E45

SERVICE MANUAL

MC^2 AUDIO Ltd.,
Units 6 & 7 Kingsgate,
Heathpark Industrial Estate,
HONITON,
Devon EX14 1YG
England
Tel: ++(0)1404.44633 Fax: ++(0)1404.44660
www.mc2-audio.co.uk

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CIRCUIT DIAGRAMS PCB710.x
701.x
712.x
703.x

LAYOUT DIAGRAM PCB710/701/712

INTRODUCTION

The **E45** amplifier is designed for maximum reliability and minimum adjustment, as well as for top quality sonic performance. Re-alignment will only normally be necessary after parts replacement in the unlikely event of failure.

There are four PCBs contained within the basic unit (plus cross-over filters if fitted):

1. The main PCB (PCB710) containing the power amplification, which is located in the base of the chassis.
2. The input PCB (PCB701) containing input, limiting and some control circuits.
3. The front panel display PCB (PCB703), which contains status LEDs and volume controls.
4. The power supply PCB (PCB712) switchmode power supply.

Refer to the relevant paragraphs for details of dis-assembly, repair, adjustments and re-assembly.

WARNING: REFER ALL SERVICING TO QUALIFIED PERSONNEL.

MAINTENANCE

All models incorporate filters in the air intake apertures. These should be cleaned or replaced periodically, e.g. 6-12 months. The filter is fitted behind the blue front panel and can be replaced without removing the front panel. The filter should be 'dry' cleaned, using a vacuum cleaner preferably. Running the unit without a filter is not recommended unless it is within a 'clean room'. Replacement filter material is available from MC^2 Audio.

No other regular maintenance is required.

NOTE: Any internal cleaning should only be carried out by a competent person.

CIRCUIT DESCRIPTION

1. GENERAL

The **E45** amplifier operates in modified class H with mixed bi-polar and FET output stages powered from a switchmode power supply. This ensures optimum sonic quality and high reliability. Full protection circuitry and preset limiting maintain the amplifiers within safe operating parameters, even under adverse conditions. High quality, low noise operational amplifiers are used through-out the pre-amp circuits, driving a hybrid IC/discrete output amplifier.

PCB710, 701 - Circuit references are designated 1xx for Ch. A and 2xx for Ch. B. Single digit and two-digit numbers are common to both Ch. A and Ch. B. In the following description Ch. A references are given, with Ch. B references in brackets.

PCB703 - Circuit references are RR1-RR10 etc.

PCB712 - The power supply has 2 digit references and is dealt with in paragraph 7.

2. INPUT STAGE - PCB710, 701

* U101d (U201d) form a balanced input circuit with unity gain.
* CMR adjustment is by VR101 (VR201).
* J104 (J204) links the signal out to the crossover card when fitted. The signal then returns to J103 (J203) on the gain control connections. The signal from the gain control then passes to U101b (U201b).

* U101b (U201b) form an adjustable gain amplifier. The gain is set by a series of link positions.
* The signal then passes to the output connector J105, (J205) PIN2 and is sent to the main amplifier on PCB710.
* The signal is also passed to the limiter control circuit.
* On Ch. A ONLY, the signal is inverted by U101a and passed to Ch. B via the bridge switch for bridged operation.

3. LIMITER CIRCUIT and POWER REDUCTION CONTROL (PRC) – PCB701

* The audio signal from U101b (U201b) is passed via the PRC switches, which attenuate the signal, to U101c, where it is buffered before being rectified by the circuit of U102b. The d.c. voltage (relative to the audio signal strength) is applied to PIN3 of U102a (U202a) and also to PIN2 (6) of U5a (U5b). PIN2 of U102a (U202a) and U5a (U5b) PIN3 (5), are connected to a reference d.c. voltage derived from 'Vcc +ve', the high voltage rail that supplies the output amplifiers. This reference, called 'V-threshold', is adjustable (on PCB710) and is used to set the limiter threshold.
* The d.c. control voltage out of U102a (U202a) controls Q101 (Q201) via a fast attack, slow decay circuit and controls the gain of the audio channel via LED OPTO LDR, LDR101 (LDR201).
* U102a (U202a) PIN1 will only start to move +ve when PIN3 exceeds the reference set on PIN2. Hence the limiter threshold is set.
* The PRC switches control the gain and therefore the voltage into PIN3 of U102a (U202a). thus the threshold of limiting can be lowered to reduce the maximum output of the amplifier.

