Using the HCA125ACREF Amplifier Module

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Introduction

The HCA125ACREF reference design delivers 125W of RMS power into an 8Ω load and 220W into an 4Ω load. Since the amplifier's power efficiency is greater than 90%, heatsink and power supply size, weight, and expense are greatly reduced compared to conventional class A and AB designs.

The amplifier module is part of Intersil's Cool Audio™ program. The Cool Audio program supports customers' efforts to achieve minimum time-to-market for audio end products. As part of the program, the amplifier design is offered after execution of a Licensing Agreement. Intersil provides to licensees a documentation package containing: 1) a circuit description, 2) schematics, 3) test and manufacturing information, 4) A bill of materials with all vendors and vendor part numbers, 5) Intersil's engineering support contacts, and 6) one evaluation unit.

Class D Amplifier Overview

Class D ("switching") amplifiers are radically different from conventional audio amplifiers in their operation and design. Although the concepts embodied in class D amplification have been around at least since the 1950s, it is only recent advances in MOSFET and integrated circuit technology that have allowed feasible, full audio bandwidth designs to come to market.

What is Class D Amplification?

Traditional class A, B, and AB amps use output devices that are operating in their linear region. They therefore simultaneously have both current flowing through and voltage dropping across their output devices. Power dissipated in the output devices is a product of the current flow and voltage drop. Most of the power consumed by traditional amplifiers is converted directly to heat instead of being used to produce audio output (music). Large, heavy heatsinks are needed for conventional high power amplifiers to operate at reliable temperatures.

Class D amplifiers are much more efficient than class AB amplifiers because they use their output MOSFETs as switches instead of as linear devices. When the voltage across the MOSFETs is large (MOSFET is off), the current is small. When the current is large (MOSFET is fully enhanced), the voltage is small. The net result is to minimize the power dissipation in the MOSFETs, which in turn results in a dramatic improvement in efficiency. Most of the amplifier input energy is delivered to the loudspeaker.

The output devices in a class D amplifier are switching at frequencies well above the audio band. This switching frequency is modulated by the audio signal so that when passed through a low-pass filter only the audio output with some residual carrier remains. The carrier does not effect the sound quality.

As a result of this binary on/off state, power dissipation is very low when compared to traditional amplifiers. Higher efficiency means that designers are no longer as limited by the current available from a 15A wall socket. Audio engineers don't have to worry as much about how to fit a large heatsink into a small chassis. Cost and weight savings in power supplies can be realized. System weight, and therefore shipping costs, can be reduced.

A switching amplifier works by employing an intelligent modulator to drive the output MOSFETS. Depending on system design, various forms of feedback and modulation can control the output signal.

Older switching designs have been plagued with issues of reliability, distortion, and background noise. The Intersil CoolAudio HCA125ACREF class D amplifier module solves all of these problems.

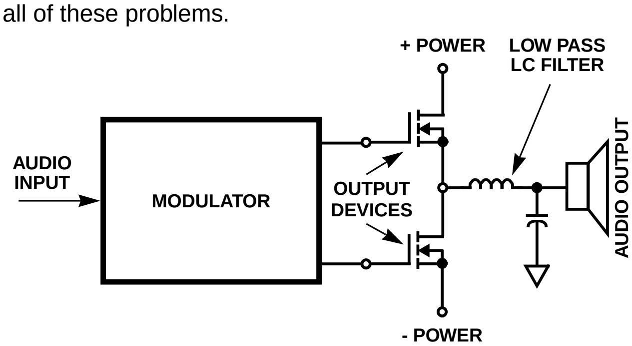

FIGURE 1. OVERVIEW OF A CLASS D AMPLIFIER SYSTEM SUCH AS THE HCA125ACREF MODULE. THE OUTPUT MOSFETs ACT AS VERY RAPIDLY TOGGLING SWITCHES INSTEAD OF AS LINEAR ELEMENTS FOUND IN TRADITIONAL AMPLIFIERS.

Why Use the Intersil HCA125ACREF Module?

The Intersil HCA125ACREF amplifier lets you, the designer, reap all of the benefits of class D amplification without requiring extensive design work on your part. All of the details of creating a low distortion, EMI/RFI compliant efficient amplifier with great sound have been taken care of by the CoolAudio engineering team. With the help of this document, the Intersil reference design can be easily modified to suit almost any audio application.

