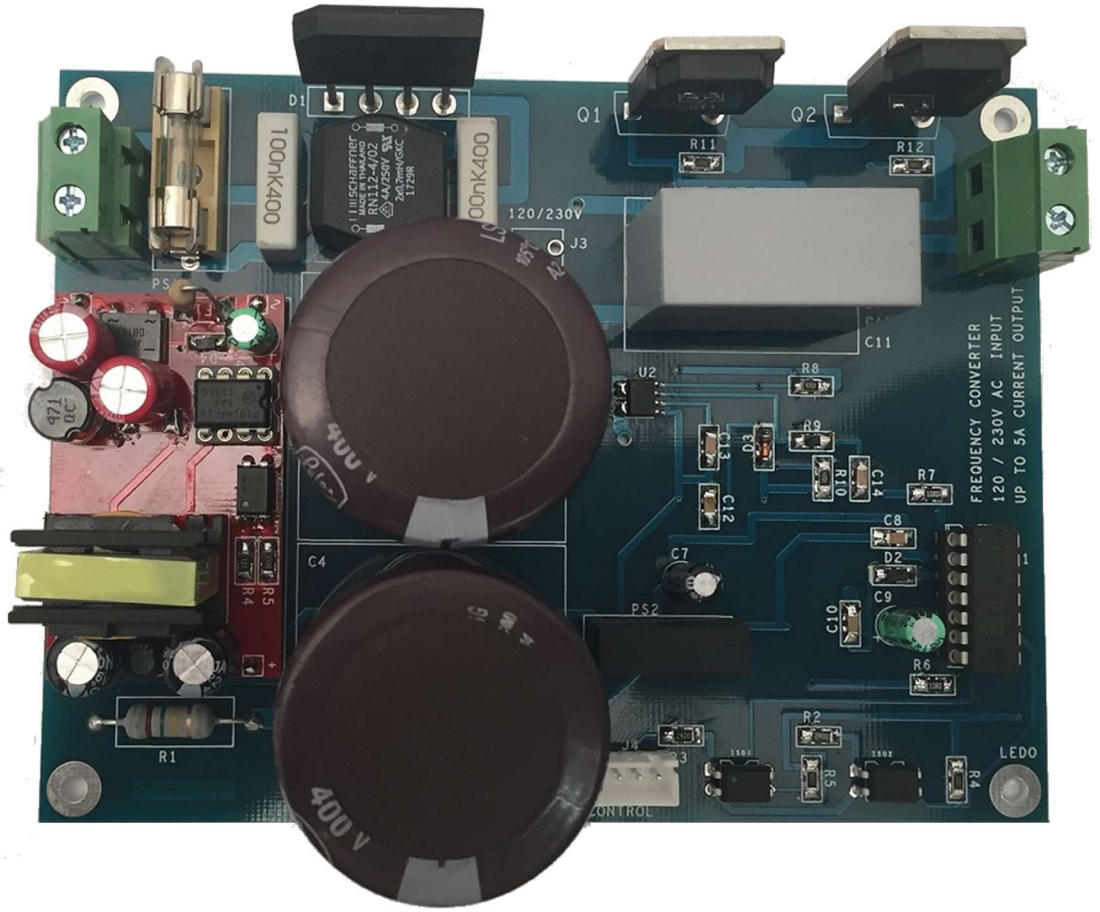
SINGLE PHASE FREQUENCY CONVERTER



- **110V / 230V AC Supply Voltage**
- **Up to 5 A Output Current**
- **Driver IR2110 on Board**
- **Current Protected**
- **High quality C Snubber**
- **Output Frequency up to 50 KHz**
- **Arduino compatible**
- **12V DC available to power the control system**

The module contains all the necessary power elements for the implementation of an efficient and versatile single-phase frequency converter.

Although it is intended to serve as a training and learning kit for students, it can also be used as part of a professional converter, with very diverse applications:

- Speed control by frequency of a single-phase alternating current motor up to 1HP
- High voltage generation, using high frequency transformer
- Ultrasonic cleaning equipment
- Feeding of vibrators with electromagnet
- Etcs.

