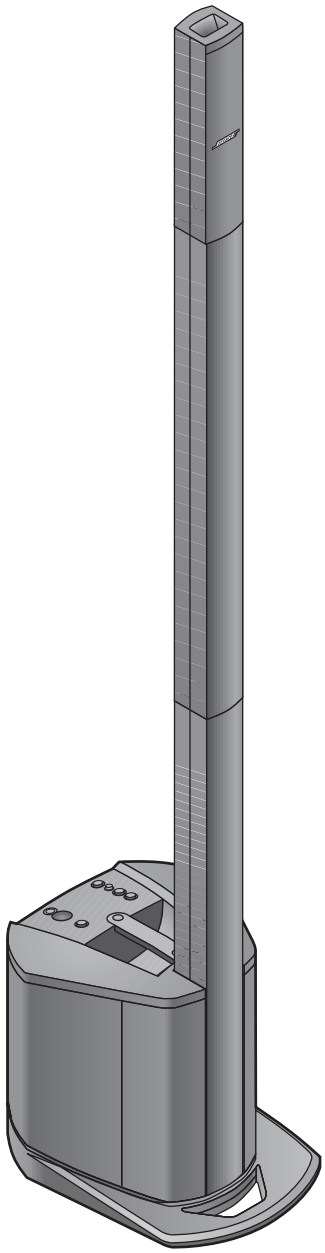
L1® Compact
Portable Line Array System
Theory of Operation



Service Manual
Reference Number 318882-TOP Rev. 00
Electronic Copy Only

L1 Compact - Theory of Operation

General

This document refers to schematic revision 01 for both the I/O Board and PS & Amp board.

The L1® Compact comprises a Power Stand base unit that houses input and output connectors and all electronics, a removable Twiddler™ Array, and two extension sections used to raise the Twiddler Array to ear level when standing.

The electronics in the base are on two circuit boards: an I/O Board directly beneath the top cover, and the PS & Amp Board which is mounted vertically on the back wall of the enclosure.

I/O Connectors

- AC mains input- IEC connector
- XRL Microphone Input Jack
- 1/8" Stereo Input Jack
- Two RCA Input Jacks
- ¼" Balanced Input Jack
- ¼" Line Out Jack
- Two RCA Line Out Jacks

Controls

- **Power Switch** - Switches the system on and off
- **Mic Volume -** Adjusts the Audio Output Level from the Microphone Input
- **Mic Treble** - Adjusts the Treble for the Microphone Audio Output
- **Mic Bass** - Adjusts the Bass for the Microphone Audio Output
- **Channel 2 Volume** - Adjusts the Audio Output Level from the Channel 2 Inputs:
  - 1/8" Jack, RCA Jacks, or ¼" Jack.

Indicators

- **Power Indicator -** Indicates power status: Blue = system on.
- **Signal/Clip Indicator -** Ch1 (Mic) and Ch2 - Indicates the level of the Audio Output:
  - Green = Normal. Red = Over Maximum Audio Level.

Power Supply

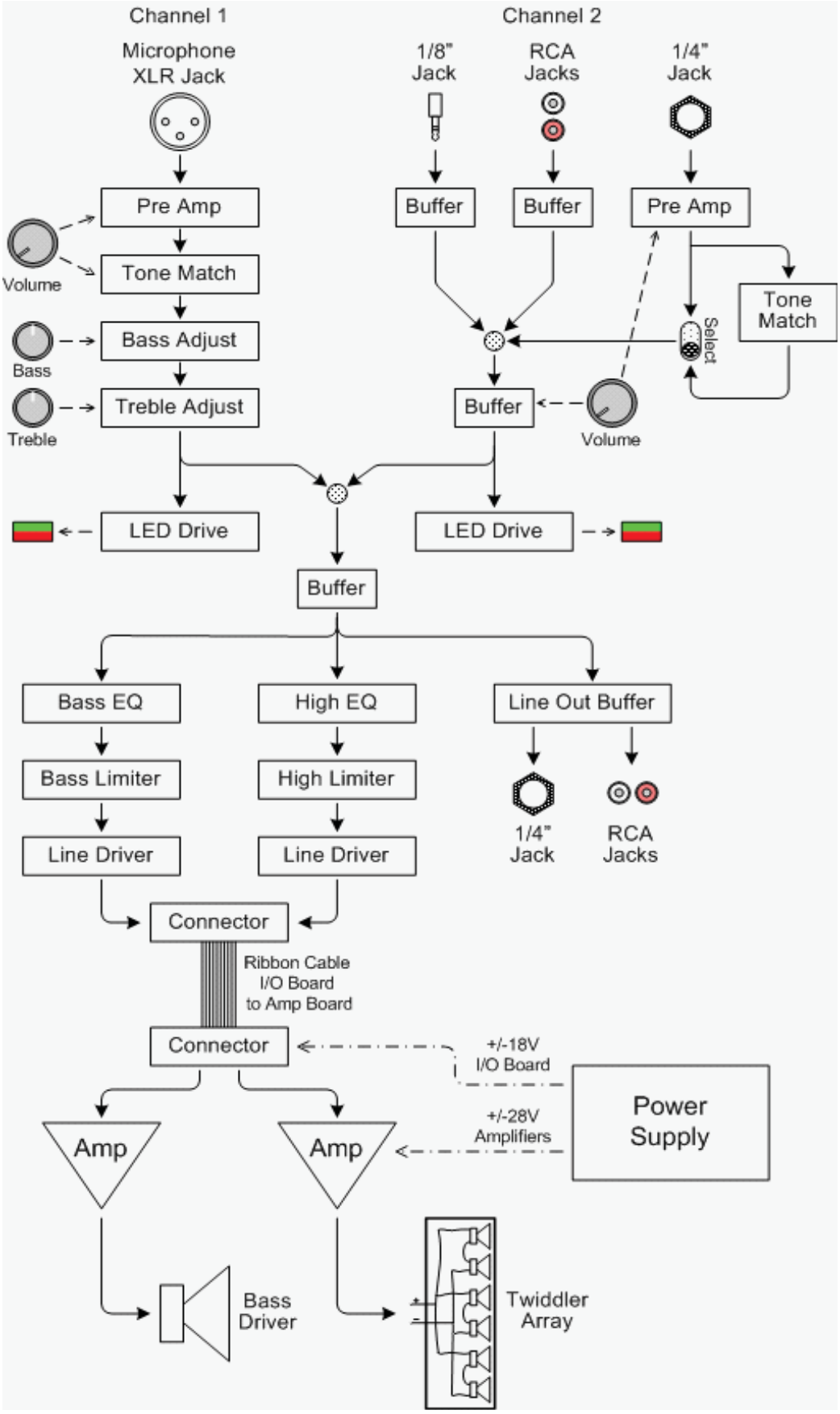
The L1 Compact Power supply is a Flyback switching supply based on Power Integrations TOP258 which provides Under voltage, Over voltage, and Thermal Protection internally. This produces four regulated DC Power Rails from the secondary: +28V and -28V for the amplifier (Philips / NXP TDA8920BTH) and +18V and -18V which are provided to the I/O board over the 10 pin ribbon cable. These +/-18V rails are post regulated on the I/O board to +/-15V by U315 & U316.

