Design Note 31
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High Voltage Generation for Xenon Tube Applications

Introduction

The ignition timing lights in common use range from simple neon to complex units. Neon timing lights have a drawback that due to their low light output, the user is forced to operate them in subdued lighting. This becomes a safety hazard as one tends to hold the unit close to the timing mark and to the "invisible" (or apparently stationary) fan blades.

The ignition lights which use Xenon filled stroboscopic tubes are much better, since their light output is of much higher intensity. The circuit described in this note incorporates such a tube, which has an anode voltage rating of 500 volts maximum and requires a trigger voltage between 2-6kV.

The circuit was designed for a four stroke engine. It will be seen later that the unit can be converted for use as a low power stroboscope with some slight modifications.

The required high voltage for the tube was achieved by using an inverter. The inverter must drive a capacitive load and also withstand the secondary being shorted. Operating the inverter in the flyback mode seemed the best choice, since the energy transfer only takes place when the switching transistor is off, thus effectively isolating it from the load.

Circuit Action

In the circuit diagram shown in Figure 1, the transistor Tr7 is the switching device. The transformer T1, converts the voltages and also transfers the energy. The capacitors C10 and C11 are used as energy storage elements. When the tube is triggered, this stored energy is discharged into the tube - which produces a bright flash of light. The brightness of the flash depends on the size of the storage capacitors and the voltage to which they are charged. The switching of Tr7 is controlled by the Schmitt trigger, formed by Tr3 and Tr4, which senses the 'current' through the primary and secondary. On switch on, the transistor Tr3 will be off and Tr4 will be on. Thus, turning on transistor Tr5 pulls the gate of the MOSFET transistor up to approximately the supply voltage. Whilst the MOSFET is on, the energy is stored in the primary inductance of the transformer. The current in the primary increases as a linear ramp whose slope is inversely proportional to the primary inductance. The resistor R11 senses this

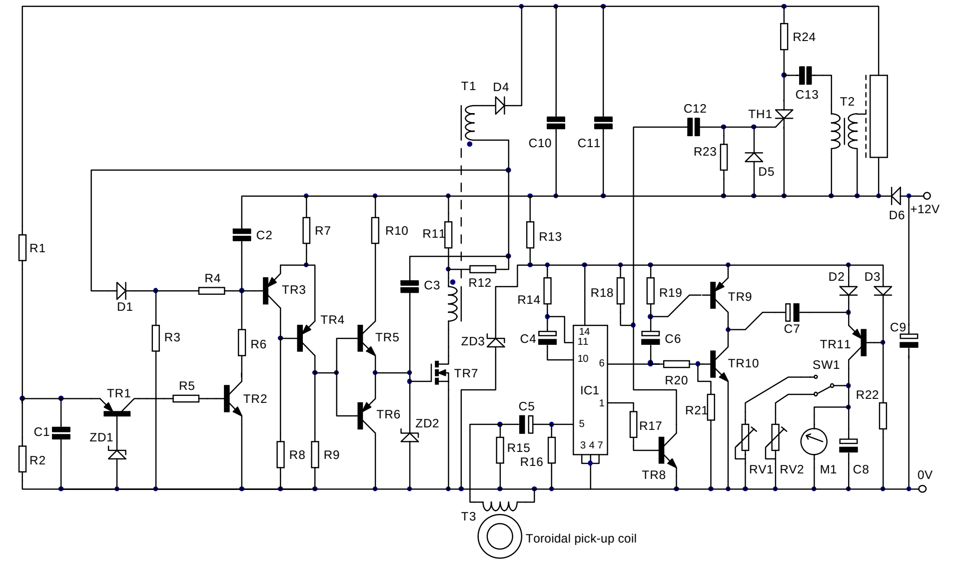

Figure.1
Ignition Timing Light (Parts list in Appendix A)

current and when it reaches a pre-set peak value, sufficient voltage drop is developed across R11 to turn Tr3 on. This in turn switches Tr4 off, which pulls the bases of Tr5 and Tr6 to ground. The gate capacitance of the MOSFET now discharges through Tr6 turning the MOSFET transistor off. When Tr7 turns-off, the primary current immediately ceases and the collapsing magnetic field produces a current ramp of opposite slope in the secondary winding - charging up the output capacitors C10 and C11. The value of this current is the peak value of the primary current divided by the turns-ratio of the transformer T1. This secondary current is also sensed by the same Schmitt trigger circuit. This is achieved by connecting a resistor, R12, in series with the secondary as shown in the diagram. Note that this current also flows through R11.