Class D Amplifier Output

Sonic performance demands that audio amplifiers have a bandwidth greater than 20kHz. The bandwidth of the HCA125 is 80kHz. A special compensation technique is used to achieve this bandwidth and still filter most of the carrier. However, removing all of the carrier from the output is not practical, so some carrier reaches the loudspeakers. The amplitude of this carrier depends upon the power, but it is generally no more than $0.5V_{P-P}$ at low power and $0.5V_{P-P}$ at full power.

The carrier is at a frequency well above the top of the audio band and cannot be reproduced by a loudspeaker. It will not damage speakers that are rated to handle the power of the HCA125. The carrier is visible on a high-bandwidth oscilloscope as a small signal high frequency (>100kHz) sine wave.

The carrier makes it difficult to observe the clean small square wave response of the HCA125. To the untrained eye, the carrier is perceived as high frequency instability - it is not.

Unfortunately, most test equipment like an Audio Percision (AP) test set has no way to differentiate between amplifier noise and the carrier. The carrier is inaudible. It is not noise. As a result, additional filtering is required to obtain meaningful THD measurements. The 3 pole 30kHz low-pass filter built into the AP should be engaged when measuring noise or distortion. Similar filters are required for other test equipment. An oscilloscope connected to the reading output of the AP can be used to determine if the filtering is adequate. Any carrier observed here is interpreted by the AP as noise.

Heat Sinking

The shield supplied with the HCA125 is not an adequate heatsink for 4Ω operation. It is designed to be bolted to additional aluminum, like the back plate in a powered sub woofer or the chassis of an amplifier. Additional heatsinking is required for full power operation into 4Ω loads. Another option is to use a cooling fan. For bench testing a small cooling fan is required.

The top cover should be aluminum not steel as this dramatically improves the thermal performance.

Setting the Low Frequency Roll Off and Phase

The HCA125ACREF can accept either a differential or single ended audio signal. Since the input is DC coupled, a DC blocking cap is required between the preamp and the HCA125ACREF. Failure to block DC can potentially damage the amplifier and the loudspeakers.

BLOCKING CAPACITOR	-INPUT ROLL OFF (-3dB)	+INPUT ROLL OFF (-3dB)
2.2µF	14Hz	7Hz
4.7µF	7Hz	3.5Hz

The “-” input (pin 3) is the inverting input to the diffamp (see Figure 2). Since the modulator inverts the audio signal, audio applied to pin 3 will maintain the phase of the signal at the amplifier output. Likewise, the “+” input (pin 7) will invert the phase of the signal. If absolute phase is not critical, audio should be applied to the “+” input, because a smaller DC blocking capacitor can be used. For the best possible sound, the blocking cap should be polypropylene; however a film capacitor is also acceptable. Bipolar electrolytics can be used if cost is more important than sound quality.

Setting Amplifier Gain

The HCA125ACREF module has been designed to have a voltage gain of 20 V/V (26dB). It is possible for system designers to modify this value. Balanced inputs provide for the highest possible amplifier performance. However, most systems only have provisions to drive the amplifier module with a single-ended signal. The HCA125 can accommodate both types of drive signals.

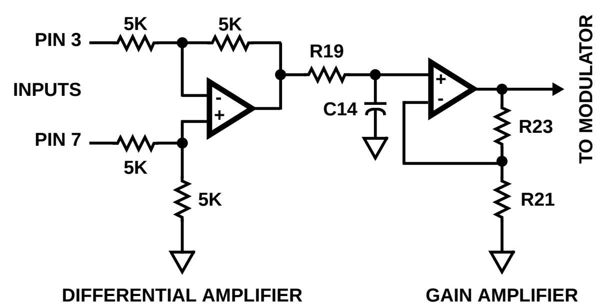

FIGURE 2. PREAMPLIFIER STAGES INSIDE THE HCA125ACREF MODULE

Single-Ended Input

Single-ended signals are transmitted with a two wire system. One wire carries the signal; the other is a ground lead. In this mode of operation one of the two inputs to the amplifier module will be grounded and the other will carry audio. **The DC blocking cap must be placed in series with the audio input line.**

The gain of the amplifier can be adjusted using the opamp in the second stage of Figure 2:

$$Gain_{Inv} = Gain_{Mod} \cdot \frac{R21 + R23}{R21}$$

$Gain_{Mod}$ is the gain of the modulator stage. Modulator gain is described below.

