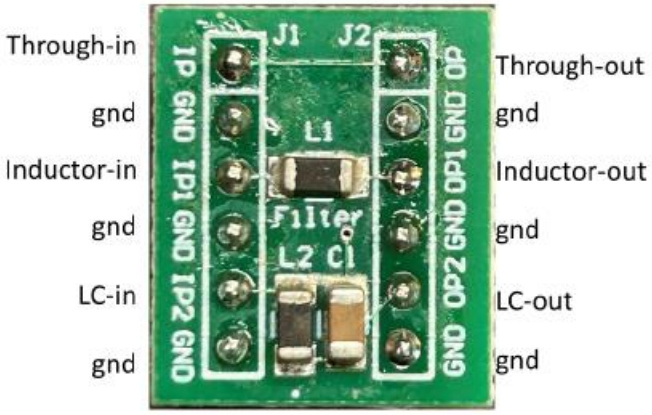
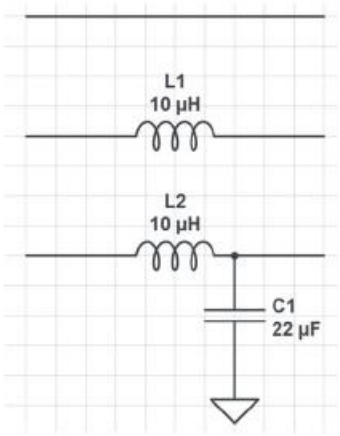
Lab 25: SBB circuits: Ferrites

Purpose: To understand reduction of noise on a power line using a ferrite filter or a LC filter, using a ferrite filter test board provided by professor.

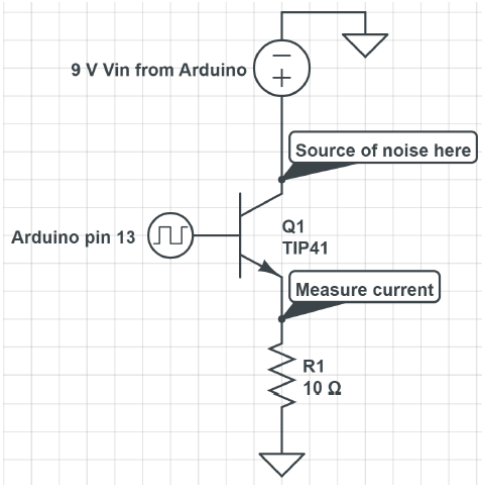
Experiment:

For this experiment a ferrite filter test board is used with three different circuits of direct power line, with a ferrite filter and with an LC filter. The test board looks like,

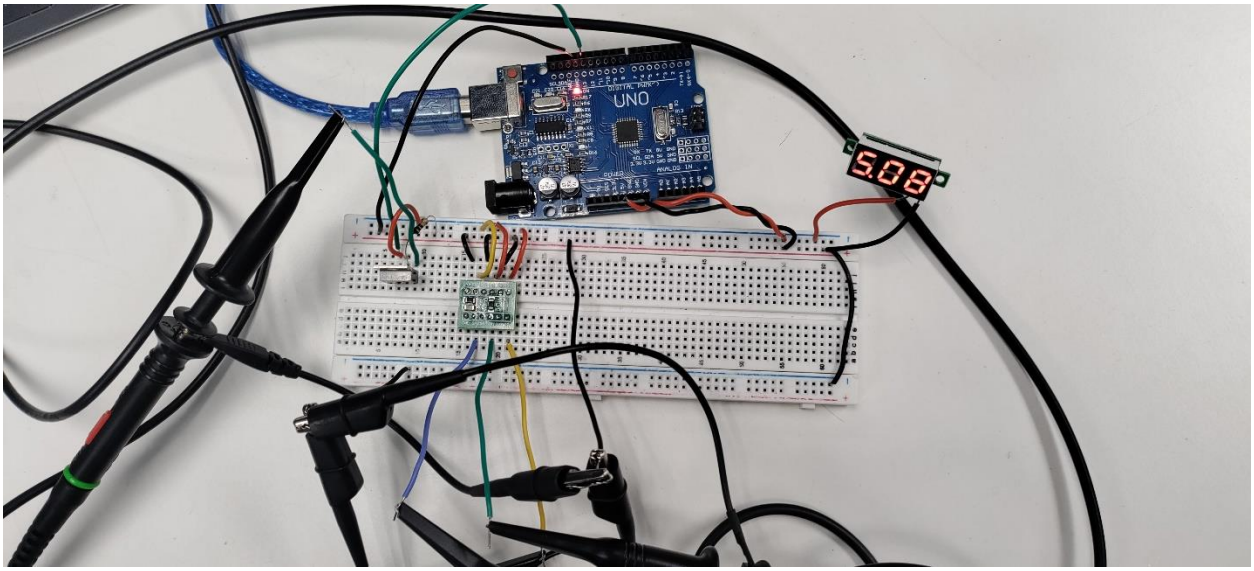




The input to this test board can be given through a slammer circuit. This is built using slammer circuit given as below.



