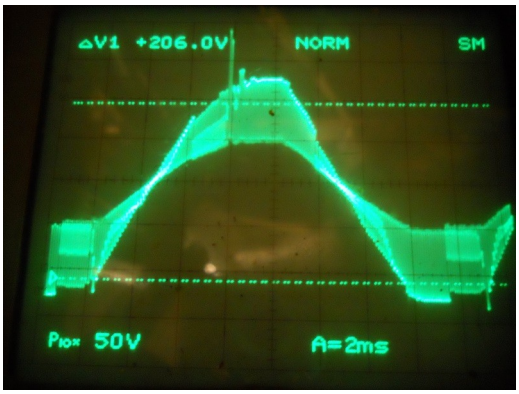
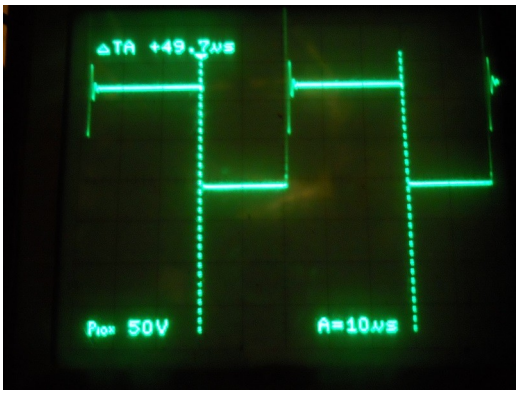
PWM Vernier Project

03/19/19

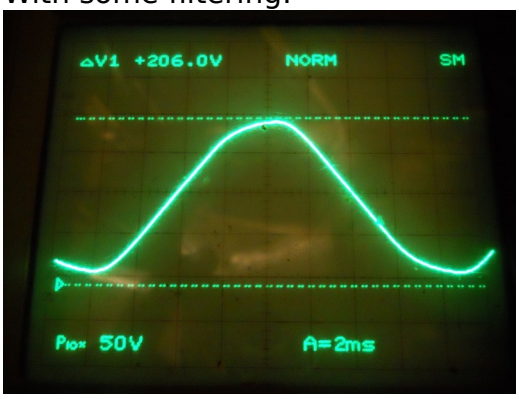
The PWM Vernier project is essentially a solid-state Variac. It uses two sets of two back-to-back MOSFETs, driven alternately with a 20 kHz PWM signal. Here is the raw waveform (distorted due to sampling aliasing):



Details of PWM:



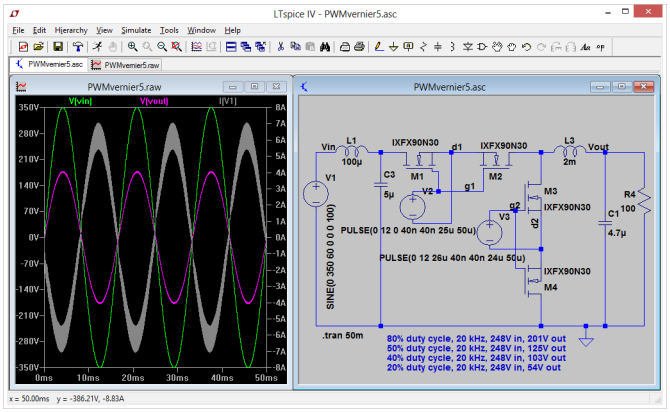
With some filtering:



Video showing adjustment:
http://enginuitysystems.com/pix/electronics/PWM_Vernier_5079.AVI

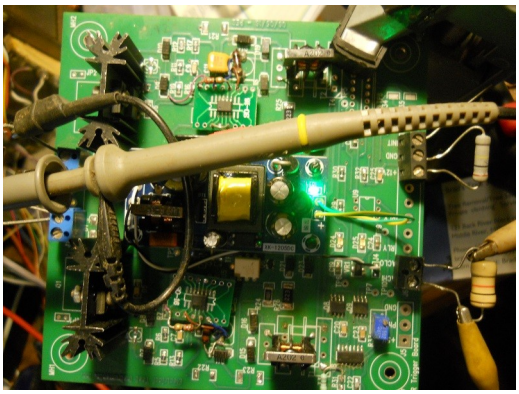
This design differs from a VFD in that it does not use a rectified DC bus link, but instead operates directly on the sinusoidal waveform. Thus it maintains the same wave shape and phase. The concept and circuitry are very simple.