Balanced Inputs

For the lowest noise performance, balanced audio inputs are recommended. Two identical DC blocking caps are required, one for each input if there is any chance that the source material has DC content.

Input Clamp

The input signal is clamped to avoid overdriving the amplifier. This clamp clips both positive and negative excursions and is fully adjustable by changing R12.

R12	CLAMP VOLTAGE (PEAK)
10K	1.6V
20K	2.6V
30K	3.5V
40K	4.7V
50K	5.6V

The clamp voltage is linear and can be approximated by the equation when R12 is greater than 10kΩ:

Vpeak = (0.096) x (R12 value in kΩ) + 0.7V.

The accuracy of the clamp is ±15%. Distortion will rise dramatically when clamps begins to reduce the audio input. Resistors smaller than 10K should not be used. The input clamp is important as it ensures that the modulator does not stop switching when the amp is overdriven with a large input signal.

Modulator Gain

The low frequency modulator gain can be determined from the following relationship:

$$Gain_{Mod} = \frac{(R20 + R30)(R25 + R27)}{(R20 + R30 + R25 + R27) \cdot R29}$$

When the amplifier is assembled using reference BOM part values, the modulator's gain is 8.70. R29 can be changed to modify the modulator gain. Changing the other resistors will effect the amplifiers stability and frequency response. This should not be attempted without guidance from the cool audio engineers.

For best noise performance, do not adjust the gain of the modulator. Adjust gain with the non-inverting opamp stage. At full power, the output of the non-inverting opamp should be between 5V and 6V peak.

High Frequency Roll Off

R19 and C14 form a low pass filter that may be useful for trimming high-frequency response. When the amplifier is assembled using the reference BOM part values of 2200pF for C14 and 681Ωs for R19, the high-frequency pole of those two components is at 106kHz. The pole may be calculated for other component values as:

$$\text{HF Pole} = \frac{1}{2\pi \cdot R19 \cdot C14} \quad \text{Hz}$$

Setting Input Impedance

Figure 1 shows the differential input amplifier and its associated external components R13 and R14. The 5K resistors are all found on-chip inside the HCA125 module. It is recommended that R13 and R14 each have 1% or better tolerances and be of identical nominal values. The primary reason for modifying R13 and R14 is to change input impedance, but modifying their values will change the amplifier's gain. Single-ended input impedances, with the unused input grounded, are determined with the following relationships:

$$Z_{IN,Inv\ Input} = 5000 + R13\Omega$$

$$Z_{IN,NI\ Input} = 10000 + R14\Omega$$

Note that changing the input impedance will affect amplifier gain and reduce its CMRR. For best performance, do not adjust R13 and R14. The 200Ω specified on the BOM is optimal.

EMI/EMC Compliance Issues

The HCA125ACREF module is designed to be incorporated into a larger amplifier chassis, powered speaker, or other audio product. Special care must be taken to ensure that systems using the HCA125 amplifier module follow best-practice EMI guidelines. The shield is an important part of the amplifier's EMC system. **Do not remove it.** Additional shielding is required to pass FCC and CE specifications.

It is important that any chassis into which the HCA125 is installed provide at least 40dB of shielding effectiveness. This means that it must be a closed box with no holes greater than 1 inch in length (i.e., a metal chassis with a plastic front plate is not an effective shield). In addition, 1000pF leaded ceramic chassis feed through capacitors should be installed at all points where the amplified audio signals leave the chassis (such as at the positive speaker binding posts). Ground returns for all audio signals should all be connected at a common point on the chassis - preferably the same point that a safety earth ground wire (if present) is connected to the chassis.

In powered speakers where there is no metal chassis, shielded speaker wires are required. The amplifier should be attached to an aluminum or steel plate, and a 1000pF ceramic bypass (npo) cap is needed between the audio input and this plate, located right at the plate.

Twisting power supply return wires around there source is recommended. A 1µF capacitor across the AC input line along with a power entry module with filtering is required to pass the conducted emission tests.

