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U.S. DEPARTMENT OF ENERGY

FEAST Switching Frequency Measurments

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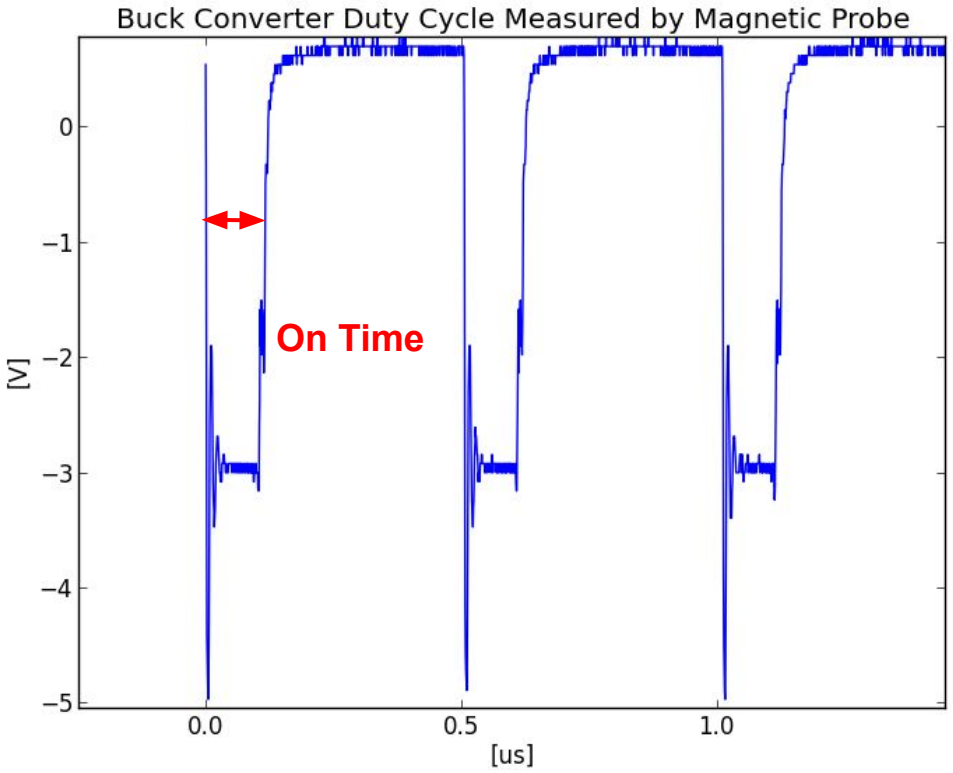
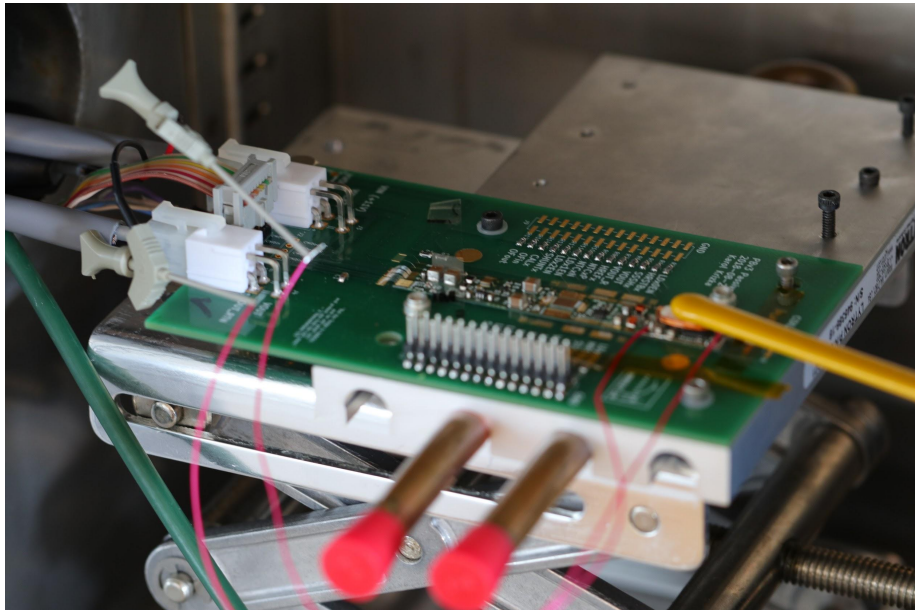
FEAST On/Off Cycle



