DC Detection/ Solid State Relay

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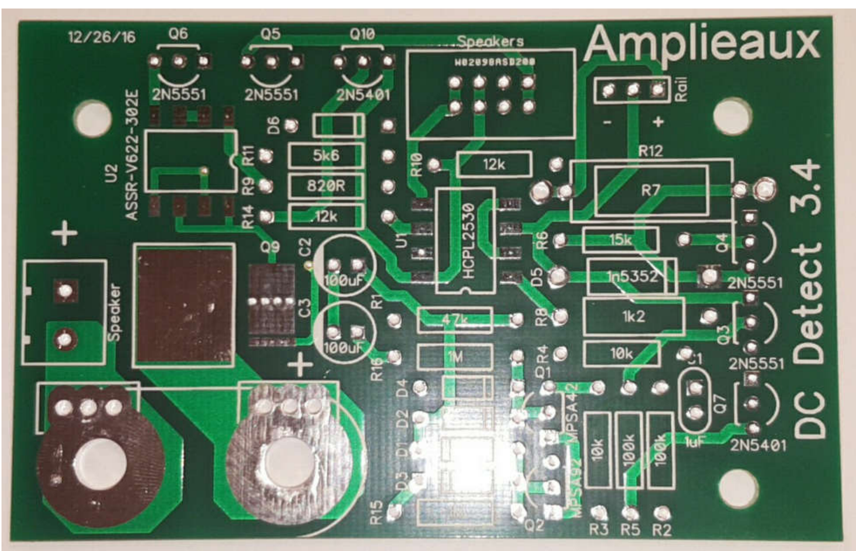


DC Detect 3.5 is a DC offset detection board with an integrated solid state speaker relay designed to mount on the power studs of a standard ¾” center 5 way binding post assemblies. It communicates with an Amp Control board to operate. The speaker output from the amplifier is completely optically isolated from the control board to eliminate the possibility of damage to the control board, as well as eliminating the possibility of ground loops between amplifier channels.

Basic Operation

A small signal from the speaker connection is fed past a low pass filter, which removes any AC from the signal. In normal operation of a correctly working amplifier, no signal would remain, but on a damaged amplifier producing DC on its output, a small voltage will remain.

There is a constant current source fed by the amplifier rail feeds that powers the input of an optoisolator. This optoisolator signals the solid-state relay, and also signals the Amp Control board that all is good. If DC signal makes it past the low pass filter, it causes feed to the optoisolator to be interrupted, turning off the speaker relay, and also signaling the Amp Control board of trouble at the same time. If rail power were to be interrupted, again the optoisolator would turn off, disconnecting the speaker and signaling problems to the Amp Control board again.

The solid-state relay also requires a go signal from the Amp Control board to turn on. This allows the Amp Control board to control on delay and off muting of the speaker.

BOM

Qty	RefDes	Name	Value	Mouser	Digikey	Newark
1	C1	CAP	1uF	80-C340C105K1R	399-4426-ND	18K5927
2	C2, C3	6.3x11x2	100uF	647-UVZ1V101MED1TD		65R3213
5	D1, D2, D3, D4, D6	DIODE_1N4148	1N4148	512-1N4148	1N4148FSTR-ND	05R0353
1	D5	1N4744	1N4744	78-1N4744A	1N4744AVSCT-ND	33C2792
1	J1	282836-2	Speaker	571-2828362	A98076-ND	282836-2
1	J3	Speakers	75869-132LF	649-75869-132LF	609-3530-ND	62K8136
2		IDC Connector	71600-108LF	649-71600-108LF	609-3569-ND	
1		Ribbon Cable			HF365/08SF	
1	J4	HDR-1x3	Rail	538-22-23-2031		
2	J5, J6	Faston		571-624091	A-24742-ND	01J0288
1	Q1	MPSA42	MPSA42	512-MPSA42	MPSA42FS-ND	97K5369
1	Q2	MPSA92	MPSA92	610-MPSA92	MPSA92CS-ND	
4	Q3, Q4, Q5, Q6	2N5551	2N5551	512-2N5551TA	2N5551TAFSCT-ND	31Y5847
2	Q7, Q10	2N5401	2N5401	610-2N5401	2N5401CS-ND	
2	Q8, Q9	MOSFETN_D	IPB025N-10N3 G	726-IPB025N10N3G	IPB025N10N3 GCT-ND47W3462	
1	R1	RES500	47k			58K3860
2	R2, R5	RES500	100k			58K3798
2	R3, R4	RES500	10k			58K3797
1	R6	RES500	15k			58K3813
1	R7	RES700	4k2 3W	71-CPF24.221%T1		
1	R8	RES600	1k2			58K3805
1	R9	RES500	820R			58K3879
2	R10, R14	RES500	12k			58K3806
1	R11	RES500	5k6			59K8680
1	R12	RES900	4k2 3W	71-CPF24.221%T1		
1	R13	RES500	470k			58K3861
2	R15, R16	RES500	1M			58K3799
1	U1	Optoisolator	HCPL2530	512-HCPL-2530	HCPL2530-ND	67K0214
1	U2	Mosfet Driver	ASSR-V622-302E	630-ASSR-V622-302E	516-2689-5-ND	