Significant changes should not be made to the board layout inside the shield. The board has been very carefully engineered for minimum Electro Magnetic emission and any changes may increase its radiated or conducted interference with EMI-susceptible products. However, if the product design engineer wishes to use a connector other than the card-edge design embodied in the reference amplifier, it is acceptable to change the connector style outside of the shielded enclosure.

Start Up Issues

The ENABLE pin on the module provides for quiet startup and shutdown of the amplifier. It is best to keep ENABLE low during power cycling to prevent transient noises through the loudspeakers. Capacitor C1 sets the startup delay time as follows:

$$T_{Startup} = 80000 \cdot C1$$

With the reference design value for C1 of 1µF, the startup delay time is set to 80ms. If the startup delay needs to be increased, increase the value of C1.

Power sequence is not important with one exception. If the -Bus is energized before the +Bus the amplifier may not start. Simultaneous, power of both +BUS and -BUS is desired and recommended. Since almost all supplies work this way, this is a minor issue that is usually only observed when using two bench supplies to power up and evaluate the board.

Power Supply Specifications

Voltages greater than ±85V will activate the overvoltage shutdown circuit. This will latch the amplifier off until power is recycled. Very large overvoltage transients will not damage the amplifier.

It is important to operate the amplifier at full power as close as possible to its specified ±60VDC bus voltage rating. The module has under voltage protection that keeps it from switching when bus voltages are less than about ±45VDC.

Unregulated supplies are fine as are switching supplies. Switching supplies should operate in the range of 100-200kHz to minimize interference with the amplifier.

The power supply capacitance is determined by the minimum frequency of operation, power and speaker load impedance. Half bridge amplifiers can source current into the power supplies, and this action causes the supply voltage to rise (pump up). This energy must be stored in the power supply capacitance. In stereo applications this effect can be minimized by inverting the input and output of one channel. Most recordings are mastered in such a way that the low bass signals are in phase. By inverting one channel, each channel compensates the other. Pump up is not an issue when the amplifier is bridged.

Pump up for a given load, frequency and power is easy to calculate. Roughly 25% of the RMS load current on each sinusoidal half period will tend to charge the power supply capacitance. In a 4Ω load, the peak rms current of the HCA125 is 8As. If a 10Hz sine wave drives the amp to full power, the half period is 0.05 seconds. If the power supply capacitance is 10,000µF per rail, then one supply will rise by 6V during this half cycle. Fortunately, at full power unregulated supplies droop more than 6V. This effect becomes serious when very low frequencies are applied to the input. For example, a 3Hz signal, would cause an 18V surge each half period in the example just given.

Multiple Channel Systems (Note Caution)

Systems using multiple HCA125ACREF modules can have various power supply protection fuse configurations. Designers who elect to fuse the ±Bus supply for each module independently need to use extreme caution. Each module must include an additional blocking diode for the $+V_{12FLOAT}$ supply (see Figure 3). Should one module fail ($-V_{BUS}$ fuse opens), this diode (V_B > 200V, 0.5W) protects all other modules from failure by preventing the floating +12 supply's negative reference point ($-V_{BUS}$) approaching ground. In multiple channel systems where only one fuse is used for all Bus voltage protection, the diode is NOT required.

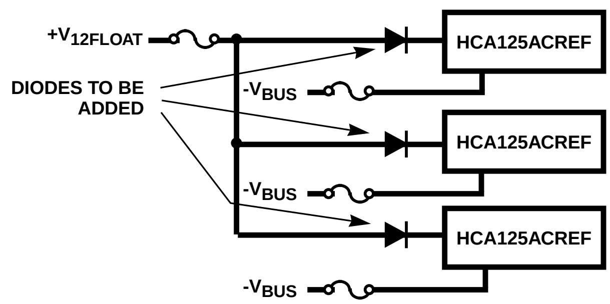

FIGURE 3.

Soft Clipping

When traditional class D amplifiers clip, the sound is very harsh. The poor sound of many early designs is due to this clipping. Soft clipping prevents 100% modulation. The output never reaches the rail, and the sound during clipping is actually pleasant as only low order harmonics are produced.