As the output capacitors C10 and C11 are charged up by the secondary current, the voltage across them gradually increases. Also, as the secondary current ramps down, the voltage drop across R11 and R12 decreases. When the upper threshold voltage of the Schmitt trigger is reached, the transistor Tr3 again turns-off and the next cycle begins. This action continues to dump the energy into the output capacitors until the output voltage reaches the required value. When this has been achieved, the potential divider formed by R1 and R2 and the voltage sensing elements Tr1 and ZD1 inhibit the inverter

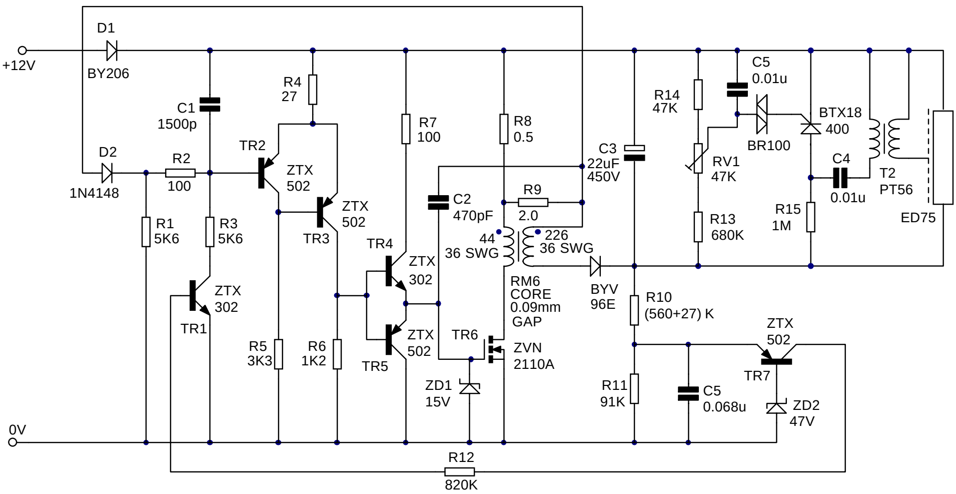

Figure 2
Xenon Beacon

by keeping Tr3 on. When the tube is triggered, the capacitors are discharged and the output voltage drops. The transistor Tr1 turns-off and unlatches the Schmitt trigger and therefore the inverter action resumes.

The use of capacitor C3 enhances the switching of the MOSFET. As Tr7 begins to turn on, the C3-T1 node swings positive by transformer action. This swing is capacitively coupled via C3 to the gate. The regenerative action rapidly switches Tr7 hard on. When Tr7 begins to turn off, the C3-T1 node swings negative. Again the regenerative action rapidly switches the MOSFET transistor off.

The Xenon flash tube is triggered by the firing of the first spark plug in the engine firing order. The transformer T3 is placed over the spark plug and produces a trigger pulse for the monostable every time the spark plug is fired.

A single monostable circuit, a 74121, is used for both the thyristor trigger and a revolution counter. One of the outputs is used to control the transistor Tr8, whose collector is capacitively coupled to the gate of the thyristor. This form of triggering ensures a positive turn-off of the thyristor in each cycle. Hence, the possibility of it remaining in conduction for more than 1 cycle is removed. Prior to the thyristor triggering, the capacitor C13 will be charged to the output voltage. When the thyristor conducts, C13 and the primary inductance of the trigger transformer T2, form an oscillatory circuit. The secondary of T2 produces the required high trigger voltage.

