REALTEK ALC650 APPLICATION NOTES

0. Revision History

Version 1.4:
(1) Add GPIO control circuit to switch MIC bias voltage.

Version 1.5:
(1) Modified GPIO control circuit to switch MIC bias voltage.
(2) Add S/PDIF input and S/PDIF output layout notice.

Version 1.6:
(1) S/PDIF IO layout guide in section 13.
(2) Section 14 describes how to select correct optical receiver for S/PDIF-IN.

1. Introduction

The ALC650 has a 20-bit stereo DAC and 18-bit stereo ADC, full duplex AC'97 2.2 compatible audio CODEC designed for PC multimedia systems, including host/soft audio and AMR/CNR based designs. The ALC650 incorporates proprietary converter technology to achieve a high SNR, greater than 90 dB. The ALC650 AC'97 CODEC supports independent variable sampling rates and built-in 3D effects.

This document contains some notes on application circuits for the ALC650.

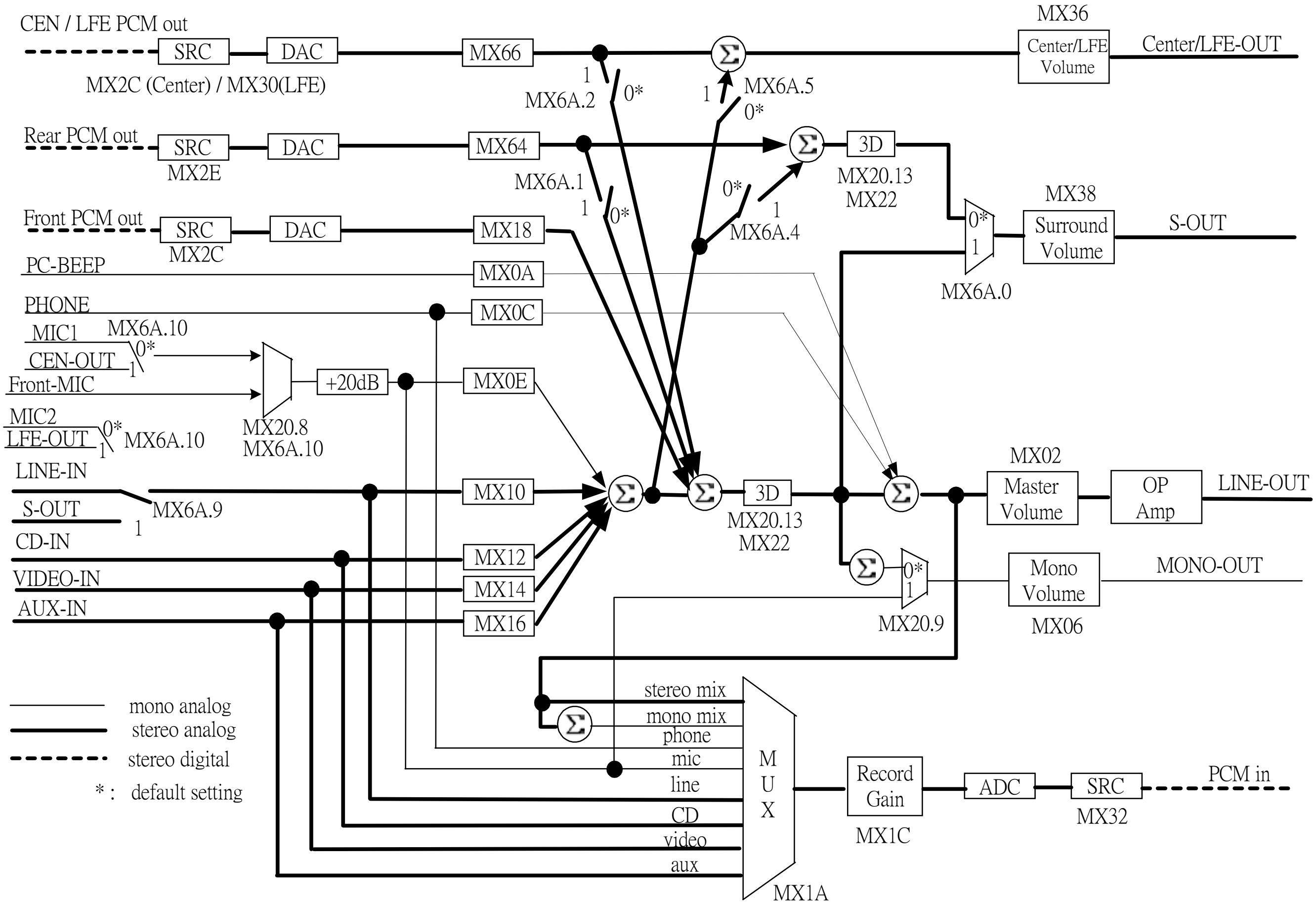
This guide is intended for the Realtek customer who will be designing a hardware system around the Realtek ALC650 chip. Using this guide, the following goals can be achieved:

(1) Create a noise-free, power stable environment that is suitable for the ALC650.
(2) Reduce the possibility of EMI and EMC and their influence to the chip.
(3) Simplify the task of routing signal traces, so as to make a better circuit for the ALC650.

All information provided in this guide has been tested by Realtek systems engineers to be accurate and directly applicable to proper system designs using the ALC650.

