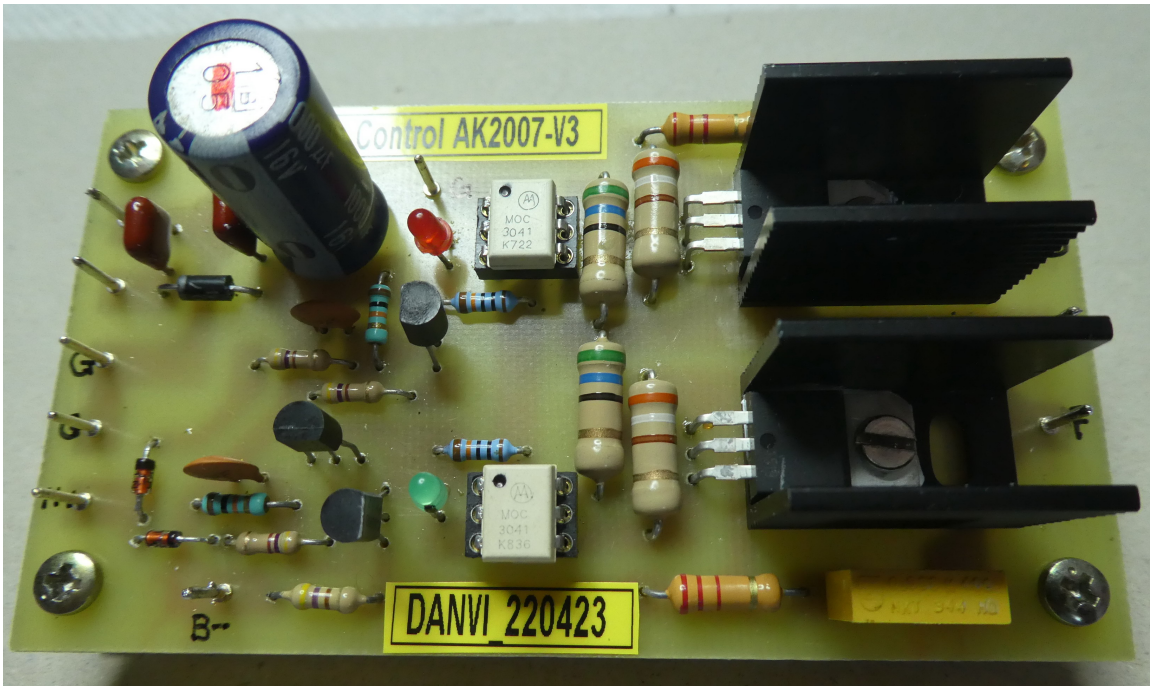
Fast/Slow motor control circuit for vintage Leslie's

by Dan.Vigin



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Binche / Belgium **April 2022**

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1 Forewords – Purpose of this project.

This article is mostly destined for owners playing on vintage Hammond organs (B3, C3) and associated to Leslie cabinets such as L122, L147 and the like.

The original speed switching systems of Leslie cabinets used is somewhat questionable and to my opinion does merit some improvements. Some static relay systems are available on the market to alleviate the shortcomings such as clunky relays, tube replacements, pop noise during switching, etc..

The objective is to provide a simple and easy to implement solution with some basic knowledge avoiding complex modifications at both organ console and Leslie sides.

Way of F/S switching at organ console is rather elementary, only one ON/OFF switch has to be installed at swell pedal end f.i. or via half-moon device of Leslie kits.

The proposed solution does offer several advantages. There is no AC or DC voltages during switching, only the 'ON/OFF ground level' does the job. Moreover, the original Leslie cable (generally 6 leads) remains as it is. Therefore, no drastic modifications on mechanical level are needed. The circuit can easily drive either 115V or 230V motors.

To be noted that if 8 leads link between the console organ and Leslie is used (f.i. Neutrik Speakons) by replacing the ON /OFF switch with one inverter, then the 'Leslie Stop' feature becomes available. Two connecting leads are compulsory instead of one in this case.