4. OUTPUT AMPLIFIER – PCB710

The unique MC^2 Audio sliding op-amp drive circuit combined with multiple bi-polar output transistors form the power output stage. The rail switching is performed by a bank of FETs.

* Bias adjustment is via VR104 (VR204).
* VR103 (VR203) allows minor gain adjustments for alignment.
* OPTO coupler, OPT103 (203) is used to detect onset of clipping.
* Q114 (Q214) and Q115 (Q215) form a current detecting circuit which will trigger the protection circuit via OPTO101 (OPTO201) and OPTO102 (OPTO202), also clamping the drive signal at R168 (R268) and R169 (R269).
* R140 (R240), ZD101 (ZD201) and R141 (R241), ZD102 (ZD202), develop the ±15V supplies for the 'sliding' op-amp relative to the output rail.
* Q51, Q52, Q53, Q54 provide the gate drive for the FET switching rails.

5. PROTECTION

The amplifier has built-in protection against various conditions:

a. Excessive temperature: heatsinks and PSU
b. Excessive drive: limiting circuit at onset of clipping
c. Output short circuit or low impedance
d. DC shift on output.

a. TEMPERATURE

* Thermistors Thxa and Thxb sense the output stage heatsink temperature, whilst Th4 and Th5 sense the FET bank temperatures.

* The voltages from the sensors are logic 'OR'd' through D1, D2, D3 and D10 into latching comparator U1a, PIN4. This voltage also controls U2 to drive Q1a and Q1b, which supply the cooling fans. The fan speed is proportional to temperature. U1b forms an additional comparator to switch relays RLY2, RLY3 via CONN1 PIN4 (on PCB712) at approximately 90°C. This reduces the output stage supply voltage to limit the available power.
* If the temperature rises above around 100°C, U1a, PIN2 will swing low when PIN4 voltage exceeds PIN5 voltage and latch in that state because of R7, D5.
* The speaker outputs will be disconnected via D6, U1c, Q2A and Q2b and RL4 and RL5.
* D109 (D209) reduce the voltage on Q101 (Q201) drain to about 1.5V thus reducing the LDR resistance to very low, attenuating the audio signal.

b. EXCESSIVE DRIVE

* The limiter circuits prevent ANY continuous excessive drive condition, provided that the INPUT signal is less than +18dBu.

c. OUTPUT SHORT CIRCUIT

* In the event of a short circuit or very low impedance load being present on the amplifier output, excessive current will pass through the sensing resistors R156 (R274), R151 (R253) on the emitters of transistors Q112 (Q216), Q107 (Q209). The voltage developed across the resistors will cause conduction of Q114 or Q115 (Q214 or Q215), which will pull current through the relevant OPTO coupler LED, OPT101 or OPT102 (OPTO201, OPTO202). The output transistor of the relevant OPTO coupler will cause comparator U1d to change state and latch (due to R12, D9). This will disconnect the speaker output relays RLY4 and RLY5 via D7, and mute the drive signal. (See Temperature, para. a.)

d. DC SHIFT

* R24 and R25 detect any DC shift at the output terminals. If the average voltage on either output connection differs from 0V by a significant amount (approx. 100mV) U1c output will change state (high to low) disconnecting the speaker outputs via RL4 and RL5 and muting the drive signal via the limiter circuit. Spurious operation due to AC signals is prevented by C18, C19.

