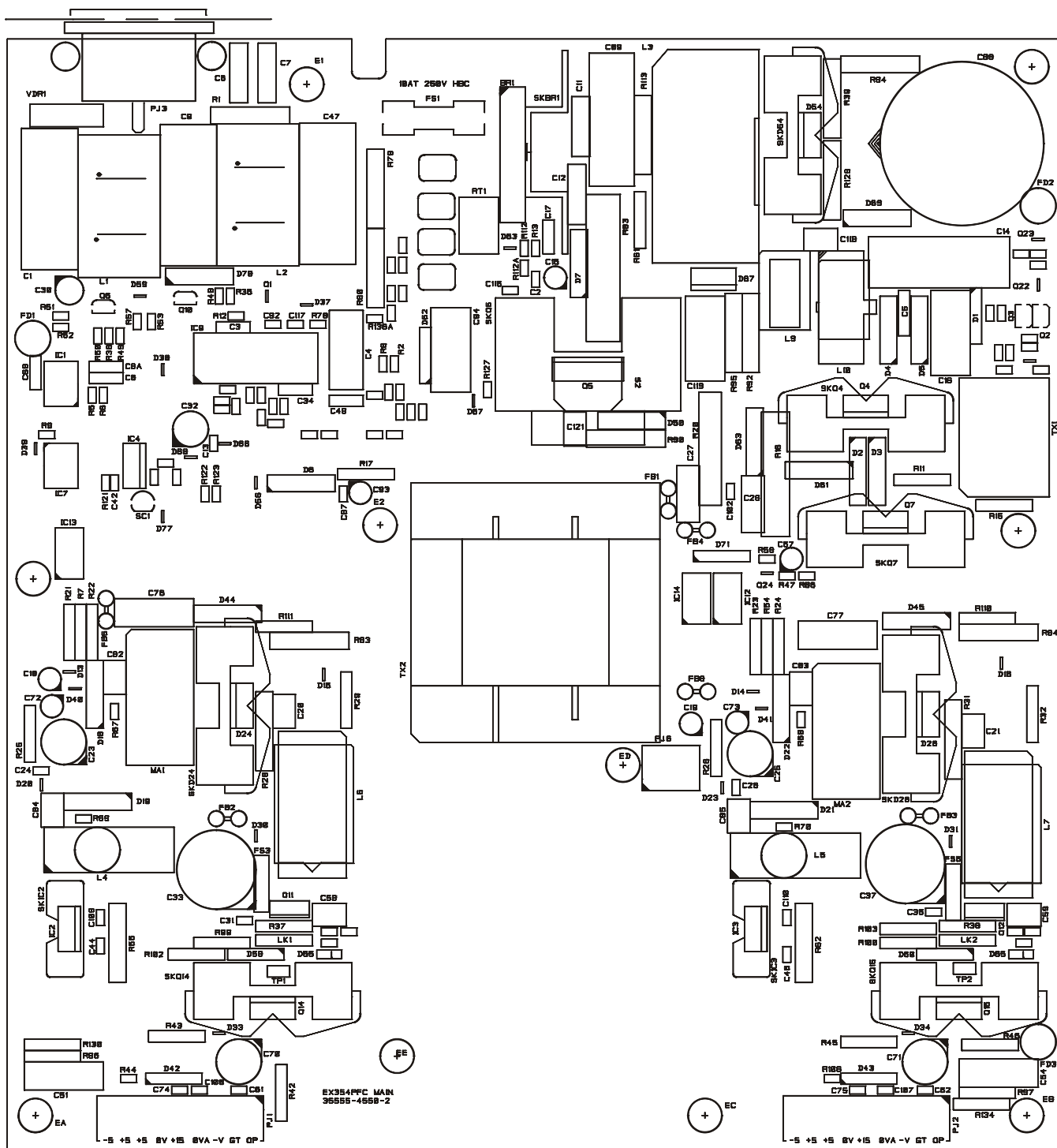


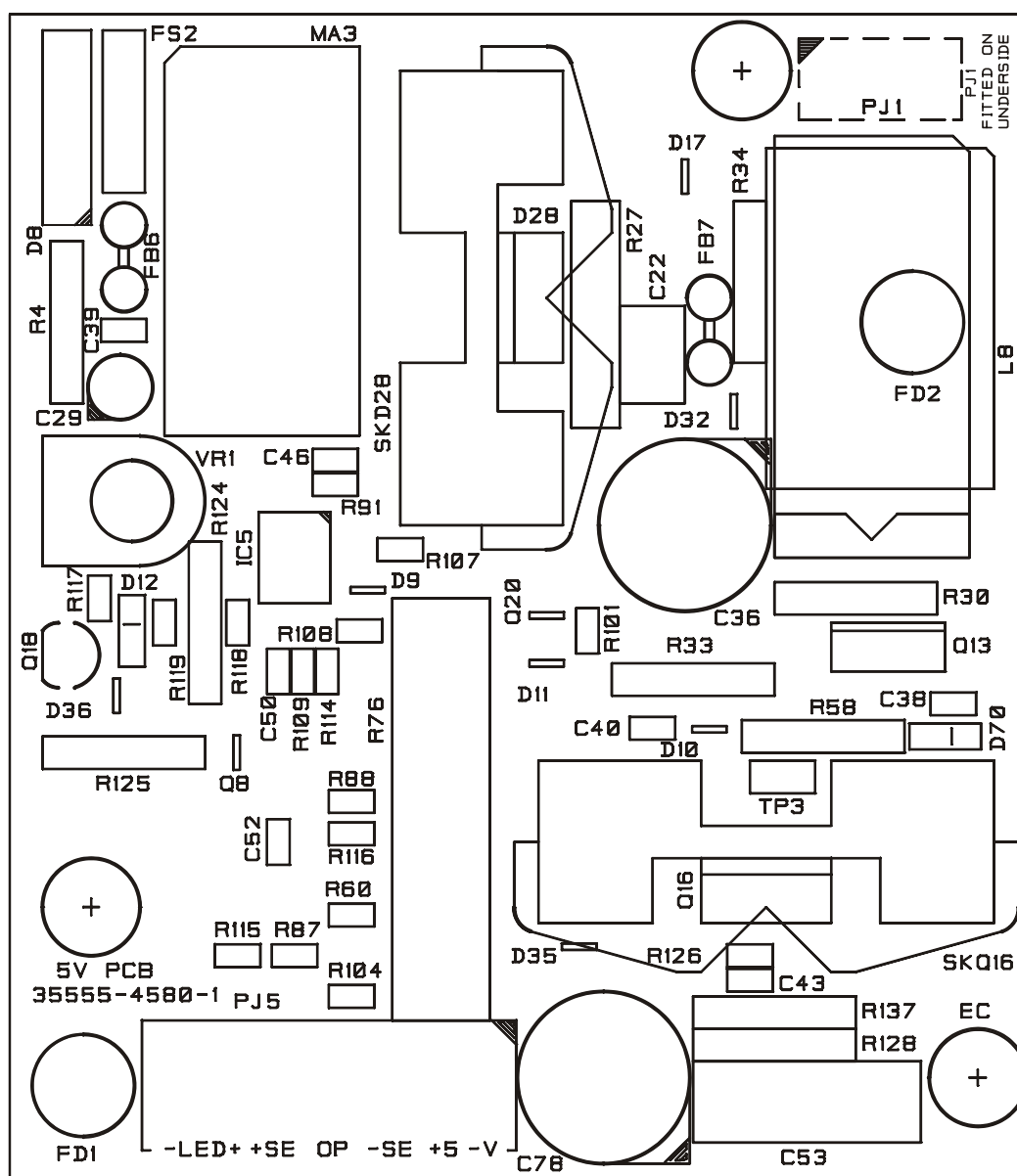
