EXP 03- DESIGNING OF INDUCTOR AND MEASURING INDUCTANCE

Report by:

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AIM:

DESIGNING OF INDUCTOR AND MEASURING INDUCTANCE

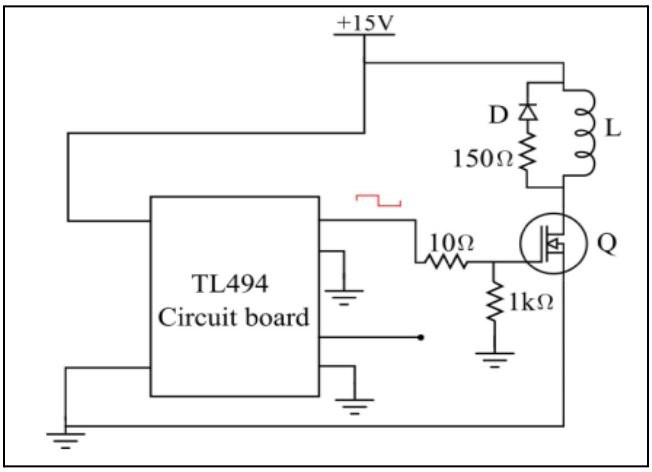
COMPONENT USED:

- TL494 PWM Controller with IC Base
- Resistors - a) 47kΩ, 4.7kΩ, 10Ω, 1kΩ ; 0.25W b) 150Ω; 2W
- Rheostat (50kΩ; 10kΩ)
- Circuit of Uncontrolled Rectifier (using LM317 or IC7815)
- Shorting pins
- Capacitor(100nF, 10nF, 100nF)
- Inductor 1.2mH
- Diode FR107
- MOSFET IRF540
- PCB Board
- Wires(M & F), Wire stripper
- Regulator IC 7815 & LM317
- Soldering Equipment
- Oscilloscope
- Regulated Power Supply

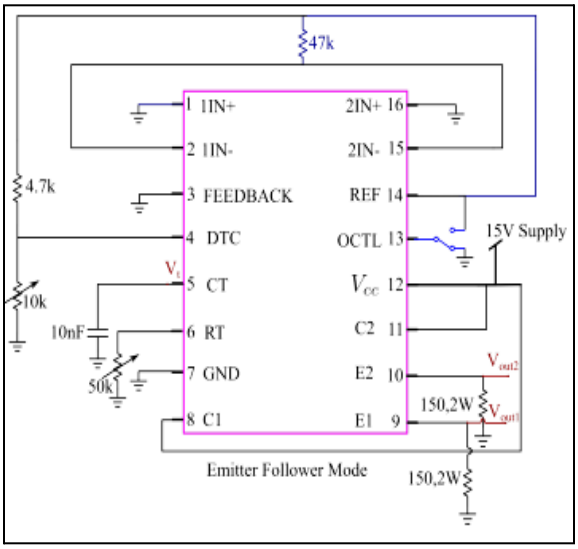
SUMMARY:

In this experiment we are using designing inductor and then measuring its inductance.

CIRCUIT DIAGRAM:



Fig(a): Circuit diagram for connecting TL494 with qthe inductor in single-ended supply.

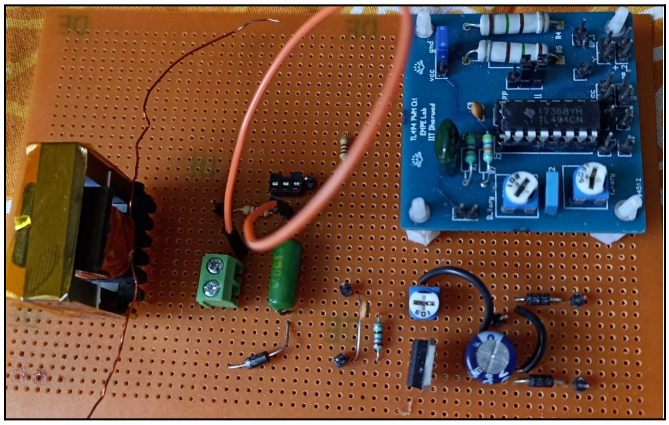


Fig(b): Connection diagram of TL494 to work as in emitter follower mode with single-ended supply