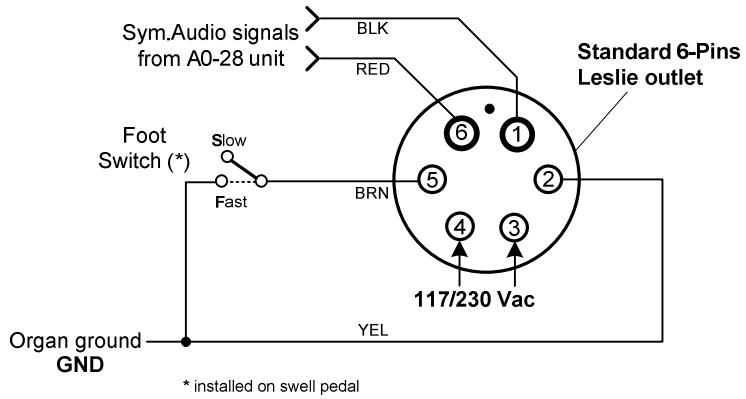
At Leslie end a small printed circuit has to be installed in the Leslie amplifier.
Only current electronic components used and this circuit is simply powered by the 6.3Vac voltage of the transformer (filament heater).

It is important to recall that some areas of the circuit are carrying AC mains voltages. Evident safety protections have to be taken into consideration.

*Note: **F/S** stands for Fast/Slow function.*

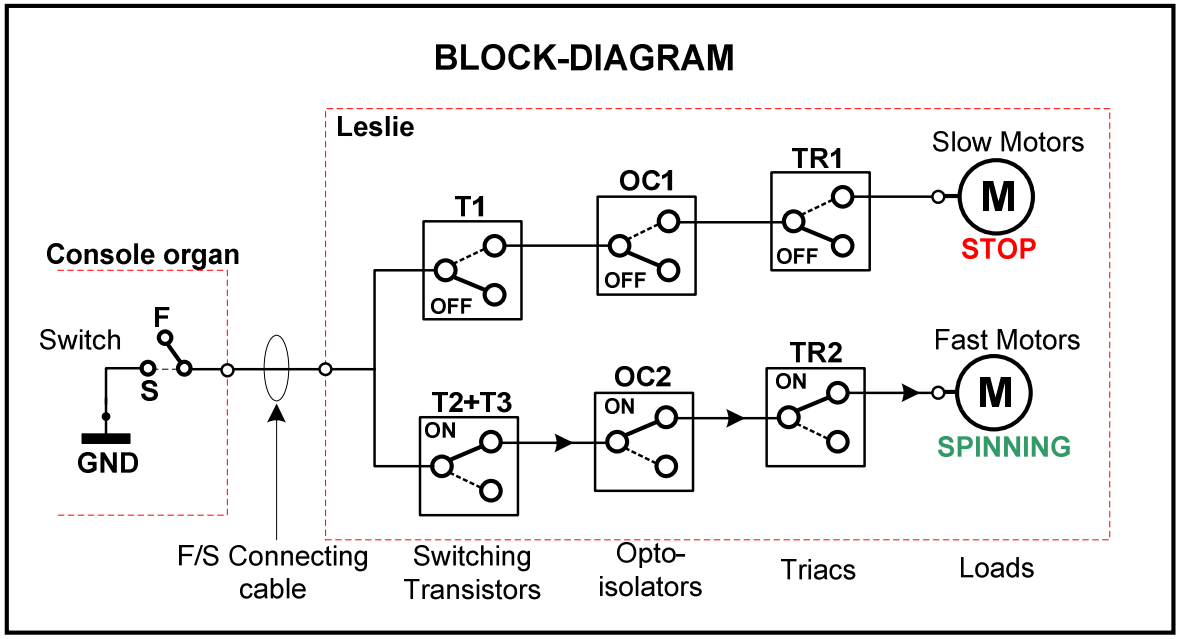
2 OVERALL BLOCK DIAGRAM.

Generally, the connecting cable used between vintage organs and Leslie cabinets is composed of 6 wires as described here-below (organ side).



The high DC voltage coming from Leslie cabinet at pin #5 is no more needed and this wire will be used to monitor the F/S control circuit.

At the other end, at the Leslie inlet, this wire has to be recuperated to command the F/S control circuit.



The signal from Pin #5 available at Leslie inlet will trig the F/S circuit. Of course, the main ground connection at Pin #2 coming from the organ must be maintained as it is to make the system operating. See later in cabling section.