6. STATUS LEDs – PCB703 and PCB701

* The status LEDs are mounted on PCB703 (display panel).
* The blue signal LEDs are driven from the signal to the gain controls, via DU1a (DU1b) on PCB703.
* The remainder of the LEDs are driven via signals or voltages from PCB701 via CONN5 (ribbon cable).
* The -3dB indicators are driven from U5a and U5b. (See paragraph 3 above.)
* The limit indicators are driven from U4a and U4b.
* The protection indicator (A/P) is driven from CONN6 PIN5 on PCB701, which connects to U1c PIN14 on PCB700.

7. SWITCHMODE POWER SUPPLY – PCB712

The mains input, via in-rush and RF filter circuits, and switching is bridge rectified by BR1 and smoothed by C6 to C9.

* PTC1 is a protection device.

* T3, BR2, BR3, REG1, REG2 establish the low voltage rails +24V, ±15V.
* Q3 circuit delays switching of RLY1 until the oscillator formed as part of U1 has started.
* Drive signals for the IGBT switching transistors are from U1 PINS11 and 14 via isolator transformer T2.
* The IGBTs form a resonant push/pull circuit with C14-15, L3 and T1 primary.
* T4 is a sensing transformer for control circuits.
* The secondary of T1 is rectified and smoothed to form the high voltage rails for the power amplifiers.
* RLY2 and RLY3 switch the rails if the amplifier temperature exceeds certain limits.
* T4 and D15 to D18 develop a d.c. voltage relative to the current drawn through T1. This is used via U3b, U2b to switch off the drive to the IGBTs by shutting down U1 if the current drawn through T1 exceeds certain limits. U2b comparator latches once triggered.
* U3a buffers the output from the attack/decay circuit formed by D11, R33, R34, C37. This voltage passes to the limiter control circuits via CONN1 PIN5 to PCB700, U3a where it acts upon the limiter threshold voltage 'V-threshold' at VR1.
* U2a compares the high voltage rail 'Vcc' with a reference voltage from the +15V rail. If 'Vcc' exceeds certain limits, U2a via D10 shuts down the IGBT drive. This is non-latching.
* Q4 drives the relays RLY2 and RLY3, which step down the 'Vcc/Vss' rails. The base of Q4 is driven from PCB700 via CONN1 PIN4.
* NTC4 senses the IGBT heatsink temperature within the power supply. D12 adds a small d.c. voltage to that on C37 to also control the limiter circuit as above.

SAFETY COMPONENTS

* FS1 is a 1AT fuse to protect the low voltage circuits.
* Th Trip1 is the main unit thermal trip fitted to the rear panel. (240V version = 20A)
* PTC1 protects the switch circuit if something prevents RLY1 operating at switch-on.

<u>WARNING</u>: LETHAL VOLTAGES ARE PRESENT ON THIS POWER SUPPLY. ENSURE VOLTAGES HAVE DISCHARGED BEFORE REMOVING PCB712 (PSU).

<u>DIS-ASSEMBLY</u> (See equipment list for tools - Appendix 1)

Access to the circuitry is via the top panel which is retained by 12 x Pozi-head (PZ1 and PZ2) set screws. Side panels can be removed for access if necessary. (6 x Pozi-head PZ2)

Most servicing can be carried out without removing the main PCB since it is double sided and component side soldering/de-soldering is normally possible. However, when necessary the PCBs can be removed as follows:

a. INPUT PCB PCB701

* Remove connectors J103, J203, CONN5 and CONN6. (Cut tie wraps as necessary.)
* Remove 8 x POZI head screws from XLR connectors. Note position of screws with spring washers (2).
* Remove 2 x POZI head screws holding PCB to main PCB.
* Carefully raise PCB to gain access to J105, J205 underneath linking PCB701 to PCB710. Remove cables from J105, J205.
* PCB701 can now be removed completely.

b. MAIN PCB PCB710

* Remove PCB712 as in section d.
* Remove PCB701 as above.
* Remove connectors CON1 and 2 and all spade terminals (5).
* Remove rear fan connectors (2).
* Remove rear panel socket retaining screws 6 x PZ1.
* Remove PCB retaining nuts and washers 5 x M4 (7.0mm socket), 2 x M3 pillars, 4 x PZ2 screws.