Soft clipping engages at a fixed percentage of the voltage rails and cannot be modified. This feature is a big reason why the Cool Audio amplifiers sound better than the competition. The drawback to soft clipping is that distortion begins to rise before the amplifier output reaches the rail. The end result is that a cool audio 125W amplifier will sound louder and better than any competitor's Class D 125W amplifier.

Changing Bus Voltage

There are a number of components in the amplifier that must be modified to change the operating bus voltage. This is not recommended. If the need is real, consult cool audio technical expertise.

Operating from a Low Current Power Supply

It is possible, if so desired, to run the amplifier control circuitry from positive and negative low current and low voltage power supplies instead of deriving operating voltages from the main power bus. If regulated ±12V is available, then these changes are recommended: do not populate R36, R17, R16, or R37. Instead populate R45 and

R46 and supply external positive and negative supply voltages through card-edge connector pins 26 and 28 respectively. Page 3 of the HCA125ACREF schematic shows these connections. In the calculations presented in the previous section, R45 replaces the parallel combination of R36 and R17. R46 replaces the parallel combination of R16 and R37. For ease of use, suggested resistor values for 12V and 15V operation are shown in the table below.

TABLE 1. RESISTOR VALUES FOR LOW-VOLTAGE SUPPLY OPTION

SUPPLY VOLTS	R45	R1	R32	R46	R15	R18
±12V	50Ω/ 75mW	180Ω/ 0.15W	510Ω/ 50mW	50Ω/ 0.10W	160Ω/ 0.15W	270Ω/ 0.10W
±15V	50Ω/ 0.10W	330Ω/ 0.25W	900Ω/ 0.10W	40Ω/ 0.10W	330Ω/ 0.25W	560Ω/ 0.20W

NOTE: The edge connector supplied with the kit does not support this mode of operation.

Current Limiting System

There are three modes of current limiting built into the HCA8001 control IC. (1) When the amplifier encounters a hard short in its output stage (such as shorted output terminals), the amplifier will shut down. (2) In situations where the current demanded by the output stage is more than the amplifier can safely handle, as determined by the ratio of R8 and R6 to R7, the control IC will “throttle back” the output. (3) If the amp stays in its current limited mode for too long (as set by the current limit time-out capacitor, discussed below), the amplifier will shut down. A circuit to automatically reset the shutdown latch and restart the amplifier is presented in the “Enable Circuit” section of this application note.

The control IC has built-in current limiting circuitry to protect the output stage of the amplifier module. To set current limit, size R6 and R8 so that 200µA of current flows through them when the amplifier is running at the chosen bus voltage:

$$R6 = R8 = \frac{V_{BUS}}{200x10^{-6}} \quad \Omega$$

V_{BUS} and V_{SHUNT} are the magnitude of the bus voltage and shunt voltage (7.0V for this control IC), respectively.

R7 is sized proportionally to R6 and R8 depending on the minimum load impedance for which the amplifier will be used. To ensure that current limiting is enabled when driving a 2Ω load, set R7 as follows:

$$R7 = 0.894 \cdot R6\Omega$$

For other load impedances, the following equality must be satisfied:

$$R7 = R8\frac{(Bus - ILrms2xr_{DS(ON)} \text{ of MOSFET})}{Bus}$$

Current sensing is accomplished by sensing the voltage drop across the MOSFETs. This means current limit will engage earlier as the MOSFETs get hot and their $r_{DS(ON)}$ rises.

The card-edge connector board supplied with evaluation amplifier modules includes a red LED that lights when current limiting is active. If the red LED lights at too low of a power level, the values of R6, R8, and R7 need to be modified according to the equations above. These resistors are also constrained by the over voltage and under voltage set points - see below.

Current Limit Time-out Capacitor

Capacitor C11 controls the amount of time that the amplifier can be in current limit before automatically latching off. Latch-off time is determined as:

$$T_{Latchoff} = 80000 \cdot C11$$

As listed in the reference Bill of Materials, C11 is a 1µF capacitor and therefore yields a latch-off time of 80ms.

R24 should always be at least 1.5 times the value of (R28 + R29) to ensure proper functioning of the current limiting circuitry. As supplied in the reference design, R24 is 2.15 times the value of (R28 + R29). If this guideline is not followed, the amplifier may be damaged if the outputs are shorted.