Note – Values of R7 & R12 may need to altered to match rail voltages used in the amplifier. See testing instructions below.

Tools Required

These instructions are written assuming you are using a conventional soldering iron. Basic tools and supplies are required. You will need a fine tip for small parts, as well as a large tip. A good temperature controlled 40W station set to 700F makes soldering very easy. Aside from this you will need the following:

- Isopropyl alcohol
- Liquid or gel flux
- Flux remover
- Good quality flux core solder
- Solder wick or a solder sucker
- Good quality fine tip tweezers
- A good light. A Luxo type with a fluorescent ring tube bulb and magnifier works great
- Multimeter
- Adjustable power supply
- USBtinyISP or similar in circuit programmer
- USB to serial UART. Our rear panel mount USB adapter will work great here.
- A clean work surface, preferably over a smooth hard freshly swept floor.

Assembly

To begin, first wash the circuit board thoroughly with isopropyl alcohol. Wipe it dry with clean paper towel and immediately coat all solder pads with liquid or gel flux to prevent oxidization.

Proceed with assembly by installing all the lower height parts first, and work your way up to the tallest parts.

Before installing the speaker relay Mosfets, insert some cut off resistor leads or single strand wires through the via holes in the pads and solder in place. This is done easily with the board standing vertically while you solder the wires in place. These wires will be carrying the amplifier output signal from one side of the board to the other. The vias alone wouldn't handle the current from the amplifier. If you happen to have some low temperature solder paste apply this to the large Mosfet pad now. Next set a Mosfet in place and reflow the solder. If the Mosfet is straight and sitting flat, solder all the pins down. Next begin heating the tab of the Mosfet and the large pad on the board with an iron with a large tip. This will take a lot of heat. Once solder is flowing go around the whole perimeter with heat and solder. Press down lightly on the Mosfet with your tweezers to squeeze out excess solder. Hold it in place while the solder solidifies. Immediately flip the board over, trim the leads on the opposite side and install the next Mosfet while the board is still hot. It solders much easier this way. Repeat this with the other pair of Mosfets.

Follow soldering by washing all the excess flux off the board. Flux remover or Isopropyl alcohol will remove most of the goo. This can be followed by a mild soap and water wash and distilled water rinse if you used the suggested wash approved relays. Allow some time for complete air drying before applying power.

Testing

The DC detection circuit is designed to operate at 15VDC from the rail feeds, and is regulated by R7, R12 and D5. R7 and R12 need to be selected to deliver approximately 16mA (8mA each) to the circuit. Their value is calculated by subtracting 15(V) from the rain voltage and dividing the remainder by 0.008(A).

With no DC present on the speaker input connector, current flow through R8 should be approximately 8mA.

Once the DC detection board is assembled and connected to an Amp Control board and is receiving the speaker on signal from the Amp Control board, current flow through R9 should measure approximately 8mA. Drain to source resistance should be very close to zero ohms when on, and very high when off.

To test operation, apply low voltage to the speaker power input connection with an adjustable power supply. Connect the supply ground to the rail feed ground. Speaker ground on the control boxboard is not connected to the sensing circuit. Slowly increase this until the protection system is activated. This should happen at less than 2VDC. Power cycle the protection board and repeat the test with the voltage source reversed. Again, it should trigger a shutdown at less than 2VDC.