  NOTE THE POSITION OF THE GREEN AND YELLOW EARTH WIRE CONNECTED TO RIGHT-HAND REAR STUD.
* Carefully raise the PCB at the edge towards the front of the unit until the PCB is clear of all pillars except the 4 rear most ones.
* Slide the PCB towards the front of the unit until the sockets clear the rear panel.
* Raise the PCB clear of the chassis.

c. DISPLAY PCB703

* Remove front panel (6 x 2.5mm Hex screws). Retain spacers behind outer 2 fixings.
* Remove 3 x 2BA plastic pillars and 1 x M4 metal pillar.
* Disconnect ribbon and audio cables from PCB701. Cut tie wraps as necessary.
* Withdraw display assembly through front panel.

d. PSU PCB712

WARNING: ENSURE CAPACITORS ARE DISCHARGED BEFORE PROCEEDING. (LEAVE UNIT SWITCHED OFF FOR 30 MINUTES.)

* Remove spade terminals: LIVE, NEUTRAL
* Remove CONNs 2a, 2b and CONN1.
* Remove spade terminals RED, BLACK, BLUE, WHITE, YELLOW.
* Remove 5 x M4 retaining nuts and 1 x PZ2/M4 screw.
* Remove any cables passing over the PCB702, e.g. ribbon cable and audio cables.
* Withdraw PCB assembly.

RE-ASSEMBLY

PCB710 - Re-assembly is largely obvious after dis-assembly has been carried out. However, care must be exercised when re-fitting the main PCB to ensure the rear panel sockets align with the rear panel apertures before sliding the PCB towards the rear and downwards onto the mounting studs.

Do not over tighten the Neutrik output socket retaining screws. (6 off)

PCB701 - Reverse of above dis-assembly procedure. Ensure connections on underside of board are made (J105, J205)

ADJUSTMENT/ALIGNMENT

Normally no adjustment will be necessary after the ex-works alignment procedure. However, with time some drift of POT settings and component ageing may require some re-alignment to be made.

After component replacement, re-alignment and testing to the original specifications should be carried out. **THIS MUST BE DONE BY COMPETENT PERSONNEL WITH CERTAIN MINIMUM TEST EQUIPMENT.** (See Appendix 1.)

A copy of the test specifications PTS **E45** is available on request.

ADJUSTMENT OF THE VARIOUS PRE-SETS ARE AS FOLLOWS: (References for Ch. B in brackets.)

a. VR101 (VR201) CMR

* Inject 1kHz @ +10dBu unbalanced with signal to relevant input XLR, pins 2 +3 (hot and cold) and ground to pin 1.
* Monitor J103 (J203) pin 1 on the oscilloscope.
* Adjust VR101 (VR201) for minimum output level.
* Repeat for Ch. B.

b. VR103 (VR203) GAIN

* Inject a balanced 0dBu @ 1kHz signal into the relevant input XLR connector.
* Monitor the unloaded speaker output with a suitable audio analyser or audio level meter.
* Adjust VR103 (VR203) for an output level of 32dBu. (Gain link set for 32dB, Pins 1-2)
* Repeat for Ch. B.

c. VR104 (VR204) BIAS CURRENT

* Connect suitable dummy 4 ohm load to relevant speaker output.
* Inject 4dBu @ 1kHz balanced into relevant input XLR.
* Monitor the output across the 4 ohm load on a suitable audio analyser capable of measuring THD + N down to 0.003%.
* If possible monitor the residual signal from the analyser monitor output on an oscilloscope.
* Set VR104 (VR204) fully anti-clockwise.
* Slowly adjust VR104 (VR204) clockwise. The THD + N should reduce gradually to a minimum level of around 0.009% and then start to increase with continued rotation of the POT. The correct setting is as far anti-clockwise as possible consistent with minimum THD + N. **NOTE:** We recommend using an IEC 'A-WTD' filter for this measurement.
* Repeat for Ch. B.