## Main PCB – Version 1



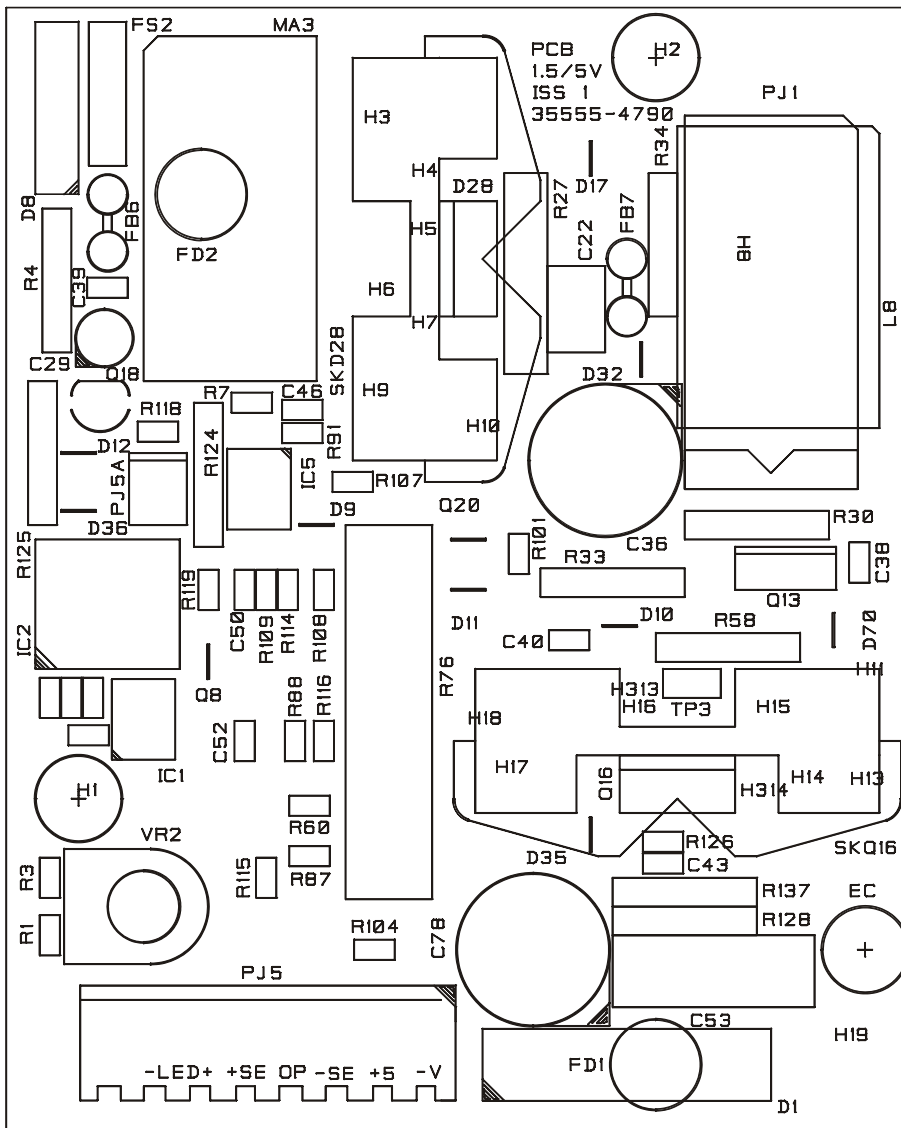


