Pulsed Magnetic Field Therapy (PMFT) Circuit

Greetings everyone!

Here is a simple circuit based on 555 IC that generates a pulsed magnetic field. You may use this field for pulsed magnetic field therapy.

Human body is influenced by natural magnetic fields such as Earth's magnetic field, fields due to geomagnetic storms, magnets, and magnetic rocks etc. Pulsed ELF magnetic fields (PEMFs) help cells to maintain their health (energy production, removing waste, self-repair, and regeneration) and cause motion of ions and electrolytes in cells and tissues. PEMFs remove stress, accelerate healing, and slow aging process. Stress exhausts body and lowers the cell's membrane potential which is usually 70 to 90 mV. The cell dies if this potential drops to zero level. A cell uses 50% of its energy to maintain this potential. PEMFs help building this membrane potential. High-intensity PEMFs (very short and strong magnetic pulses like lightning) destroy cancer cells. Suggested PEMF frequencies are between 1-50 Hz.

Here is the circuit that generates pulsed magnetic fields from about 1.5 Hz to 30Hz.

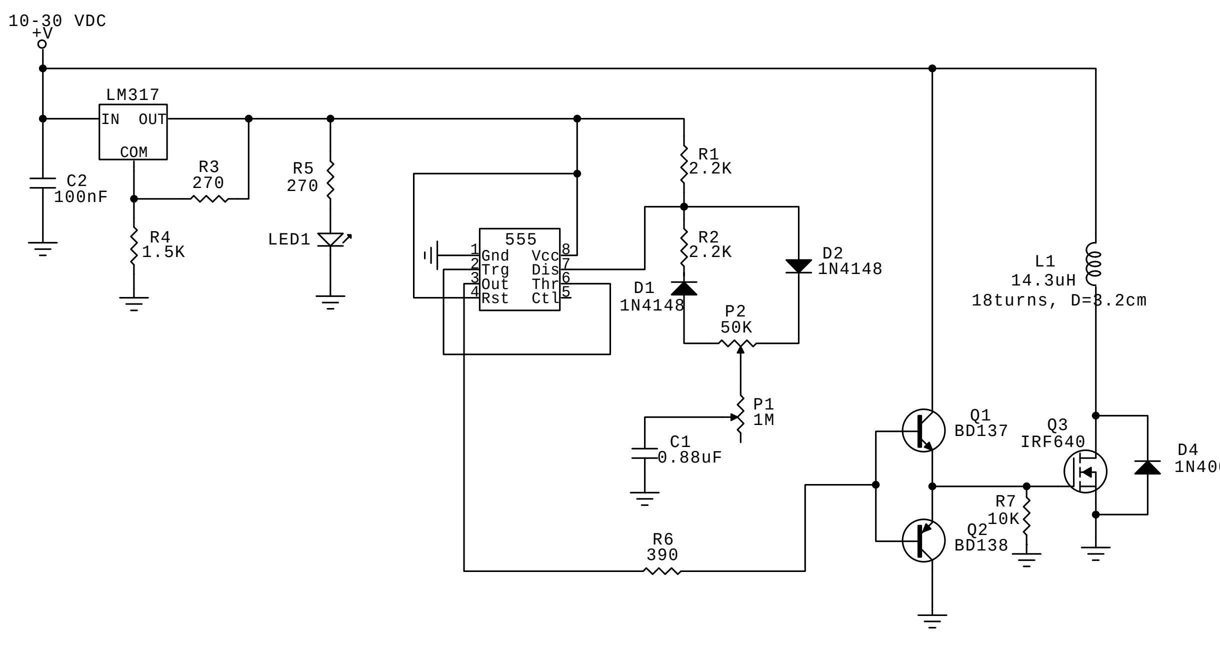

Fig. 1. PMFT circuit with adjustable frequency and adjustable duty cycle.

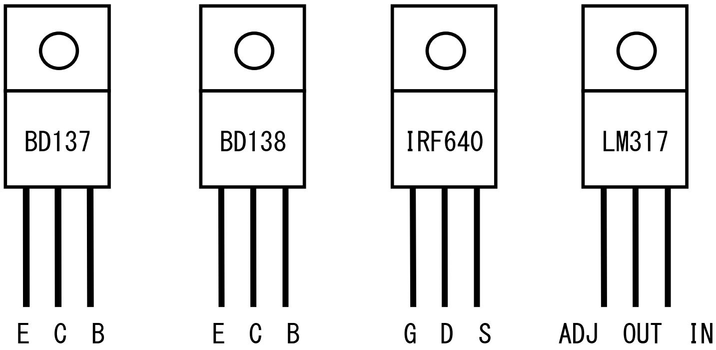

Fig. 2. Pin descriptions of the semiconductor components.