Alignment of the limiters should only be carried out if clipping is evident when the amplifier display indicators show a limiting condition and is carried out as follows:

THIS MUST BE CARRIED OUT TO ONLY 1 CHANNEL AT A TIME.

- Ensure that all PRC switches are out (off) and gain controls set for maximum.
- Set a level of +6dBu from a tone generator at 1kHz sine wave applied to Ch. B input of the amplifier. Increase the level until the Ch. Limit LED illuminates.
- Monitor the amplifier Ch. B output, loaded with 4-ohms, on an oscilloscope.
- Turn VR1 on PCB700 slowly clockwise until clipping of Ch. B is evident on the oscilloscope.

- Monitor Ch. B output and turn VR1 anti-clockwise until clipping just disappears. Measure and note the Ch. B O/P power.
- Monitor Ch. A output power. Apply the input signal to only Ch. A and adjust VR105 on PCB701 to match Ch. B in output power.

  NOTE THAT POWER MEASUREMENTS OF BOTH CHANNELS TOGETHER CAN ONLY BE MADE USING A BURST TONE IF A SINE WAVE SOURCE IS USED. CONSULT MC^2 FOR FURTHER INFORMATION IF REQUIRED.

There are no further adjustments but a check of power and frequency response should be made with reference to the specification in Appendix 2.

APPENDIX 1

Equipment Required

Repair:	Pozi	PZ1 and PZ2 driver
	10mm	SOCKET (front PCB only)
	M4	SOCKET drive 7.0 mm
	2BA	SOCKET drive

Re-alignment / re-test:

1. Signal Generator 10Hz to 40 kHz @ <0.001%THD (Burst tone for power measurements)
2. Audio analyser capable of measuring: dBu, Watts @ 4 ohms, THD% to 0.003% accuracy (Recommend: Audio Precision AP1 or similar.)
3. Oscilloscope: 10MHz band width minimum
4. Dummy loudspeaker loads 4 ohm /2000W (Qty. 2)
5. Voltmeter: D.C. volts 1 to 100V
6. Suitable screwdriver/trimmer for POTs

APPENDIX 2

Specification:

	E45
Output power (Watts RMS) per channel	
8 ohms @ 1kHz	1200
4 ohms @ 1kHz	2250
2 ohms @ 1kHz	3200
Mono Bridged	
8 ohms @ 1kHz	4400
4 ohms @ 1kHz	6400
THD @ rated power	
4 ohms 1 kHz	<0.009%
20Hz-20 kHz	<0.03%
Input CMRR	>90dB
Hum & Noise	-105dB
Gain (selectable)	+32Db/+26dB/+35.7dB
Sensitivity for rated output, 4 ohms	+9.75dBu/+15.75dBu/+6dBu (1.5V)
Damping Factor 1 kHz, 8 ohms	>400
Frequency response	20Hz-20kHz - +0/0.5dB
Input impedance (actively balanced)	20k ohms
Dimensions (mm) - 2U	88x482x428
Weight	11kgs
Power requirement	230 VAC @ 20 amps max
	115 VAC @ 40 amps max

Table of PRC settings and resulting Output

	Output Per Channel (Watts)	Bridged Mode (Watts)
Max Power into 4ohm	2250	6400
-2dBu PRC Setting	1400	4000
-4dBu PRC Setting	900	2500
-6dBu PRC Setting	560	1600
Max Power into 8ohm	1200	4400
-2dBu PRC Setting	800	2800
-4dBu PRC Setting	525	1800
-6dBu PRC Setting	350	1200
Max Power into 2ohm	3200	N/A
-2dBu PRC Setting	2000	N/A
-4dBu PRC Setting	1250	N/A
-6dBu PRC Setting	800	N/A