Here is the LTspice simulation and representative circuit:



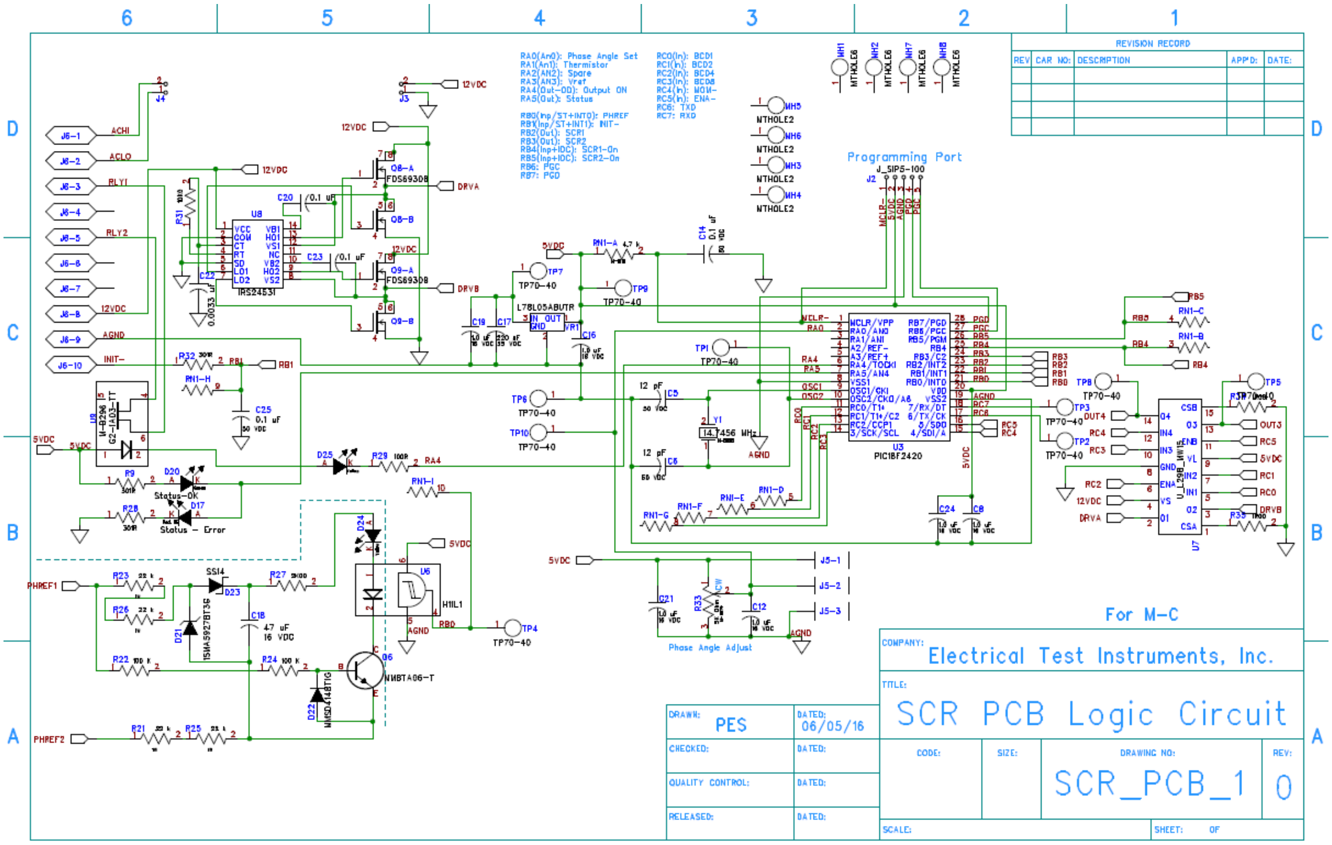
The LTspice ASCII file (with some modifications from above): http://enginuitysystems.com/pix/electronics/PWMvernier6.asc