Setting Overvoltage and Under Voltage Points

R6 and R8 set the over and undervoltage trip points for the HCA8001. As discussed previously, the HCA8001 IC expects a nominal 200µA of current through R6 and R8. By sizing R6 and R8, the overvoltage trip voltage can be increased. This provides less current to the sensors in the HCA8001 when the amp is running at its nominal operating voltage. Setting R6 and R8 to allow only 190µA instead of 200µA to flow will increase the overvoltage shutdown point significantly. Note that the current sensors in the HCA8001 are only accurate to within 15%, so any further changes to R6 and R8 should take that into consideration.

The under voltage shutdown occurs when the currents through R6 and R8 drop below 100µA. Startup during a power-on-reset event won’t take place until at least 150µA flows. That hysteresis allows smooth amplifier startup and shutdown. The MOSFETs used in the bridge have a 200V limitation. Overvoltage must set in by ±85V, or the amplifier is vulnerable to overvoltage transients.

Bridging Two Amplifier Modules

If the system designer wishes to increase the power output of a system using the HCA125ACREF module, it is possible to “bridge” two modules. The differential amplifier that is the first stage of each module makes such a connection very easy. One module is connected as an inverting amplifier and the other as a non-inverting amplifier. By taking the speaker output across the positive terminals of both modules, the output voltage delivered to the speaker is twice that of a single module. Since output power is a function of the square of output voltage, output power will be four times that of a single module. At 0.1% THD the bridged modules will produce 500W into an 8Ω load and nearly 800W into a 4Ω load. Figure 4, below, depicts the wiring required to bridge two amplifiers. Note that C17 in one of the two modules must be changed slightly from its reference value to prevent interaction between the two oscillators. Since the current is now higher, R7 should be adjusted so that current limit set in at 14A instead of 7A. Each amp module will dissipate twice the power so the heatsink must be re-evaluated.

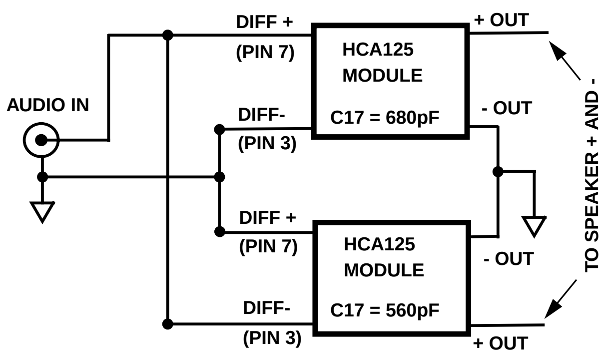

FIGURE 4. BRIDGING TWO HCA125ACREF AMPLIFIER MODULES

As built with the factory BOM part values, each module has a voltage gain of 26dB.

Fan Control and Other Thermal Issues

Although the HCA125 is more than 90% efficient, it still does generate some waste heat. Some users will want to cool the amplifiers with a fan. Presented below is an optional external fan control circuit that uses the fan control pin (pin 13 on the HCA125 card edge connector) to control a DC fan one of two ways. The fan can be run as a variable speed fan using components from the center column of the following table. The fan can also be controlled as an on/off device with some temperature hysteresis using the component values from the right-hand column in the following table.

