

16-Bit Audio Motherboard Example Design

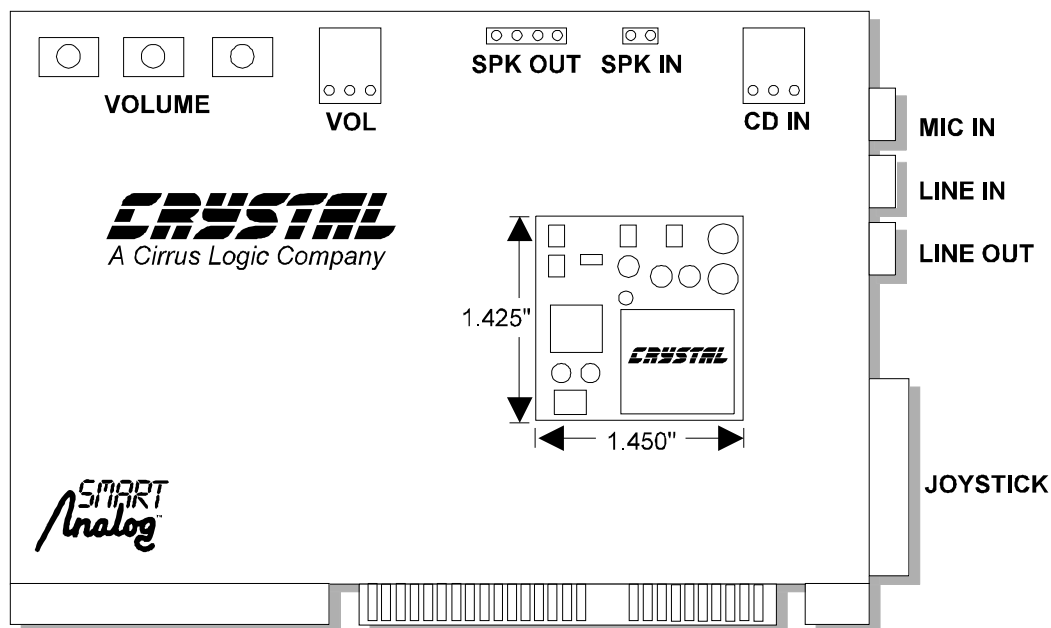
Features

- MPC2 compliant (with enhancements), Windows Sound System™, Sound Blaster™ and AdLib™ compatible
- 4-Layer Size-Optimized Planer Example Board
- Joystick/MIDI Interface
- CS9236 Wavetable Synthesizer Included
- Features:
Mono In / Mono Out
Headphone Drive
Microphone Preamp

General Description

The CD-quality CRD4236B-7, CRD4237B-7, and CRD4238B-7 reference designs are fully MPC3 compliant, and compatible with Ad Lib, Sound Blaster Pro, and Windows Sound System. The design is a half size two-sided ISA-bus PC adapter board, based on Crystal's CS4236B, CS4237B, or CS4238B and the CS9236 Single Chip Music Synthesizer. The layout is representative of a typical motherboard implementation, and requires only 2.0 sq. in. The CRD4236B-7, CRD4237B-7, and CRD4238B-7 operates in both Plug-and-Play compliant systems, as well as systems that do not support Plug-and-Play. In addition, this reference design includes hardware master volume controls, as well as volume mute.

ORDERING INFORMATION: CRD4236B-7
CRD4237B-7
CRD4238B-7



GENERAL INFORMATION

The CRD4236B-8, CRD4237B-8, and CRD4238B-8 reference designs are PC-AT adapter cards using Crystal's CS4236B, CS4237B, or CS4238B Multimedia Audio Codecs. These cards are designed to emphasize the layout space requirements for a motherboard implementation, while delivering superlative audio performance at a low manufacturing cost. These designs incorporate Crystal's industry-leading Delta-Sigma conversion technology featuring a Plug-and-Play multimedia system on a chip containing a full duplex stereo codec, an MPU-401 interface, a joystick interface, and an internal FM synthesizer. For simplicity, this document will refer to all three kits and audio codecs as "reference design" and "Crystal Codec" respectfully. The the only difference between kits will be the audio codec installed on the reference design board.

Included in this design are CD (red book) audio inputs, low noise microphone preamplifier, line/headphone output amplifier, and a PC speaker power amplifier. Jacks are provided for microphone and line input, as well as amplified line output. The dual joystick and MIDI interfaces are provided at the 15-pin D connector. Connection and support circuitry are provided for routing the PC speaker (beeper) to the output amplifiers as well as the line output to the PC's speaker. To supplement the internal FM music synthesis, Crystal Semiconductor's CS9236 Wavetable IC has been included in these kits.

Due to the nature of the design, this reference design does not incorporate build options. However, cost, features, and performance trade-offs were carefully considered and optimized for the OEM.

Software that operates under the Microsoft Windows™ environment is also included, along with applets that control all of the features supported by this reference design. This software also pro-

vides full Windows 3.1 and Windows '95™ compatibility with extensions to utilize the powerful features of Crystal's Single-Chip Audio Codec.

All aspects of the design have been optimized to ensure top performance at the lowest cost. Care was taken with signal routing and component placement to minimize sources which can degrade audio performance. Crystal's analog design know-how has resulted in a board which preserves the exceptional analog performance of the Audio Codec.

ADD-IN CARD FEATURES

The features included on this reference design are:

Audio Codec, PC Bus, E ² PROM	Figure 1
Joystick/MIDI Interface	Figure 2
Wavetable Header	Figure 3
Microphone Preamp	Figure 4
Line In	Figure 5
Headphone Drive	Figure 6
PC Speaker Driver	Figure 7
PC Beeper Input	Figure 8
CD Input	Figure 9

The Crystal Codec performs the analog-to-digital and digital-to-analog conversions, as well as signal mixer functions. It also provides emulation for games as well as support for wavetable-based audio. Three externally accessible stereo jacks allow connection to a mono Microphone input, a stereo Line input, and a stereo Line output. Headers allow on-board connection to a CDROM's analog output (using the codec's Auxiliary 2 inputs). The base addresses, DMA channels, and IRQs needed for the Codec are set via software provided by Crystal.

Analog Inputs and Output

Two of the three external 1/8" jacks are for analog inputs. The mono microphone level is

boosted 17 dB by the amplifier shown in Figure 4. For microphones with small signals, the 22 dB gain block inside the codec can be enabled in software. The microphone circuit input is single-ended (as opposed to differential), supporting the most common type of microphones available.

Phantom power microphones with a stereo $\frac{1}{8}$ " plug are supported directly with power being supplied to the microphone via the right jack pin.

The second input jack (shown in Figure 5), designated **Line In**, is for line inputs and is connected to the AUX1 (Auxiliary 1) input of the Crystal Codec. Each channel has an input impedance of approximately 13.6 k Ω . The maximum full scale into **Line In** jack is 2 V_{RMS}.

The third and lower most jack is **Line Out**. The output level and drive capability are fixed to drive amplified speakers and headphones down to 32 ohms.

FM Synthesis

FM synthesis is achieved through Crystal internal FM synthesis. For a complete description, please refer to the Crystal product data sheet.

Plug & Play E²PROM

The Plug and Play configuration data is contained in an external (2 kByte) 8-pin E²PROM. On power up, the Crystal Codec detects the presence of the E²PROM and transfers its contents to internal RAM on the part. An E²PROM is recommended for all Crystal Codec applications.