2. Mixer Block Diagram

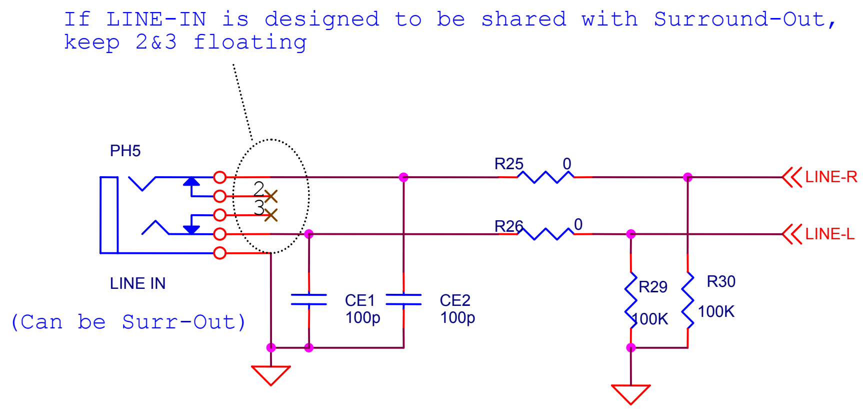
The Mixer Block Diagram shows the analog data path, and its control mixers. The ALC650 supports flexible analog paths to fit different multi-channel applications.



Analog data path

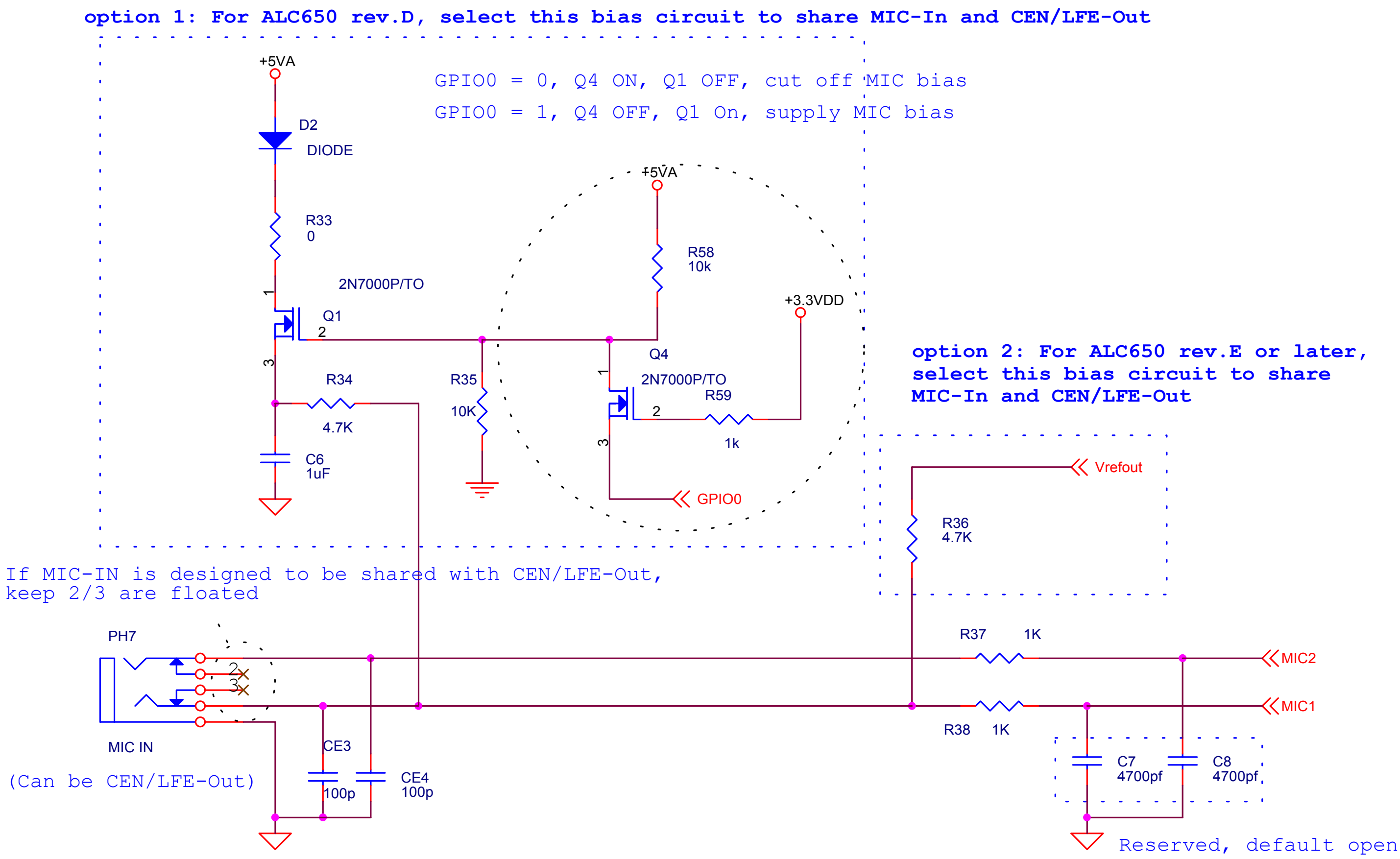
3. Audio Jack Sharing

The current standard for motherboards includes only 3 audio jacks on the back panel. The ALC650 embeds an internal analog switch to share LINE input with Surround output, and share MIC input with CENTER/LFE output. No external analog switch is needed.