Basically, the F/S circuit is composed of two channels of devices.
The upper one T1 + OC1 + TR1 will drive the **Slow** motors.
The bottom one T2/T3 + OC2 + TR2 will drive the **Fast** motors.
The power supply is not displayed on this block diagram and will be covered later on.

3 BASIC DESCRIPTION OF OPERATION.

On the next page, the sketch exhibits the different states of operation for each channel.
For clarity purpose, several components do not appear on this sketch since there are not relevant to understand the four states of this circuit.

S/F switch closed.
In this condition, diodes D1 and D2 are both grounded.

At Slow motor end, the base of NPN transistor T1 becomes more positive than its emitter and T1 becomes fully conductive (saturated).
LED 1 and LED 2(1) are so conductive and triac TR 1 switches ON the Slow motors.

At Fast motor end, the situation is just reversed, transistor T2 and T3 being mounted in inverse coupling configuration, the base of T3 stays at same level as its emitter. Therefore, T3 no more conducting and then fully blocked.
LED 1 and LED 2(1) are switched OFF as well.
The opto-isolator MOC 3041 is not in operation as well as triac TR 1.
Consequently, Fast motors are stopped.

S/F switch opened.

In this condition, diodes D1 and D2 are no more grounded (floating).

At Slow motor end, the base of NPN transistor T1 is equal to the voltage of its emitter. This transistor is blocked.
The opto-isolator and associated triac TR 1 are no more activated.
Slow motors are so inoperative.

At Fast motor end, here again the behaviour of this channel is reversed due to the inverse coupling of T2 and T3. The base of PNP transistor T3 is 0.7 V more negative than its emitter and T3 becomes fully conductive activating both LED 1 and LED 2(1).
Triac TR2 switches ON and full voltage drives Fast motors that are spinning.

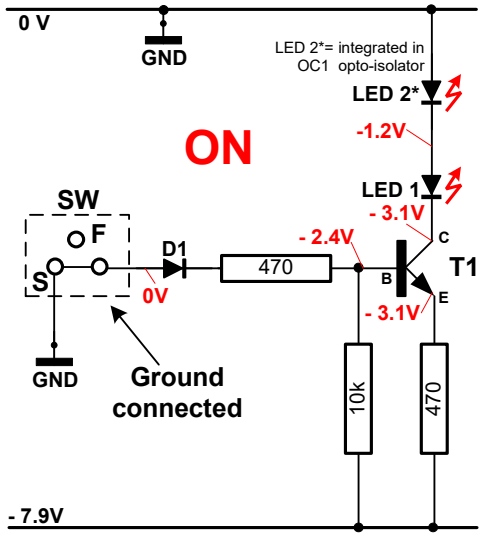
(1): built in opto-isolator MOC3041

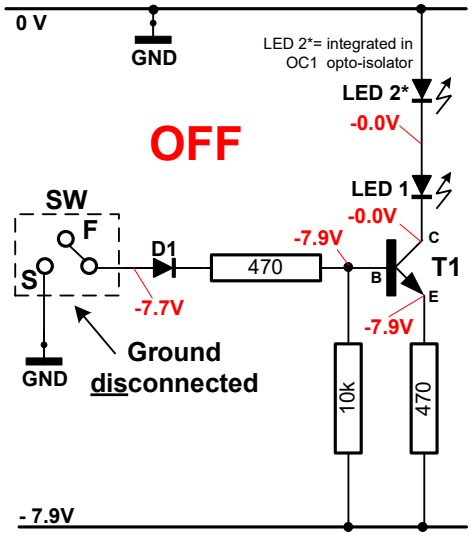
Different states of operation

This left column shows the circuit operations **with the switch closed.**

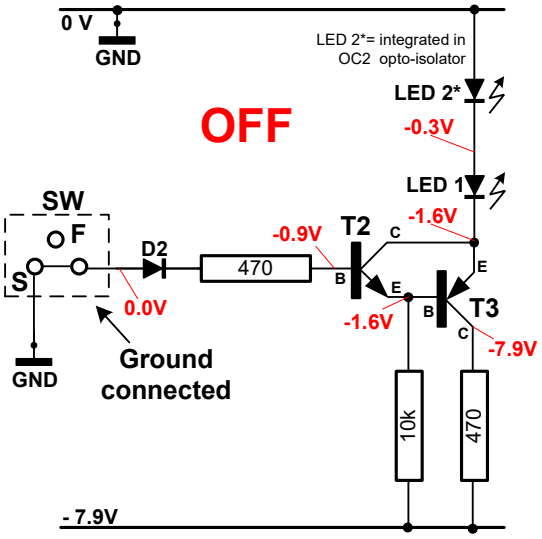
This right column shows the circuit operations **with the switch opened.**