Joystick/MIDI Interface

All plug-in multimedia audio cards support a joystick. The joystick is normally an option for motherboard/planer designs. The DB-15 connector, shown in Figure 2, provides an interface to

an external joystick and MIDI I/O. MIDI inputs are received by an on-chip UART through a FIFO. The joystick interface supports two joysticks: two pair of X/Y coordinates and four buttons. The 4.7 k Ω resistors and 1000 pF capacitors provide the correct debounce period for the joystick buttons. The timing for the joystick position is determined by the joystick potentiometer, the series 2.2 k Ω resistors and the 5600 pF capacitors. Deviations from the 2.2 k Ω and 5600 pF component values will result in improper joystick positioning. The MIDI TXD and RXD signals are TTL level signals and not compatible with direct MIDI cabling. An external "break out" box attached to the 15-pin D connector interfaces the TTL MIDI signals to an isolated MIDI connector. A 500 mA polyfuse will limit the current for the joystick or "break out" box. If the 500 mA rating is exceeded, this fuse will reset after being allowed to cool down.

Line-Out Headphone Drive

This reference design supports a wide variety of low-impedance self-powered speakers, as well as headphones, with exceptional quality. The output jack has a maximum voltage of 1.4 V_{RMS} and maintains 100% of the Codec's audio quality. The Line-Out circuitry is shown in Figure 6.

Microphone Preamp

A dual low noise op-amp comprises the microphone pre-amplifier. One section is a unity gain buffer for the 2.1 V VREF signal. The buffered reference provides a low noise source for phantom powered microphones as well as setting the operating bias for the microphone pre-amp section. Phantom power is permanently applied through a 2.2 k Ω resistor to the right channel of the stereo jack for microphones that require bias on the first ring of the microphone's plug.

The second half of the amplifier package is used as a high input impedance, low noise pre-amplifier. The voltage gain of the amplifier is

set at 17 dB. (This corresponds to a maximum full scale of 89 mVRMS at the microphone jack). The upper frequency response is set at 16 kHz, the lower end at 25 Hz. The amplified output is fed to both right and left microphone channels. A 78M05 voltage regulator supplies a clean analog 5 Volt supply for the microphone pre-amp, the headphone amplifier, and the Codec's analog section. This guarantees that under any condition the output swing from the amplifier cannot exceed the maximum input limits for the Crystal Codec.

Mono PC Speaker Drive

The Crystal Codec contains an MIN (mono in) pin and MOUT (mono out) pin that may be placed in between the internal PC speaker and the beeper chip, allowing traditional PC beeps to be mixed into the audio path. The MOUT pin is a mix of both left and right channels and has an independent software mute. It provides an audio output when no other source is available.

The Mono PC speaker circuit is illustrated in Figure 8, and provides a mono speaker driver from the MOUT pin on the Crystal Codec. The internal PC speaker should be connected to the 4-pin **SPK OUT** header.

PC Beeper Input

This feature requires a cable as well as the minor amount of circuitry shown in Figure 10. Connect the cable, which goes between the PC beeper chip (on the motherboard) and the PC speaker, to the **SPK IN** header. The 2-pin cable connector, pin 1, should be placed on pin 1 of the 2-pin **SPK IN** header on the reference design card. The 4-pin side of the cable should be connected to the motherboard speaker connector, with pin 1 of the cable connector and pin 1 on the motherboard connector aligned. If the PC speaker beeps are not mixed into the codec, try reversing the connector on the motherboard four

pin connector, or the 2-pin connector on the audio card.

Volume Controls

This reference design implements external push-button switches for volume control: (VOL_UP), (VOL_DOWN), and (VOL_MUTE). Three different volume control mute formats are supported by the Codec (Please refer to the Codec Data Sheet for a complete description):

1. Toggle mute
2. Push-button mute
3. Mute button not used
(up and down together comprise the mute function).

Although the type 2 (push-button) mute is designed into the card, the type 1 (toggle) mute is programmed into the E²PROM. This provides protection from inadvertently leaving the card muted when placed inside the computer. Therefore, the hardware volume will only mute while the mute button is pressed.

Additionally, an external connector is provided to cable external switches to the front of the PC.

CS4236 vs. CS4236/7/8B Grounding

This reference design features an improved grounding scheme over previous Crystal reference designs. Large signal ADC (Analog-to-digital) distortion can be decreased up to 6 dB by following the schematics and layout examples in Figures 13 and 14. The new

layout and grounding does not effect the DAC (digital-to-analog) performance.

CS9236 WAVETABLE SYNTHESIS

This reference design includes the Crystal CS9236 single-chip wavetable synthesizer, which provides 32-note polyphony and 16-part multi-timbral capability. The CS9236 has a TTL level MIDI interface, is fully compliant with the IMA General MIDI (GM) standard, and also supports many of the Roland General Synthesizer (GS). See the CS9236 Data Sheet for more detailed information on the wavetable IC.

Accessing the CS9236 from DOS

Whereas DOS applications access the internal synthesizer by writing parameter data directly into the internal synthesizer registers, DOS applications access the wavetable synthesizers by writing MIDI data directly to the MIDI interface transmit buffer.

There are currently two defacto standards for MIDI interfaces for the PC; the Creative Labs Sound Blaster MIDI interface, and the Roland MPU-401 MIDI interface. DOS applications which support MIDI synthesizers will generally provide support for one or both of these MIDI interface standards. DOS applications should use the MPU-401 MIDI interface standard to talk to the Crystal Codec.

Accessing the CS9236 from Windows

Windows applications generally access hardware devices, such as music synthesizers, through drivers. The software included with this refer-

ence design kit provides drivers for both the internal synthesizer, and for the MPU-401 MIDI interface. Some Windows applications may write MIDI data directly to the synthesizer driver, but it is generally preferable for applications to access synthesizers indirectly by sending MIDI data to the Microsoft Windows MIDI Mapper applet.

The MIDI Mapper, which appears in the Windows Control Panel Program Group after the MIDI driver is installed, routes MIDI data from an application to the installed MIDI device driver(s). The MIDI Mapper can selectively route MIDI messages, sorted by MIDI channel number, to a number of different MIDI drivers simultaneously. Since most Windows applications output MIDI data to the MIDI Mapper, the MIDI Mapper must be correctly configured before running applications which utilize the music synthesizer capabilities of this reference design. The board installation program installs the MIDIMAP.CFG file, which provides several predefined "maps", in the Windows\System sub-directory. As an example, the "FM(1-16)" map routes all 16 MIDI channels to the internal synthesizer. The "MIDI OUT(1-10)" map routes MIDI channels 1-10 to the Codec's MPU-401 interface, and channels 11-16 are ignored. To use the CS9236 Wavetable Synthesizer under Windows, the MIDI Mapper should be config-

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ured to use either "MIDI OUT(1-16)", the "MIDI OUT(1-10)", or the "FM and MIDI OUT" map.

Accessories

The four accessories that are included with this reference design kit:

1. A 6 foot cable that has a $\frac{1}{8}$ inch plug on one end, and two male RCA phono plugs on the other end. The RCA phono plugs connector scheme is:
TIP = LEFT = BLACK or **ORANGE**
RING = RIGHT = RED or **GRAY**
2. A short 6 inch cable that has RCA female connectors on one end and a $\frac{1}{8}$ inch plug on the other. The RCA phono plugs connector scheme is:
TIP = LEFT = BLACK
RING = RIGHT = RED

These two adapters allow connection to most external audio equipment. Together they provide an $\frac{1}{8}$ inch plug to $\frac{1}{8}$ inch plug cable. Apart, they provide a $\frac{1}{8}$ inch plug that connects into the audio jacks with the other end being RCA male and RCA female phono plugs.

3. Telex "Voice Commander II" phantom powered microphone.
4. PC Speaker In cable.

SCHEMATICS

The following pages contain the full schematics for this reference design, along with board layout plots and BOM.