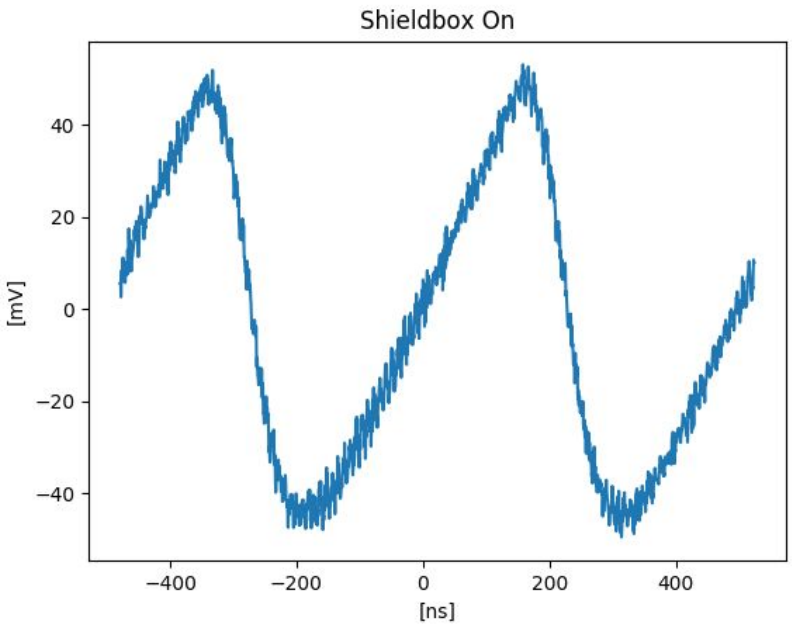
- Duty Cycle = On Time/Period
- We are interested in measuring the duty cycle and switching frequency of the FEAST for varying temperature, powerboard input voltage, and load current.

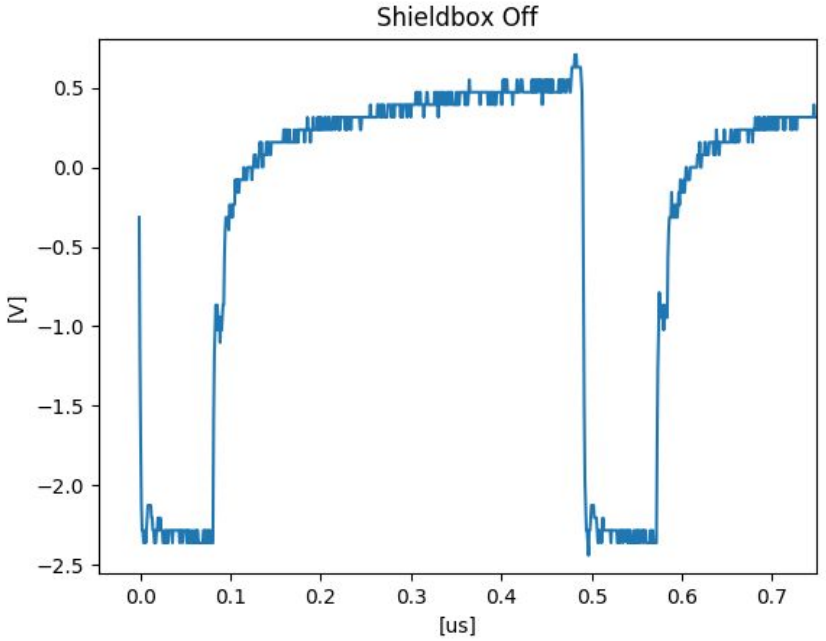
Cold Box Setup



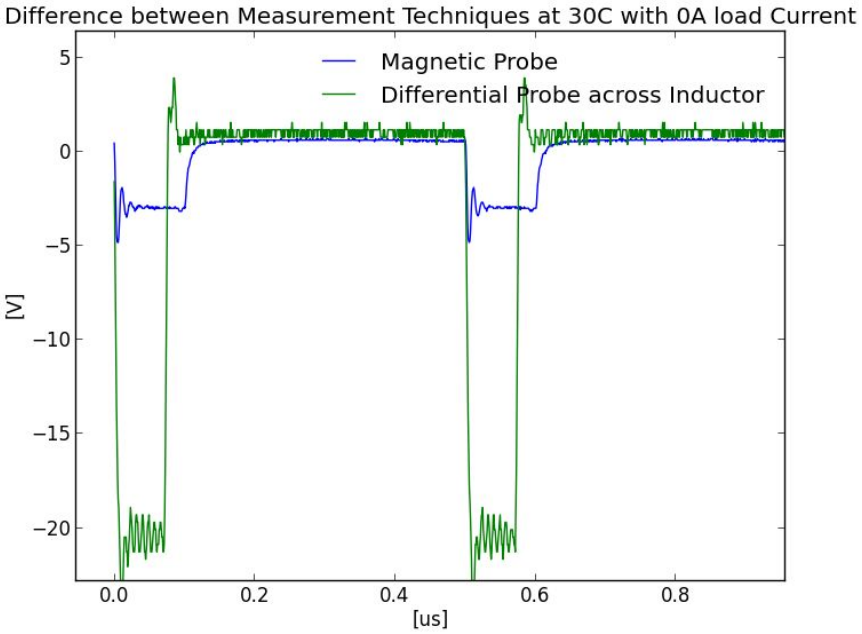
- Powerboard is placed inside of a cold box, for which we vary the temperature from -40C to 40C.
- Magnetic probe is placed over the powerboard coil (the inductor in the DCDC buck converter).
- Differential probes are placed across the coil.