Diagrams – Pages 3 to 6

- **L1 Compact Block Diagram**
- **L1 Compact PCB Layout**
- **L1 Compact I/O Board**
- **L1 Compact Channel 1 Input Section**
- **L1 Compact Channel 2 Input Section**

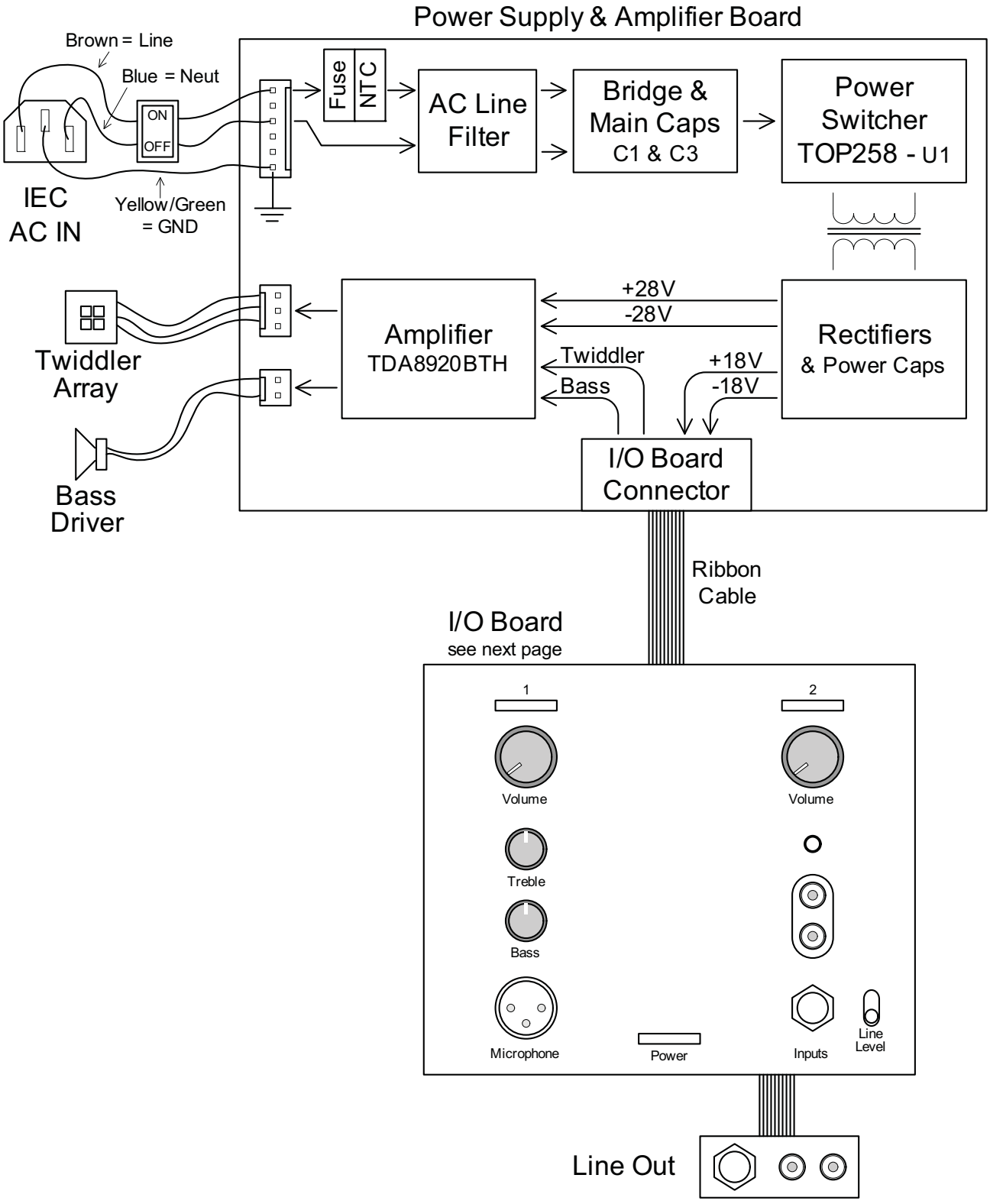
L1 Compact - Theory of Operation

L1 Compact Power Stand Block Diagram



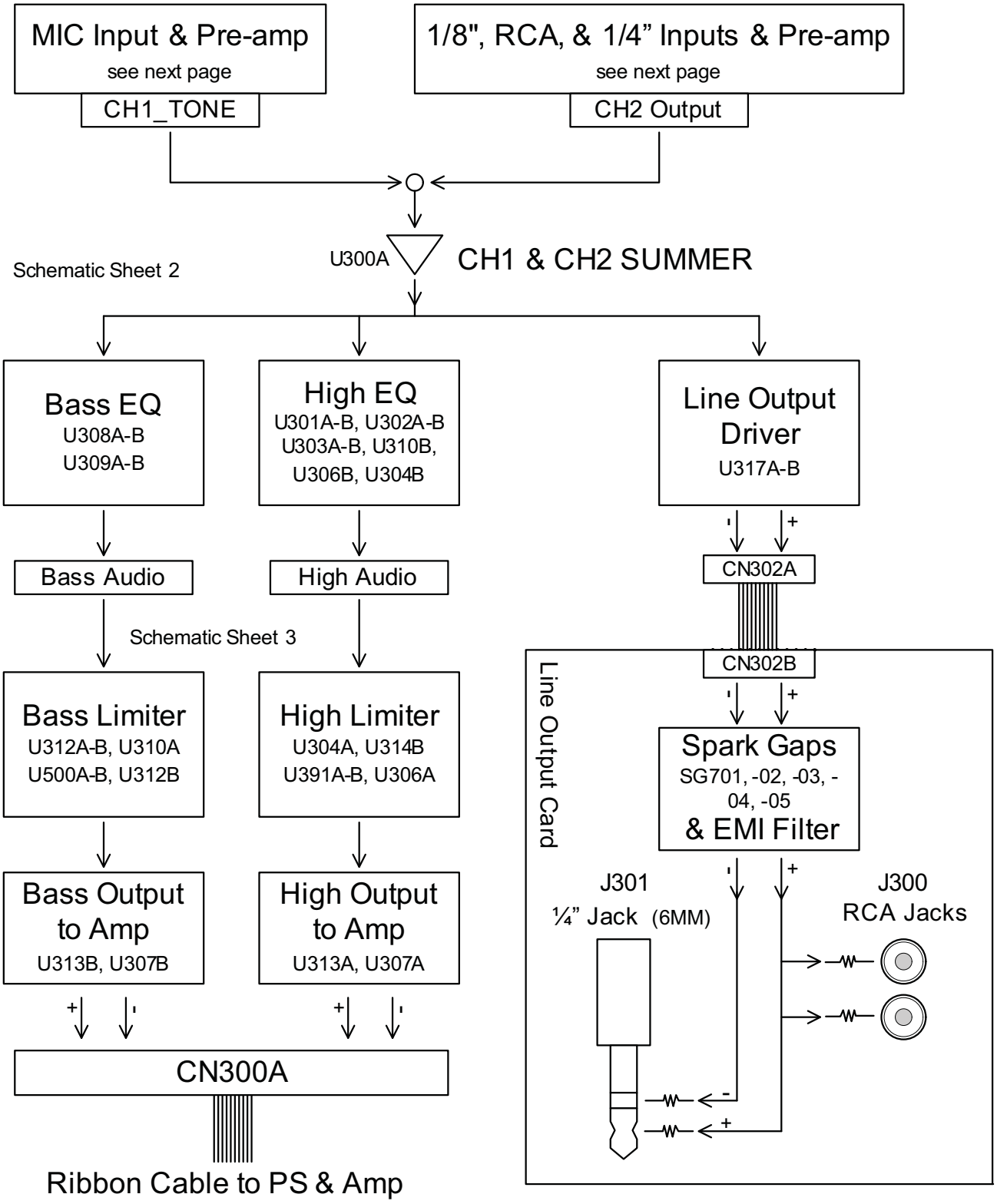
L1 Compact - Theory of Operation

L1 Compact PCB Layout



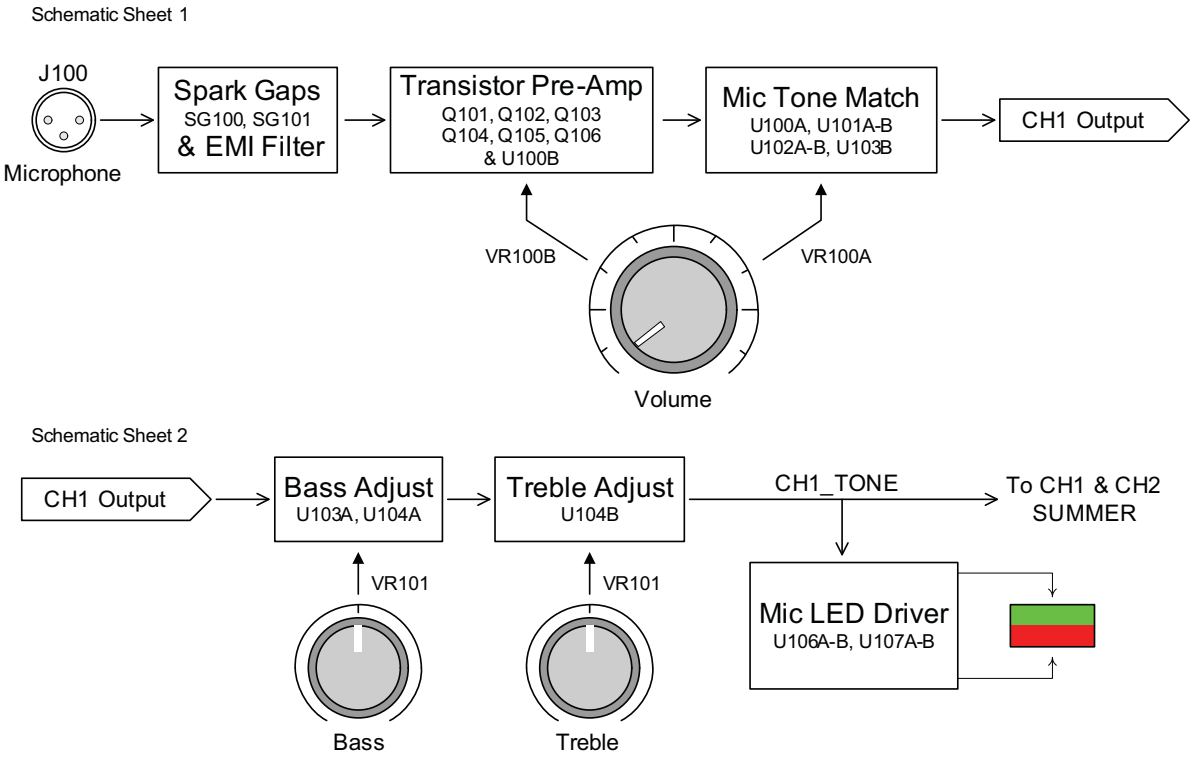
L1 Compact - Theory of Operation

L1 Compact Input / Output Board

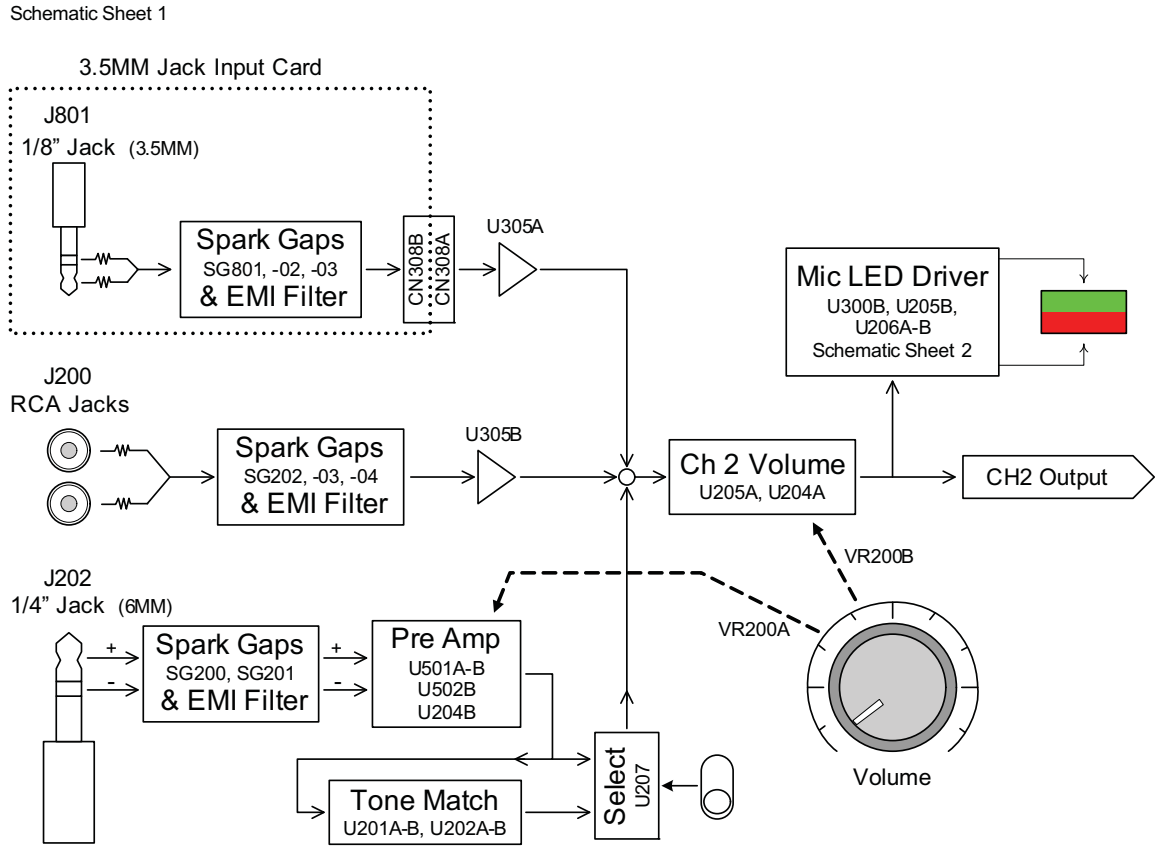


L1 Compact - Theory of Operation

L1 Compact Channel 1 (Microphone) Input Section



L1 Compact Channel 2 Input Section



L1 Compact - Theory of Operation

L1 Compact Power Supply and Amplifier

Refer to Diagram on page 4

AC Power In - Refer to schematic sheet 1

1 IEC Connector for Universal AC Voltage In: CON3
2 5 Amp SB Fuse: FUS1
3 Soft Start NTC: TH1
4 AC Line Filter X Caps: CX1, CX2, XYC1, XYC3, XYC5
5 AC Line Filter Y Caps: YC6, YC7
6 AC Line Filter Chokes: L2, L4
7 AC Line Filter Bleeder Resistors: R7, R8, R10, R60
8 Bridge Rectifier: B1
9 Over Voltage Protection: RV1, RV2
10 Main Power Caps: C1, C3
11 Power Cap Bleeder Resistors: R9, R11, R14, R15
12 Main Power Switcher TOP258: U1
13 Main Power Flyback Transformer: T1
14 Control Circuit for Power Supply: U2A-B, U4