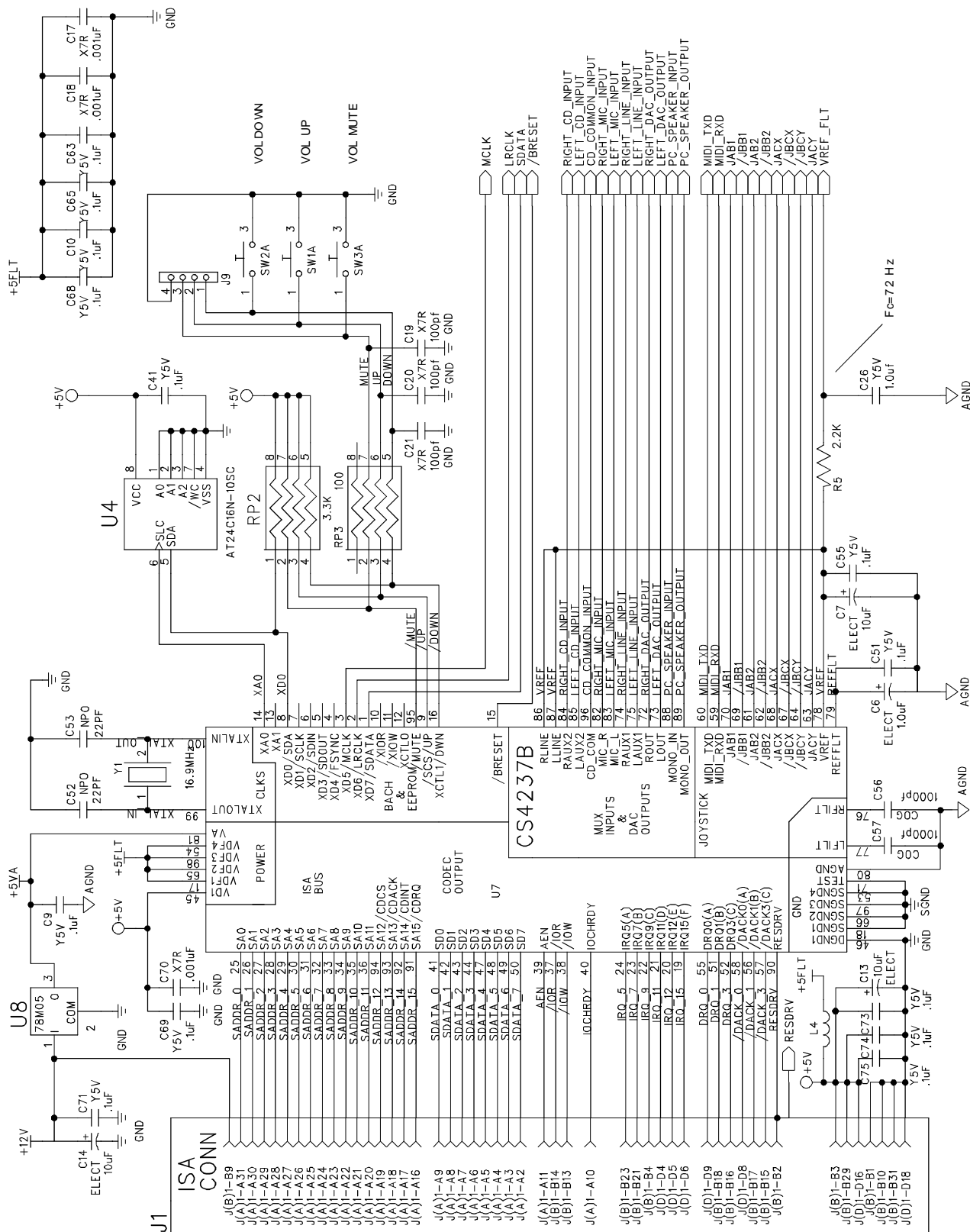


Figure 1. Crystal Codec, ISA Bus

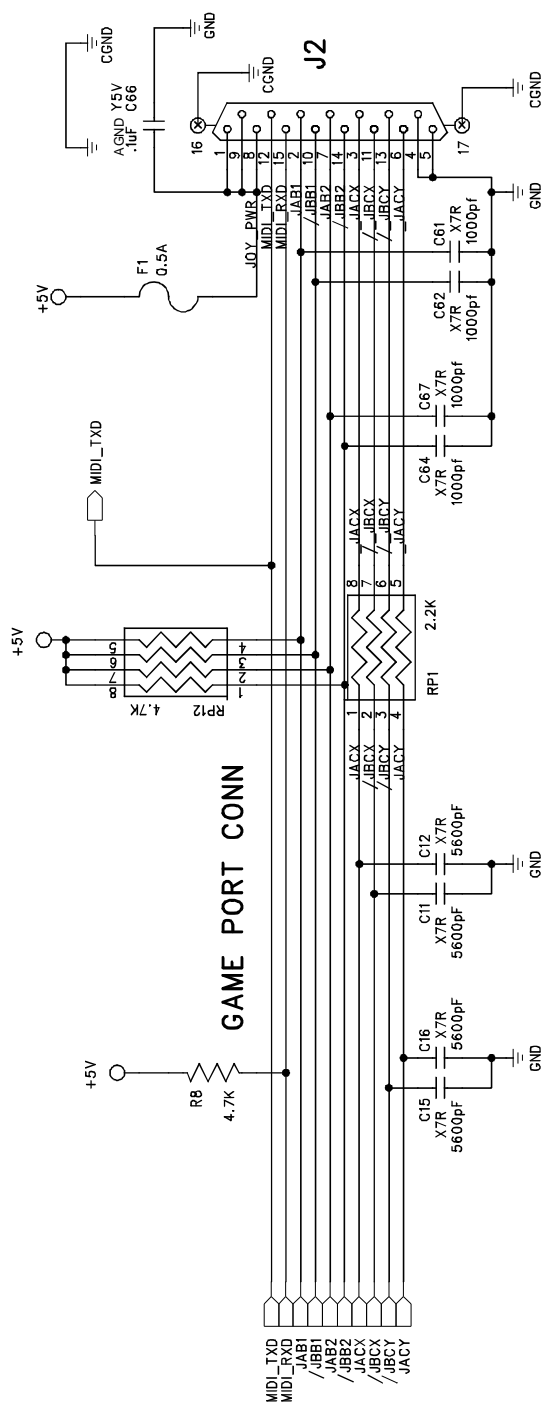


Figure 2. Joystick/MIDI Interface

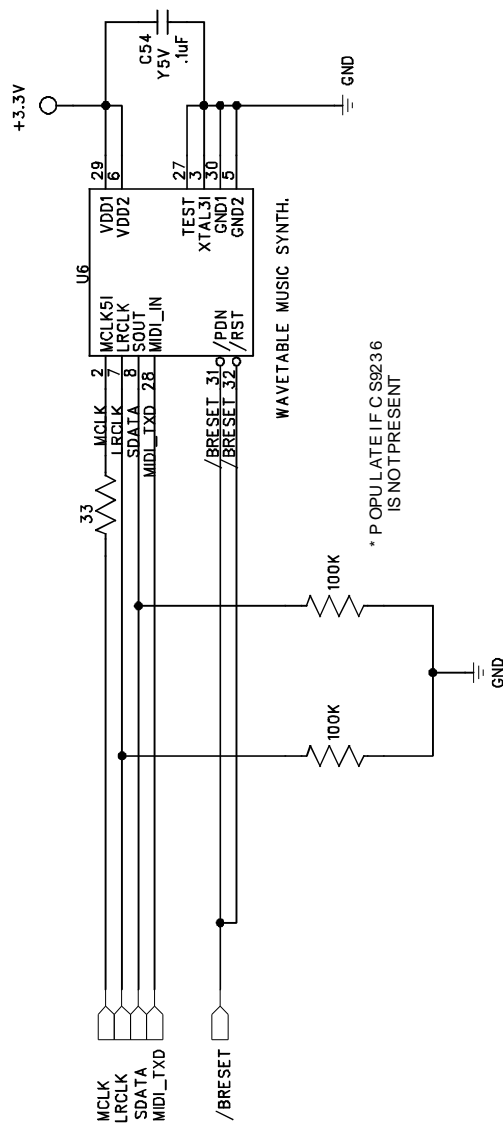
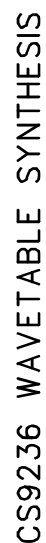
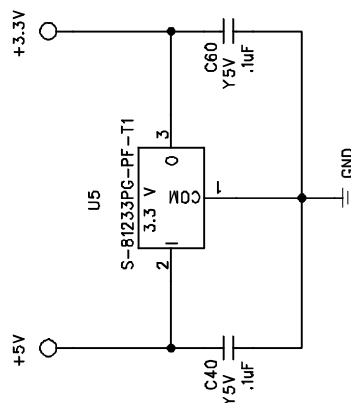