# Main PCB – Version 3 & 4



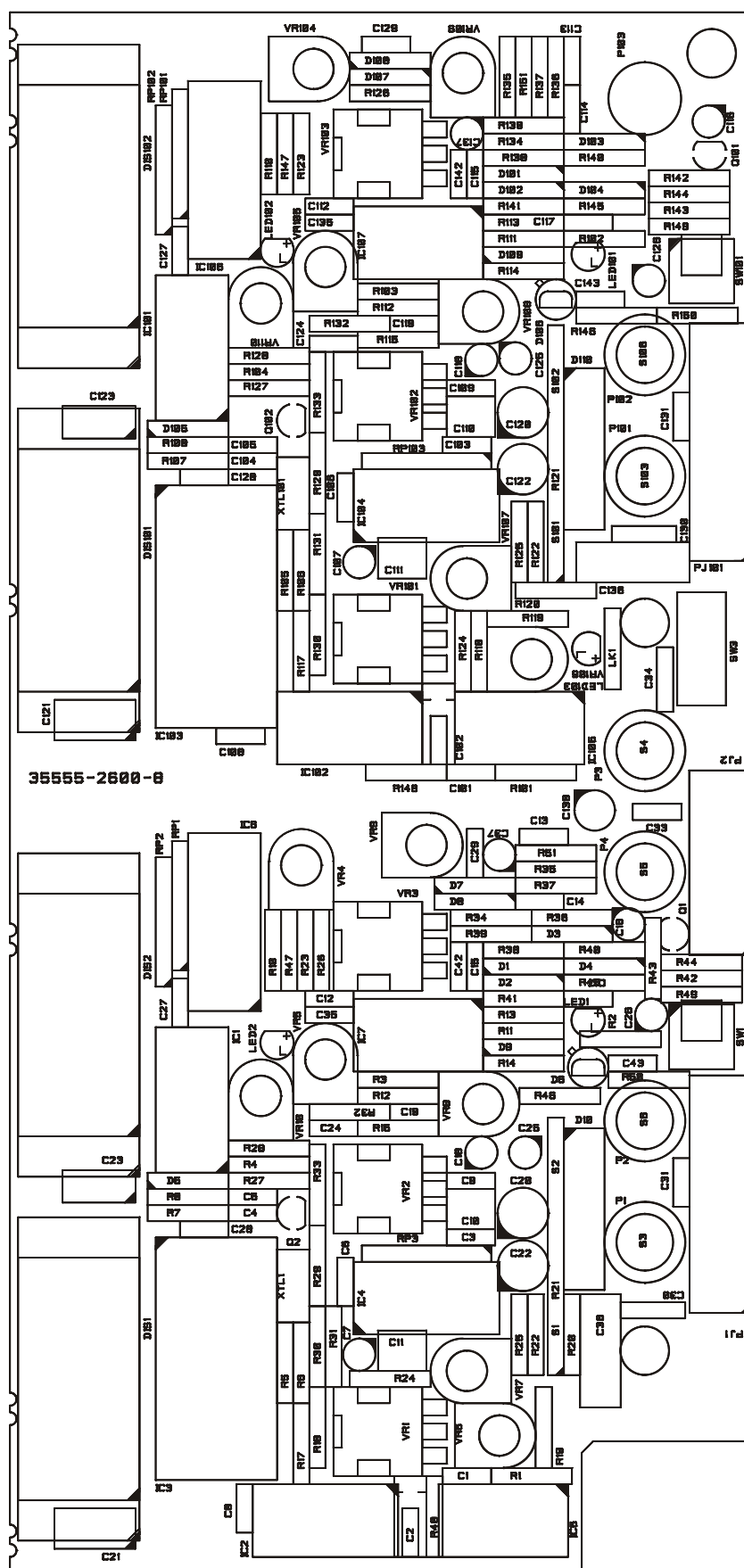


## 1.5V to 5V