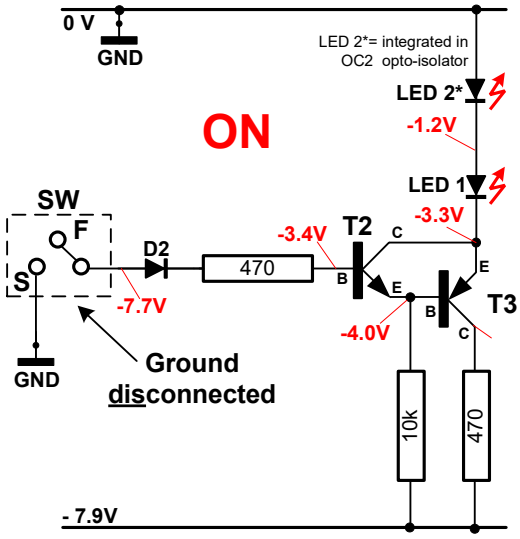
SLOW MOTOR





FAST MOTOR





5 Fast/Slow switching circuit.

The overall schematic diagram is shown on the next page and can be summarized as follows:

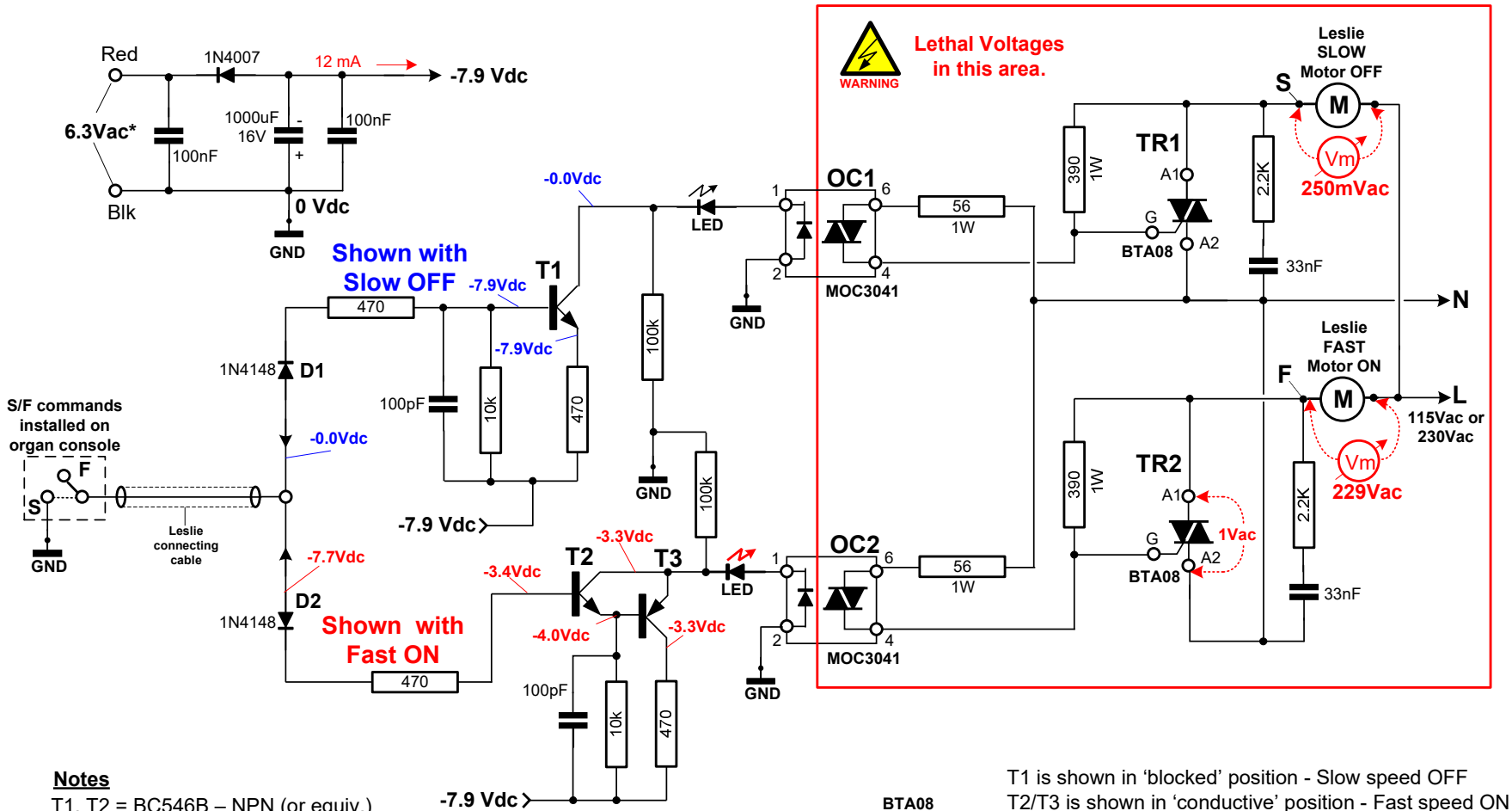
- **Power supply**: quite basic. The 6.3V AC voltage is provided from the filament heater of the power transformer of the Leslie amplifier. Simple rectifier assured by one single diode 1N4007 filtered by one capacitor of 1000 µF/16V. Two decoupling caps of 100nF have been added. A DC voltage of -7.9 Vdc is so available to supply the overall switching circuit. Total consumption is max.12mA to feed the low voltage section of S/F switching components.