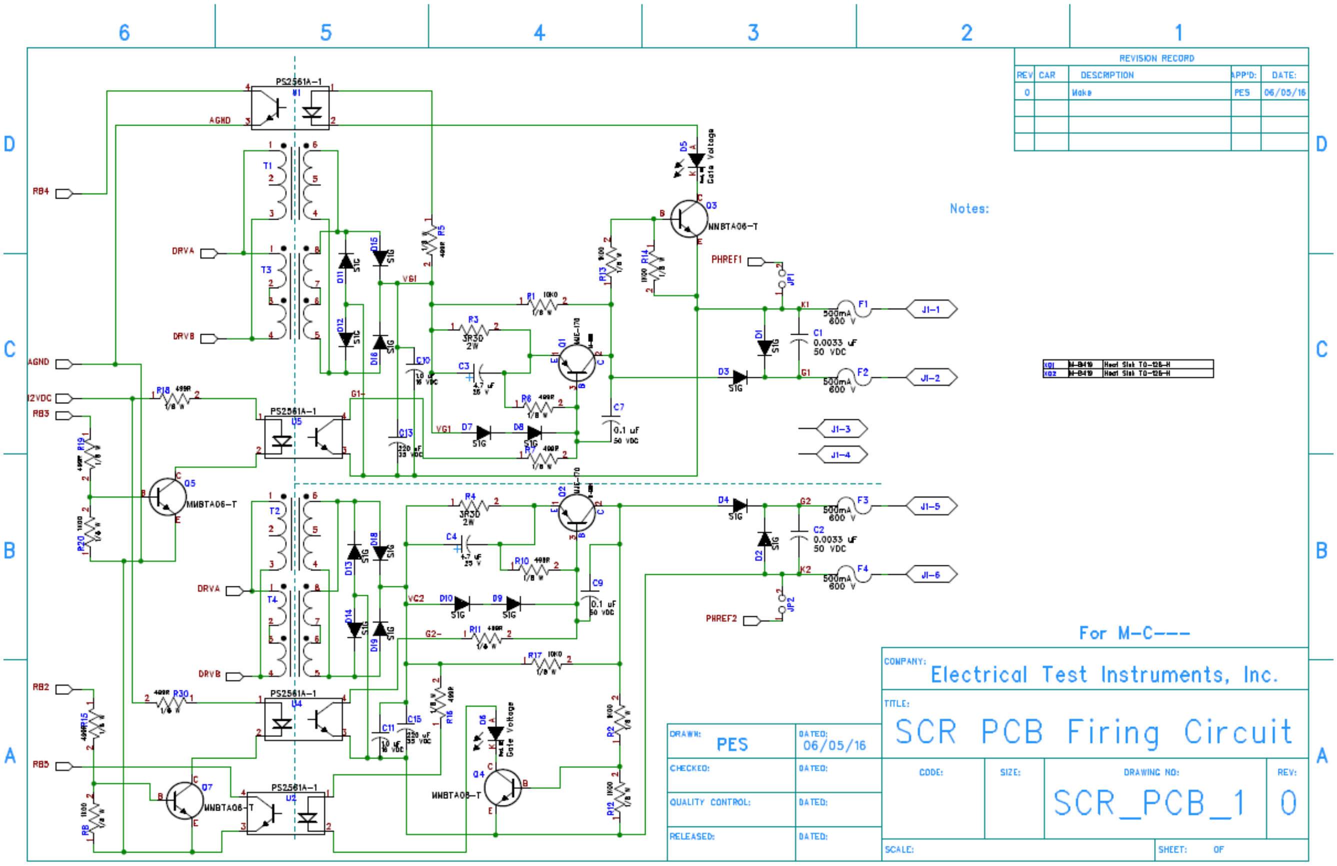
I repurposed an SCR drive circuit, designed to fire the gates of a dual SCR in antiparallel configuration. This uses the AC line power, or the voltage across the SCRs, as a phase reference so that the initial phase angle can be adjusted to fire at about 70 degrees from zero crossing for minimal DC offset into inductive loads. It can also be programmed for a specific ON time in cycles or seconds, optionally using a serial connection or Bluetooth. The modified PCB:



The two common mode chokes are used as transformers to provide two isolated 12V drive power supplies for the two SCR gates, or in this case, MOSFET gates, using an IRS2453 self-oscillating Hi-Lo dual gate driver, at 100 kHz and two dual NMOS devices. They use SI8261 opto-emulated gate drivers, controlled by the PIC16F1778, which provides a 20 kHz PWM. The main 12VDC is supplied with a 12V 1A switching supply (about $3 from Banggood).

The schematic (for the original SCR design):


For M-C
Electrical Test Instruments, Inc.
SCR PCB Logic Circuit
DRAWN: PES
DATED: 06/05/16
DRAWING NO: SCR_PCB_1
REV: 0
Programming Port
Phase Angle Adjust
REVISION RECORD


For M-C---
Notes:
Electrical Test Instruments, Inc.
SCR PCB Firing Circuit
DRAWN: PES
DATED: 06/05/16
DRAWING NO: SCR_PCB_1
REV: 0
REVISION RECORD

The PWM vernier design is much simpler. I might commit to a new PCB, after I do some more testing. I estimate the total parts cost will be under $30 for a 120/240 VAC unit rated for about 5-10 amps nominal. The same basic design could be used for several hundred amps using high power MOSFETs or possibly IGBTs.

My use of the term "vernier" comes from the second definition as a device that facilitates fine adjustment, as applies to my experience designing circuit breaker test equipment which uses typically nine coarse taps, with a fine "vernier" adjustment between tap settings (with some overlap), to obtain any desired test current.

Let me know if you are interested and have use for such a product, and I might be inspired to finish the design and offer it for purchase.

This is essentially a lamp dimmer or variable voltage motor control that uses high frequency PWM instead of phase angle modulation (using TRIACs or SCRs). It will work equally well on raw DC as well as AC, as long as the voltage is within the range of the switching power supply (85-265 VAC or 120-375 VDC). Being based on a PIC, it offers additional features, such as:

1. Remote control of output via serial connection or Bluetooth

2. The ability to supply pulses of precise time duration.

3. Adjustment of initial phase angle (when used on AC).

4. Programmable soft start and turn-off.

5. When supplied with DC, and a full H-bridge, the device can operate as a single phase VFD for induction motors or other devices.

6. The basic design can be adapted to operate on voltages as low as 12V (AC or DC), and as high as 600V (AC or DC).

7. With some simple added circuitry, it could be configured as a battery charger.

8. It might work well as the control element for a spot welder, or perhaps even a stick welder.

9. It could be used as a programmable bench power supply (DC or AC).

10. It could be configured as an arbitrary waveform generator, within the parameters of what is possible using PWM.

As usual, I may be getting carried away by fantasizing about various bells and whistles that might be added, and already I envision possibly adding more PWM channels to build a three phase VFD, but then I get caught in the loop of endless "feature creep" and stalled development that has led to my well-known habit of "never finishing anything".

Perhaps I will create a new thread on this project, as it seems to have considerable possibilities within the general umbrella of machining and associated electrical and electronic instrumentation and controls.