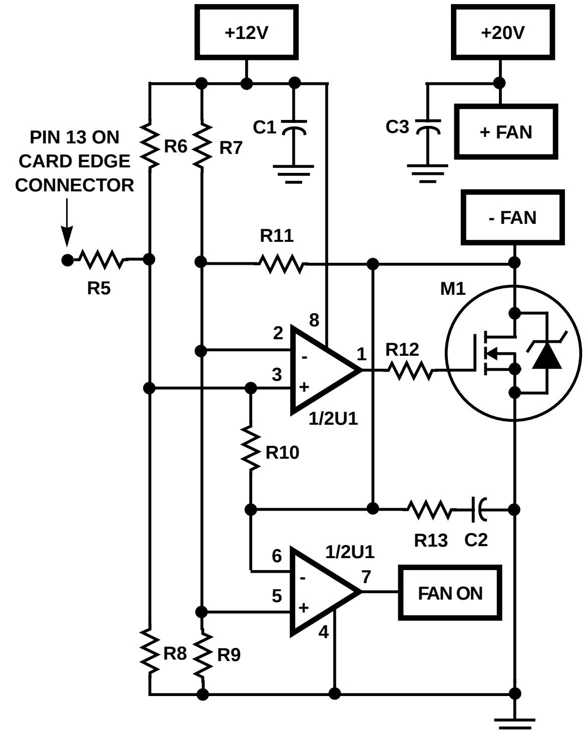

FIGURE 5. OPTIONAL EXTERNAL FAN CONTROLLER CIRCUIT SCHEMATIC

TABLE 2. EXTERNAL FAN CONTROLLER CIRCUIT COMPONENT VALUES

COMPONENT	VARIABLE SPEED FAN	FAN WITH HYSTERESIS
R5	10K	10K
R6	Open	23.2k
R7	90.9K	95.3K
R8	10K	1.5K
R9	10K	10K
R10	90.9K	Open
R11	Open	2M
R12	470Ω	470Ω
R13	2.2Ω	Open
C1	0.1µF	0.1µF
C2	1.0µF	Open
C3	0.1µF	0.1µF
U1	CA358	CA358
M1	RFD3055M	RFD3055M
ON/OFF	155µA/355µA	350µA/285µA

ENABLE Circuit

ENABLE Pin

There is an ENABLE signal on pin 11 of the HCA125 card edge connector. When the amplifier is operating properly, this signal is weakly pulled up to approximately +5VDC. A 5kΩ resistor and 1µF capacitor form an RC circuit that slows the pull-up of ENABLE at amplifier turn-on for quiet startup.

If the amp shuts down due to a fault or for any other reason, the ENABLE signal will be at ground potential. A power-on reset will reset any internal latches that may have pulled ENABLE low and deactivated the amplifier. A POR is accomplished by pulling one of the four power supplies to the HCA8001 (VDDA, VDDD, VEEA, or VEED) below approximately 5VDC. If the HCA8001 is powered through dropping resistors from the main power busses (as it is shipped in its evaluation form), the main power must be turned off and any power supply caps that are connected to the amplifier must be allowed to drain before the POR event will take place.

ENABLE also serves as a control input to the amplifier. If the amp needs to be muted or deactivated, pull ENABLE to ground. The RC time constant on the ENABLE pin ensures quiet startup. To ensure quiet shutdown, it is recommended that ENABLE be pulled down to ground before shutting down the bus voltage and floating 12V supplies. However, as long as ENABLE is pulled low within 1 to 2 seconds after the power busses and floating 12V supply go low, no turn-off transients should occur.

The ENABLE pins on each board in a system should only be tied together using diodes to isolate the different amps' ENABLE pins. Connect the cathode of a diode to each ENABLE pin and the anode of each diode to the control circuit that pulls ENABLE low. This hookup will prevent an entire amplifier from shutting down when only a single channel has a problem, thus making troubleshooting easier for the amplifier's user.

The figure below depicts a circuit that can be used to make the amplifier re-start after a fault condition. The MUTE-N pin is pin 27 on the HCA8001 and connects to the ENABLE pin on the card edge connector through the RC combination of R2 and C1.

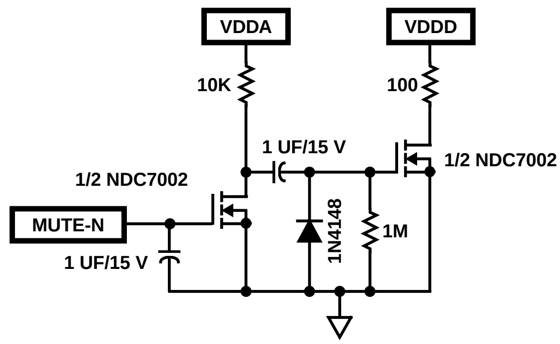

FIGURE 6. OPTIONAL CIRCUIT TO RESET THE AMPLIFIER ONCE FAULT LATCH HAS BEEN SET

HCA8001 Pinout and Description

The following table describes the pin connections for the HCA8001 control IC found on the HCA125ACREF amplifier module. The information is presented to aid in system troubleshooting. Intersil does not at this time provide support for third-party designs using the HCA8001 integrated circuit.