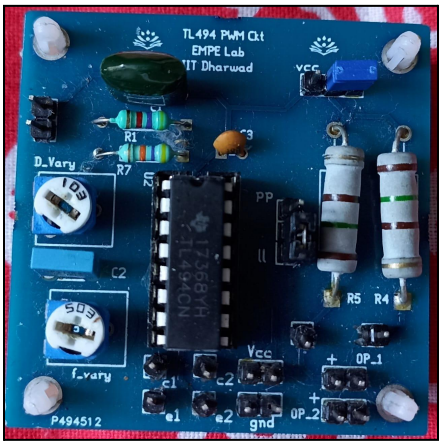
PROCEDURES:

- Focusing on the necessary calculations, we designed the inductor specifications, then we did confirmation for the inductance value.
- Tested the inductance value by wounding the inductor using the "Linear Coil And Toroidal Winding Machine."

- We built the circuit in PCB as shown in the above diagram of fig.(a) to calculate the inductance of the inductor.
- The whole circuit of PCB looked like this after connecting the inductor of unknown inductance(L) and TL494 PCB:



- Have used the TL494 PWM generator that was previously designed for applying the gate pulses:
  ⦿ With 50% of the duty cycle at a frequency of 10 kHz.
  ⦿ Isolated the mosfet gate while adjusting the TL494 PWM pulses.
  Snapshot of TL494 used while this exp. in the single-ended mode for emitter-follower connection of mosfet:



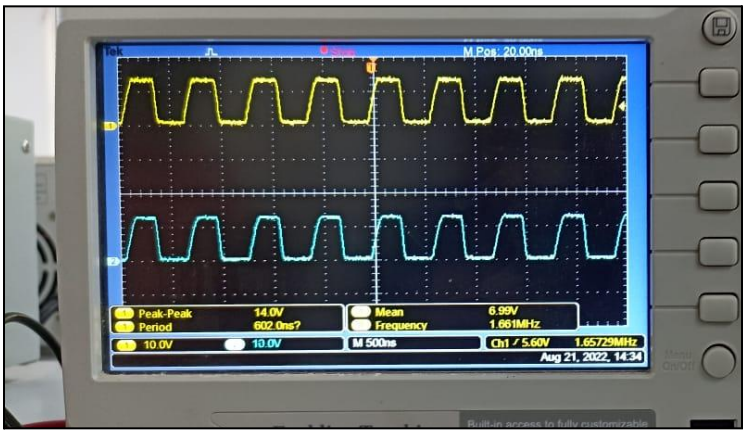
- Measured the drain-source voltage and drain current once the TL494's pulses have been set by connecting the gate pulses to the measuring circuit.
- At the beginning and end, we measured the rise time of the drain current.
- Obtained the gate pulse and inductor current as shown in fig.(d)
- After getting the output waveform of the inductor current shown in fig.(d), we calculated the value of the inductor using the equation:

$$L=\frac{V\Delta T}{\Delta I}$$

- Note: *Only once the driver is attached to the MOSFET's gate terminal then we should turn ON the power supply.*