- Low voltage switching section ('Slow' channel) circuit on the upper side is using one NPN transistor BC546 (T1) that operates as an ON/OFF switch in function of the position of the S/F command installed on the organ console. Whenever the S/F command is open, the base and emitter of T1 are on the same level and transistor T1 is blocked. The opto-isolator OC1 is not activated and Slow motors are stopped.
Inversely, if S/F command is grounded ('S' position), the base of T1 becomes more positive of its emitter and T1 is conducting (saturated), driving so the opto-isolator OC1 and latter on the slow motors chain.

- The lower switching section (Fast channel) is composed of NPN transistor T2 and PNP transistor T3. If F/S command is not grounded, as we have just seen, the Slow channel is not activated however the base of transistor T3 inversely coupled with transistor T2 is now negative that its emitter and T3 becomes conductive, as well as opto-isolator OC2, and at the end fast motors are spinning. If the S/F command is grounded, then the base of PNP transistor T3 becomes more positive than its emitter via T2 and transistor T3 is totally blocked and fast motors are stopped.

- High voltage section located on the right side is carrying AC mains voltages. The role of both opto-isolators OC1 and OC2 is to provide a total galvanic isolation between the switching section and the AC power section.
Operations of this section is rather simple. The infrared emitting diode is optically coupled to a silicon detector that perform the function of a zero voltage crossing bilateral triac driver. Those opto-isolators are designed for use with triacs in the interface to equipment powered from 115Vac or 230 Vac lines.
The terminal #4 of opto-isolator trigs the gate of the related triac TR1 or TR2. Once trigged, triac reacts as a basic power switch and either activate or switch off the load (motors in this case). The RC cell with resistor 2.2K and capacitor 33nFavoids transients during triac switching if any. This part of the circuit carries AC mains voltages and usual safety protections are therefore compulsory.

- S/F command (simple ON/OFF switch) installed on console organ allows the player to use either Fast or Slow speeds of the Leslie motors. This switch can be a foot-switch installed on the swell pedal or an half-moon system currently found in Leslie kits. Of course, the original ground connection of the organ has to be kept and connected to the ground terminal of the low voltage switching section (zero volt).