Circuit Explanations

The board has a DC detection circuit for one amplifier output, and one output Mosfet relay. There are two separate grounds on the board, digital ground and analog ground. These do not connect together.

DC Detection

A small sample from the output of the amplifier is taken through R1. Any AC in this sample is shorted to **analog ground** (there are two separate “grounds” in the control board, analog and digital. They are not connected to each other) through a pair of opposite orientation series capacitors (C2 and C3). In normal operation, there no voltage will remain after the capacitors. If there is enough DC present, the capacitors will block it from ground and pass it to D1 and D2. If there is positive DC present, current will flow through D2, into the base of Q1. The emitter of Q1 is connected to the emitter of Q2. The base of Q2 is held at near analog ground potential through D3. If the DC voltage becomes high enough to overcome the forward voltage of the two diodes and the two transistor bases, current will flow through R3 and R4. If negative DC is present on the output, it is routed through D1 to Q2 and causes the same reaction. We add R15 and R16 to drain any stray voltage from the bases of Q1 and Q2.

The emitter of Q7 is connected to positive rail voltage from the amplifier. It’s base is connected to rail voltage through a 100k resistor (R2) to create a simple constant current source. The current that flows through the collector of Q7 flows to the base of Q3 through a 100k resistor(R5). When there is no current flow through Q1/Q2, Base and emitter voltage of Q7 will be equal, so no current will flow through it’s collector. We add C1 to stabilize the voltage to the base of Q7. This is required if there is a large amount of ripple in the rail voltage feeds. We add the 470k resistor (R13) to the base of Q3 to ensure it turns off.

We pass rail voltage through a pair of “ballast resistors” (R7 and R12) and regulate it to around 15V with D5. We pass this voltage to the collector of Q4. We also pass this voltage to the base of Q4 through a 15k resistor (R6) to form a constant current source. Current flows through the emitter of Q4, through the inputs of an optoisolator (U1). We need to put R8 in series with the inputs (LEDs) of U1 to stop them from burning up. In normal operation with no DC present on the output of the amplifier, there should always be approximately 8mA of current flowing through the inputs of U1. This is called operating in failsafe configuration. If there was an open circuit failure in the DC detection circuit, or in the rail feeds to it, U2 would switch off signaling an alarm and turning off the speaker output.

If there is DC present on the output of the amplifier, current will flow through the bases of Q1 and Q2, causing current to flow through the collectors of Q1 and Q2 to rail negative. This will cause voltage to drop at the base of Q7, causing current to flow through it’s collector, through the base of Q3. When current flows through the base of Q3, it causes all the available current provided to the base of Q4 to flow through the collector of Q3 to ground. This causes Q4 to switch off, which in turn switches off U1.

DC Offset Alarm

The emitter of Q5 is connected to DC Alarm pin from the control board. There is a 5V pull up signal from the control board on this pin. We feed current to the base of Q5 through a resistor (R10) from the 12V feed from the control board. This will cause current to flow through the emitter of Q5, through D6 to

digital ground. This will signal an alarm condition to the microcontroller, telling it there is DC in the output signal of the amplifier, causing a shut down.

