Conversion of a DC-AC inverter to 400 Hz

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As a user of a 618T-3, I was needing a power supply putting out around 150 VA under 115V at 400 Hz.

In the beginning I was using a rotary inverter a.k. a dynamotor.
It worked perfectly but the noise was hardly bearable for long periods of time.

This paper describes the conversion of a 300W solid state inverter to make it working at 400 Hz.

1 The inverter

The first thing to do is to obtain an inverter from 12V (or 24V) DC to 110V AC. The one I got was a 24V DC to 110V AC inverter made in R.P.C for the US market and allegedly running at 60 Hz. However, a quick check of the ouput frequency measured a value closer to 50 Hz than 60 Hz.

But anyway the original frequency makes no difference once the conversion to 400 Hz has been completed.

Here are pictures of the inverter and the front and rear faces.

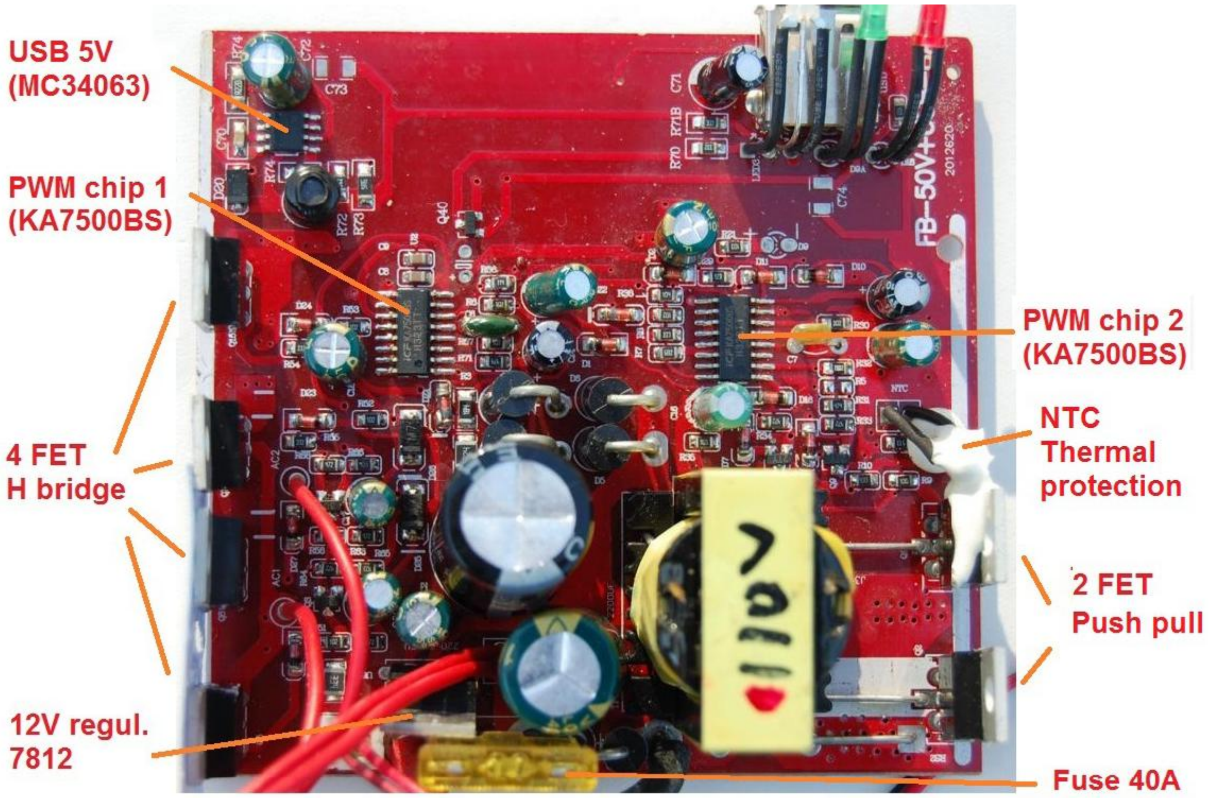
2 Inspection of the circuit

To open the box, simply remove the screws (8) on the front and back panels and then slide the top cover to give access to the PCB.