Sharing the Audio Jacks

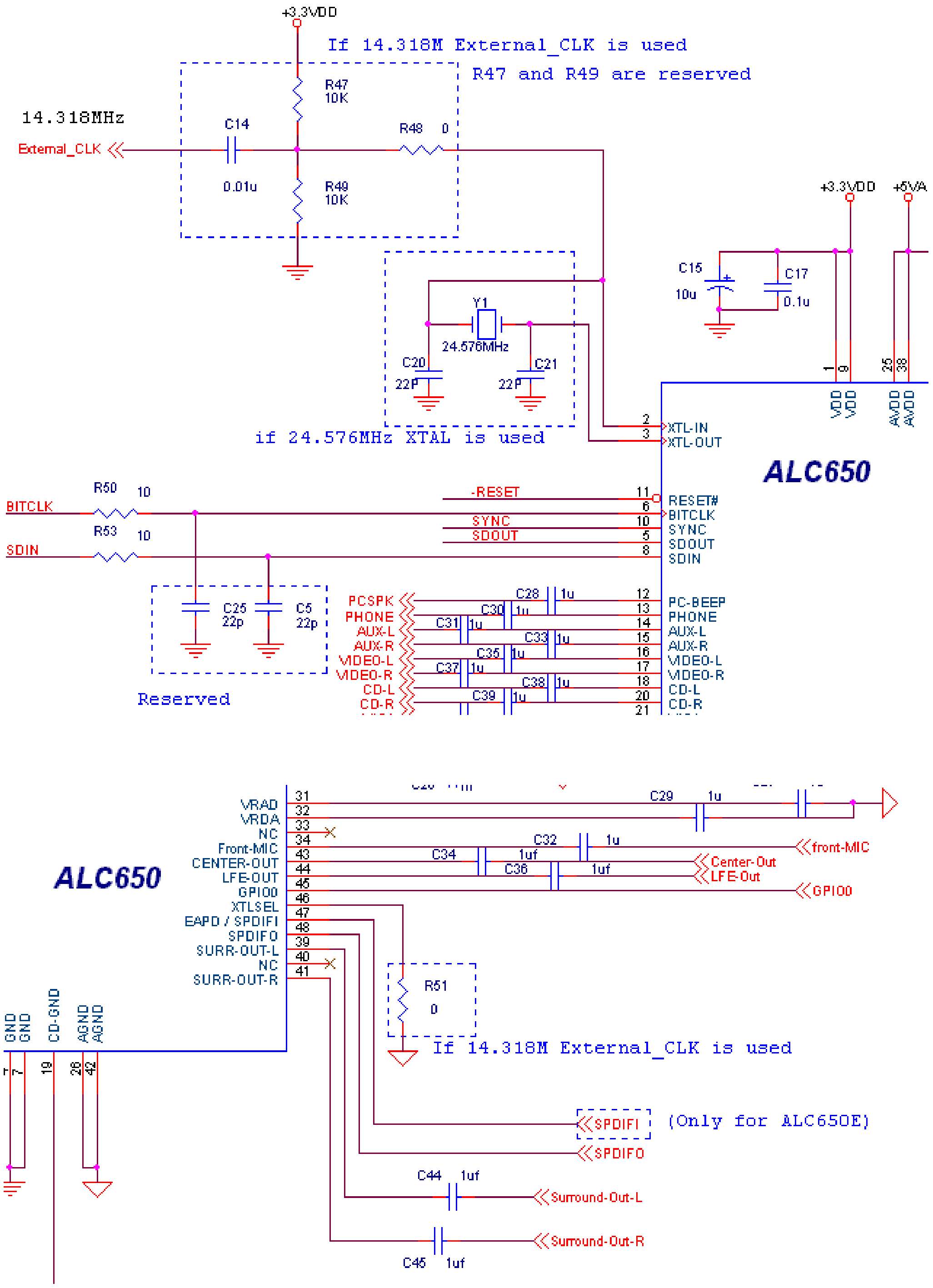
There are two option circuits for MIC to disable bias voltage. For ALC650 ver.E or later, there is Vrefout-disabled function, so bias voltage from Vrefout(pin28) is recommended as option2 circuit. When MIC is shared with Center/LFE, software should disable Vrefout. For ALC650 ver.C/ver.D, Vrefout-disabled function is not implemented yet, so GPIO is used to switch bias voltage as option1/option3 circuit.



In order to share LINE/MIC input jacks with Surround/Center/LFE output, system designers must follow the information in the illustration above to modify jack circuits. Pins 2 and 3 should not be grounded.

4. Saving 24.576MHz Crystal

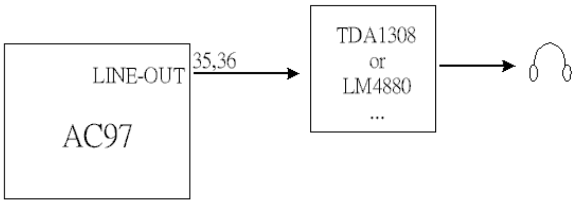
The ALC650 has a built in 14.318MHz to 24.576MHz phase-lock-loop clock generator. The 14.318Mhz frequency from the clock generator can be used as the clock source for the ALC650 by pulling XTLSEL (pin-46) low.



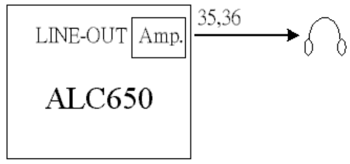
Pull XTLSEL low if External 14.318MHz Clock is Used

5. Output Amplifier at LINE-OUT

The ALC650 embeds a 50mW @ 20Ω amplifier in front of the LINE output to drive the headphones, saving external earphone driving circuitry.