AUX Output PCB (for Version 4)

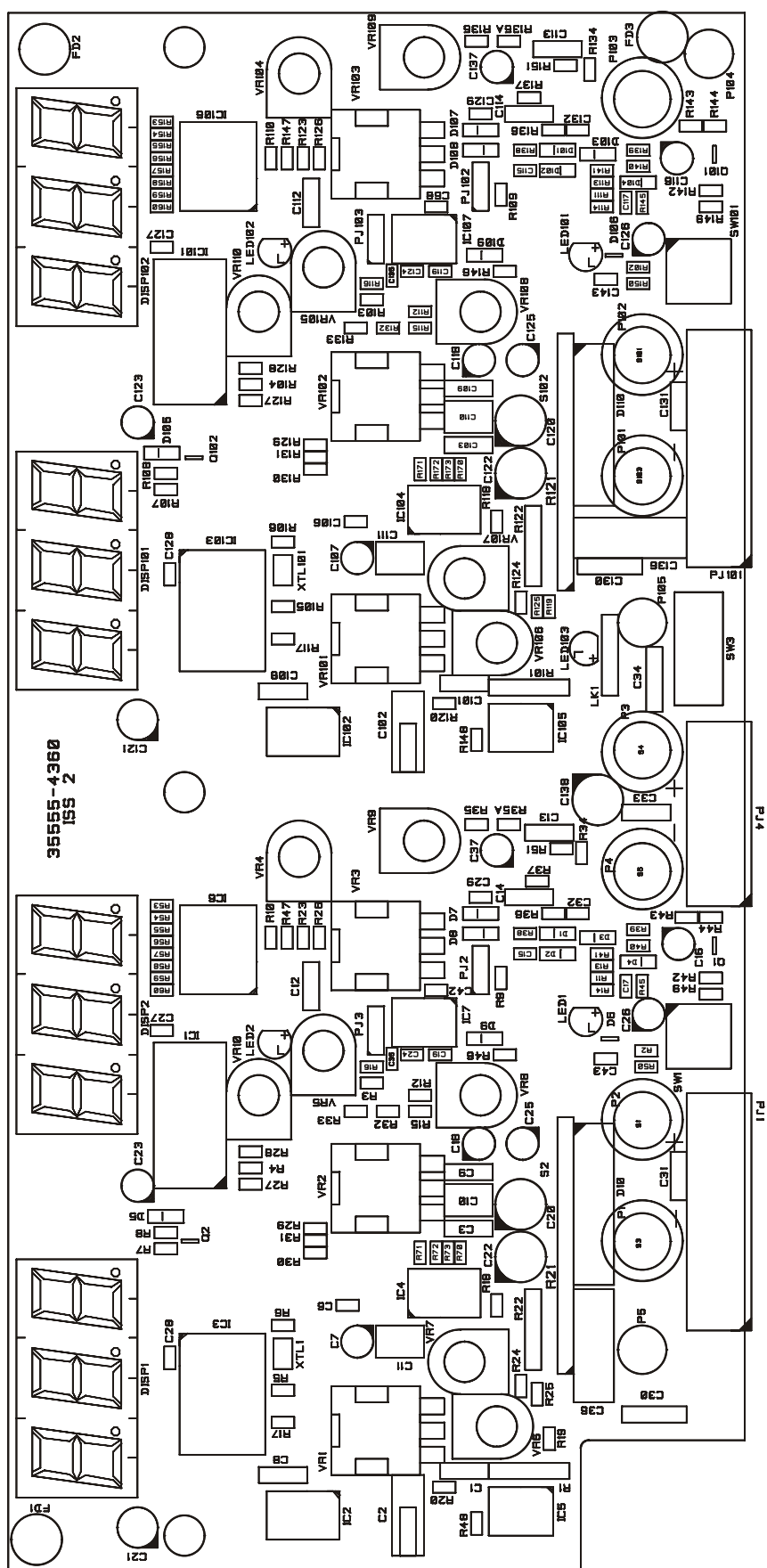