DC Power Rails - schematic sheet 1

1 Power Rectifiers for +28V and -28V: D3, D4
2 Bulk Caps for +/-28V Rail: C29, C33, C30, C35
3 Rectifiers for +18V and -18V: D5, D6
4 Bulk Caps for +/-18V Rails: C38, C34

Amplifier - schematic sheet 2

1 Audio Input from I/O Board Connector: CN3
2 NXP (Philips) Amp Chip TDA8920BTH: U3
3 Bulk Caps for Amp Chip: C12, C15, C16, C17, C18
4 Turn on delay for Amp (prevent pop): Q1, Q2, C20, Z5
5 LC Filter for Twiddler: L14, C8
6 EMI Filter for Twiddler: L7
7 Connector to Twiddler Array: CN1
8 LC Filter for Bass: L15, C9
9 EMI Filter for Bass: L13
10 Connector to Bass Driver: CN2

L1 Compact Audio Signal Flow

Refer to Diagram on page 5

Microphone Input - schematic sheet 1

Please see the L1 Compact Channel 1 (Microphone) Input Section diagram on page 6.

Microphone Preamp - schematic sheet 1

1 Received on XLR connector J100
2 ESD protection with Spark Gaps: SG100, SG101
3 EMI filters: C100, C102, C103, C162
4 Over voltage protection: D100, D101
5 DC Block: C105, C106
6 Preamp discrete transistors: Q101 thru Q106
7 Balanced constant current source for Preamp: Q100, Q107, Q108, Q109

L1 Compact - Theory of Operation

Microphone Preamp - schematic sheet 1 (continued)
8 +/- 15V Power filter for Preamp: R199, R215, C136, C173
9 Preamp Gain control: VR100B
10 Preamp buffer: U100B

Microphone Tone Match - schematic sheet 1
11 Tone Match Filter Stage 1: U100A
12 Tone Match Filter Stage 2: U101A
13 Tone Match Filter Stage 3: U101B
14 Tone Match Filter Stage 4: U102B
15 Tone Match Filter Stage 5: U102A
16 2nd Volume Control (for full shut off): VR100A
17 Tone Match Filter Stage 6: U103B

Low & High Tone Controls - schematic sheet 2
18 Bass Adjust (+/- 6dB): VR101, U103A, U104A
19 Treble Adjust (+/- 6dB): VR102, U104B
20 Audio passes to Main Summing Junction at U300A

Microphone Signal / Clip LEDs - schematic sheet 2
21 Buffer and Gain for Level Detect: U106B, U106A
22 Peak Follower Cap for Level Detect: C172
23 Green LED Level Detect: U107A
24 Green LED Driver: Q110
25 Green LEDs: D102, D103
26 Red LED Level Detect: U107B
27 Red LED Driver: Q112
28 Red LEDs: D107, D108

Main Summing Junction at U300A - schematic sheet 2
1 Audio from Channel 1 (Microphone) and Channel 2 summed: D311, R312
2 Buffered by: U300A
3 Audio from Buffer goes to:
- Line Output
- Twiddler Equalizer, Limiter, Line Driver
- Bass Equalizer, Limiter, Line Driver

Channel 2 Inputs - schematic sheet 1
Please see the L1 Compact Channel 2 Input Section diagram on page 6.

¼" Jack (Guitar) Preamp
1 Received on ¼" connector J202
2 ESD protection with Spark Gaps: SG200, SG201
3 EMI filters: C131, C133, C203, C204
4 Over voltage protection: D202, D203
5 DC Block: C242, C245
6 Preamp: U501A, U501B, U502
7 +/- 15V Power filter for Preamp: R503, R504, C520, C521
9 ¼" Jack Gain controlled by VR200A

L1 Compact - Theory of Operation

Guitar Tone Match - schematic sheet 1
10 Tone Match Filter Stage 1: U201A
11 Tone Match Filter Stage 2: U201B
12 Tone Match Filter Stage 3: U202B
13 Tone Match Filter Stage 4: U202A

Tone Match / Line Level Select - schematic sheet 1
14 Select between ¼" Jack PreAmp or Tone Match Audio: U207
15 Controlled by Switch: SW200A & SW200B
16 Audio from ¼" Jack passes to Ch 2 Summing Junction at U205A

RCA Jack Inputs - schematic sheet 1
17 Received on RCA Jack - R & L : J200
18 ESD protection with Spark Gaps: SG202, SG203, SG204
19 EMI filters: C233, C236, C309
20 R & L Audio combined into Mono: R213, R214
21 Ground Buzz (from PCs and Projectors) Filter: C325, C240 – shared with 1/8" Jack
23 Over voltage protection: D304, D305
24 Input Buffer: U305B
25 Audio fro RCA Jacks passes to Ch 2 Summing Junction at U205A

1/8" (3 mm) Jack Input - schematic sheet 1
26 Received on 1/8: Jack - R & L : J801
27 ESD protection with Spark Gaps: SG801, SG802, SG803
28 EMI filters: C801, C802, C803, C804
29 R & L Audio combined into Mono: R801, R802
30 Connector to main I/O Board: CN308B & CN308A
31 Ground Buzz (from PCs and Projectors) Filter: C325, C240 – shared with RCA Jack
32 Over voltage protection: D306
33 Input Buffer: U305A
34 Audio fro RCA Jacks passes to Ch 2 Summing Junction at U205A

Ch 2 Summing Junction at U205A - schematic sheet 1
35 Audio from ¼" Jack, RCA Jacks, 1/8" Jacks Summed at U205A
- Input Level Balancing done by R290, R306, R304
36 Gain controlled by VR200B
37 Buffered by: U204A
38 Audio passes to Main Summing Junction at U300A

Channel 2 Signal / Clip LEDs - schematic sheet 2
39 Buffer and Gain for Level Detect: U300B, U205B
40 Peak Follower Cap for Level Detect: C260
41 Green LED Level Detect: U206A
42 Green LED Driver: Q200
43 Green LEDs: D204, D205
44 Red LED Level Detect: U206B
45 Red LED Driver: Q202
46 Red LEDs: D209, D210

L1 Compact - Theory of Operation

Line Output - schematic sheet 2

1 Audio from Main Summing Junction
2 Buffered for Positive Line Out Audio: U317B
3 Inverted and Buffered for Negative Line Out Audio: U317A
4 Over voltage protection (from external line): D401, D402
5 DC Block: C301, C442
6 EMI filters: C349, C350, C446, C448
7 Connectors and Cable to Line Out Board: CN302A & CN302B
8 EMI filters: C701, C361, C362, C351, C702, C449, C450, C447
9 ESD protection with Spark Gaps: SG701, SG702, SG705, SG703, SG704
10 Positive Line Out on RCA Jacks R & L: J300
11 Balanced Line Out on ¼" Jack: J301