It has a line rectifier, which allows selecting the supply voltage between 110V and 230V AC, to obtain a rectified and filtered voltage of about 300V DC at its output. The capacitors C3 and C4 of the filter also fulfill the function of a voltage divider, offering a middle point for the load connection.

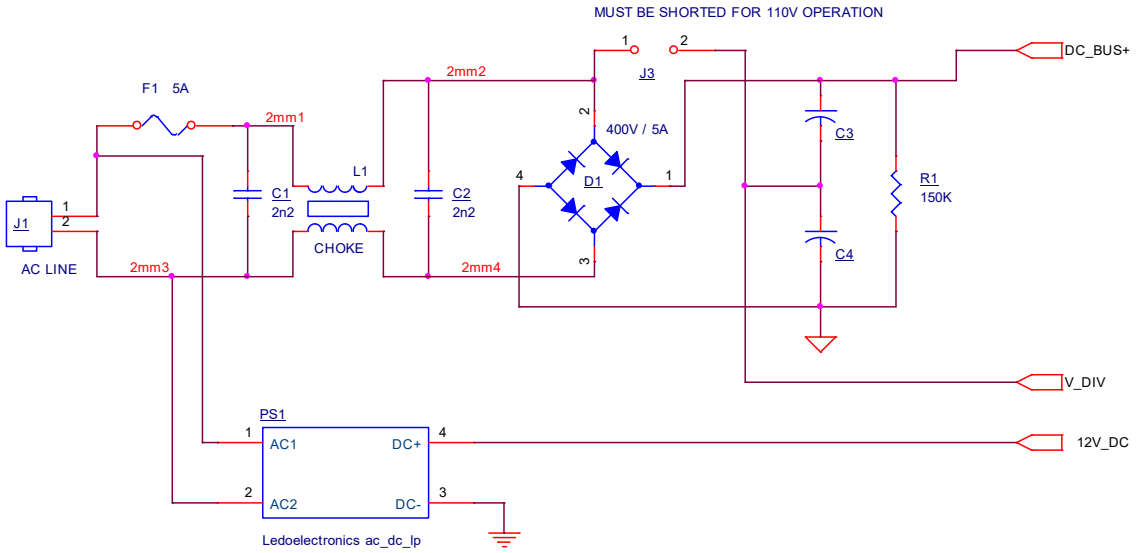


Fig.1. AC-DC Circuit.

The board incorporates the PS1 power module, manufactured by Ledoelectronics, which produces 12V DC isolated from the network, to power the control system.

For the excitation of the MOSFETs or IGBTs a gate amplifier has been implemented, based on the popular IC IR2110 from International Rectifier in its standard connection. For its power supply we use the isolated DCDC TMA1212S, since we need the 12V DC

Isolated from the AC line potential, available for the control circuit. For the same reason, we use two optocouplers to isolate the control signals.