Notes

T1, T2 = BC546B – NPN (or equiv.)
T3 = BC556B – PNP (or equiv.)
Triacs TR1,TR2 = BTA08-600B
* = 6.3Vac from Leslie transformer (fil.heater)
S = Slow speed motor operation
F = Fast speed motor operation

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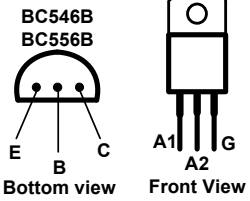
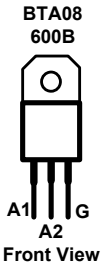




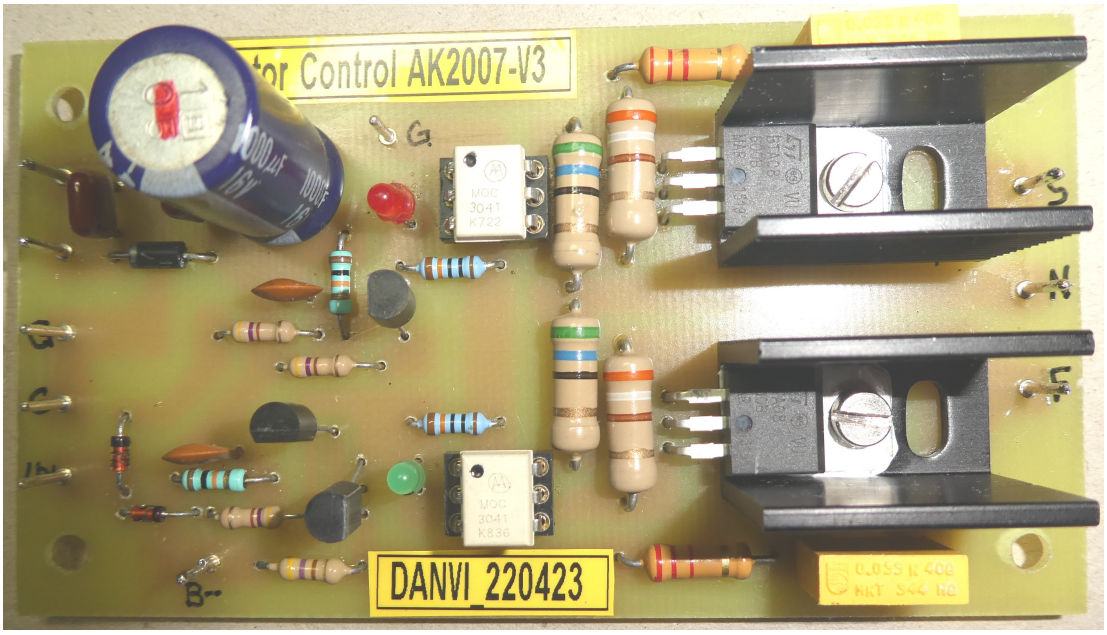
T1 is shown in 'blocked' position - Slow speed OFF
T2/T3 is shown in 'conductive' position - Fast speed ON
All resistors are ¼ W unless specified.
This circuit operates with 117Vac or 230Vac Leslie motors

Fast/Slow switching circuit L122

Static Universal - Version 3 AK_2007
Re-Designed by : Dan.vigin
Date : 220422

7 Realization and cabling.

All components are mounted on a single layer epoxy PCB of 105 mm x 57 mm.