Figure 3. CS9236 Wavetable

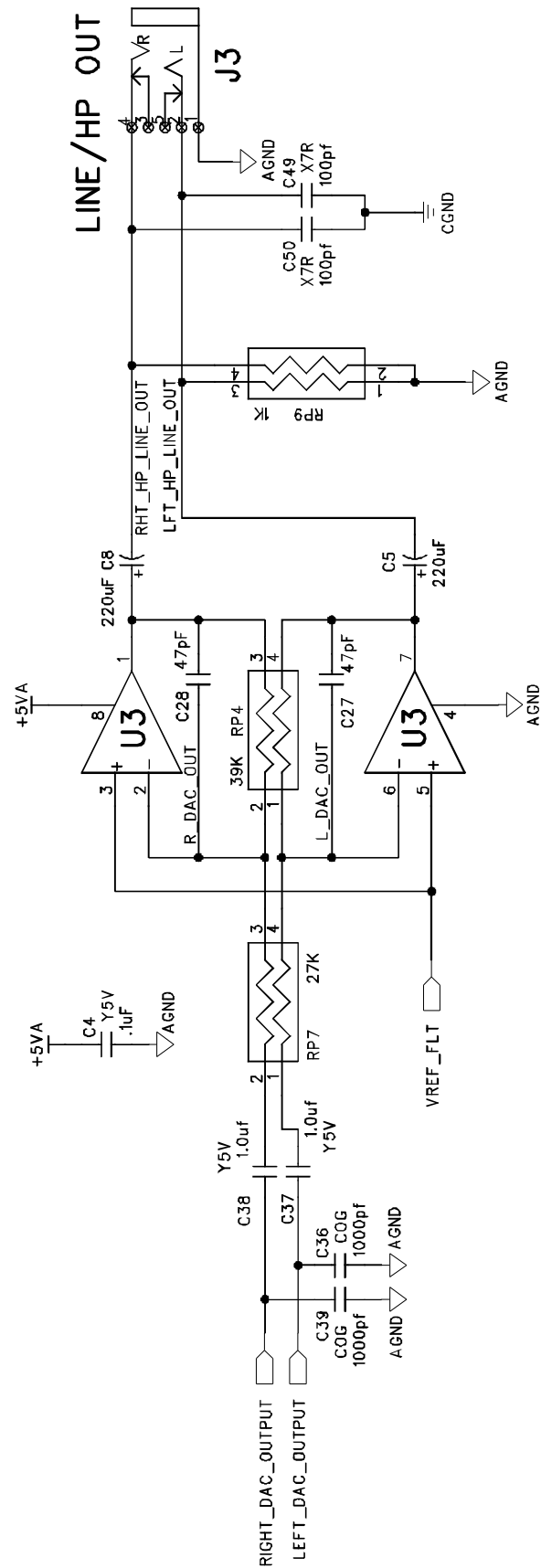


Figure 6. Headphone Driver

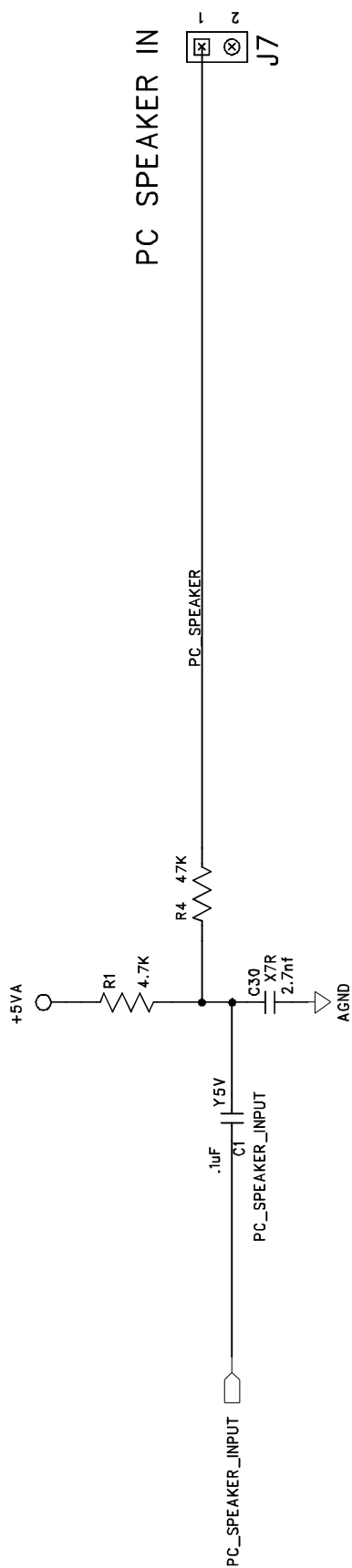


Figure 7. PC Speaker Driver

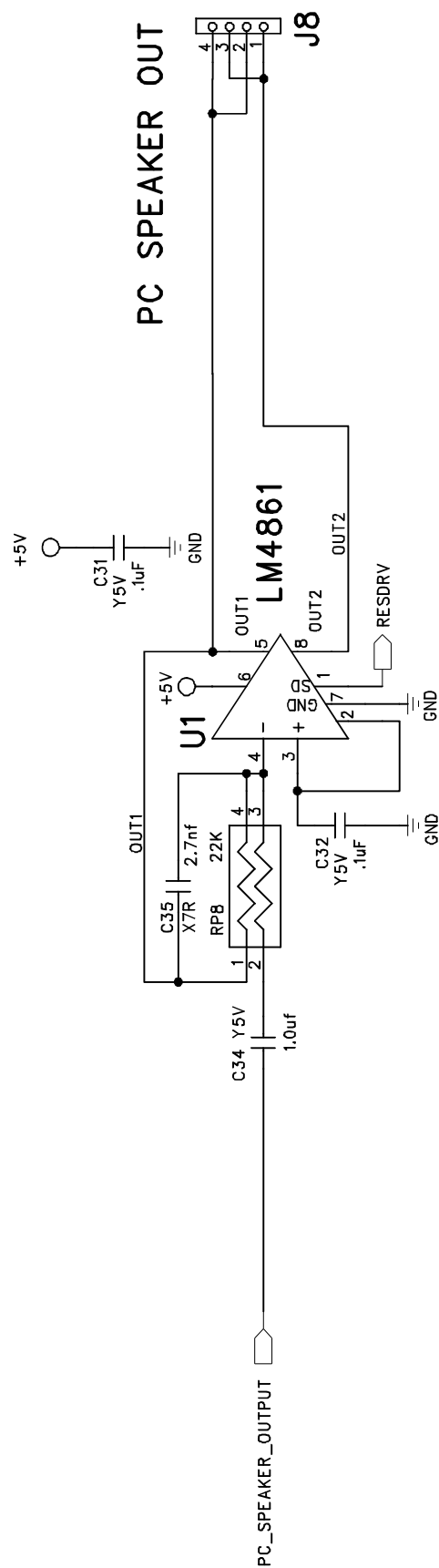