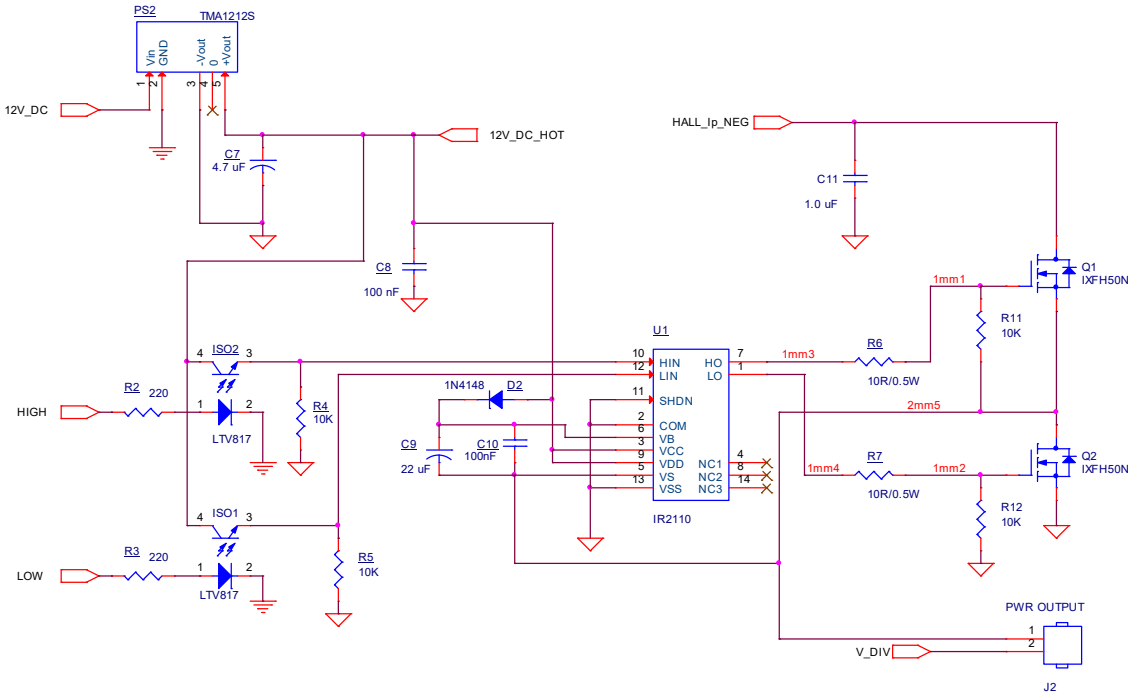


Fig.2. DC-AC Circuit.

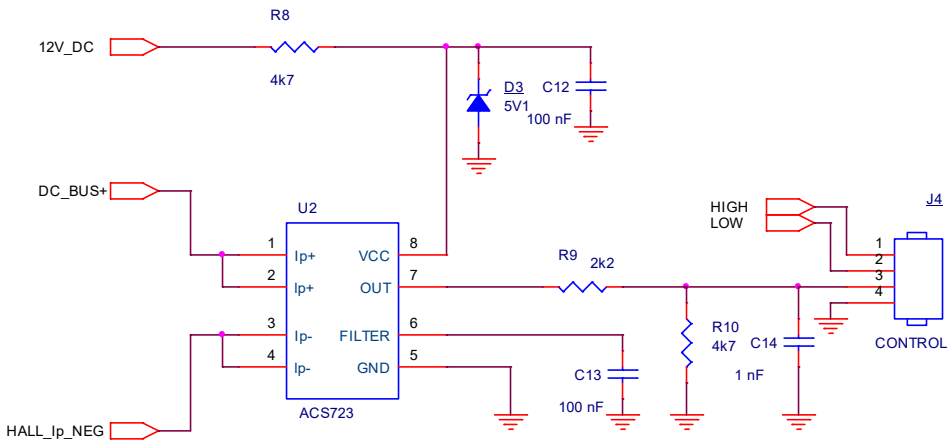


Fig.3. Hall Sensor and signal Inputs.

The IC ACS723-05 offers an analog voltage at its output that is linearly dependent on the current flowing through the drive load. Its value is 2.5V in the absence of current, and it increases at a rate of 400 mV / A. Resistors R9 and R10 form a voltage divider, to adapt their output to 3.3V microcontrollers. The current analog signal present on pin 4 of the J4 connector can be used by the control circuit to protect the converter.

CONTROL SYSTEM

This module does not have any control system. For its operation, it requires a minimum of two digital signals out of phase 180º for the excitation of the power transistors. Furthermore, it would be useful to be able to manage the analog current signal, as a means of protection.

The control circuit for this converter is relatively straightforward, and those unfamiliar with microcontroller programming can implement it with hardwired logic.