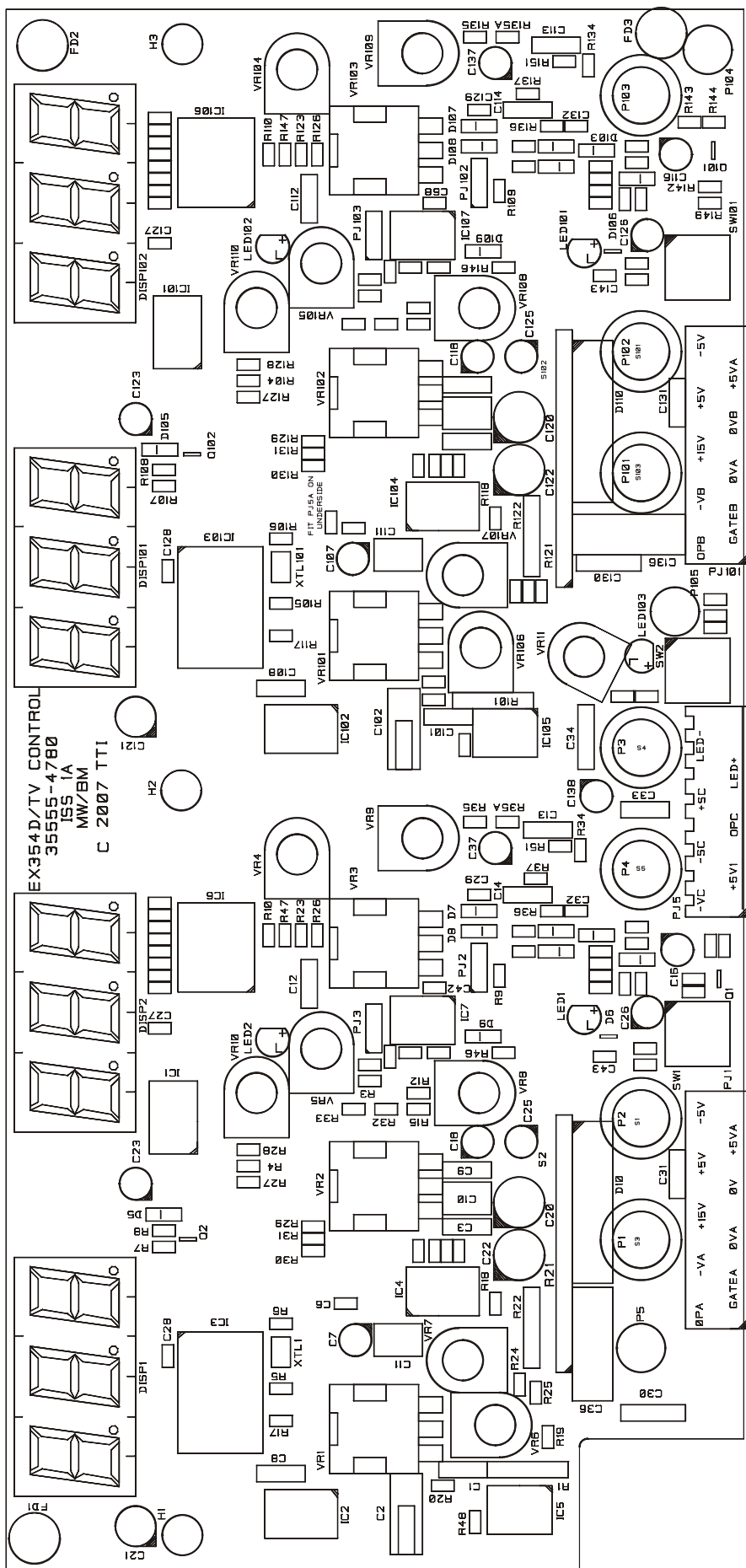


### Control PCB (for Versions 1 & 2)