Standard AC97 Requires External Amplifier



ALC650 Has an Embedded Headphone Amplifier

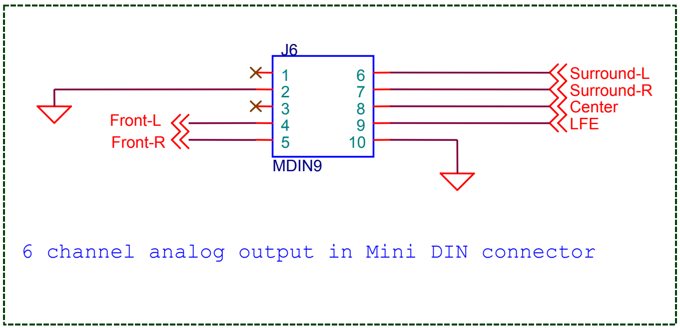
6. General Purpose I/O (GPIO)

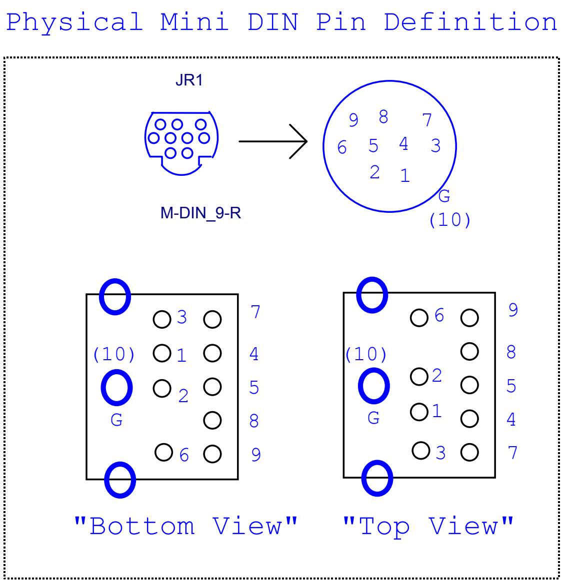
The ALC650 supports 2 GPIO pins for specific applications. In the standard package, only GPIO0 is supported at pin-45, and pin-46 is bonded to select the crystal frequency (XTLSEL). Therefore, only GPIO0 (pin-45) is usable in the standard package.

If Jack Sharing is required at the MIC input, it is recommended to use GPIO0 to control the Q1 switch as shown in the figure in Section 3. Doing this will isolate the DC reference voltage when MIC1/MIC2 is configured as Center/LFE output. The default driver supports this operation unless special consideration is required by the system designer.

7. 6-Channel Mini DIN Connection

The illustrations below describe connection with the 6-channel mini DIN, compatible with Jazz's 6-channel speaker system, the most popular speaker in current multi-channel applications. It is recommended to implement the mini DIN connector with a circuit breaker.

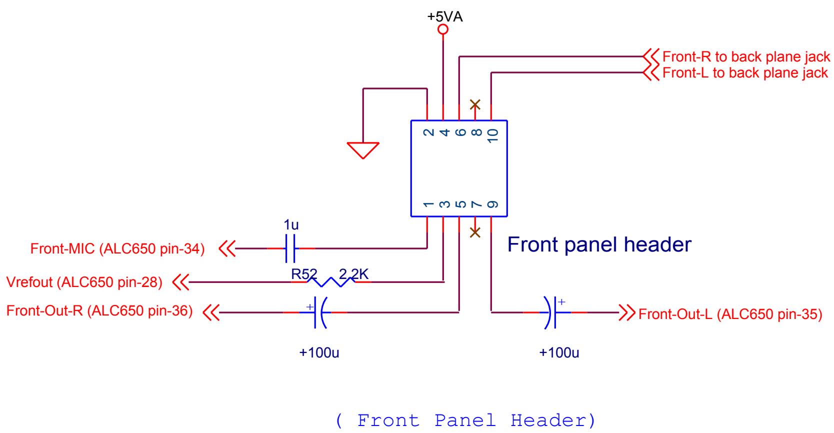




Mini DIN Connection for 6-Channel Applications

8. Front-MIC Input

If the jack sharing function is designed to switch MIC1 and MIC2 to Center and LFE output, the normal microphone jack in the back plane will no longer function as the microphone input. The ALC650 supplies a dedicated microphone input, named Front-MIC. This can be used as the microphone front panel jack if front panel IO is implemented according to the illustration below, which follows INTEL's "Front Panel IO Connectivity Design Guide V1.0" specifications.

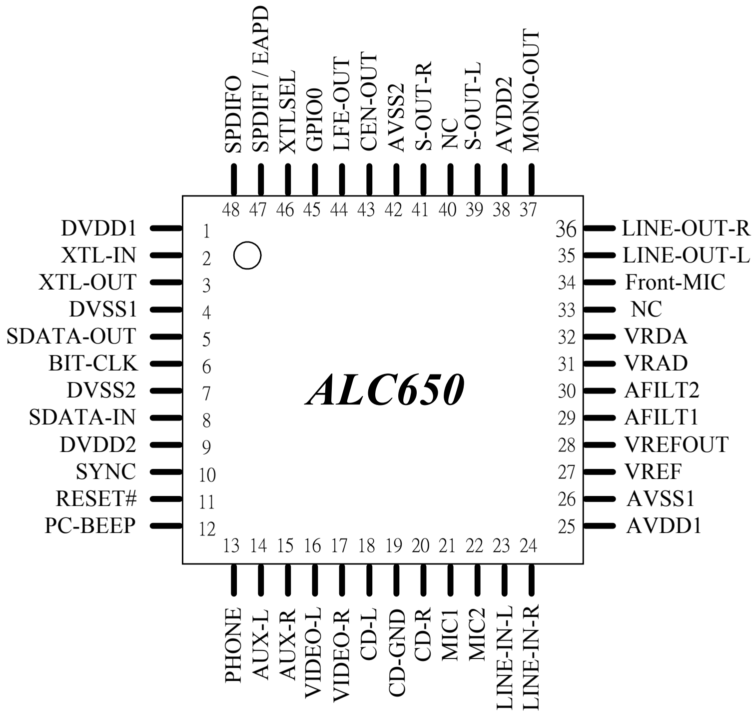


Front-MIC Input in a Front Panel I/O implementation

9. S/PDIF-In Function

Only ALC650 Rev. E or later versions support the S/PDIF-In function. The frequency of the S/PDIF signal is about 1.5MHz~6MHz. Therefore, to prevent cross-talk interference from S/PDIF output, *do not* layout S/PDIF input and S/PDIF output traces in a parallel configuration. It is recommended to maintain double width or ground between S/PDIF input and S/PDIF output traces.