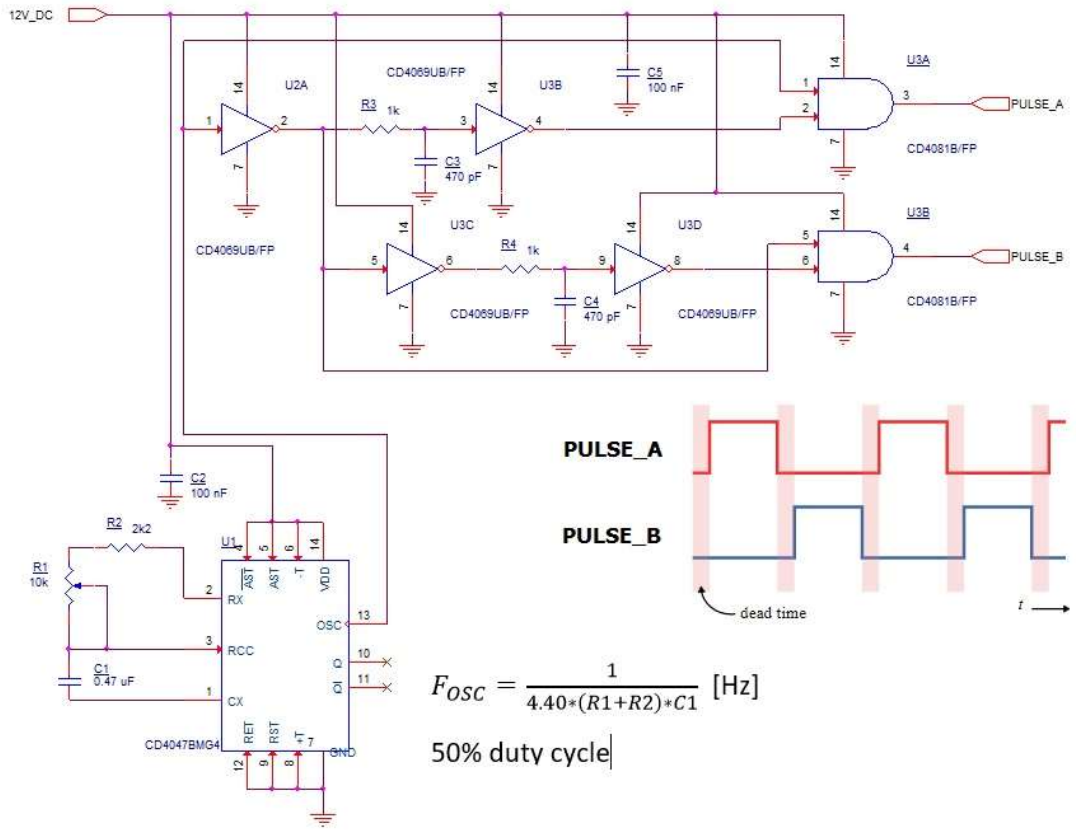


Fig. 4. Control circuit based on IC CD4047.

The CD4047 IC already generates the two 180º out-of-phase signals, necessary for the operation of the converter (these are present on pins 10 and 11), however, their use is not recommended, due to the absence of dead times.

In this type of converter both power transistors are on the same arm, and the working voltage is high (more than 300V). A peculiarity of all power semiconductors that are used as switches is that they are all faster to turn on than to turn off. This is even more pronounced in the case of IGBTs and thyristors.

If we use two signals 180º out of phase and with a 50% duty cycle, then in each commutation (twice per period) both transistors are conducting at the same time for hundreds of nanoseconds. Although very short, this is a full-blown short circuit, which

lowers the performance of the converter, generates a lot of noise, and can damage the transistors. In English literature this is known as Shoot-through Current.

For this reason, in the circuit of Fig. 4. We use additional circuitry to generate the dead times. To this circuit we could also add an analog comparator LM293 and combine it with the two unused AND gates in U3 to protect the converter using the current signal from the Hall detector ACS723-05.

Hardwired logic is the past. Much more attractive is to make the control system taking advantage of the hardware resources present in modern microcontrollers that we see in all digital platforms. The microcontroller control allows to implement PWM modulation, to reduce the output voltage, as we decrease the motor working frequency, keeping the flux at its nominal value.