Figure 8. PC Speaker In

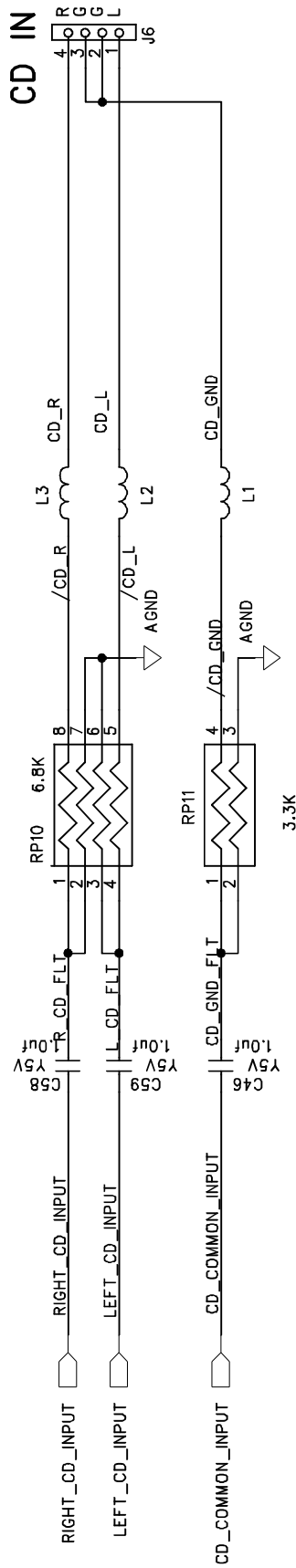


Figure 9. CD In

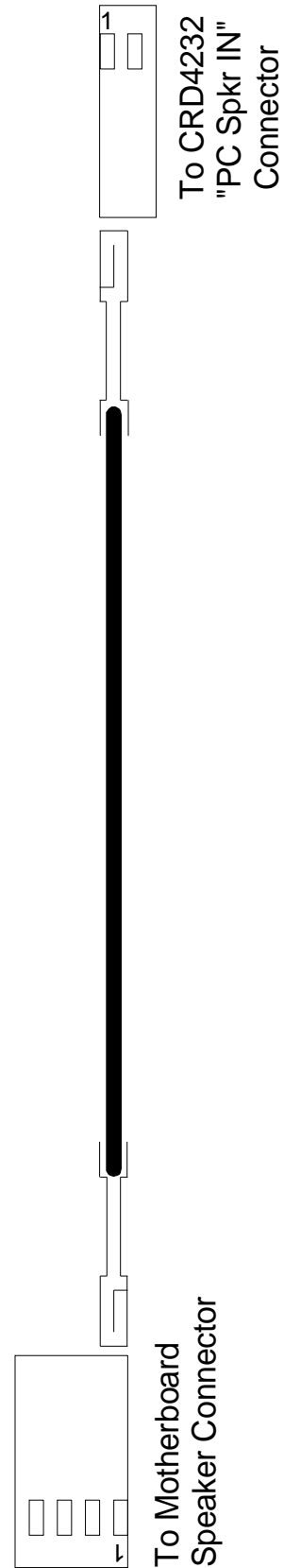


Figure 10. PC Speaker Cable



CRD4236B-7
CRD4237B-7
CRD4238B-7