10. Pin Assignments



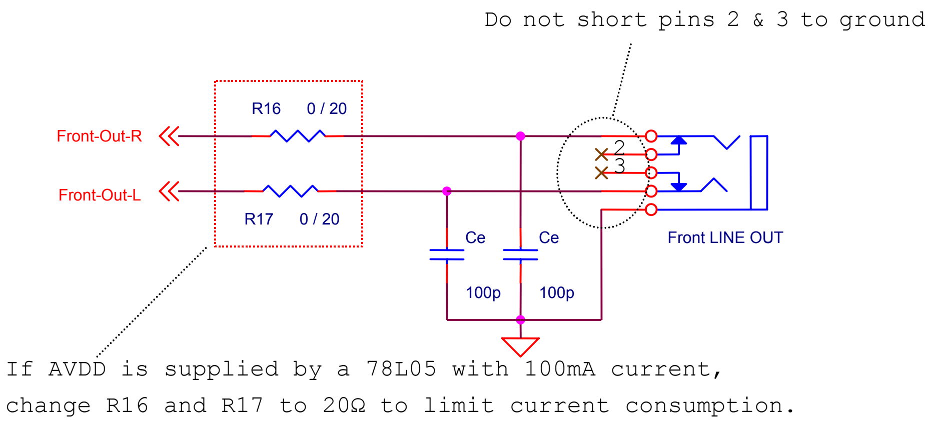
11. Complete Application Circuits

The application circuits are contained in a separate file. Please refer to the file titled "ALC650_Demo_Circuit_Ver_xx.PDF" for the schematics for those circuits.

12. Regulator Selection

The ALC650 has a built in amplifier. It normally consumes 60mA from +5V AVDD when driving active powered speakers. If the ALC650 is driving earphones with a 16 ohm load, the amplifier will consume almost 100mA from the +5V regulator when it is playing a full swing test sine wave. To prevent the power regulator from overheating, it is recommended to use a +5V regulator with internal thermal overload protection and at least 200mA output current capability. For example the LM7805CT can be used.

If only a 78L05 is used to supply 100mA output current, a 20Ω resister should be placed in the front LINE-OUT path to limit current consumption. This will protect the 78L05 from damage.



The following table shows the maximum current consumed from AVDD under various loads. These test values are measured by a 6-channel DAC playing a full-scale sinusoidal wave (1KHz, 44.1KHz sampling rate), which is the worse case, consuming maximum current.

	Powered Speaker	20 Ω Earphone	16 Ω Earphone	8 Ω passive speaker
R16, R17 = 0 ohm	50 mA	93 mA	104 mA	129 mA
R16, R17 = 20 ohm	50 mA	79 mA	83 mA	93 mA

Playing a full scale sinusoidal wave, power consumed from +5V AVDD

13. S/PDIF IO Layout Guide

Crosstalk is an undesirable feature with S/PDIF signals. It causes a disturbance between S/PDIF-IN and S/PDIF-OUT signals. Mutual coupling mechanisms will be form if S/PDIF-IN and S/PDIF-OUT are parallel, the mutual capacitance and mutual inductance between traces have capacitive and inductive coupling of electromagnetic field generated by S/PDIF-OUT. Figure 13-1 indicates the coupling energy from S/PDIF-OUT may interfere S/PDIF-IN operation.