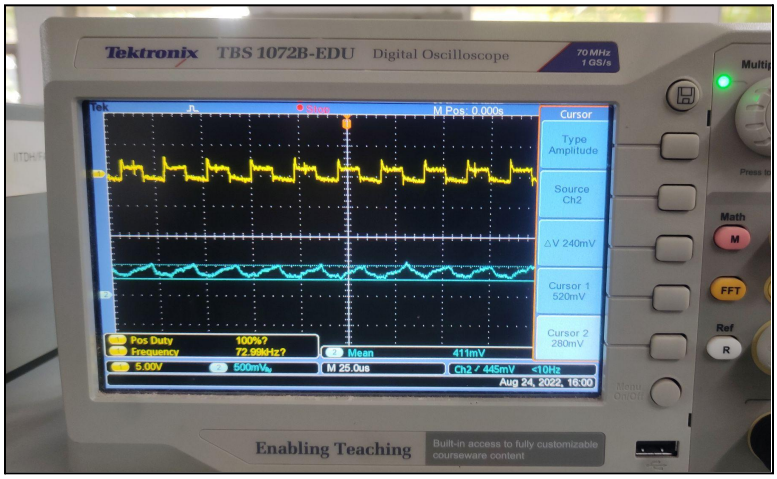
RESULTS AND OUTPUTS:

➢ The output PWM produced by the TL494's emitter follower circuit in single-ended power supply mode.



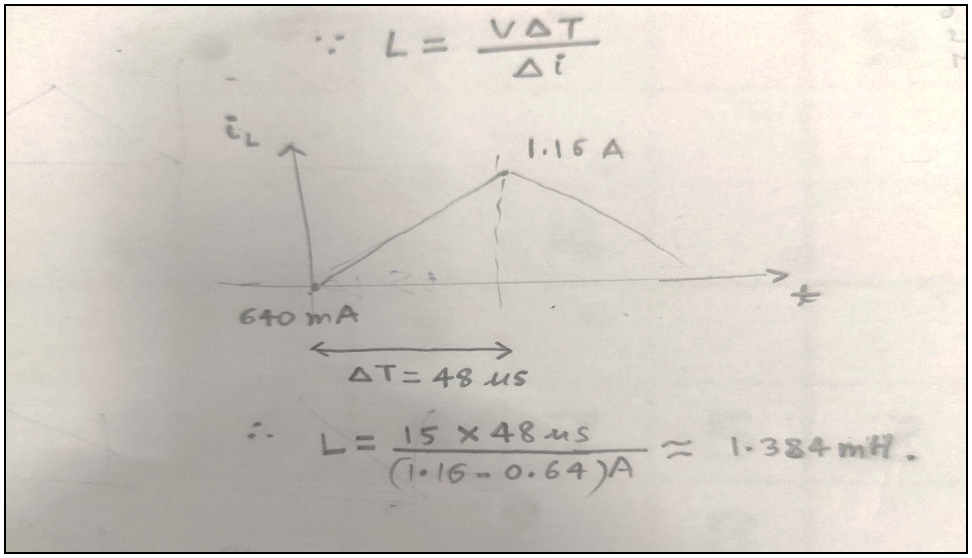
RESULT: Fig.(c)We obtained an emitter follower waveform in single-ended mode with a duty cycle in the range of 50% and frequency around 50kHz.

➢ After utilizing these pulses to the circuit as shown in fig.(a), we observed the pulse of MOSFTE'S gate terminal and also the current output across the inductor as a triangular waveform:

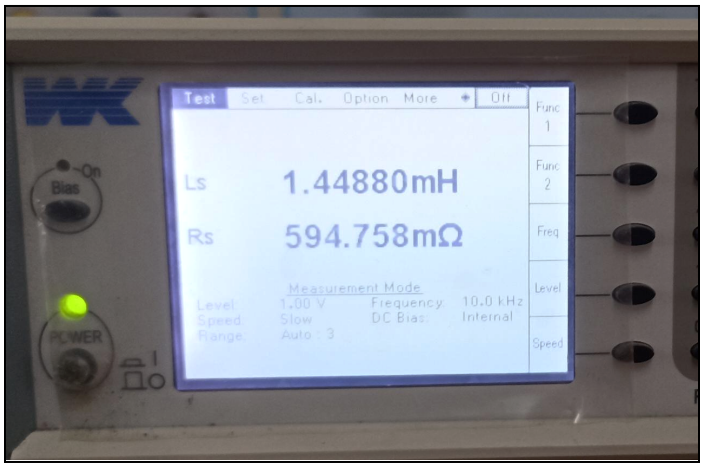


RESULT: Fig.(d)We obtained the gate pulses with a mean voltage of 5V in the form of square signals and triangular waveform of the inductor current. Then, we calculated the peak-to-peak current of the inductor waveform and calculated (**L≈1.38mH**) using the equation:

$$L=\frac{V\Delta T}{\Delta I}$$



➢ After theoretically calculating the inductance value (**L≈1.384mH**), we again checked the inductance (L) using an LCR meter with shown value:



RESULT: LCR meter clearly shows that the wound inductor which we implemented in the circuit has an inductance value of **1.44880mH** close to the theoretical value of **1.384mH**.

ANALYSIS:

- The characteristics of voltage and current across the inductor branch of the circuit (fig.a) can be explained as shown:

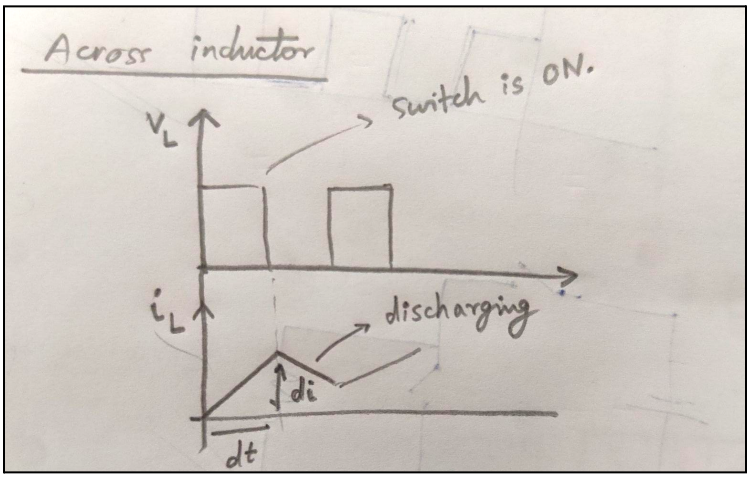
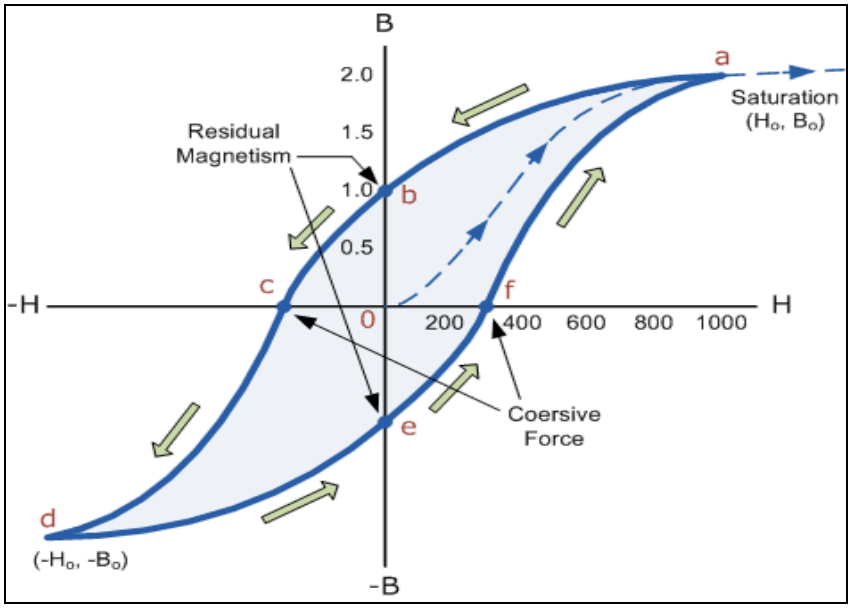
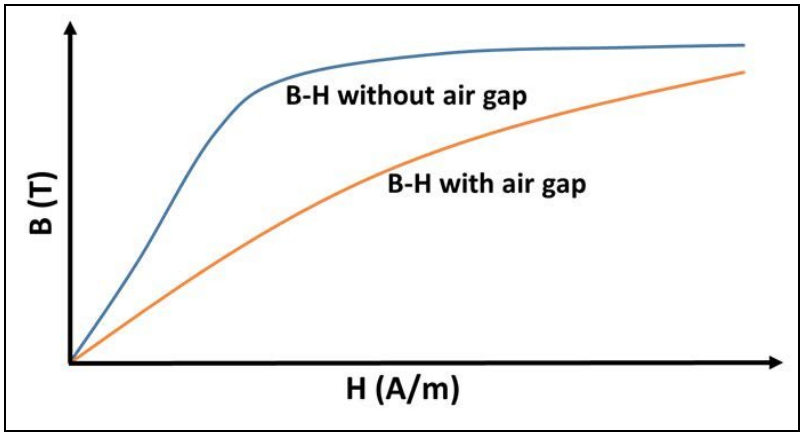