For the circuit in Fig. 1, capacitor C1 charge and discharge times are denoted as t_{ON} and t_{OFF} , respectively.

$$t_{ON} = 0.693(R_1 + nP_2 + P_1)C_1$$
$$t_{OFF} = 0.693(R_2 + (1-n)P_2 + P_1)C_1$$
$$T = t_{ON} + t_{OFF} = 0.693C_1(R_1 + R_2 + P_1 + P_2)$$

For the desired minimum frequency of f=1Hz, P1 should be a maximum, and for the maximum frequency (f=30Hz, T=33.3ms), P1 should be a minimum (=0Ω). Then

$$0.693C_1(R_1 + R_2 + P_2) = 0.0333$$
$$0.693C_1(R_1 + R_2 + P_1 + P_2) = 1$$

Since it's difficult to find a suitable potentiometer, I select P1=1MΩ and P2=50KΩ initially. I also assume R1=R2=2.2KΩ. C1 is calculated as 0.88µF for f_{max}=30Hz. Four 220nF capacitors are connected in parallel to form 0.88µF. For P1=1MΩ, f_{min}=1.5Hz. Pulse width can be adjusted from about 1.5ms to about 31.5ms using P2. Thus, it's possible to vary duty cycle from about 5% to about 95%, for any frequency point.

The field coil is 1.6cm in radius and has 18 turns. It has an inductance of 14.3µH. Supply current is about 0.4A when duty cycle is 5%, and it's about 4.8A when duty cycle is 95%.

Next step is to calculate the magnetic field strength. Except along the axis, the magnetic field of a circular coil cannot be expressed in closed form. Along the coil axis, if the origin of the coordinates is taken at the center of the coil and if the z axis is taken along the coil axis, the magnitude of the magnetic flux B, which points in the z direction, is given by

$$B = \frac{\mu_0 N r^2 I}{2\left(r^2 + z^2\right)^{3/2}}$$

At the center of the coil:

$$B = \frac{\mu_0 N I}{2r}$$

Where B is in Tesla and

$\mu_0 = 4\pi \times 10^{-7}$: Vacuum permeability (H/m)

N : Number of turns of the field coil

I : Current in the wire (A)

r : Radius of the coil (m)

z : Axial distance from the center of the coil (m)

For the coil that I used, estimated magnetic field strength is about 3 Gauss for 5% duty cycle and about 34 Gauss for 95% duty cycle.

$$B = \frac{4\pi \cdot 10^{-7} \times 18 \times 0.4}{2 \times 0.016} = 2.83$$

$$B = \frac{4\pi \cdot 10^{-7} \times 18 \times 4.8}{2 \times 0.016} = 33.9$$

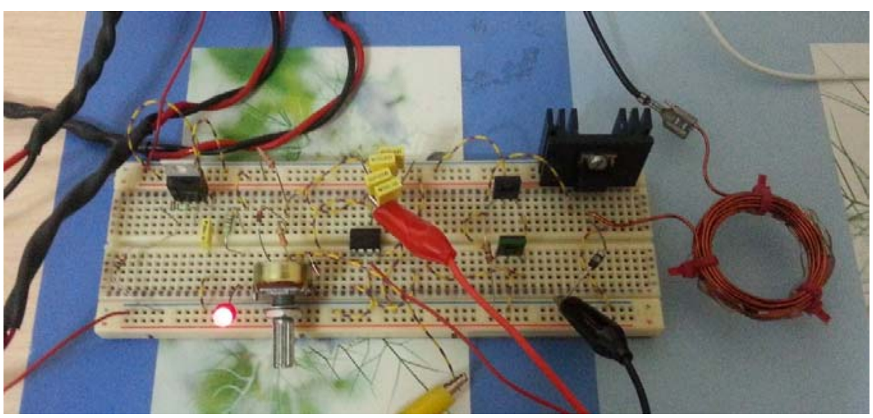

Fig. 3. The circuit on board.

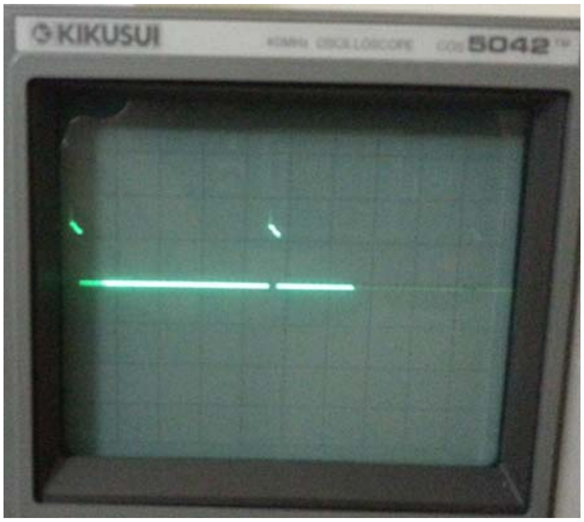

Fig. 4. 5% duty cycle at 30Hz.

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