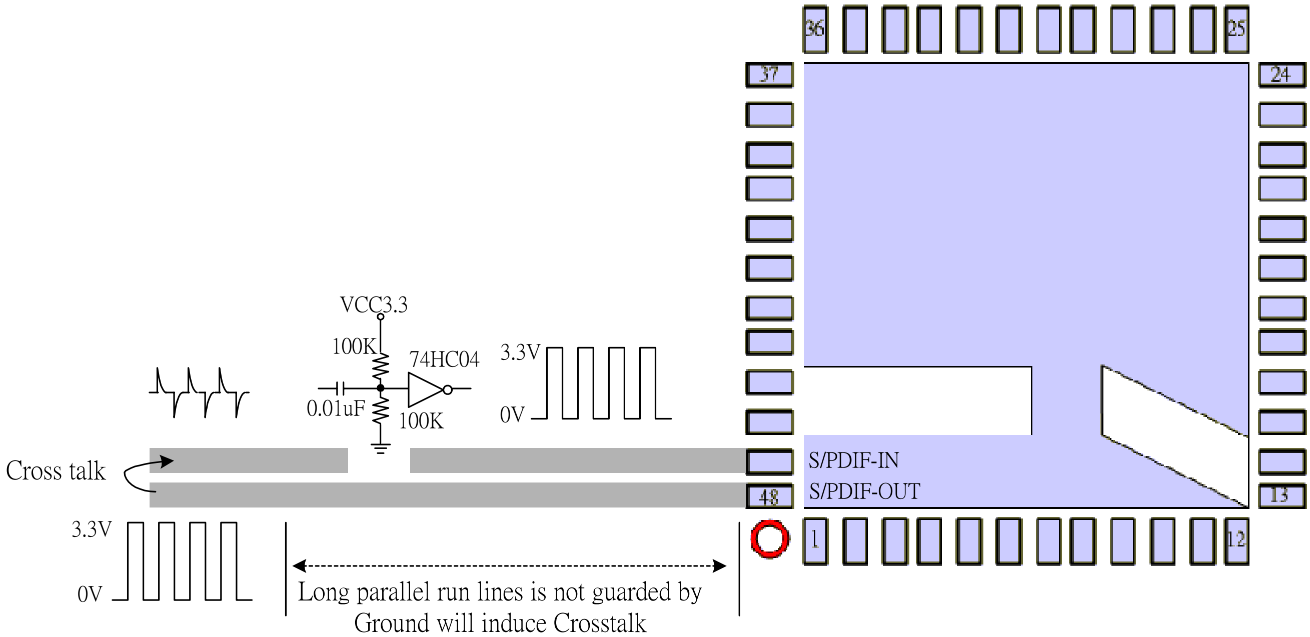


Figure 13-1 Crosstalk between S/PDIF-IN and S/PDIF-OUT traces

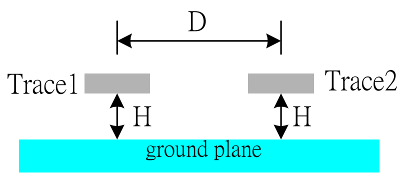
Design and layout rules listed here are useful to prevent crosstalk.

1.Minimize physical distance between IO connector (or header) and ALC650.

2.Avoid routing of S/PDIF-IN trace parallel to S/PDIF-OUT. Figure 13-2 shows an approximate equation to minimize crosstalk, distance (H) with reference plane must be minimized, and distance (D) between traces must be maximized. (Refer to “High Speed Digital Design”. Johnson, H. W., and M. Graham. 1993. Englewood Cliffs, NJ: Prentice Hall)

3.S/PDIF-IN and S/PDIF-OUT signals are separated by ground traces will reduce crosstalk. (Figure 13-3)

4.A simple rule to minimize coupling between traces is the 3-W rule. The distance separation between centerline of traces must be three times the width of a single trace. (Figure 13-4)



$$\text{Crosstalk} = \frac{1}{1 + \left(\frac{D}{H}\right)^2}$$

Figure 13-2 Approximate equation to estimate crosstalk

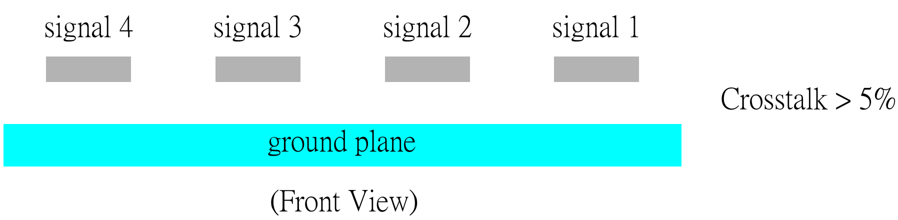


Figure 13-3a Traces without separation have significant crosstalk

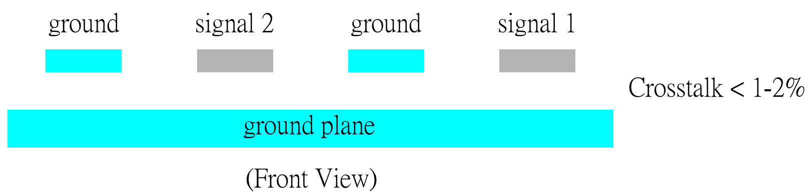


Figure 13-3b Traces separated by ground can reduce crosstalk

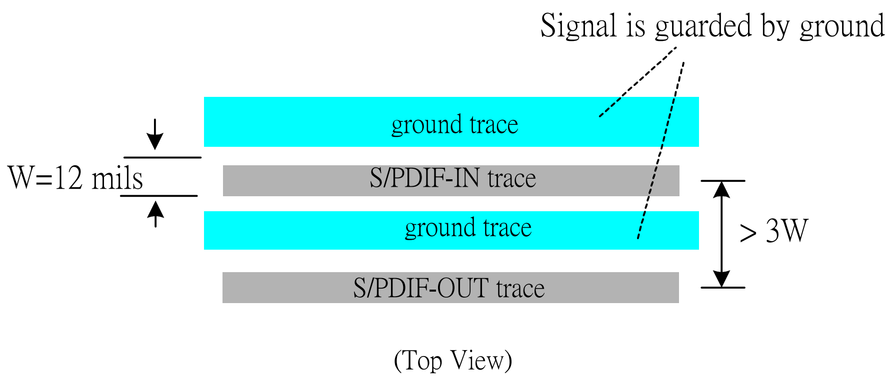


Figure 13-4 The 3-W rule to minimize coupling

Additional to above layout rules, the 3-W rule represents the approximate only 70% flux boundary, 10-W should be used to get approximate 98% boundary. (Refer to "EMC and the Printed Circuit Board", Mark I. MONTROSE) However, it may be not easy to separate traces with 10-W distance, Figure 13-5 is 5-W (W=12 mils) separations adapted on Realtek's demo board.