To get the PCB out, remove the screws (3) which tighten the FET clamps to the box and slide the PCB off the box.

To reassemble, do it the reverse way. It is a good thing to add a drop of thermal grease on the silicon insulating pads before putting the screws back in place.

Here is a picture of the PCB seen from the component side.



The inverter contains a USB socket , three LEDs, a voltage regulator, six power FET, three ICs, a thermistor, a few diodes and transistors, and the associated passive components.

In my case, a voltage regulator (7812) steps the input voltage from 24V down to 12V for the ICs. It is probably absent in 12V inverters.

An auxiliary buck converter with a MC34063 decreases the voltage down to 5V for the USB socket.

3 Conversion

All inverters of this kind are more or less built on the basis of the same technology.

The inverter basically consists of a first circuit that converts the 12V DC to around 140V DC, using a pulse width modulator (PWM) running at around 40 Khz and controlling 2 FETs in push pull. The second circuit chops the 140V DC to the AC frequency using another PWM chip that controls 4 power FETs in a H bridge topology and regulates the frequency and the voltage at the output.

A few extra components help in controlling the voltages and providing protection in case of overload, thermal runout or over/under voltage for example.

A generic schematics found on the web is given in the appendix.

Firstly you need to identify all the IC present on the board and find the pulse width modulators.

After that you need to pinpoint the right PWM chip to be modified. Commonly, these chips are connected to a resistor-capacitor (RC) network that controls the switching frequency.

Get the datasheet. It will tell which pins of the chip the RC network is connected to and the formula which relates the switching frequency to R and C.

On each of the PWM chip, find the right pins and note the R and C values to evaluate the switching frequency of each chip. You should find one frequency in the tens of Khz range and an other one close to 100 Hz.

The RC network to be modified is the one with a frequency around 100 Hz.

From there you simply need to change the constant RC by following the instructions given in the datasheet, or by trial and error by adjusting R, C or both until you get the proper AC frequency.

My own example :

For illustration here is my own experience.

The inverter has two KA7500BS which are the PWM chips. These chips are cousins of the famous TL494.

The datasheet tells that the timing resistance and capacitor are connected between ground and pin 6 and 5 respectively, and that the approximate oscillator frequency is f (Hz)= 1.1 /RC (ohms x farads).

On one chip, R=3 kW, C= 4.7 nF so that the oscillator frequency is 78 Khz. It controls the push pull converter from low voltage to high voltage DC.

On the other one, R=110 kW, C=100 nF and the oscillator frequency is 100 Hz, so that the AC output frequency is around 50 Hz. This is the H bridge chopper, the one to be modified.

To shift the frequency from 50 to 400 Hz one simply needs to decrease the constant RC by a factor 8 (being 400/50).

I elected to keep the resistor (110kW) and I replaced the capacitor. After adjustment, I have finally used a capacitor of 14.7 nF (10 nF and 4.7 nF in parallel) to obtain an output frequency around 400 Hz.