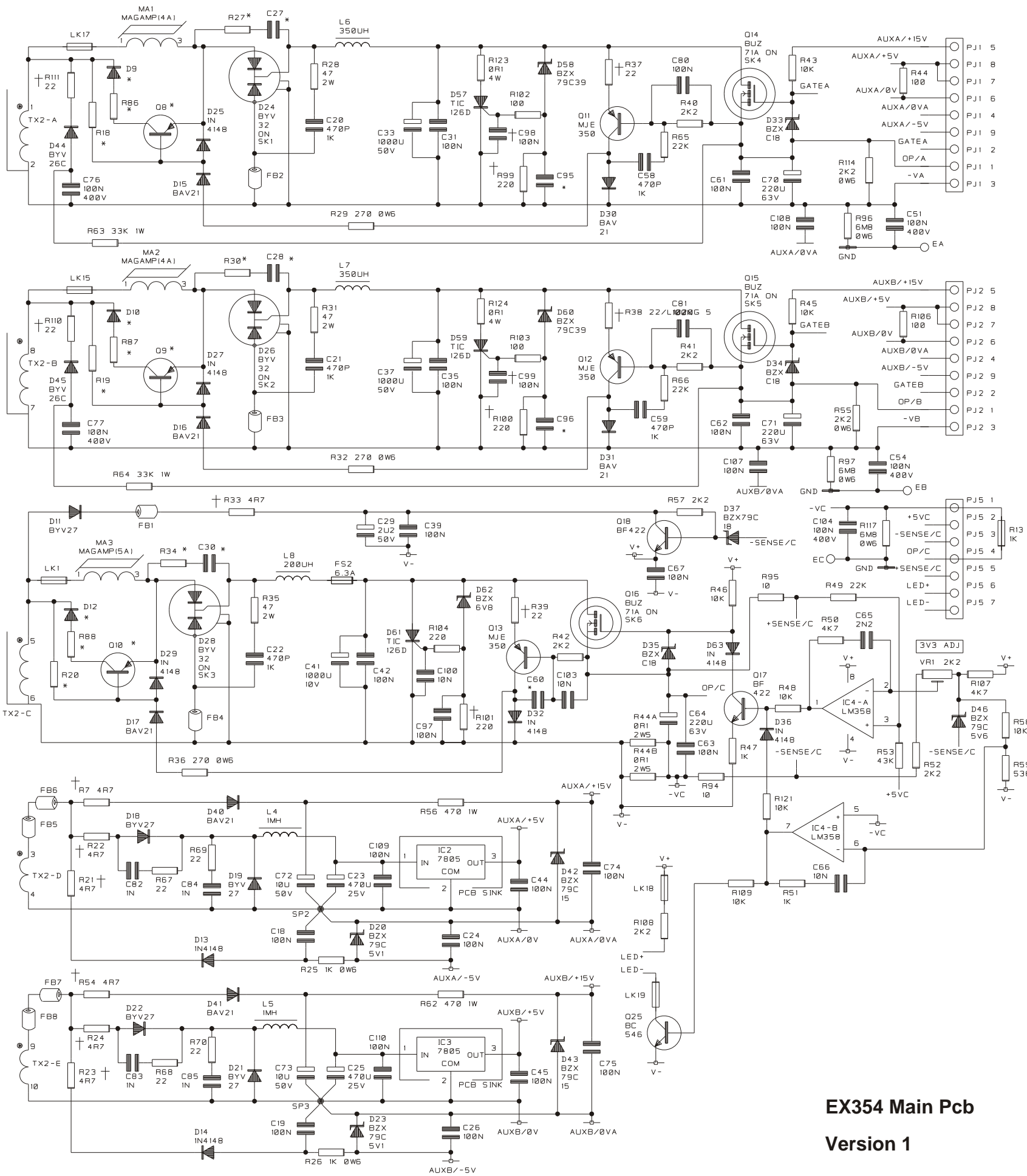
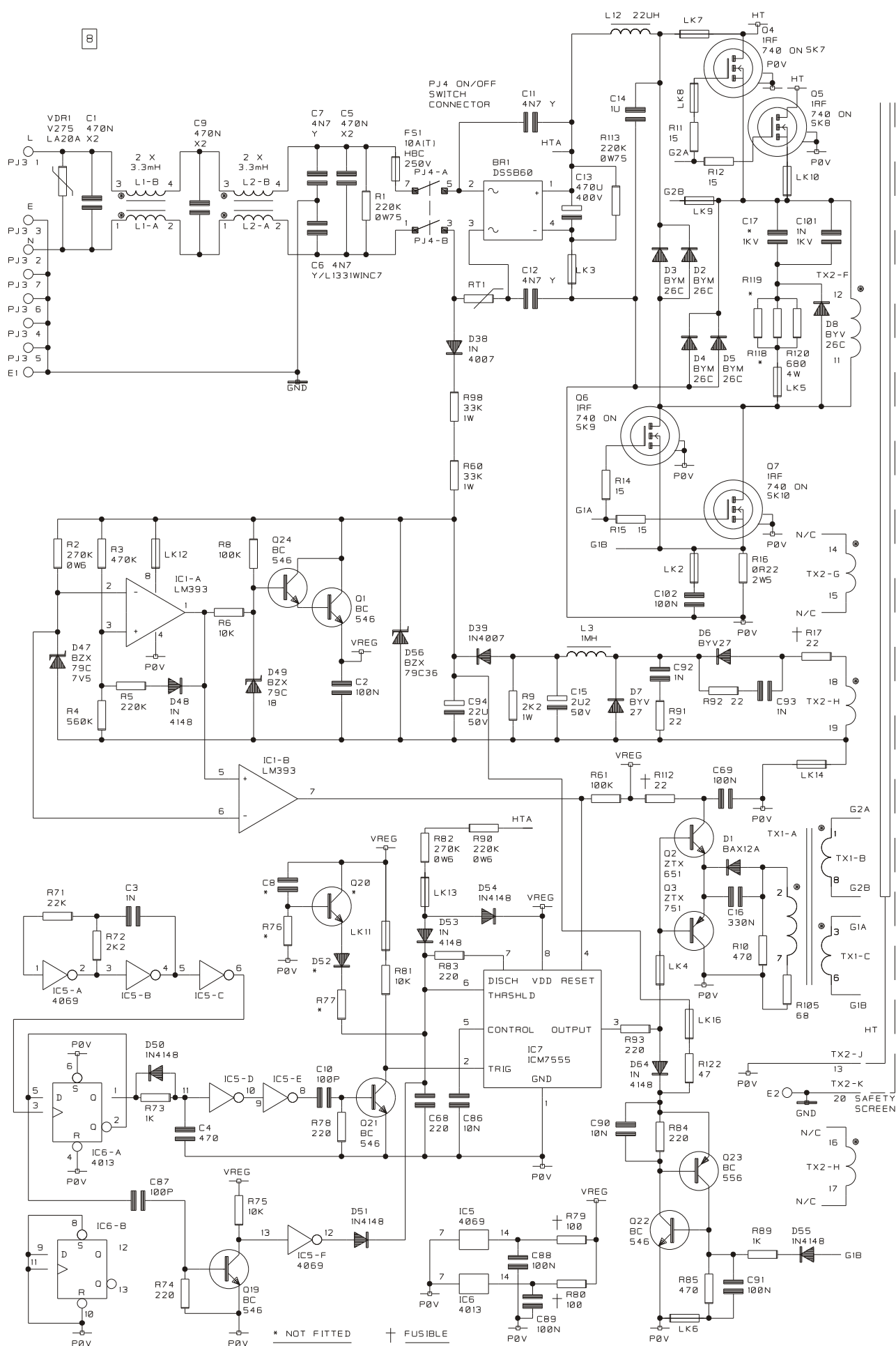