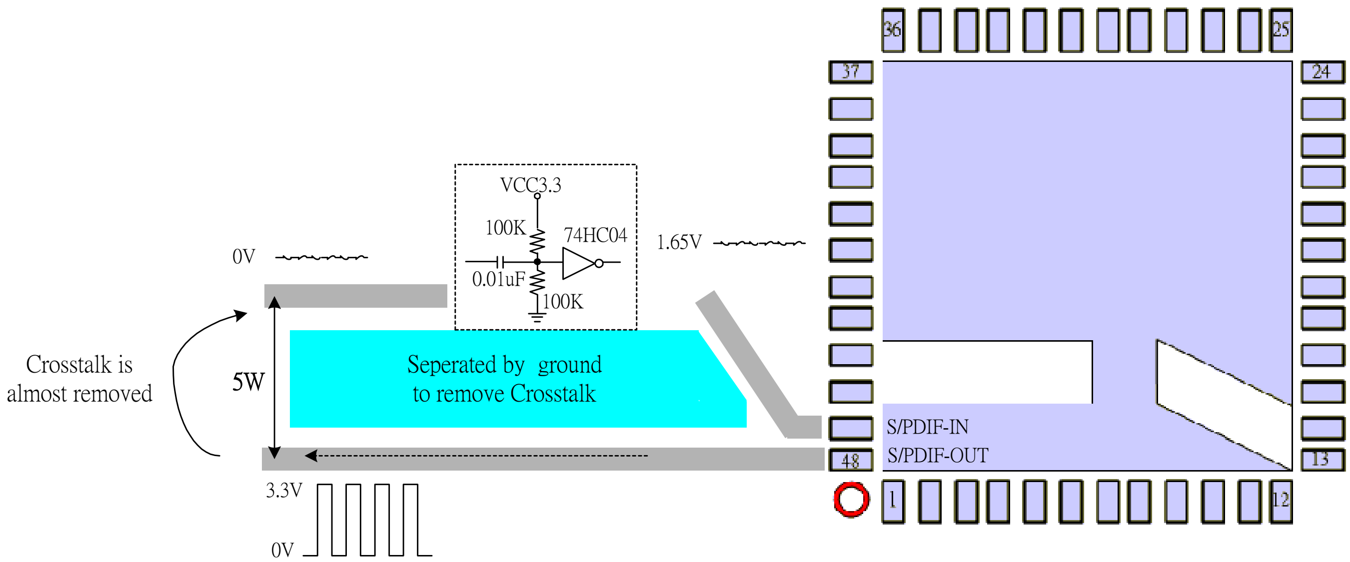


Figure 13-5 The suggested layout on Realtek's demo board

14. Select Correct Optical Receiver for S/PDIF-IN

ALC650 supports one S/PDIF-IN input. It is better to design optical receiver only or RCA connector only on the board. To make optical receiver and RCA connector can be combined on the board, specific optical receiver must be used.
An optical receiver has ATC (Automatically Threshold Control) can be connected to RCA. When non-modulated optical signal is inputted (optical signal is absent) to the optical receiver **without** ATC, its output signal is not stable. That will disturb the RCA signal randomly to be an unstable signal. (Figure 14-1 and 14-2)

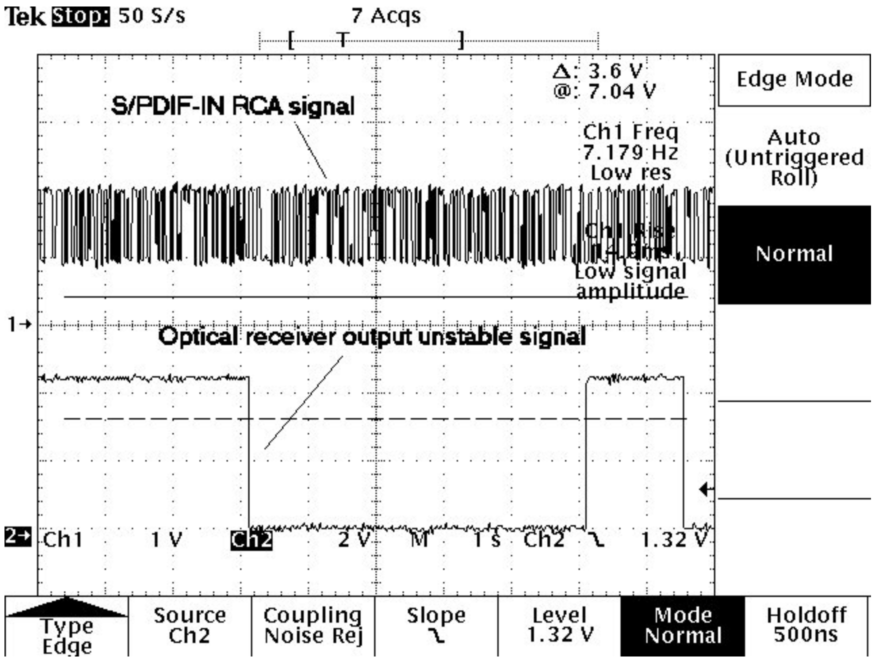


Figure 14-1 When no modulated optical signal is inputted, non-ATC receiver output an unstable signal