Twiddler Equalizer, Limiter, Line Driver

Twiddler Equalizer - schematic sheet 2

1 Audio from Main Summing Junction
2 Twiddler EQ Filter Stage 1: U301B
3 Twiddler EQ Filter Stage 2: U302B
4 Twiddler EQ Filter Stage 3: U301A, U302A
5 Twiddler EQ Filter Stage 4: U303A
6 Twiddler EQ Filter Stage 5: U303B
7 Unity Buffer: U310B
8 Twiddler EQ Filter Stage 6: U306B, U304B

Twiddler Limiter - schematic sheet 3

9 Audio from Twiddler Equalizer DC Block: C383
10 Audio Gain Reduction: U304A, U314B
11 Audio Level Detect Buffer: U391B, U391A
12 Limiter Gain Control: U306A

Twiddler Line Driver - schematic sheet 3

13 Inverted and Buffered for Negative Twiddler Audio: U313A
14 Inverted again and Buffered for Positive Twiddler Audio: U307A
15 Connector to PS & Amp Board: CN300A

Bass Equalizer, Limiter, Line Driver

Bass Equalizer - schematic sheet 2

1 Audio from Main Summing Junction
2 Bass EQ Filter Stage 1: U308A
3 Bass EQ Filter Stage 2: U308B
4 Bass EQ Filter Stage 3: U309B
5 Bass EQ Filter Stage 4: U309A
6 Audio from Bass Equalizer DC Block: C386

Bass Limiter - schematic sheet 3

7 Audio Gain Reduction: U312A, U314A
8 Audio Level Detect Buffer: U310A, U500B, U500A
9 Limiter Gain Control: U312B

L1 Compact - Theory of Operation

Bass Line Driver - schematic sheet 3
10 Inverted and Buffered for Negative Bass Audio: U313B
11 Inverted again and Buffered for Positive Bass Audio: U307B
12 Connector to PS & Amp Board: CN300A

120/230 V Universal Design
The L1 Compact is compatible with the following input AC Voltages either 50 or 60Hz mwith +/-20% tolerance: 100V, 120V, 127V, 230V, 240V.

Separate SKUs are used for different power cords and in box literature but these do not affect the functional unit.

Signal Processing
The L1 Compact does not use DSP processors for the audio processing, all audio shaping is done with linear circuits. Please see the diagrams on pages 4 and 5.
Note: There is no software or software updates for the L1 Compact.

Amplifiers
A single NXP (Philips) dual amplifier part, the TDA8290BTH, is used to drive the Bass and Twiddlers from the plus and minus 28V rails.

DC Power
A universal power supply supplies four output voltages: Plus and minus 28V for the amplifiers, and a plus and minus 18V for the I/O Board.

The +/-18V on the I/O Board is regulated to +/-15V which is used for the linear circuits (Op Amps).

The -15V on the I/O Board lights up the Blue Power On Indicator.

Switch-Mode Power Supply Detailed Description

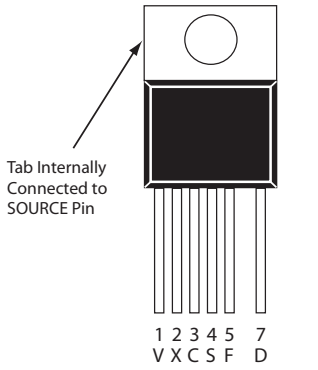
The L1 Compact Power supply is a Flyback switching supply based on the Power Integrations TOP258Y package which provides Under voltage, Over voltage, and Thermal Protection internally.

This produces four regulated DC Power Rails from the secondary: +28V and -28V for the amplifier IC (Philips / NXP TDA8920BTH) and +18V and -18V which are provided to the I/O board over the 10 pin ribbon cable. These +/-18V rails are post regulated on the I/O board to +/-15V by U315 & U316.

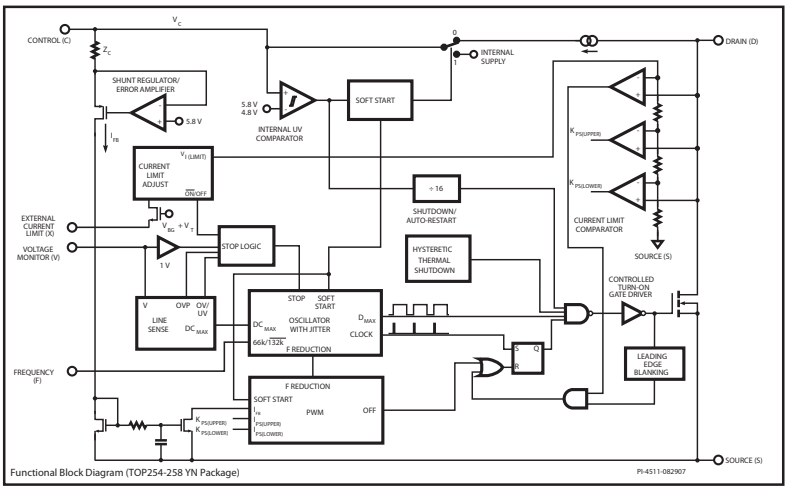
The TOPSwitch TOP258Y PWM Controller IC (U1) incorporates a 700V power MOSFET, high voltage switched current source, PWM control, oscillator, thermal shutdown circuit, fault protection and other control circuitry onto a monolithic device. The TOPSwitch TOP258Y PWM controller is an integrated switched mode power supply chip that converts a current at the control input to a duty cycle at the open drain output of a high voltage power MOSFET. During normal operation the duty cycle of the power MOSFET decreases linearly with increasing CONTROL pin current. This MOSFET is internal to the U1 (see block diagram).

L1 Compact - Theory of Operation

TOPSwitch TOP258Y Block and Pinout Diagrams and Pin Descriptions



Pin Configuration (Top View).



Pin Functional Description

DRAIN (D) Pin:
High-voltage power MOSFET DRAIN pin. The internal start-up bias current is drawn from this pin through a switched high-voltage current source. Internal current limit sense point for drain current.

CONTROL (C) Pin:
Error amplifier and feedback current input pin for duty cycle control. Internal shunt regulator connection to provide internal bias current during normal operation. It is also used as the connection point for the supply bypass and auto-restart/ compensation capacitor.

EXTERNAL CURRENT LIMIT (X) Pin (Y, M, E and L package):
Input pin for external current limit adjustment and remote ON/OFF. A connection to SOURCE pin disables all functions on this pin.

VOLTAGE MONITOR (V) Pin (Y & M package only):
Input for OV, UV, line feed forward with DC_{MAX} reduction, output overvoltage protection (OVP), remote ON/OFF and device reset. A connection to the SOURCE pin disables all functions on this pin.

FREQUENCY (F) Pin (TOP254-258Y, and all E and L packages):
Input pin for selecting switching frequency 132 kHz if connected to SOURCE pin and 66 kHz if connected to CONTROL pin. The switching frequency is internally set for fixed 66 kHz operation in the P, G, M package and TOP259YN, TOP260YN and TOP261YN.

SIGNAL GROUND (G) Pin (TOP259YN, TOP260YN & TOP261YN only):
Return for C pin capacitor and X pin resistor.

SOURCE (S) Pin:
Output MOSFET source connection for high voltage power return. Primary side control circuit common and reference point.

U1 (TOP258Y PWM Controller) Operation Detail

VOLTAGE-MONITOR (V) pin is used for line sensing by connecting a ~ 4M ohm resistor from this pin to the rectified DC high voltage bus to implement line overvoltage (OV), under-voltage (UV) and dual-slope line feed-forward with DCMAX reduction. In this mode, the value of the resistor determines the OV/UV thresholds and the DCMAX is reduced linearly with a dual slope to improve line ripple rejection. In addition, it also provides another threshold to implement the latched and hysteretic output overvoltage protection (OVP).