Instead of 9V from Arduino, a 5V power is supplied to the slammer circuit. The following is the circuit on a solderless bread board.



The 5V is connected to the 3 input pins of the test board. The outputs are probed on the oscilloscope for understanding the noise through the direct line, the ferrite inductor, and the ferrite filter.

The pole frequency is calculated with L = 10uH, and C = 22uF. The pole frequency is given by,

$$f_{pole} = \frac{1}{2\pi\sqrt{LC}}$$

Frequency = 1/6.28*sqrt(10uH*22uF) = 10.7KHz

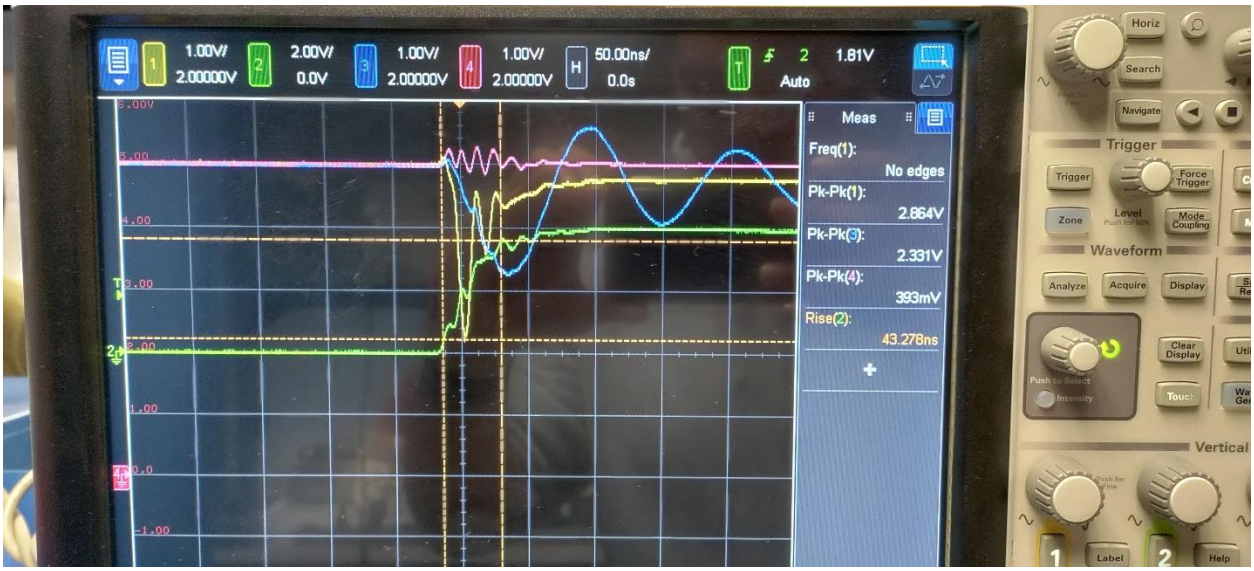
The rise time is calculated from the input signal below.

Rise time can be observed as 44nsec.

The frequency of the noise can be calculated as (0.35)/ Rise-Time = 0.35/44nsec = 7.9 MHz.

The noise frequency is 100x when compared to the pole frequency of the LC filter. Hence, for the low pass filter, this noise can be cancelled.

The noise can be observed from the three probed inputs to the oscilloscope. The following the screenshot of the noise signals.



The input switching signal of the slammer circuit is given by the green curve. From the measurements, the rise time is given approximately by 44nsec. The yellow curve is the noise on the direct connection from input to output of power line. The noise is observed around 2.864V. For the only inductor (ferrite inductor) output, the noise is observed around 2.331V and is visible on the blue curve as per the above screenshot. The pink curve is the output of the LC filter (low-pass filter), and it is clearly visible that it has the lowest noise. It is observed around 393mV of noise.

Conclusion:

Hence, the LC filter has the highest efficiency by having the lowest noise and the high frequency noise signals are eliminated by the Low Pass filter.

When the series resistance of ferrite is considered as 1 ohm, the Q for the RLC circuit is given as,

$$Q = (1/R) *(\text{sqrt}(L/C)) = 0.67.$$

Hence, in systems with high frequency noise a ferrite filter can be used and reduces the noise on the power signal. In the boards with low frequency noise, ferrite filter doesn't help to attenuate.

In a circuit to reduce the noise on the power line a ferrite bead is used rather than a power inductor since ferrite bead is noise attenuator whereas power inductor just stores energy in magnetic field and makes the current pass through.