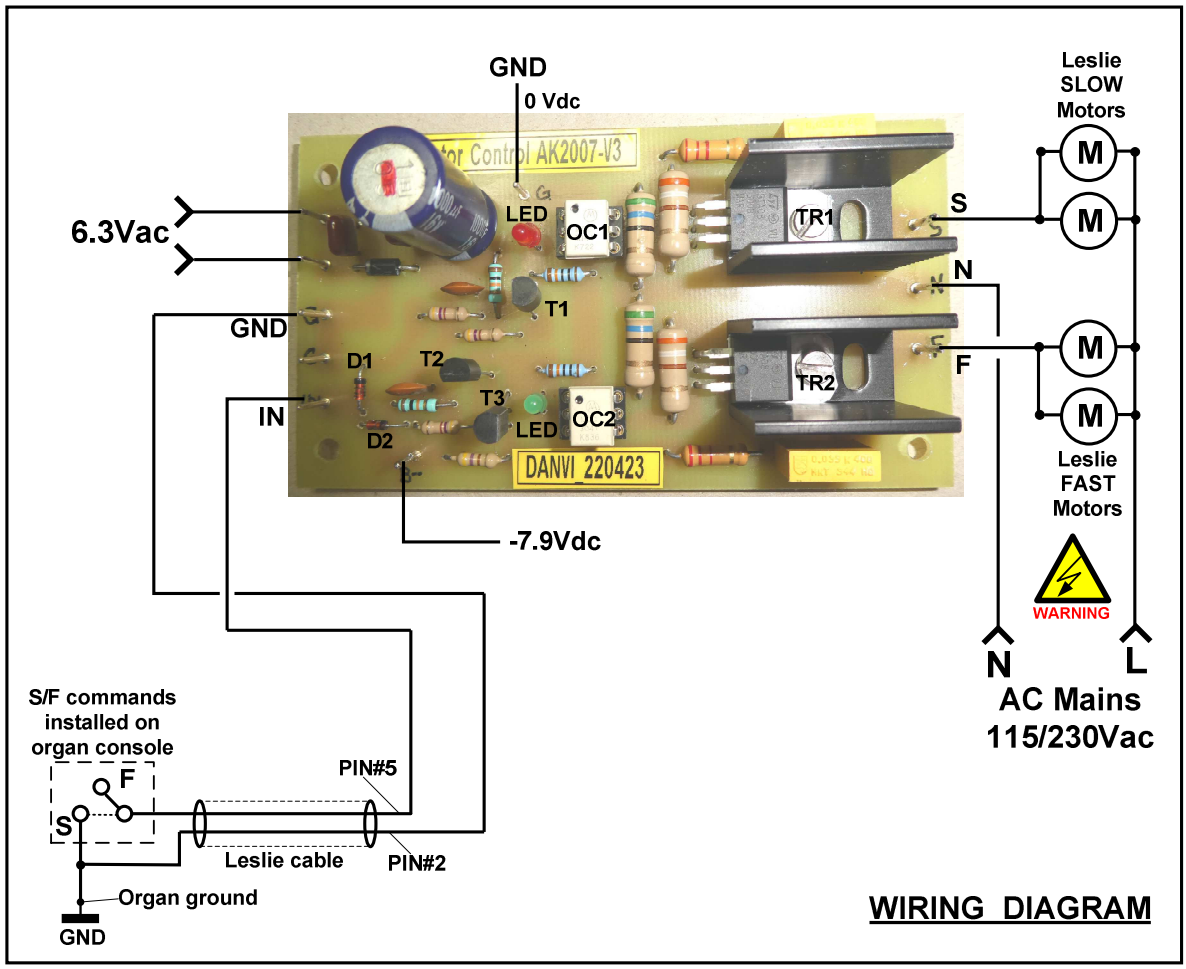
There is no special difficulty to realize this circuit. Both opto-isolators have been installed on 6-pins sockets. Triacs TR1 and TR2 are mounted on TO-220 heatsinks. The body of BTA08 being insulated there is no particular precautions to be taken on a safety standpoint.

Hereunder is another view of the PCB installed on a metal support ready to be mounted in Leslie L122 amplifier.

8 WIRING DIAGRAM

There is no special difficulty to install this small PCB in the Leslie amplifier. Evidently, former components like relay, tube and associated other components have to be removed.

The new cabling scheme has to be implemented as indicated on the sketch here-below.