Fig.(e) We can clearly see the discharging of the inductor through the free wing path when the pulse is going OFF.

- B-H curve for the inducting element can be shown in the below figure:



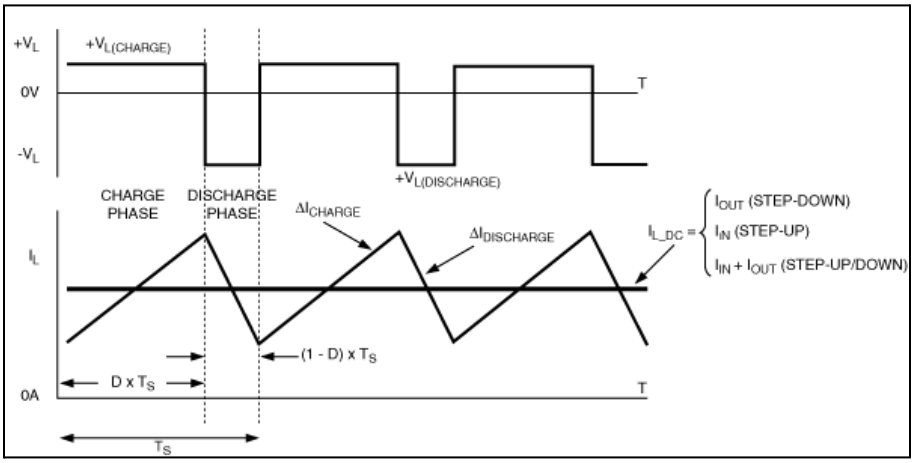
Fig(f): Hysteresis loop shows the dependency of applied current (H=μI) with the magnetic field (B).



Fig(g): The B-H curve with a specific air gap can reduce the energy loss as we can see the area of the curve is lesser in an air-gapped inductor. In our experiment, we took the air gap of $2mm^2$ in each connecting section of the inductor loop.

"Area of the hysteresis loop of any substance represents energy loss in magnetizing a substance."

- In this exp. we are using the inductor, which stores energy and supplies energy to the circuit to maintain current flow during "off" switching periods of TL494 SMPS supply.



- Magnetic field is caused by the current as [$B=\frac{\mu_o NI}{l}$], "inductor" resists the change in the current wrt. Faraday's law:

$$[\,E_L = -d\phi/dt\,] = -d\left(\frac{\mu_o N^2 IA}{l}\right)/dt = -\left(\frac{\mu_o N^2 IA}{l}\right) = -L\left(\frac{di}{dt}\right)\ ;\ \text{where } L = \frac{\mu_o N^2 A}{l}$$