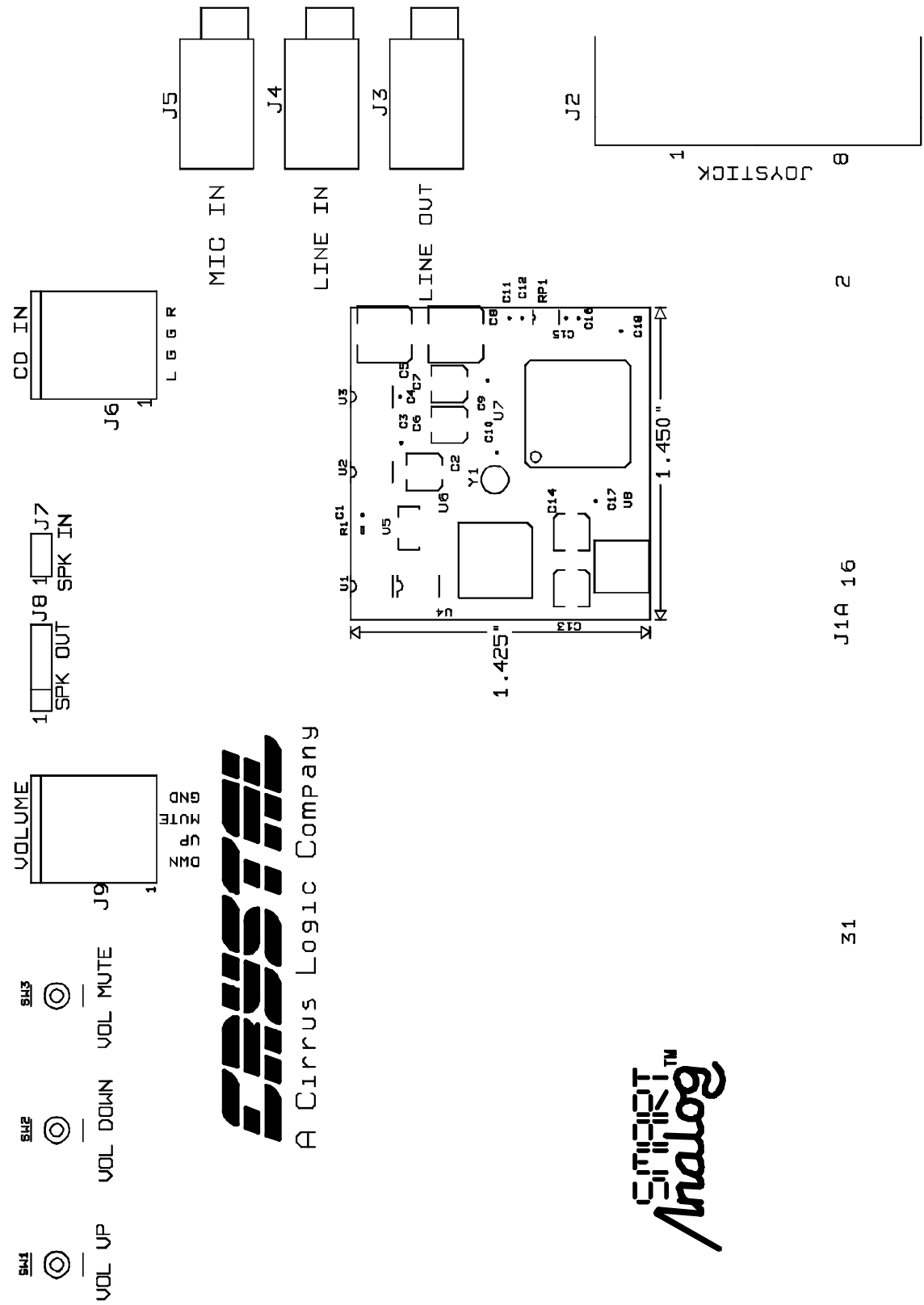


Figure 11. Top Silk

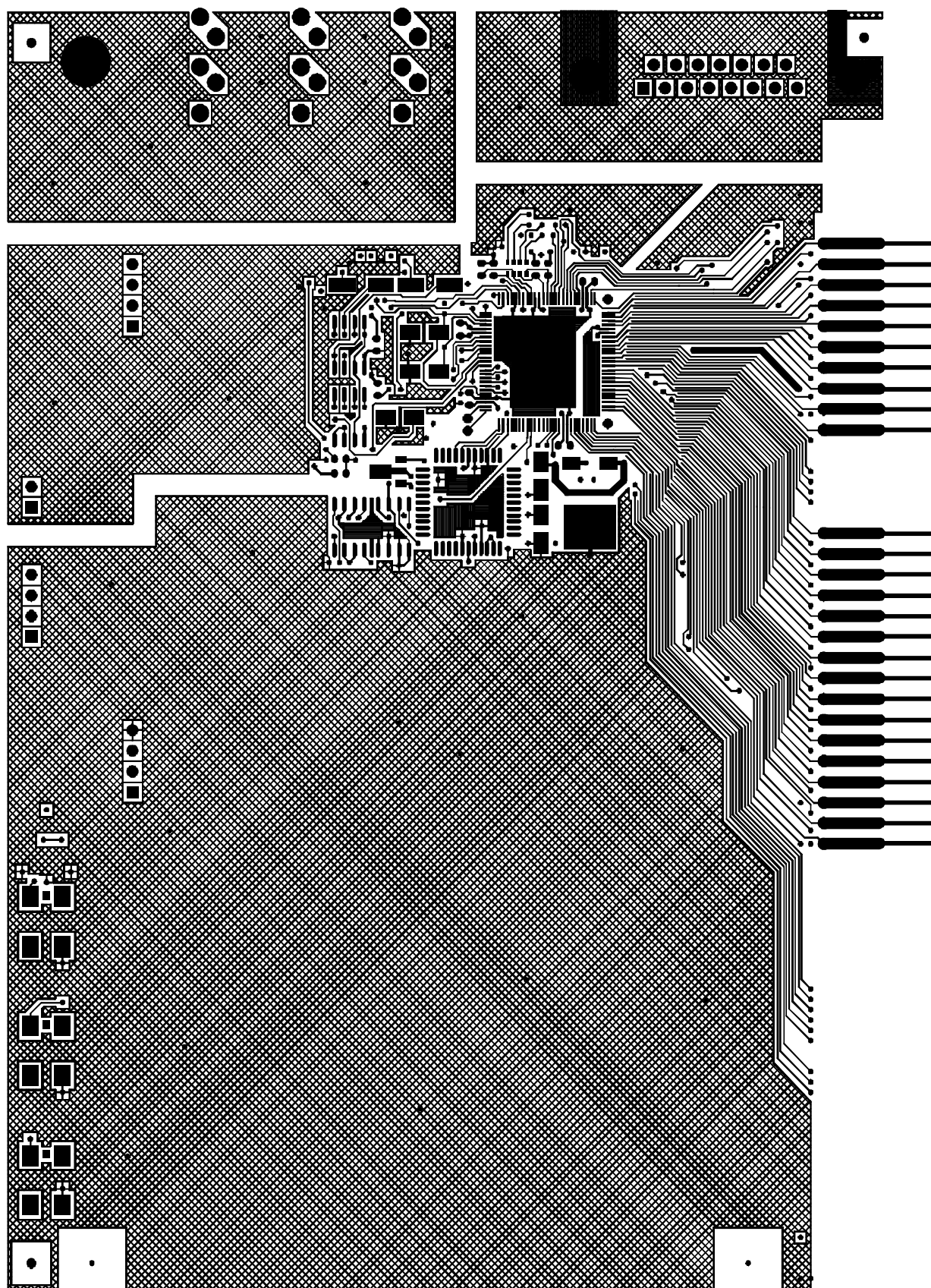


Figure 12. Component Side

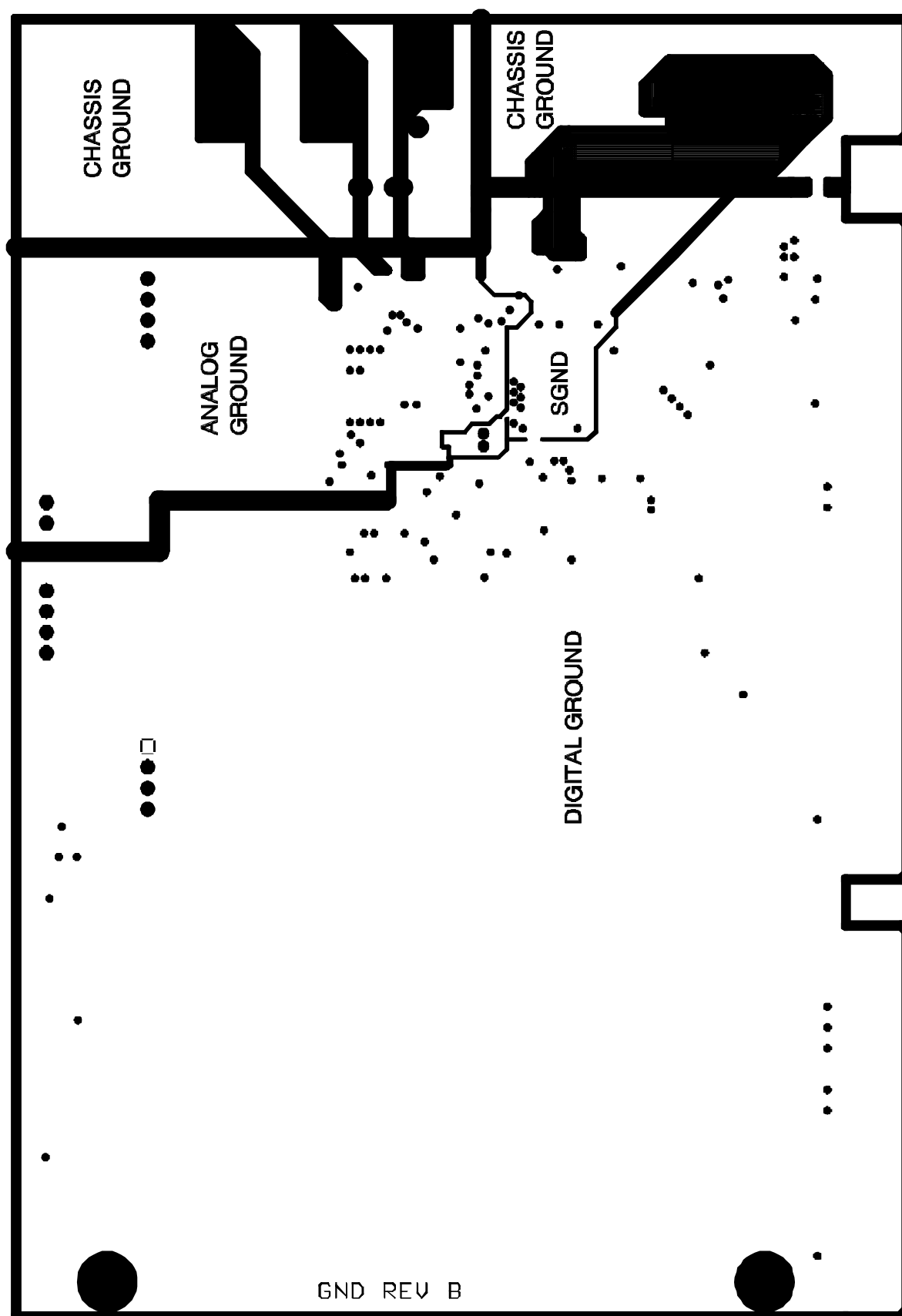


Figure 13. Ground Layer (Negative)