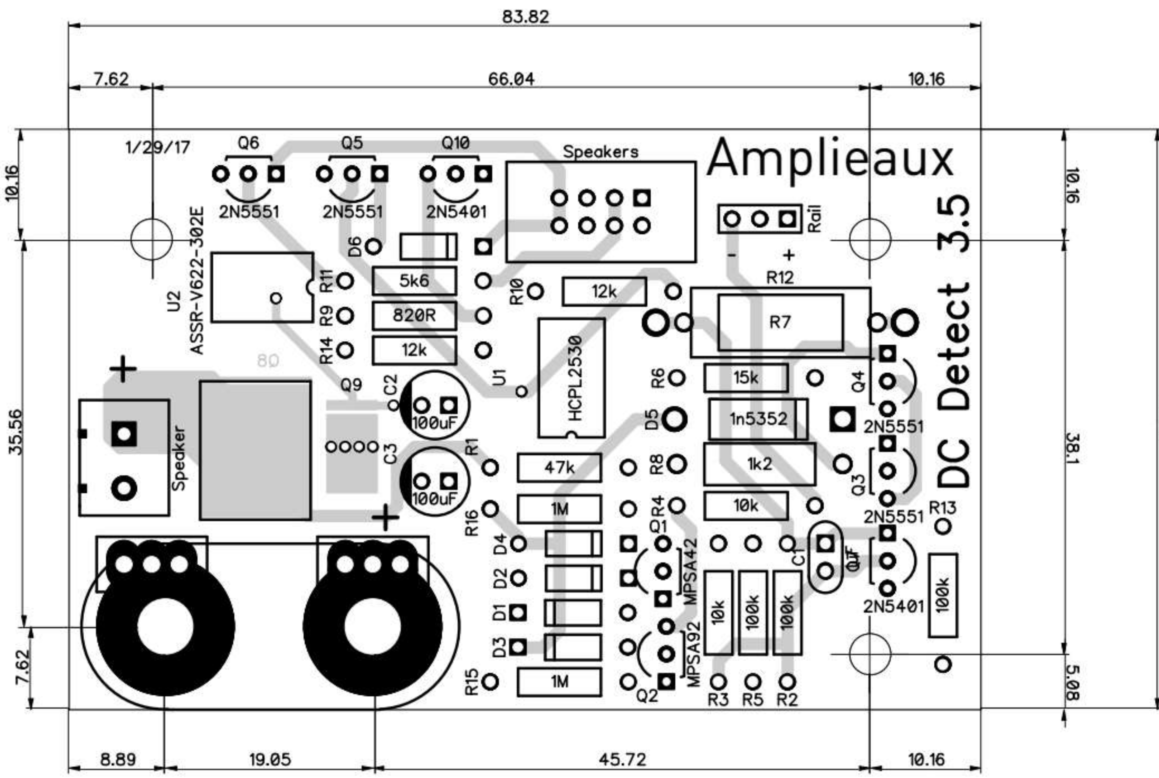
In normal operation, the inputs of U1 are active (on). The base of Q5 is connected to output 1 of U1, which causes all the current supplied by R10 to flow through U1 to **digital ground**. This prevents current flow to through the base of Q6, so no current will flow through the collector of Q5, so no alarm signal is detected by the microcontroller.

If the inputs of U1 stop receiving current from the DC detection circuit, current flow stops through the output of U1, starting current flow through the base of Q5 again. We add the diode (D6) in series with the emitter of Q5 to ground to raise the voltage required to cause current flow in the base of Q5 because the on state (low) output of U1 is around 1V.

MOSFET Relay

We use a Mosfet relay driver (U2) to drive a pair of series opposed orientation output Mosfets. The microcontroller gives an on signal through the speaker on pin of the control connector. We pass this signal through the emitter of Q10. The base of Q10 is connected to output 2 of U1 through a resistor (R14). In normal operation, the output of U2 will be at a low state, which will cause current to flow through the base and collector of Q10. Current will flow through R9, through the inputs of U6. If DC is present on the output of the amplifier, U1 will switch off, causing current to stop flowing through the base of Q10, tuning off the inputs to U2. At the same time, the microcontroller will have received an alarm signal and will have gone into protection shut down, which will shut off the signal to the speaker on pins of the control connector, adding a redundant shut down of the Mosfet relay driver.

The Mosfet driver (U2) output approximately 7V when there is current flowing through it's inputs. We parallel the outputs to add some extra current for faster charging and discharging of the output Mosfet gates. U6 also contains quick shut down circuits that quickly turn the output Mosfets off when needed. The output Mosfets contain safety diodes from drain to source to protect themselves so we need to use two in series with opposite orientation to be able to switch off an AC signal



83.82
7.62
66.04
10.16
1/29/17
Q6
Q5
Q10
2N5551
2N5551
2N5401
Speakers
Amplieaux
Rail
DC Detect 3.5
U2
ASSR-V622-302E
D6
R11
R9
R14
5k6
820R
12k
R10
12k
R12
R7
U1
HCPL2530
Q9
C2
100uF
C3
100uF
R1
R16
47k
1M
R6
15k
D5
1n5352
R8
1k2
R4
10k
Q4
2N5551
Q3
2N5551
R13
Speaker
D4
D2
D1
D3
Q1
MPSA42
MPSA92
Q2
C1
10k
100k
100k
100k
2N5401
R15
1M
R3
R5
R2
10.16
35.56
7.62
53.34
38.1
5.08
8.89
19.05
45.72

Schematic diagram