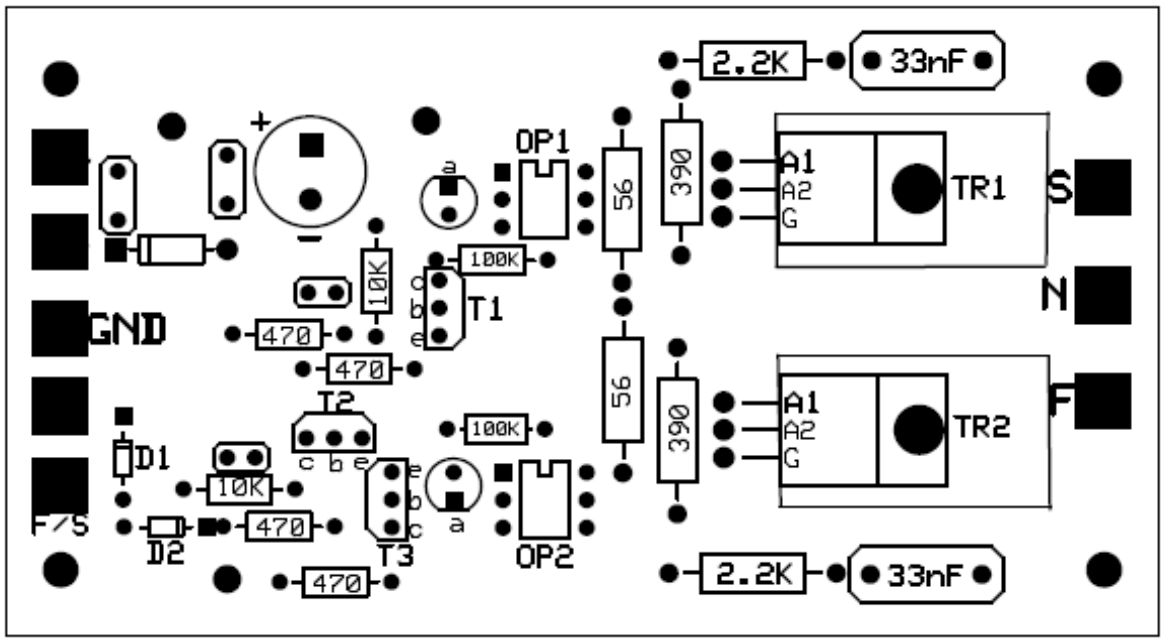


Needless to recall that some precautions have to be taken so that the PCB is mechanically fixed on the chassis with enough distance to any metal parts since it carries AC Mains voltages !

9 Printed Circuit Board.

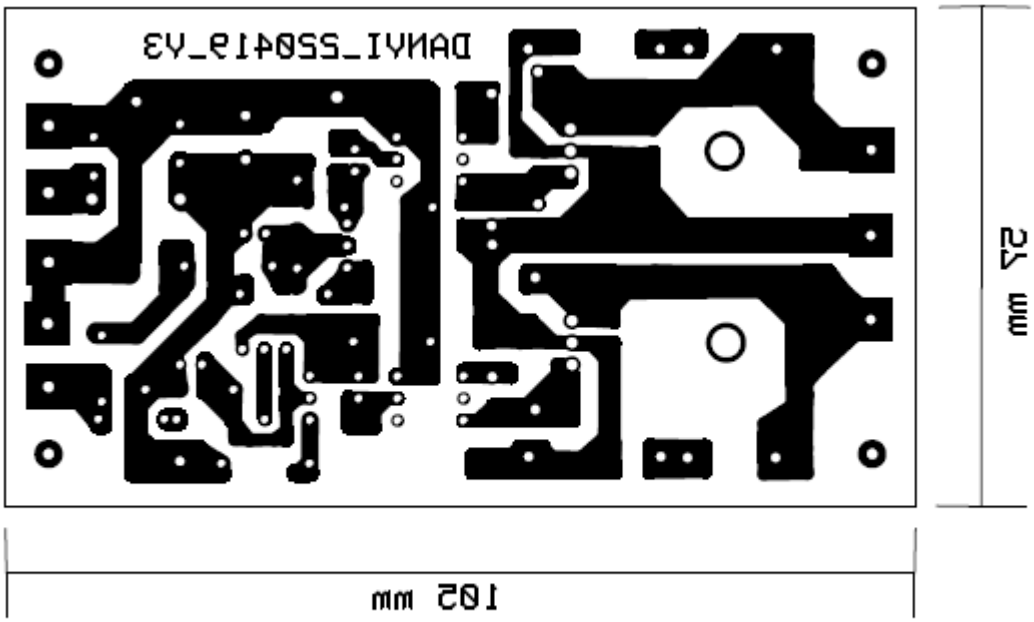
With the next drawings the PCB can be easily created.
PCB overall size: 57 mm x 105 mm.
For clarity purpose, the components layer is enlarged than reality.

Components layer.



Copper layer.

The size of copper layer here-under is somewhat greater than real size. Be sure to adapt the typon accordingly. Moreover, this view is seen from the components side and must ne inverted.



10 Conclusion.

This little project is rather easy to realize by any ‘workbench technician’ because of its simplicity.
The use of commercial components available in any electronic shop renders the project quite cost effective as well.

This F/S control circuit can be adapted to another additional function like ‘Leslie Stop’. However in this case it requires one more lead and the orginal 6-pins Leslie connecting cable has to changed and replace by 8-pins connectors (Neutrik Speakon or similar) and new cable. This solution involves serious mechanical adaptations that are not so easy.

I take this opportunity to also thank my friend Daniel Vermeulen for his contribution in this project.

Any comments or positive remarks are welcome.

Dan.Vigin