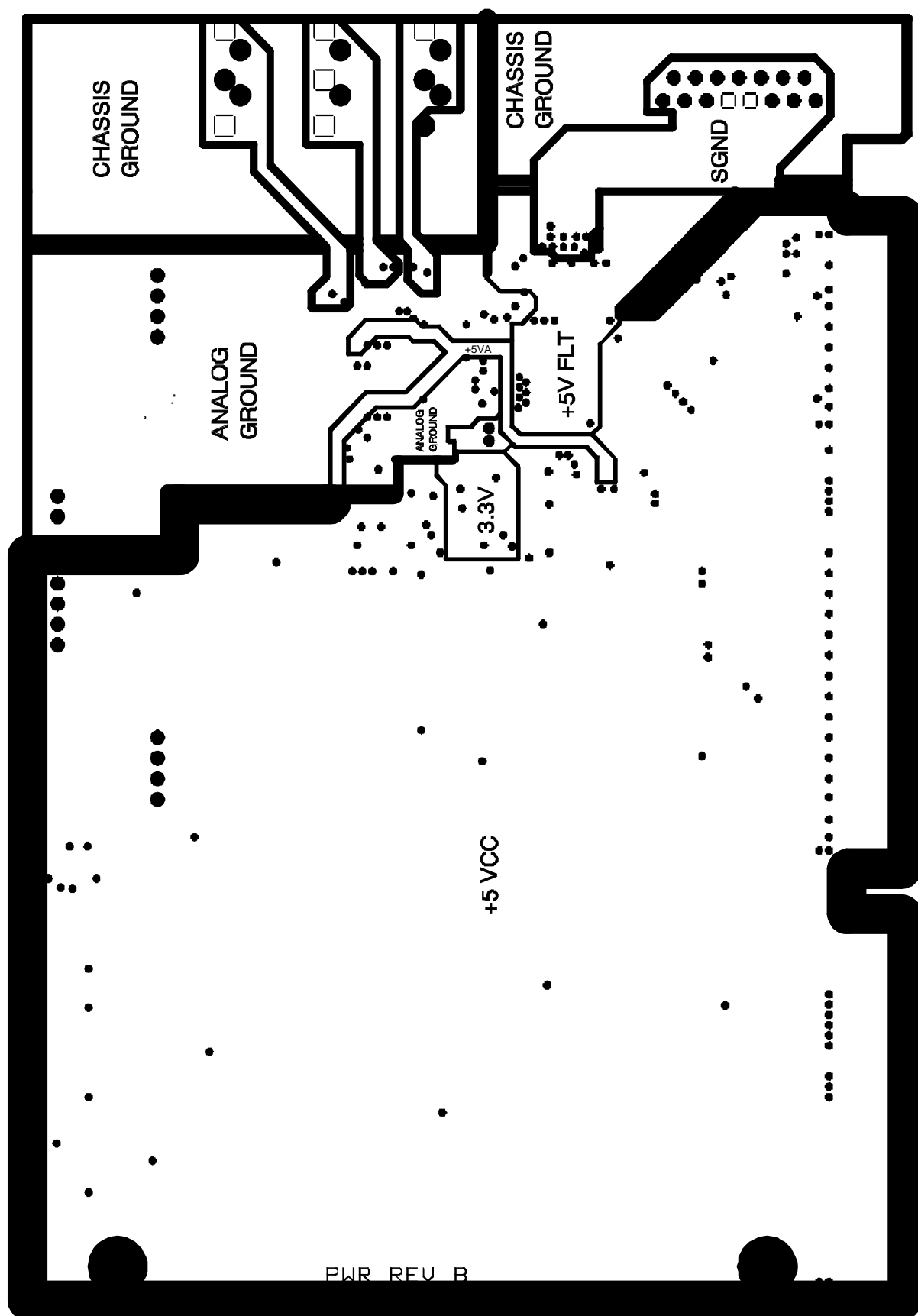


Figure 14. VCC Layer (Negative)

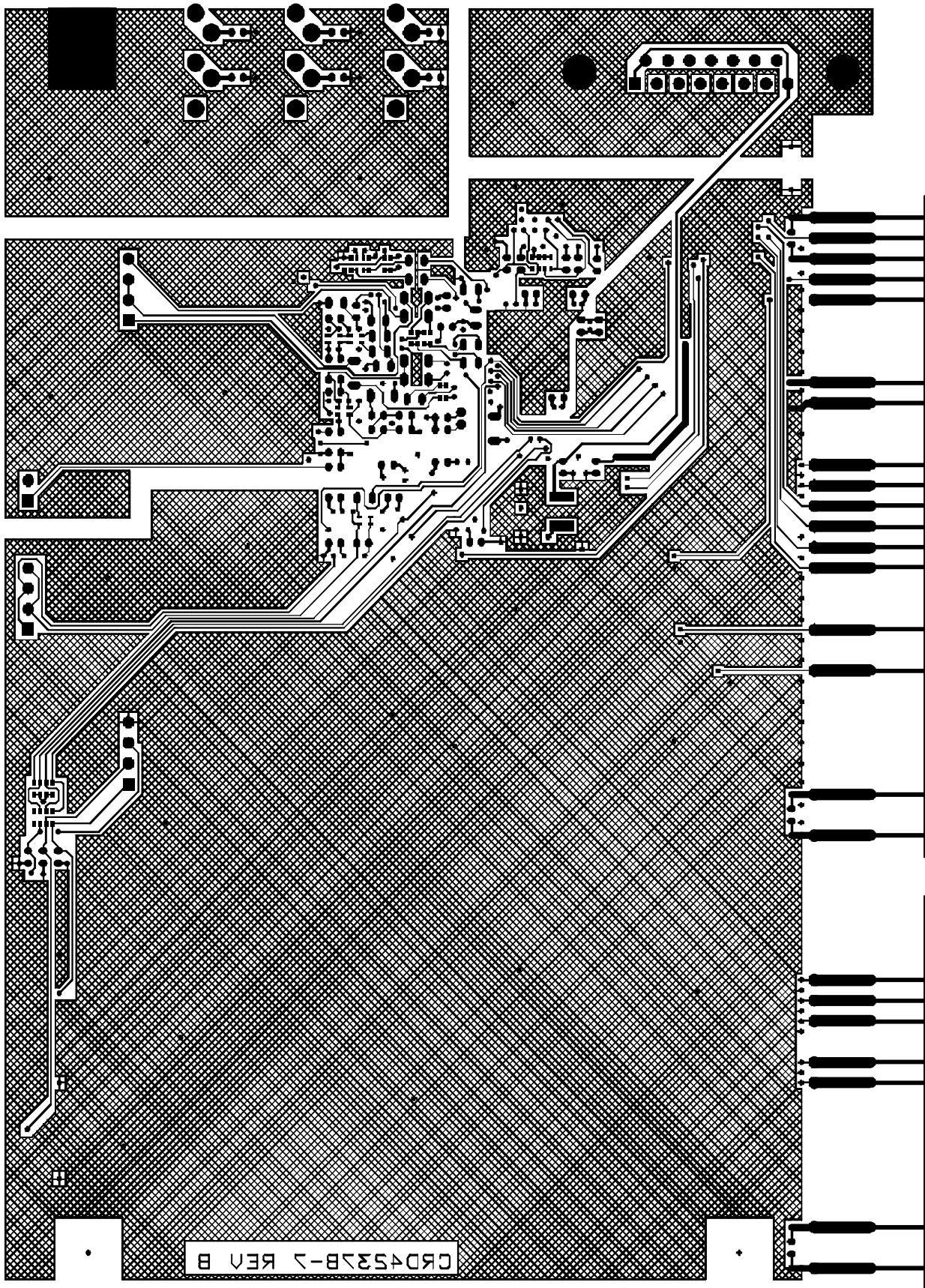
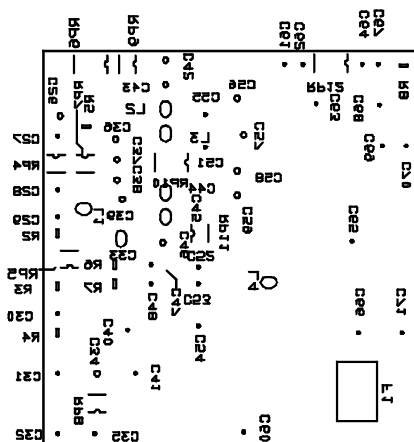
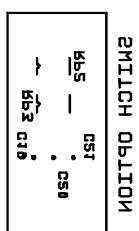