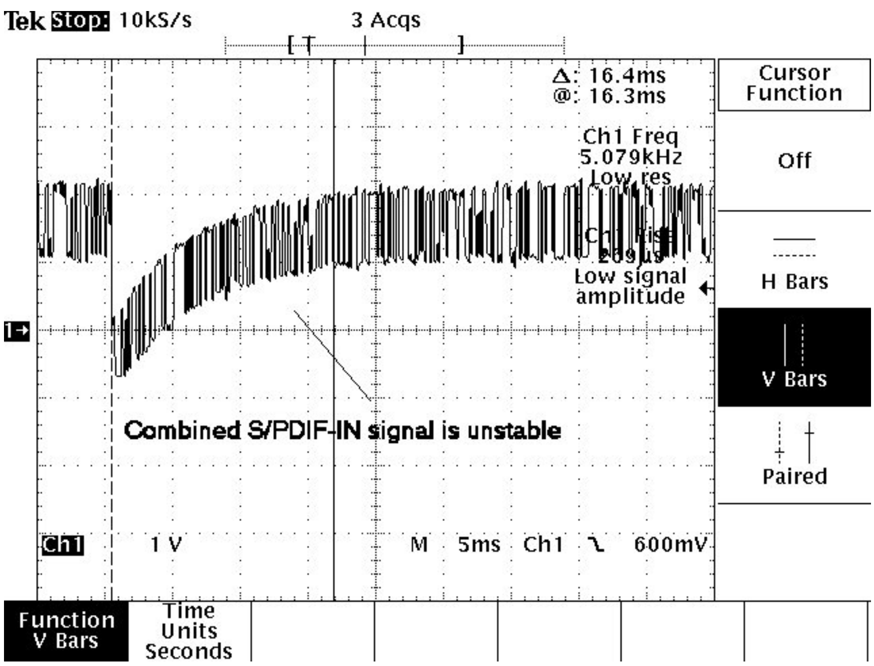


Figure 14-2 Combined signal is also unstable makes S/PDIF-IN data is lost in a short time

Figure 14-3 is a reference design uses optical receiver with ATC to accommodate RCA input. Table 14-4 lists the recommended optical receivers and transmitters by different system implementation.

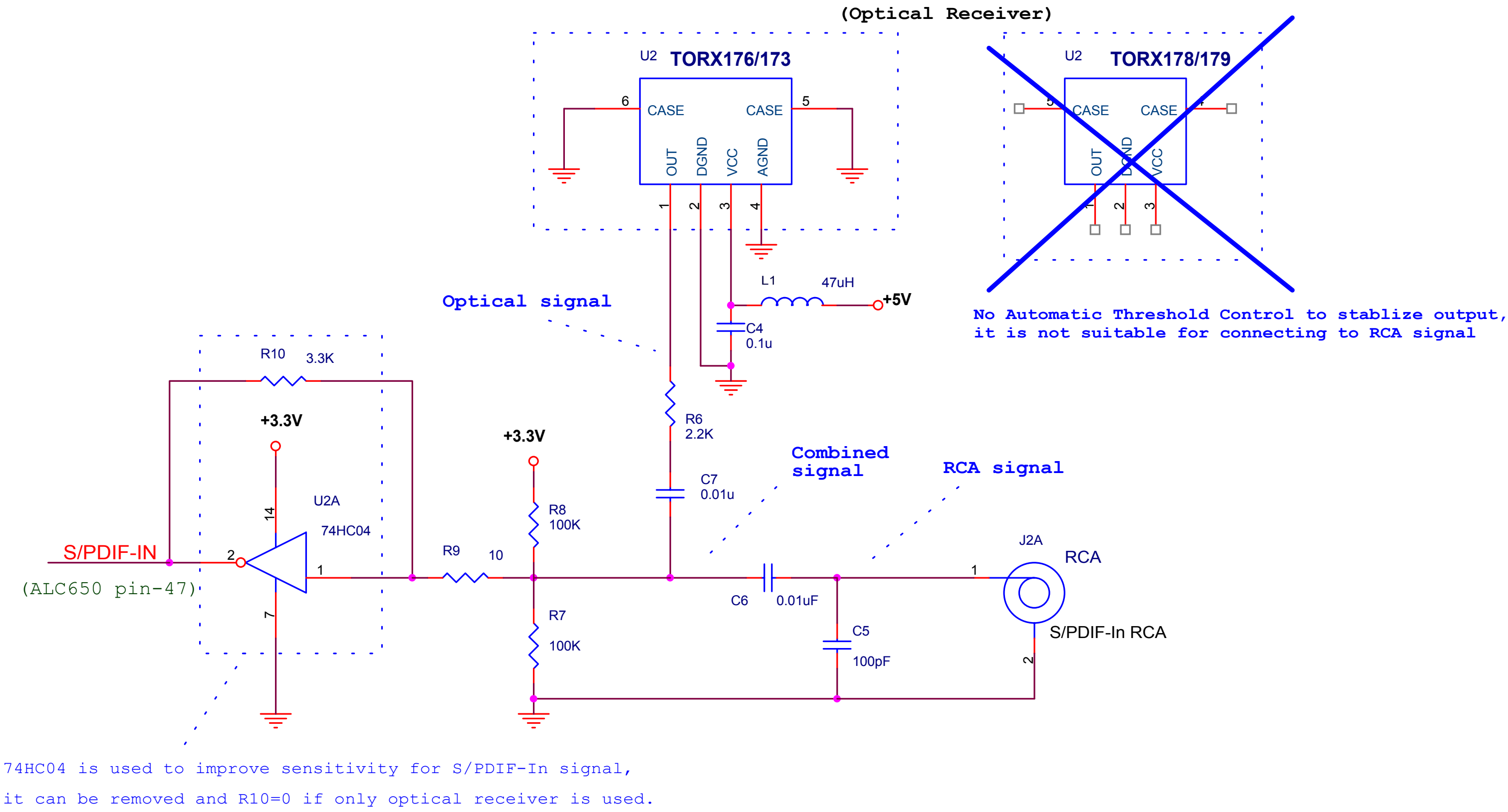


Figure 14-3 Optical receivers with ATC is recommended

Table 14-4 Recommended optical receivers by system implementation

S/PDIF-IN Connector	Recommended Optical Receivers	Note
1.Optical only	TORX173, 176, 178, 179	-
2.RCA only	-	-
3.Optical receiver + RCA connector	TORX173, TORX176	Only one of optical receiver and RCA can accept input at the same time

S/PDIF-OUT Connector	Recommended Optical Transmitters	Note
1.Optical only	TOTX173, 176, 178, 179	-
2.RCA only	-	-
3.Optical receiver + RCA connector	TOTX173, 176, 178, 179	Both optical transmitter and RCA output at the same time

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