DC-to-AC Converter

This project is an DC-to-AC converter for applications that need low current but good stability, for example to verify the AC range of multimeters. The AC stability depends entirely on the stability of the DC used for supplying the H-bridge. If you check out my YouTube channel, TheHWcave, you find a video about this converter and another one for a stable high-voltage DC converter that I use to connect to this one. The combination allows AC voltages up to 208V. The AC converter itself could go up to 400V.

The AC converter schematic is quite simple.
A 555 chip acts as an oscillator producing a square wave of about 800 Hz or, if you want 960 Hz for frequencies that are multiples of 60 Hz, but I am using the 800 Hz for the rest of this discussion.

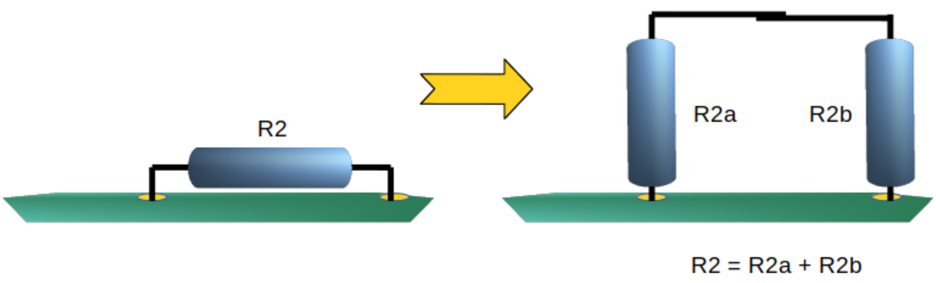
Next, this generated square wave enters a 4-stage frequency divider 74LS93 using flip-flops. Each flip-flop divides by 2. So, the first flip-flop produces 400 Hz, the next one 200 and so on until 50Hz on the last flip flop output. The main reason for using this approach is that this guarantees a 50% duty cycle on those 4 frequencies, regardless what duty cycle the 800 Hz oscillator may have. Using 50% duty cycle is essential to get AC without any DC content.

The selected frequency, which could also be from an external oscillator goes into a driver circuit made of a 74HC00 and is split into two channels that are 180 degrees out of phase. In other words, one is the inverted wave form of the other. This is simply done by using the gates as inverters and one channel has one inverter more than the other.

The driver connects to an H-bridge for which I used 4 PhotoMOS solid-state relays from Panasonic. The opto-coupling means the H-Bridge is completely isolated from the rest of the circuit which is important because of the high voltage involved. I use the type 214, which is rated to switch 400V 120mA AC or DC.

The PhotoMOS chip can handle 400Hz switching frequencies with no problems but if you go much higher, 800Hz you run into the limits of the chip’s T-on and T-off times which means the wave form is no longer rectangular.

Regarding frequency: The oscillator frequency is determined by C6 and R2. If C6’s tolerance is small, the theoretical value for R2 is 8.5K for 50Hz and 7K for 60Hz (after the divider of course). Using standard values of 8.2K or 6.8K will get you in the right ballpark and depending on tolerances of C6 may even be spot on. If you don’t want to leave this to luck, I recommend to leave R2 out initially and then measure the circuit using different combinations for R2 (the location at the edge of the board allow tapping the solder pads with alligator clips easy). In my version I ended up with a combination of 8.2K and 300 Ohm in series, which can be soldered in as below:



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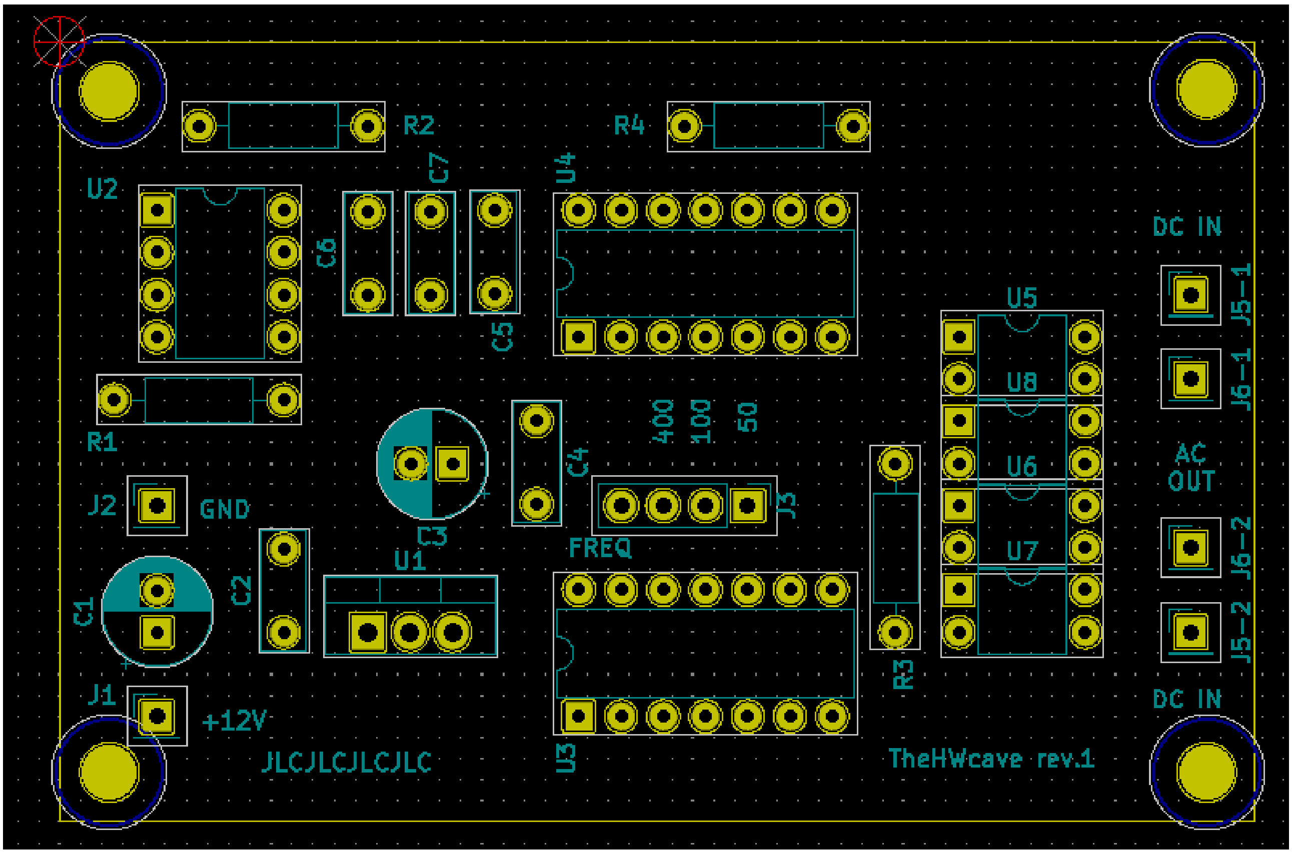
Regarding the PCB itself. After making my prototype, I edited the PCB layout slightly. The two changes are:

- Adding a no-fill zone around the area that might carry high-voltage. My prototype which did had ground-plane filling all around works with 208V without problems but the close proximity of the ground plane might cause issues if you go to even higher voltages.
- Decluttering and moving some of the silk-screened component names so they remain visible even after the component have been soldered in

In case, you are still having trouble identifying the components on the PCB you can use the drawing below:



The PCB still has a few courtyard overlap issues but those can be ignored.

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Component list:

U1	L78M05CDT-1 or similar low-power 5V regulator	RS Stock# 686-9729 £4.09 +VAT for 10
U2	LM555	
U3	74LS93	
U4	74HC00	
U5,U6,U7,U8	AQY214EH	RS Stock# 699-6581 £1.40 ea +VAT
R1	1K	
R2	About 8.5K for 50Hz (e.g. 8.2K + 300) or 7K (e.g. 6.8K+200) for 60Hz	
R3,R4	470	
C1	10uF 50V	
C2	470nF	
C3	100uF 10V	
C4,C5,C6	100nF	
C7	10nF	

I added RS-Components stock numbers (and prices) for some of the items. Pricing is for the UK and accurate as of 13-Mar-2020