# Control PCB (for Version 3)





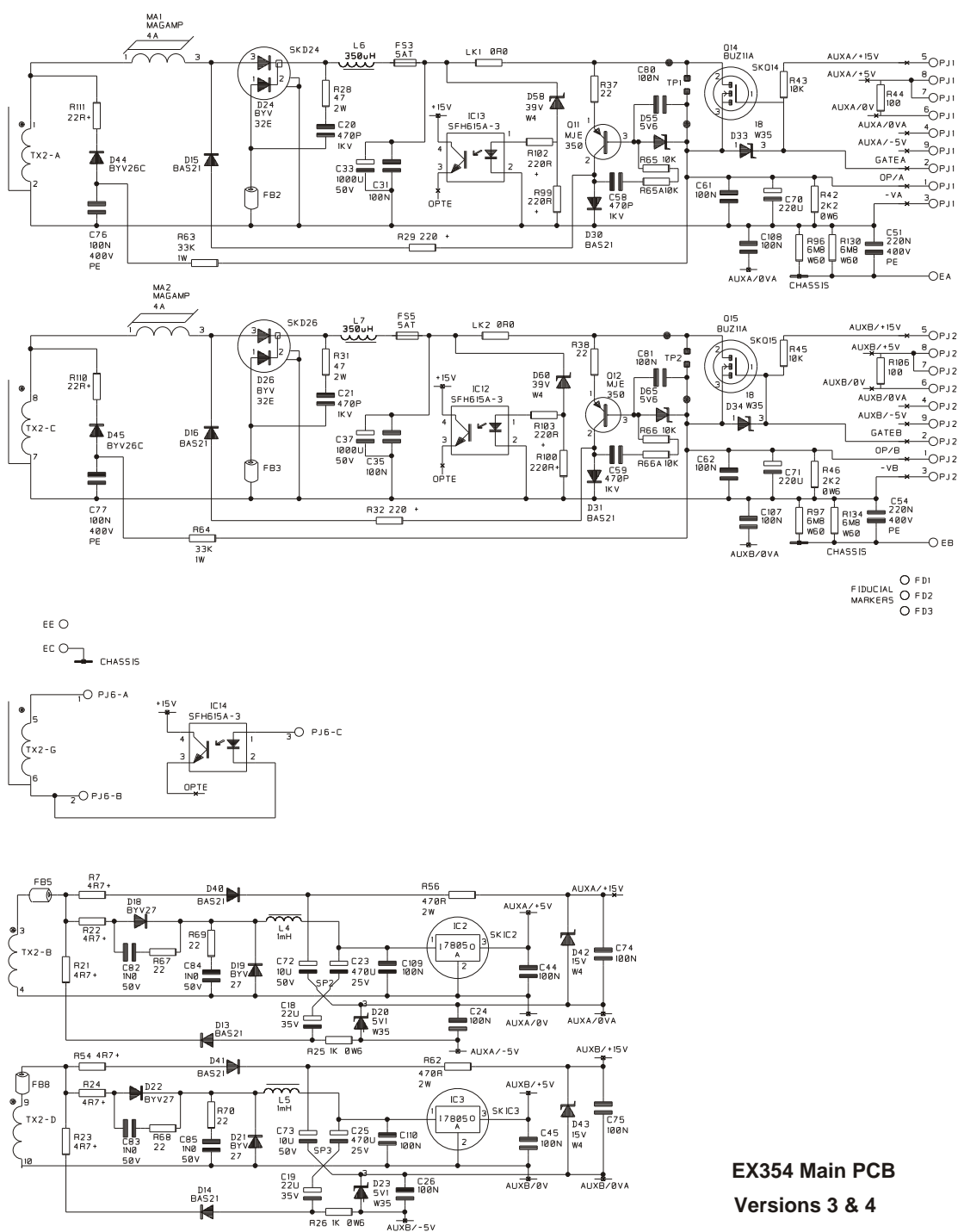




# EX354 Main Pcb

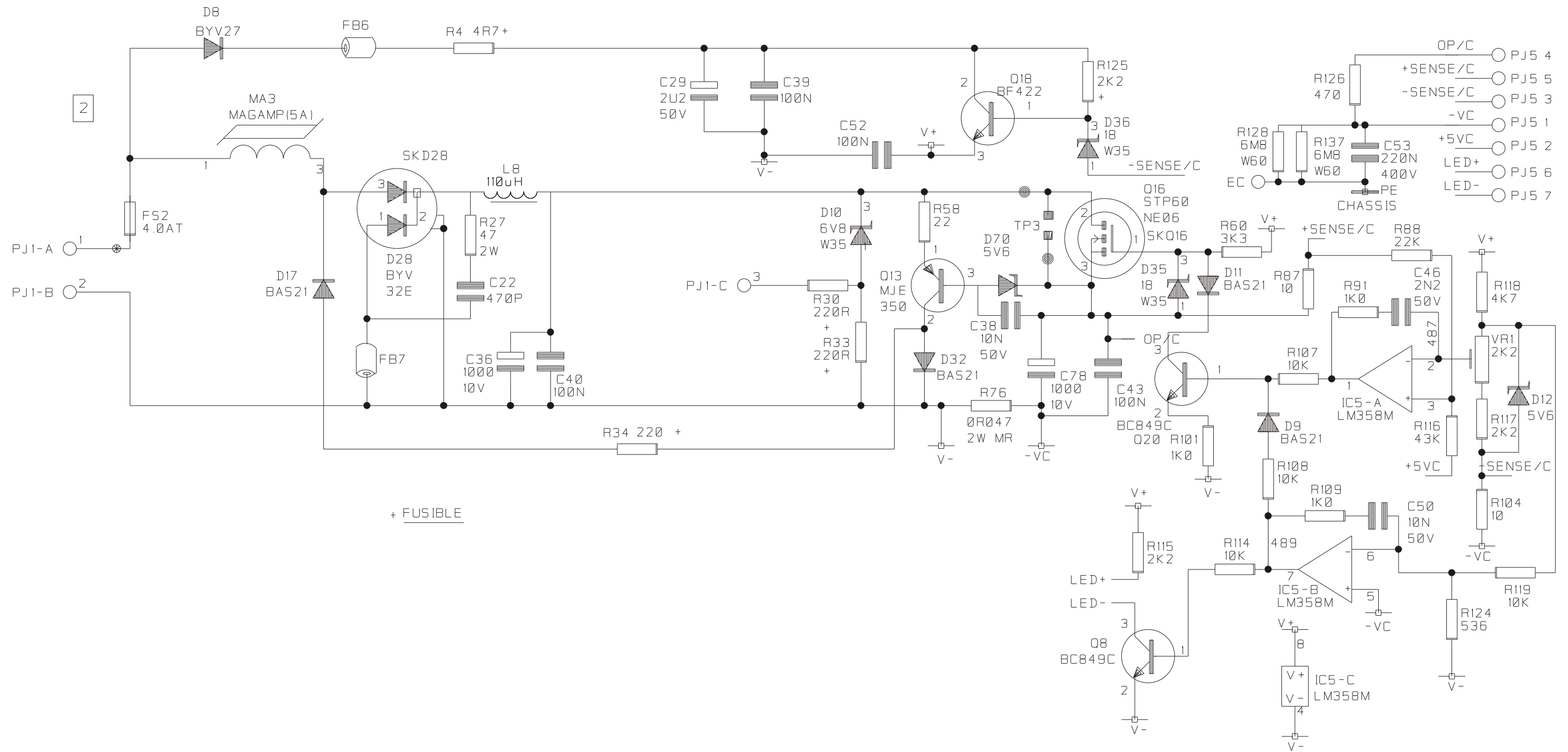
## Version 1





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