Permanent magnet alternator from an SDMO Booster 2000 suitcase generator

SDMO Booster 2000 generators use a Honda GX100 engine running at approximately 3000 rpm, a permanent magnet alternator and a built-in inverter.

Turning the alternator by hand, there are 48 torque pulses per revolution. It is a 3-phase delta connected alternator and one can see 24 stator coils i.e. 8 coils per phase, coils at 15° intervals.

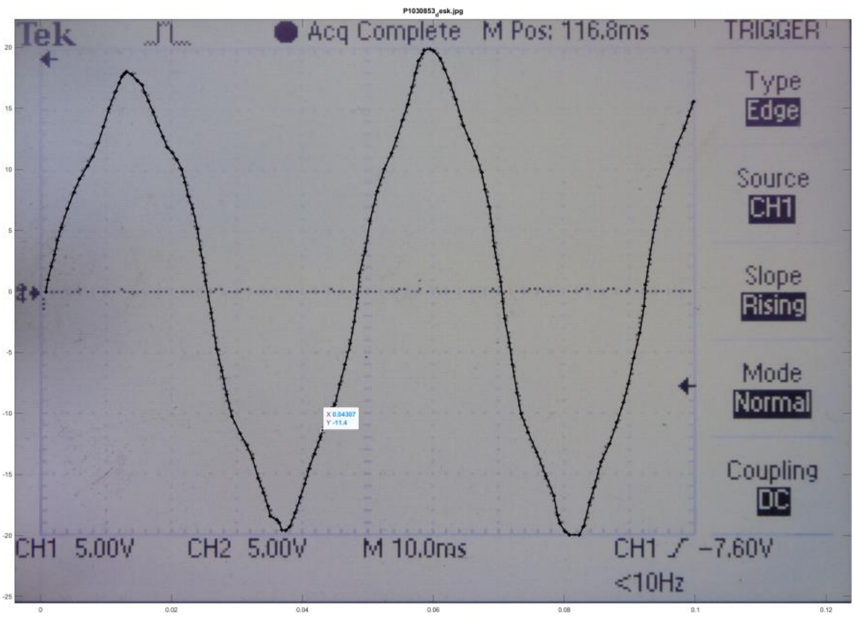
The 7.5° torque impulses are unlikely to be produced by magnet poles at 7.5° intervals because:

(a) over 15° (N-S-N) all the stator poles would see a North rotor pole – no flux through the stator iron, and

(b) it would give very high cogging torque

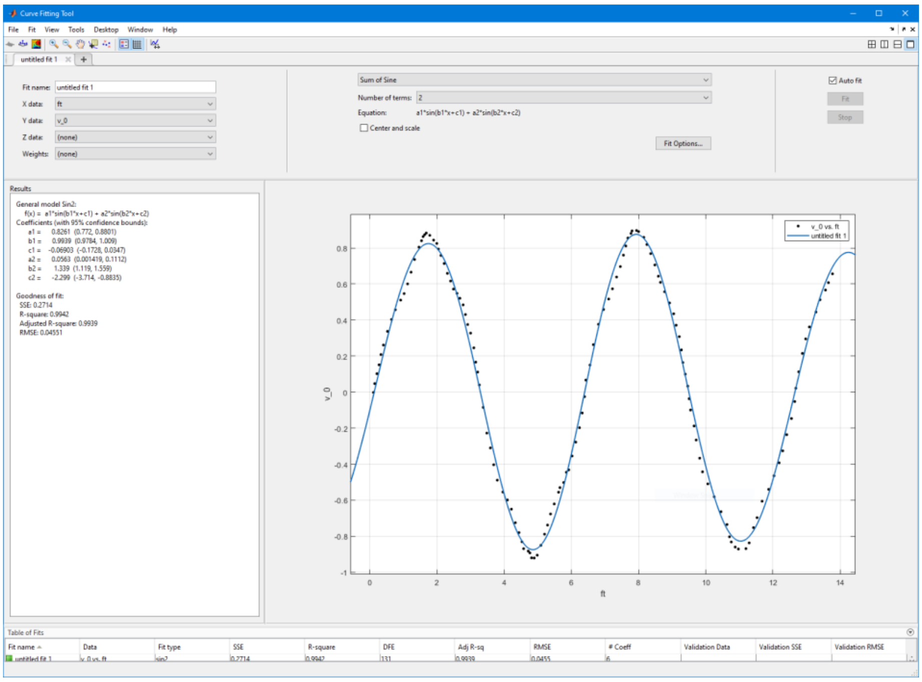
The rotor pole spacing must be $\theta = 7.5 + n15°$ to give the 7.5° torque impulses but we require $m\theta = 360°$ where m is an integer. The only possible combination is therefore $n = 1,\ \theta = 22.5°,\ m = 16$. It is therefore a 16-pole alternator and at (say) 3000 rpm would generate 400 Hz. The "repeat period" is 45° (2 rotor pole pitches, 3 stator coil pitches).

I put a storage scope on it, pulled the starter cord and photographed the screen. The photo was then straightened in GIMP before ploading into Matlab. The final stage was to click along the curve to get a series of (time,voltage) points. (I could have hooked-up a proper A-D system controlled by LabView – this is more of an "alternative energy" approach).



The generator was not pulled at constant speed so I took the time intervals between ¼ cycle points and did a curve fit of instantaneous frequency vs time. Using a first order fit, if $f = p_1 t + p_2$, by integration $ft = \frac{p_1}{2}t^2 + p_2 t + \text{constant}$. The voltage rose slightly over the couple of cycles (due to rising speed) so I non-dimensionalised it, $v_1 = \frac{v}{f}$ Volts/Hz, and interpolated a uniform set of v_1 versus *t* values.

I then did a Fourier transform and looked at the amplitude of the harmonics. More interestingly, the curve fitting toolbox lets one fit an arbitrary sine series.



This gets interesting. Having scaled the time parameter to be 2π per cycle, the curve fit is

$$v_1 = 0.826\sin(\omega t) + 0.0563\sin\left(\frac{4}{3}\omega t\right)$$

One could add more terms but this gives a reasonable fit. ωt repeats every 45° and $\frac{4}{3}\omega t$ repeats every 33.75°. I think I need more data before I really believe this.

Anyway, at 400 Hz it should make 330 V peak (233 V rms) – if rectified the DC will be 330 V which is OK for the inverter (520 V max before damage).