CONTROL (C) Pin Operation. The CONTROL pin is a low impedance node that is capable of receiving a combined supply and feedback current. During normal operation, a shunt regulator is used to separate the feedback signal from the supply current. CONTROL pin voltage VC is the supply voltage for the control circuitry including the MOSFET gate driver. An external bypass capacitor (C55) closely connected between the CONTROL and SOURCE pins is required to supply the instantaneous gate drive current. The total amount of capacitance connected to this pin also sets the auto-restart timing as well as control loop compensation.

L1 Compact - Theory of Operation

When a rectified DC high voltage is applied to the DRAIN pin during start-up, the internal MOSFET is initially off, and the CONTROL pin capacitor is charged through a switched high voltage current source connected internally between the DRAIN and CONTROL pins. When the CONTROL pin voltage VC reaches approximately 5.8V, the control circuitry is activated and the U1 soft-start begins. The soft-start circuit gradually increases the drain peak current and switching frequency from a low starting value to the maximum drain peak current at the full frequency over approximately 17 ms. If no external feedback/supply current is fed into the CONTROL pin by the end of the soft-start, the high voltage current source is turned off and the CONTROL pin will start discharging in response to the supply current drawn by the control circuitry.

If no fault condition such as open loop or shorted output exists, the feedback loop will close, providing external CONTROL pin current, before the CONTROL pin voltage has had a chance to discharge to the lower threshold voltage of approximately 4.8V (internal supply undervoltage lockout threshold). When the externally fed current charges the CONTROL pin to the shunt regulator voltage of 5.8V, current in excess of the consumption of the chip is shunted to SOURCE through an NMOS current mirror. The output current of that NMOS current mirror controls the duty cycle of the power MOSFET to provide closed loop regulation.

Power Supply Operation

AC power is provided from the IEC AC inlet connector and the AC power switch, located on the back of the unit, to connector J1. When AC is first applied, it is rectified by the bridge rectifier B1. AC Line Noise Filtering is provided by inductors L2, L4 and their associated components. Thermistor TH1 (NTC) softens the Power On current surge into the Main Caps, C1 & C3.

After the bridge rectifier, resistors R9, R11, R14 and R15 provide bleed down of the Main Caps, C1 & C3.

CAUTION: Hazardous Voltage on Heat Sink and TOP258 Circuit is up to:
203V for 120V AC Line In (at +20%)
407V for 240V AC Line In (at +20%)

This slow discharge on the Main Caps and their Hazardous Voltage may take as long as 4 minutes for 120V and 6 minutes for 240V.

With a functioning unit, the TOP258 switching will discharge this almost immediately bringing the voltage below 50V before shutting down.

Varistors VR1 and VR2 provide protection against transient spikes. A varistor looks like an open circuit until its voltage rating is exceeded where it will clamp the voltage. If the AC Line In persists then Fuse FUS1 will open.

Resistors R12 and R13 together form the line sense resistor for the V pin of U1. If the DC input rail rises above ~424VDC, then U1 will stop switching until the voltage returns to normal, preventing device damage.

C7, R1, DZ1, D2 and R4 Clamp the primary flyback voltage to below the 700V rating of U1's internal MOSFET.

L1 Compact - Theory of Operation

The DC voltage from the Main Caps is applied to the primary of transformer T1 when the TOP258, U1, enables its internal power FET as enabled by the internal the PWM controller. The maximum oscillation frequency is 66 kHz for U1 but will typically be running at 33 kHz or intermittently.

The secondary +28V and -28V is rectified and smoothed by D3, D4, C29, C30, C33 and C35. Four capacitors are used to ensure their maximum ripple current specification is not exceeded. L23, L24, C87, C93, C102 and C103 provide switching noise filtering.

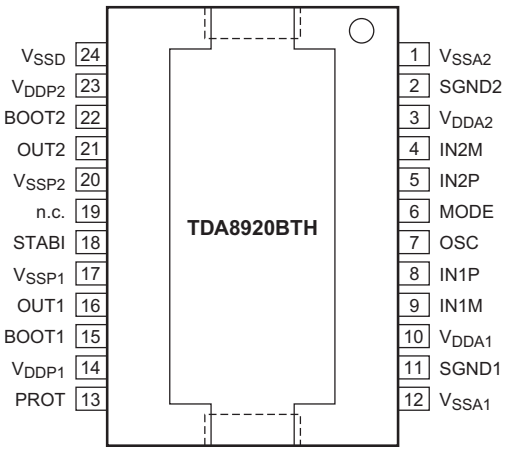
Output voltage is controlled using reference IC U4 and resistors R26, R32, and R38. VDDP is tied to the +28V line (see sheet 2, top left). R26, R32 and R38 form a voltage divider with R535 to sense the output voltage. Zener diode Z3 and R31 limit the opto-coupler LED current and set overall control loop DC gain. Control loop compensation is achieved using R27, C80, R30 and C86. D7, C27 and R25 form a soft start network. This feeds current into the control pin of U4 prior to output regulation, preventing output voltage overshoot and ensuring start-up under low line, full load conditions.

The secondary +18V and -18V is rectified and smoothed by D5, D6, C38, and C34. These voltages are provided to the I/O Board through the 10 pin ribbon cable.

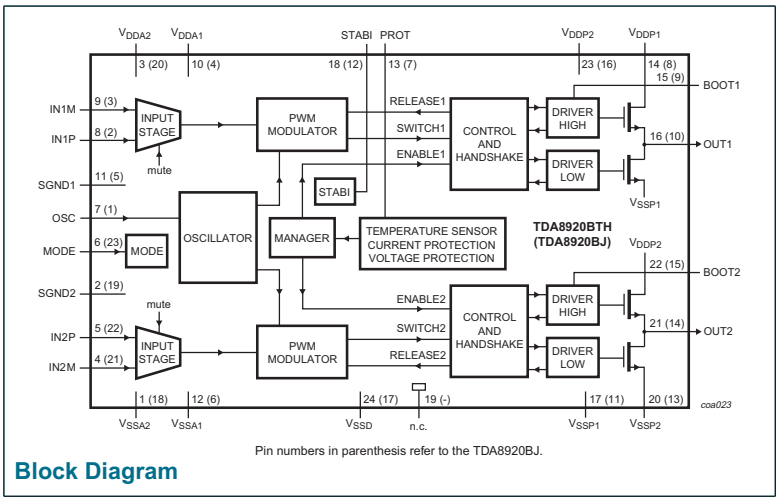
Fuses FUS2 and FUS3 (0.5A) limit the power being provided to meet safety standards. These voltages are regulated to +15V and -15V on the I/O Board.

Amplifier Operation

The L1 compact uses the NXP (Philips) TDA8920B Class-D Power Amplifier.



Pin Configuration



Pin numbers in parenthesis refer to the TDA8920BJ.

Block Diagram

The 8920 provides 30 dB of gain but has a -3.9 dB pad on its inputs provided by R56, R52, R48, R49, R46 and R45. This allows a 0 dBV audio signal on the 10 pin ribbon cable from the I/O board to provide for full amplifier output of 19V RMS.