The Ledoelectronics SAMTFT3.5 TOUCH development module is pin-to-pin compatible with this converter and is the one that has been used during its commissioning and operation. It incorporates a 32-bit ARM controller with hardware module for PWM generation with dead times and 12-bit ADC among many other peripherals.

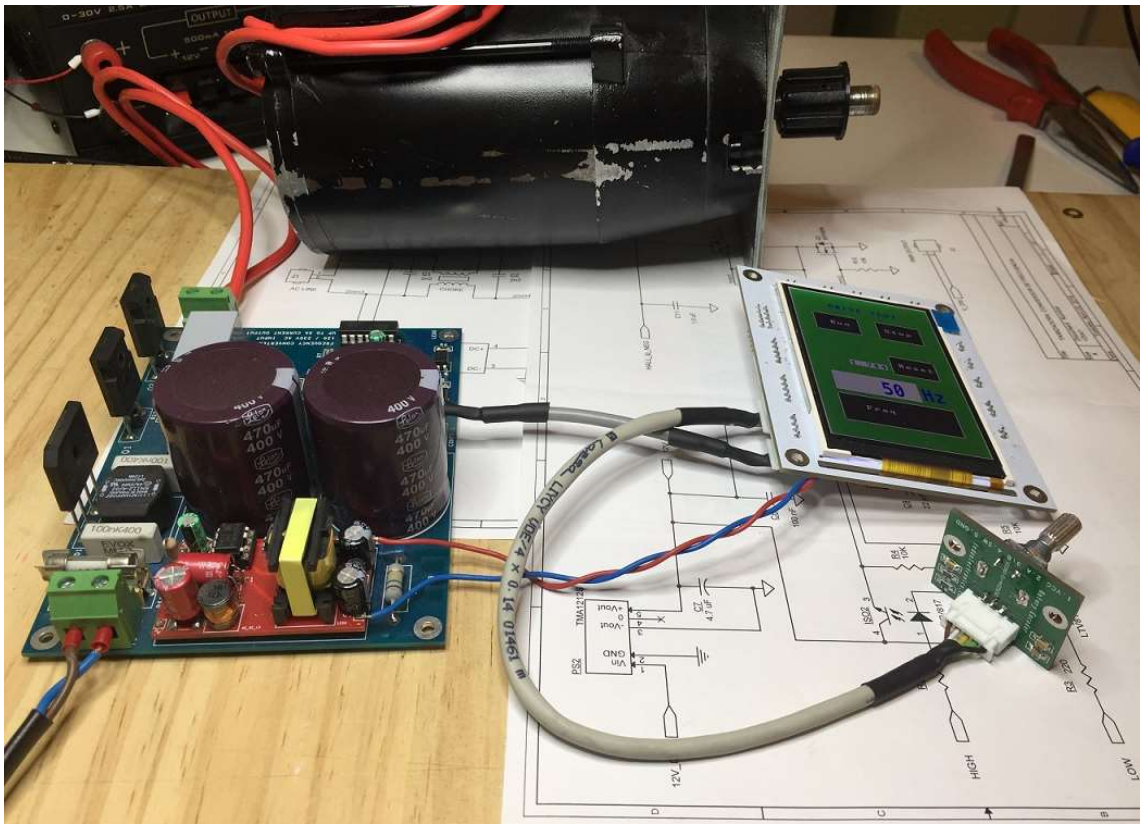


Fig. 5. Inverter control using Ledoelectronics SAMTFT3.5 TOUCH module.

To control the converter, any microcontroller-based system can be used. Its logic is compatible with 3.3V, 5.0V and 12V platforms. All control signals are duly isolated from the network potential by optocouplers. Resistors R2 and R3 must match the type of logic used for control (3.3V and 5.0V by default).

The converter has been successfully tested in the excitation of the electromagnet of a commercial sieve shaker, which requires operating frequencies between 18 Hz and 40 Hz with a consumption current of 2 amps.

Importantly, this is a circuit for adults. Power electronics is fascinating, but dangerous, it requires a minimum of knowledge about power converters, as well as strict compliance with all safety regulations. Keep out of reach of children.