Figure 15. Solder Side



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Figure 16. Bottom Silk



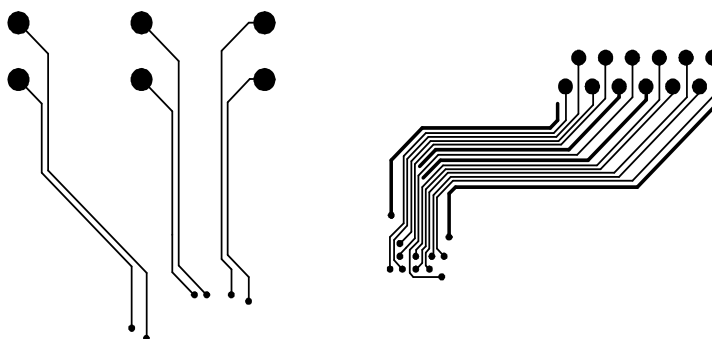


Figure 17. Traces on GND

Qty	Ref	Value	Type	Tol	Description	MFG Number	PN
1	U4				16K EEPROM	ATMEL	AT24C16-10SC
3	J3-5				3.5MM JACK	LZR	SJ-372
1	U8				+5V REG	MOTOROLA	MC78M05CDT
1	U7				AUDIO CODEC	CRYSTAL	CS4237B-KQ
1	U6				WAVETABLE MUSIC SYNTH.		CS9236-KQ
1	J2				15 D-SHELL	AMP	747845-3
4	L1-4				FERRITE BEAD	TDK	CB70-1206
1	J7				2 PIN HEADER	SAMTEC	TSW-102-07-T-S
1	J8				4 PIN HEADER	SAMTEC	TSW-104-07-T-S
2	J6 J9				4 PIN HEADER	MOLEX	70553-0038
1	U1				.5W Amp	NATIONAL	LM4861M
1	U2				DUAL OP AMP	MOTOROLA	MC33078D
1	F1				FUSE,.5A HOLD,1A TRIP	RAYCHEM	MINISMD050-2
3	SW1-3				PB SWITCH	PANASONIC	EVQ-PHP03T
1	U5				+3.3 REG	TELCOM	TC45ER3303
1	U3				OP AMP	PHILLIPS	TDA1308SB
3	C17-18 C70	.001uF	X7R	10%	SMT CAP	PANASONIC	ECU-V1H102KBV
2	C47-48	.039uf	Z5U	20%	SMT CAP	PHILIPS	06032E393M9
22	C1 C3-4 C9-10 C31-32 C40-41 C51 C54-55 C60 C63 C65-66 C68-69 C71 C73-75	.1uF	Y5V	10%	SMT CAP	PANASONIC	ECU-V1C104ZfV
3	C33 C44-45	.33uf	X7R	10%	SMT CAP	MURATA	GRM42-6X7R334K01
1	C6	1.0uF	ELECT	10%	SMT CAP	PANASONIC	ECE-V1HA010R
9	C26 C34 C37-38 C42-43 C46 C58-59	1.0uf	Y5V	80%	SMT CAP	MURATA	GRM40-6Y5V105Z01
1	RP3	100		5%	4 RESISTER ARRAY	PANASONIC	EXB-V8V101JV
4	C61-62 C64 C67	1000pf	X7R	10%	SMT CAP	PANASONIC	ECU-V1H102KBV
4	C36 C39 C56-57	1000pf	COG	5%	SMT CAP	PANASONIC	ECU-V1H102JCX

Qty	Ref	Value	Type	Tol	Description	MFG Number	PN
9	C19-25 C49-50	100pf	X7R	10%	SMT CAP	PANASONIC	ECU-V1H101KBV
3	C7 C13-14	10uF	ELECT	10%	SMT CAP	PANASONIC	ECE-V1CA100R
1	Y1	16.9MHz			16.9 MHz CRYSTAL	EPSON	CA301_16MHZ_22pf
1	RP9	1K		5%	2 RES ARRAY	PANASONIC	EXB-V4V102JV
1	RP1	2.2K		5%	4 RESISTOR ARRAY	PANASONIC	EXB-V8V222JV
2	R3 R5	2.2K		5%	SMT RESISTOR	PANASONIC	ERJ-3EKF2.2K
2	C30 C35	2.7nf	X7R	10%	SMT CAP	PANASONIC	ECU-V1H272KBV
1	C29	220pf	NPO	10%	SMT CAP	PANASONIC	ECU-V1H221KCV
2	C5 C8	220uF	ELECT	10%	SMT CAP	NICHICON	UUK0G221MCU1GS
1	RP8	22K		5%	2 RES ARRAY	PANASONIC	EXB-V4V223JV
2	C52-53	22PF	NPO	10%	SMT CAP	PANASONIC	ECU-V1H220KCV
1	RP7	27K		5%	2 RES ARRAY	PANASONIC	EXB-V4V273JV
1	RP11	3.3K		5%	2 RES ARRAY	PANASONIC	EXB-V4V332JV
1	RP2	3.3K		5%	4 RESISTOR ARRAY	PANASONIC	EXB-V8V332JV
1	C2	3.3uF	ELECT	10%	SMT CAP	NICHICON	UUK1H3R3MCU1GS
1	RP4	39K		5%	2 RES ARRAY	PANASONIC	EXB-V4V393JV
1	RP12	4.7K		5%	4 RESISTOR ARRAY	PANASONIC	EXB-V8V472JV
2	R1 R8	4.7K		5%	SMT RESISTOR	PANASONIC	ERJ-3EKF4.75K
2	R6-7	47		5%	SMT RESISTOR	PANASONIC	ERJ-3GSY47
1	RP5	47K		5%	2 RES ARRAY	PANASONIC	EXB-V4V473JV
1	R4	47K		5%	SMT RESISTOR	PANASONIC	ERJ-3EKF47.5K
2	C27-28	47pF	COG	5%	SMT CAP	PANASONIC	ECU-V1H470KCV
4	C11-12	5600pF	X7R	10%	SMT CAP	PANASONIC	ECU-V1H562KBV
	C15-16						
2	RP6 RP10	6.8K		5%	4 RESISTOR ARRAY	PANASONIC	EXB-V8V682JV
1	R2	6.8K		5%	SMT RESISTOR	PANASONIC	ERJ-3GSYJ682V