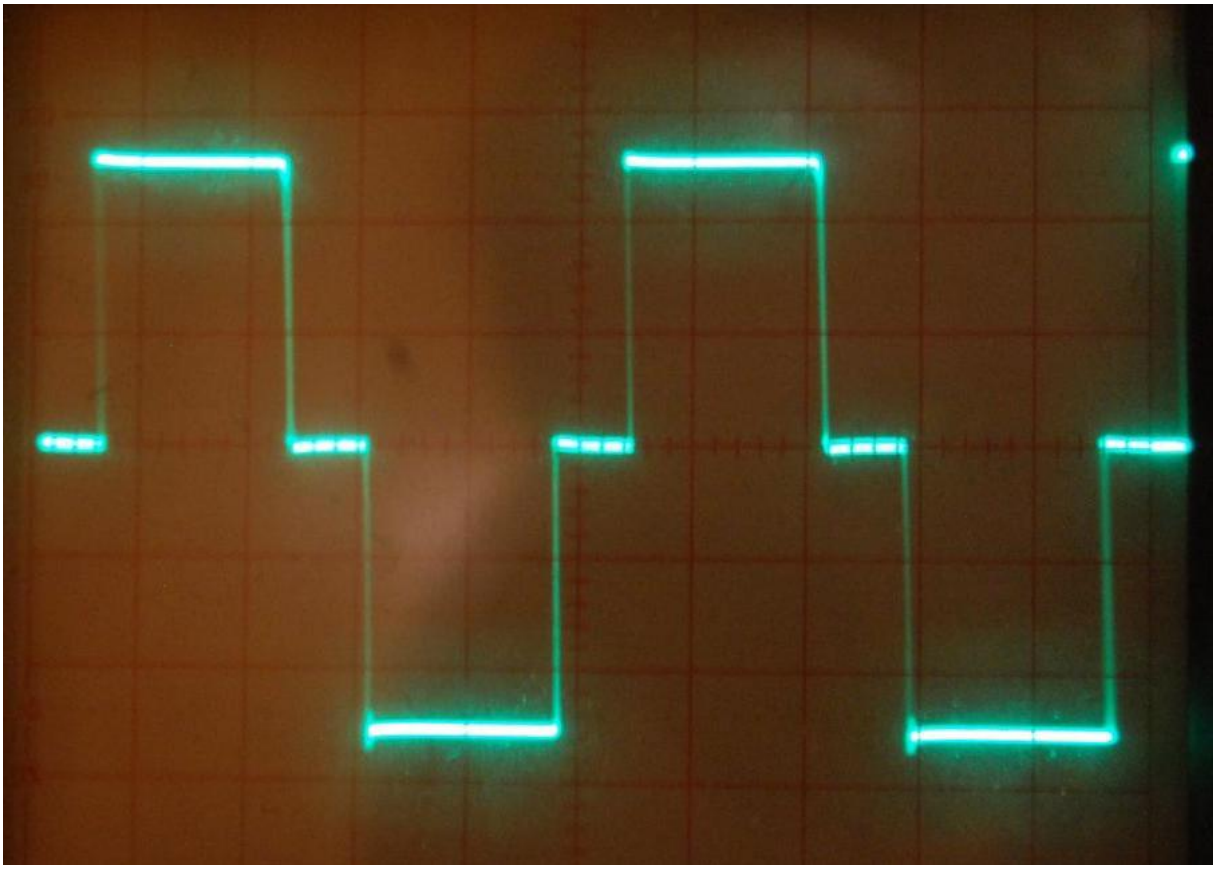
4 Waveform

The output waveform is clean, either at no load conditions or under load.

Its caracteristics are:

- Peak voltage : 135V (618T transmitting with blower on)
- Period : 2.45 ms
- Frequency : 408 Hz
- Dead time lenght : 0.65 ms
- Duty cycle : 26%

The voltage is a bit lower than the expected value of 115V , however the 618T accepts this with no noticeable problem.



Waveform with 618T on TX – H scale 0.5 ms/div – V scale 50V/div

5 Problems with the DC to AC isolation

In the 618T, the negative rail of the DC supply and one pole of the 400 Hz AC line are connected to the common chassis ground.

Doing that directly connects the 135V to ground through one of the upper transistors of the H bridge.

In effect, connecting any pole of the AC to the Negative DC rail is not accepted by the protection circuit of my inverter. Whenever, I connect one side of the AC output to the negative of the DC input, the overload protection trips, the "default" LED lights up and the inverter stops.

This problem has to be evaluated beforehand because in case there is no protection the power transistors might breakdown as well.

The only way to overcome this difficulty is either to use an auxilairy DC supply independent of the main DC supply and floating above the main ground, or to use a 400 Hz isolation transformer at the output of the inverter.

The former solution is probably simpler than the latter, unless you have a 400 Hz transformer of the right voltage and power in your junk box.

6 Appendix : Generic schematics of cheap DC to AC inverters