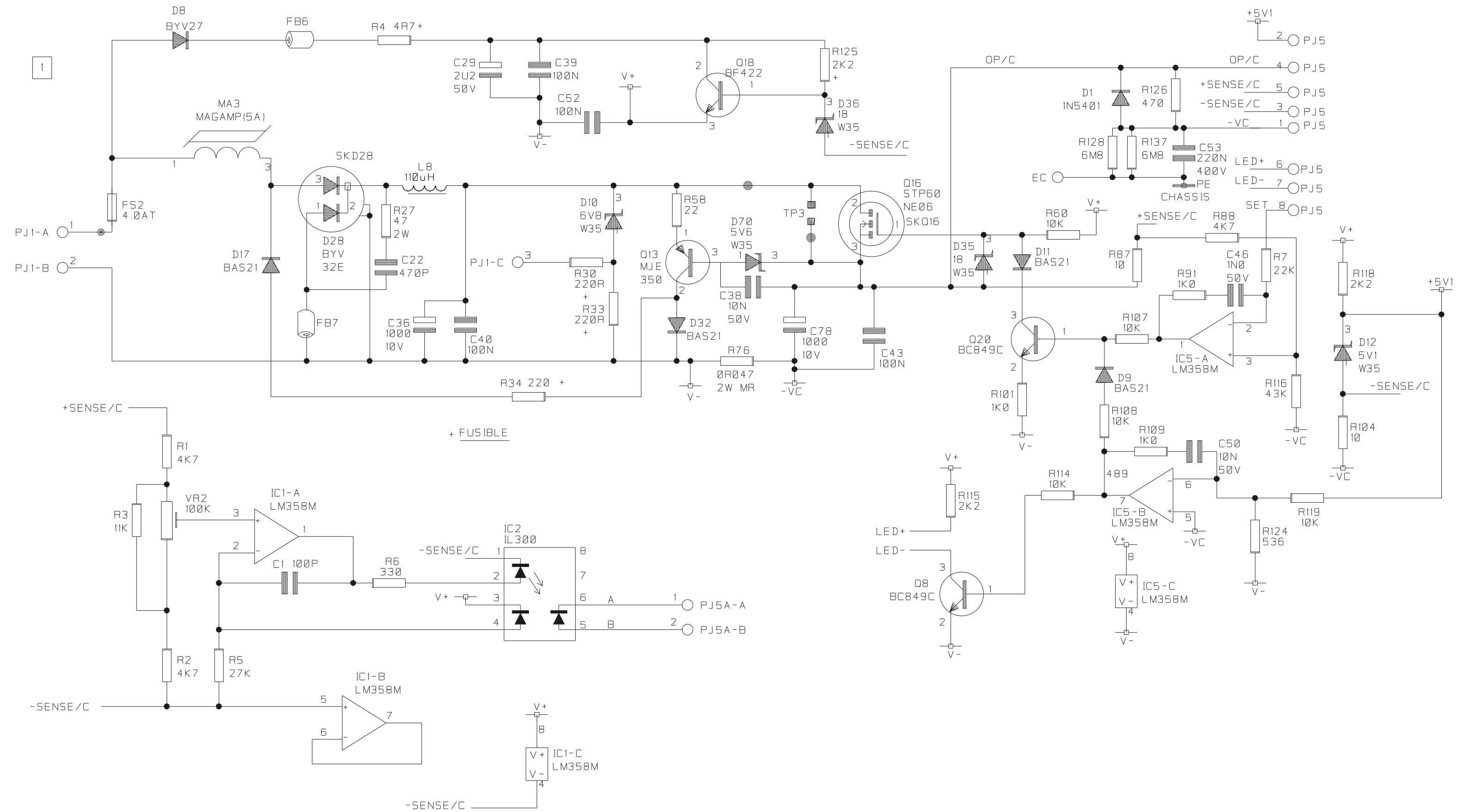




**EX354 5V/3.3V Output**

**Version 3**





EX354Tv AUX Output

Version 4



**Versions 1 & 2 - Sheet 1**



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