The second output of the monostable is used to drive the revolution counter circuit, whose operation is as follows:

When the spark plug is fired, the output of pin 6 goes high, the transistor Tr9 turns-off and Tr10 turns-on. The capacitor C7 is charged up to the supply voltage (approx.) through diode D2. When the output goes low, Tr10 will turn off and Tr9 will turn on. The capacitor C7 will now discharge through Tr9 and Tr11. This gives rise to a mean collector current in Tr11 which will depend on the frequency of firing of the spark plug. The use of Tr9 instead of a resistor allows the quick discharge of C7 and also reduces the power consumption, since the only current flowing through Tr10 is the charging current of C7.

With the component values shown, the unit gives a bright light output up to about 2500 revolutions per minute, beyond which the light output starts to fall. This is because the output capacitor is not charged to it's final value before it is triggered again. The flash tube dissipates about 4 Watts per flash.

The unit can be easily converted into a low power Stroboscope by simply triggering the monostable with an external square wave oscillator instead of the pick-up coil.

Xenon Beacon

Another possible application for the ZVN2110A MOSFET is a Xenon beacon. Since the beacon flash rate is low, a high value output capacitor can be used. This allows more energy to be dumped into the tube, giving an intense pulse of light. The circuit diagram is shown in Figure 2. The circuit is similar to that described previously.

The output voltage generated in this case is 320 volts and with a 20 micro-farads output capacitor, the tube dissipates a maximum rated 1 joule of energy per flash. The maximum possible flash rate, with the component values shown, is four flashes per second. Above this, the brightness of the flash will drop due to the capacitor not being charged up to it's final voltage before the tube is re-triggered.

A diac is used to trigger the thyristor. As the output voltage increases, the voltage drop across RV1 increases. When the voltage drop across RV1 reaches the breakover voltage of the diac, it starts to conduct. This provides sufficient gate to cathode voltage to bring the thyristor into conduction, and hence triggers the tube. When the tube discharges, the output voltage drops, taking the diac and the thyristor out of the conduction mode and the cycle begins again.

ZETEX

Appendix A
Component Values for Figure 1

R1	1M	C1	68nF	D1	1N4148
R2	120k	C2	1500pF	D2	ZDX1F
R3	5k6	C3	470pF	D3	1N4000
R4	100	C4	2.2μF, 63V	D4	BYV96E
R5	820k	C5	6.8μF, 40V	D5	1N4148
R6	5k6	C6	10μF, 25V	D6	BY206
R7	27	C7	10μF, 16V TANT	ZD1	47V Zener
R8	3k3	C8	1000μF, 25V	ZD2	15V Zener
R9	1k2	C9	470μF, 25V	ZD3	5V1 Zener
R10	100	C10	0.47μF, 1000V[1]	TH1	BT151
R11	0.5	C11	0.47μF,1000V[1]	T1	Core RM6 FX3437. Primary - 44 turns 36 S.W.G, Secondary - 226 turns 36 S.W.G., Air gap 0.09mm.
R12	2	C12	0.22μF		
R13	130	C13	47nF,1000V[1]		
R14	3k3	Tr1	ZTX214C		
R15	2k2	Tr2	ZTX384C		
R16	2k2	Tr3	ZTX214C	T2	See Xenon tube details below
R17	18k	Tr4	ZTX214C		
R18	4k7	Tr5	ZTX384C		
R19	4k7	Tr6	ZTX214C	T3	Core FX1589, 20 turns, 1mm wire
R20	2k2	Tr7	ZVN2110A		
R21	2k2	Tr8	ZTX300	Xenon Tube ED69 (Integral Reflector and Pulse Transformer T2)	
R22	4k7	Tr9	ZTX214C		
R23	10k	Tr10	ZTX384C	M1	1mA F.S.D., 75Ω
R24	100k	Tr11	ZTX214C		
RV1	100	IC1	74121		
RV2	220				

Note 1: POLYPROPYLENE