Power for the 8920 is filtered from the Power Supply by L26, L19, C17, C18, C16 and C12. +28V is renamed VDDP and -28V is renamed VSSP which provide power to the Amplifier Output drivers.
VDDA and VSSA are filtered from VDDP and VSSP by R44, R33, C31, C95, C100, C36, C96 and C97. VDDA and VSSA provide power to the audio front end in the 8920.

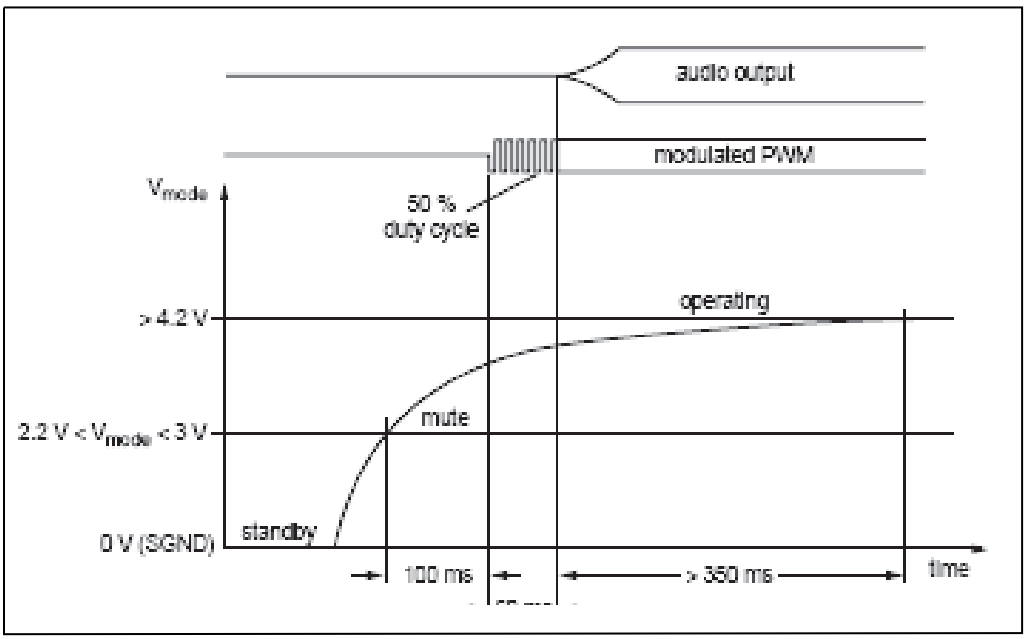
L1 Compact - Theory of Operation

The Class-D amp uses L14, L15, C8 and C9 for the audio output filters.

Snubbing for the D-Class amp switching is provided by R23, R24, C13, C74, C14 and C75.

Power On and Power Off Pop prevention is provided by the circuit that drives the 8920's MODE pin (pin 6). Under normal operation this is help at +5.6V by Zener Diode Z5.

During Power On and Power Off transitions, 24V is needed on the VDDP power voltage to allow the 8920 to function.



MODE pin voltage

Audio from the Class-D amp is filtered with L7 & L13 and brought to connectors CN1 and CN2 to be cabled to the Twiddler Array and Bass Driver.

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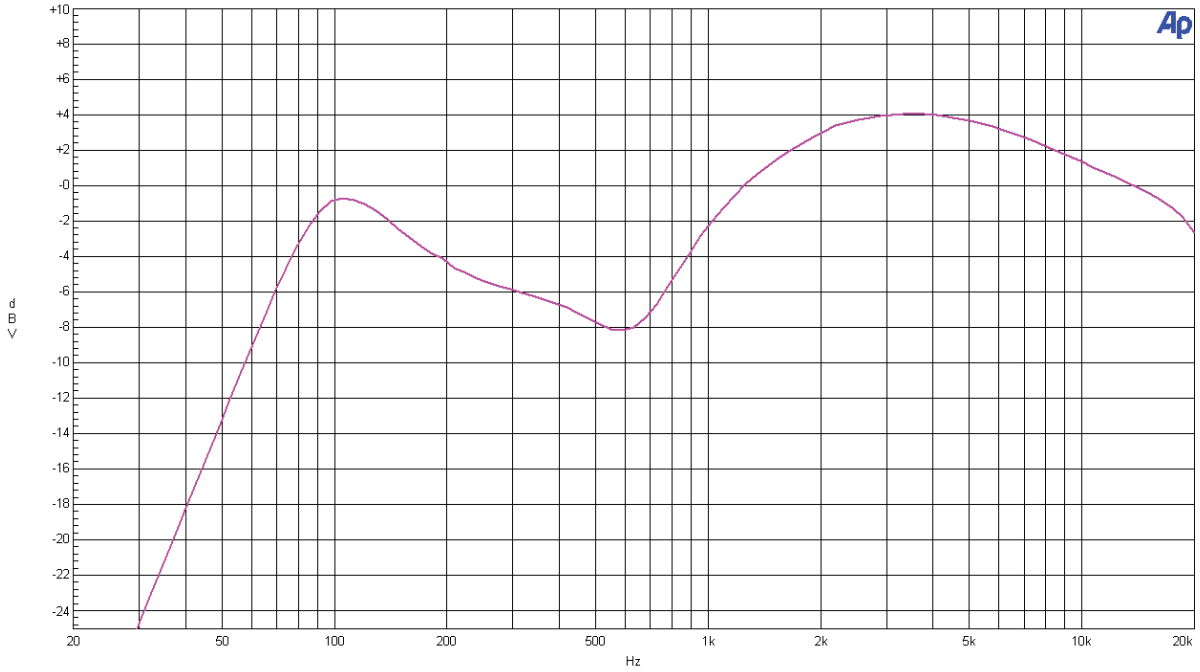

Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Magenta	Solid	2	Anlr.Ampl	Left	Ch 1 EQ

Cajun Guitar EQ MP1.at27

Channel 1 Fixed Equalizer Freq. Response

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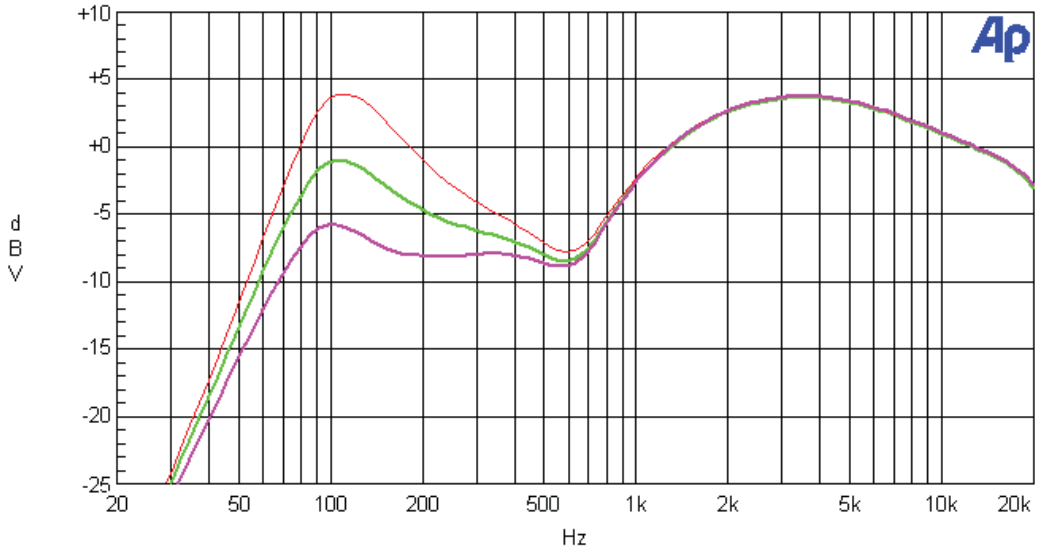

Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Green	Solid	2	Anlr.Ampl	Left	Ch 1
2	1	Red	Solid	1	Anlr.Ampl	Left	Ch 1 Bass +
4	1	Magenta	Solid	2	Anlr.Ampl	Left	Ch 1 Bass -

Cajun Guitar EQ MP1.at27

Channel 1 Bass Control Frequency Response

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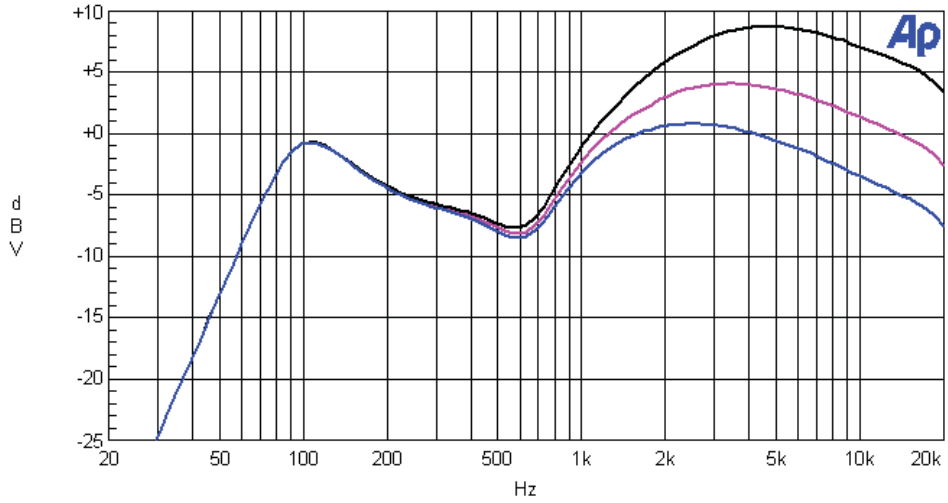

Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Magenta	Solid	2	Anlr.Ampl	Left	Ch 1 EQ
2	1	Black	Solid	2	Anlr.Ampl	Left	Ch 1 Treble +
3	1	Blue	Solid	2	Anlr.Ampl	Left	Ch 1 Trebl1 -

Cajun Guitar EQ MP1.at27

Channel 1 Treble Control Frequency Response

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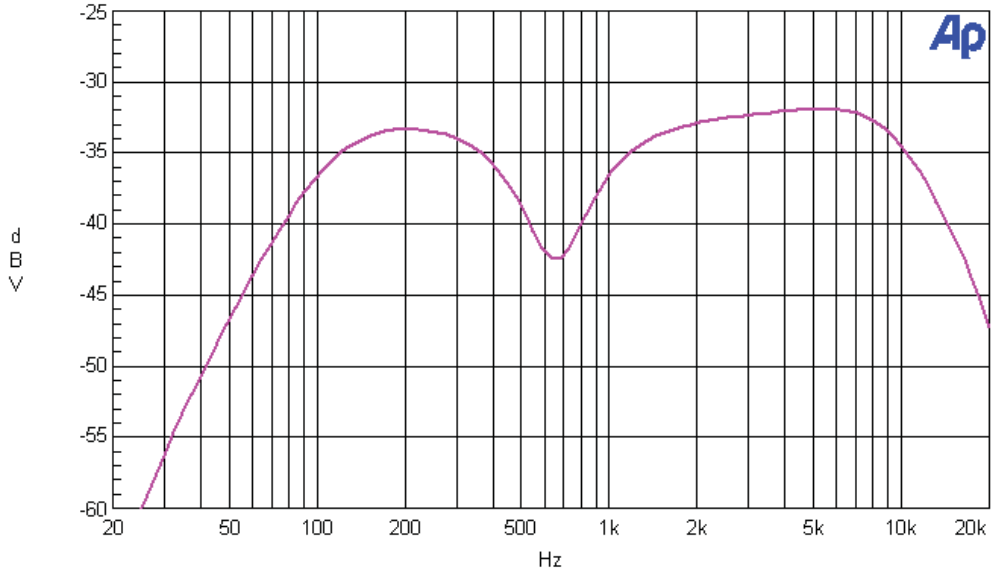
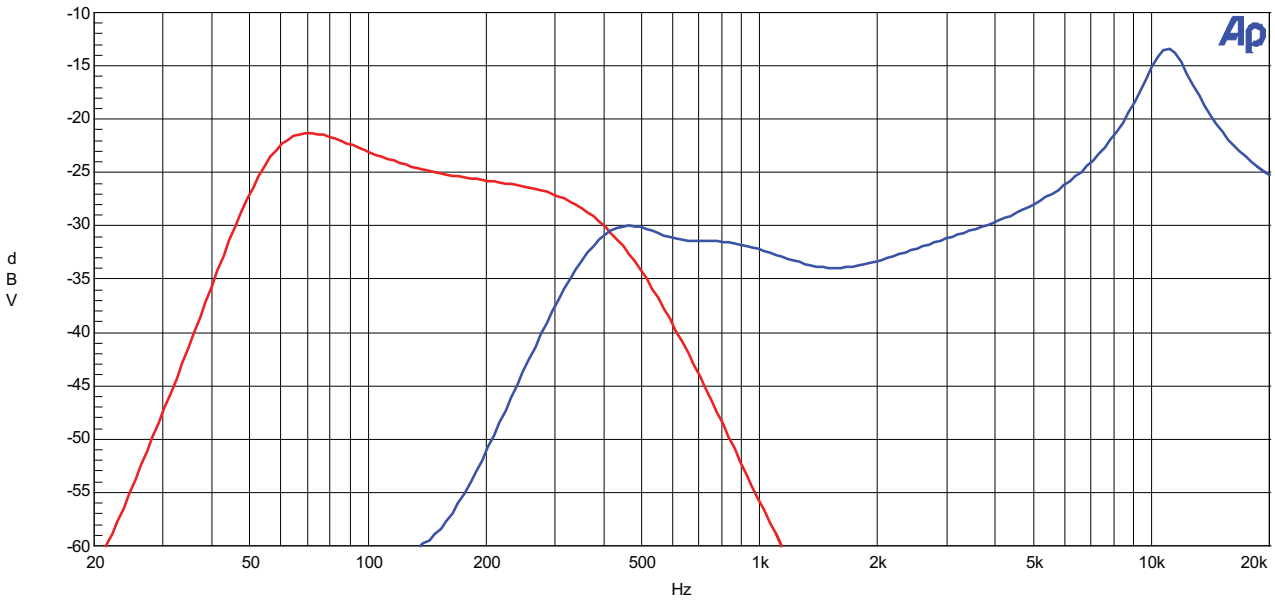


Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Magenta	Solid	2	Anlr.Ampl	Left	Ch 2 Guitar EQ

Cajun Guitar EQ MP1.at27

Channel 2 ToneMatch Guitar Equalizer Frequency Response



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
1	1	Red	Solid	2	Anlr.Level B	Left	Cajun Low EQ
2	1	Blue	Solid	2	Anlr.Level B	Left	Cajun High EQ

Low and High System EQ Response

SPECIFICATIONS AND FEATURES SUBJECT TO CHANGE WITHOUT NOTICE

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