TABLE 3. HCA8001 CONTROL IC PINOUT AND SIGNAL DESCRIPTION

PIN	NAME	NORMAL SIGNAL	DESCRIPTION
1	VDDA	+7VDC	Positive analog power supply shunt regulator input.
2	ONDEL	Sawtooth Ramp	RC time constant connected to this pin sets dead time.
3	GND	Ground	Digital control signal ground.
4	CLAMP	DC voltage set by clamp resistor	Clamp to prevent overdriving IC.
5	DIFF+	Audio input signal or ground	Non-inverting input to differential amplifier.
6	DIFF-	Audio input signal or ground	Inverting input to differential amplifier.
7	DIFOUT	Audio output signal from opamp	Output from differential amplifier.
8	OPIN+	Audio signal	Non-inverting input to uncommitted opamp.
9	OPIN-	Ground	Inverting input to uncommitted opamp.
10	OPOUT	Audio output signal from opamp	Output from uncommitted opamp.
11	AGND	Ground	Analog control signal ground.
12	FB	±10mV Ripple	Integrator input.
13	COMP	Triangle or sawtooth wave	Integrator output.
14	VEEA	-7VDC	Negative analog power supply shunt regulator input.
15	VEED	-7VDC	Negative digital power supply shunt regulator input.

TABLE 3. HCA8001 CONTROL IC PINOUT AND SIGNAL DESCRIPTION (Continued)

PIN	NAME	NORMAL SIGNAL	DESCRIPTION
16	SFCLIP	Normally ground; pulses to ±7V during soft clipping activity.	Soft clipping indicator output.
17	CLIMIT	Normally ground; pulses to ±7V during current limiting activity.	Current limiting indicator output.
18	CLTO	Normally ground; slowly charges during current limiting situation.	When CLTO reaches a threshold, the HCA8001 shuts down due to current limit time-out operation.
19	CL-	-0.7VDC	Current limit sensing input.
20	PHASE	±7V Square Wave	Feedback to IC.
21	CL+	+0.7VDC	Current limit sensing input.
22	PGND	Ground	Power ground point.
23	LO	0 to -7V Square Wave	Lower gate drive signal.
24	HO	0 to -7V Square Wave	Upper gate drive signal.
25	FAN	Hi-Z (TEMP > 2V) or +7VDC (TEMP < 2V).	Signal used to drive an external fan.
26	TEMP	0 to 7V inversely proportional to temperature.	NTC thermistor in voltage divider circuit drives this pin.
27	MUTE-N	+5V during operation; ground when amp is shut down.	Indicates whether or not amplifier is active; can also be pulled low to disable amplifier.
28	VDDD	+7VDC	Positive digital power supply shunt regulator input.

Optimizing the Amplifier for Various Load Impedances

Speaker impedance varies with frequency. The design of the HCA125 is optimized for 2Ω - 16Ω. Special techniques are employed to prevent peaking at high load impedances and early roll off at low impedances. The amplifier is stable into 2Ω. For generic amplifiers, the design is already optimized. For powered speakers, parameters can be changed to optimize the circuit for any desired response. The advice of the CoolAudio engineer is recommended before attempting this optimization.

Optimizing Sound - Capacitor Selection

The BOM specifies a 1.5µF mylar capacitance for the output filter, C95. The sound of the HCA125 is enhanced by the use of a polypropylene. The additional cost should be weighed against the incremental cost.

The BOM specifies an npo for the integrator capacitor, C17. Sound is improved by the use of polypropylene, teflon or polystyrene. Since this capacitor is small, the incremental cost is small. Gerber files with a footprint for such a cap are available from cool audio.

X7R capacitors should be used only for power supply by pass. The voltage coefficient of these capacitors will introduce significant distortion. The BOM specifies npo for capacitors that are in the signal path. X7R substitutions for these key capacitors will compromise the sound and should be avoided.

Board Configurations

The samples are all built with an edge connector for the power supply connections. The gold plating on the pins of this connector add to the cost of the board. The gerber files for the HCA125 with a cheaper connector are available from cool audio.

References

For Intersil documents available on the internet, see web site http://www.intersil.com/
Intersil AnswerFAX (321) 724-7800

[1] Intersil Digital-5 Memo of EMC Compliance www.tecknit.com. EMI/EMC Design Information