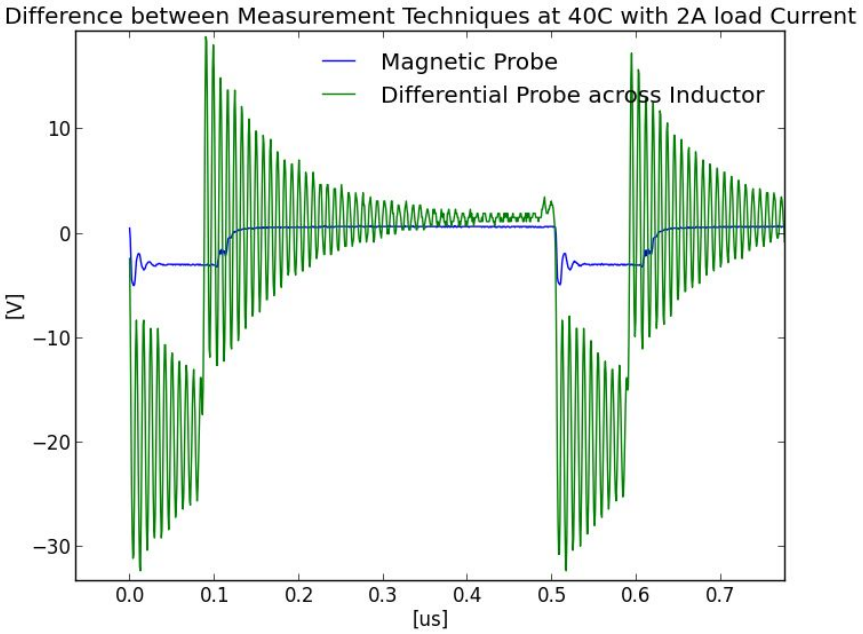
Shieldbox Attenuation





- We first performed measurements of duty cycle with the shieldbox on.
- As the shape is a sawtooth, we originally thought that what we were seeing was the current. (Current in a buck converter has a sawtooth shape.)
- The shieldbox attenuates higher frequencies so removing it gave us a square wave, which is the shape of the voltage across the inductor.





- **There is a clear difference in the size of the on time between the two measurement techniques.**
- **Our differential probe could not clearly measure the signal with a load current applied, so we restricted ourselves to the magnetic probe results.**
- **Note: The differential probe measurements are scaled by a factor of 2.**

Why do we see a difference in pulse width between the two techniques?

Magnetic field through a solenoid with short length compared to radius.

$$B_z = \frac{\mu_0 I N R^2}{2(R^2 + z^2)^{\frac{3}{2}}}$$

Magnetic probe measures change in B field:

$$\frac{dB}{dt} \propto \frac{dI}{dt}$$

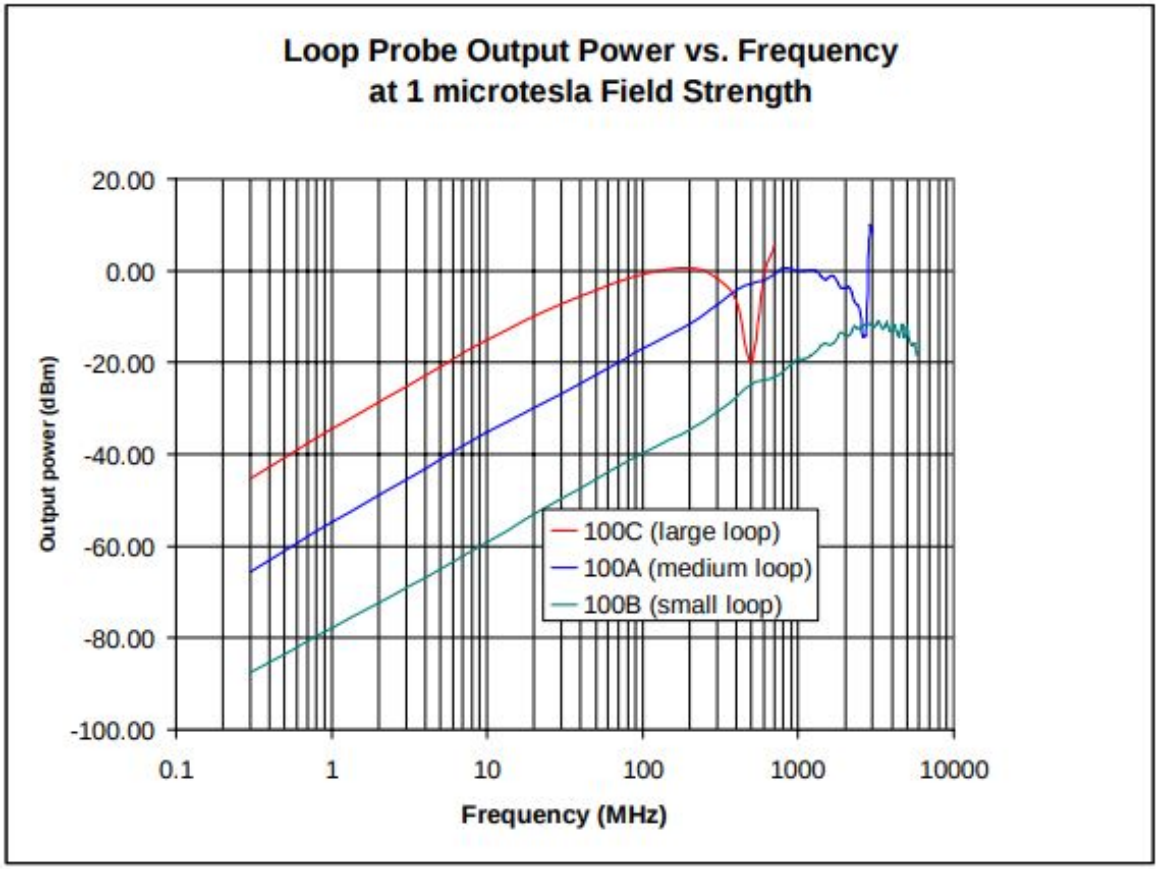
The voltage across the inductor is given by the following:

$$V_L = L\frac{dI_L}{dt}$$

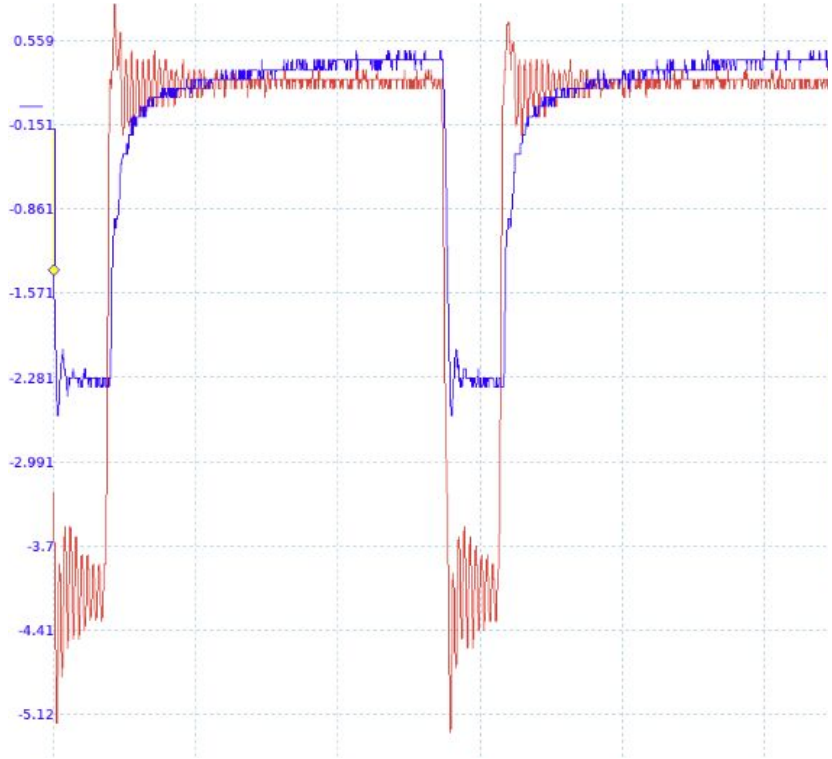
As the frequency at which the voltage across the inductor switches is the switching frequency, what we see as measured by the magnetic probe gives us that same frequency.

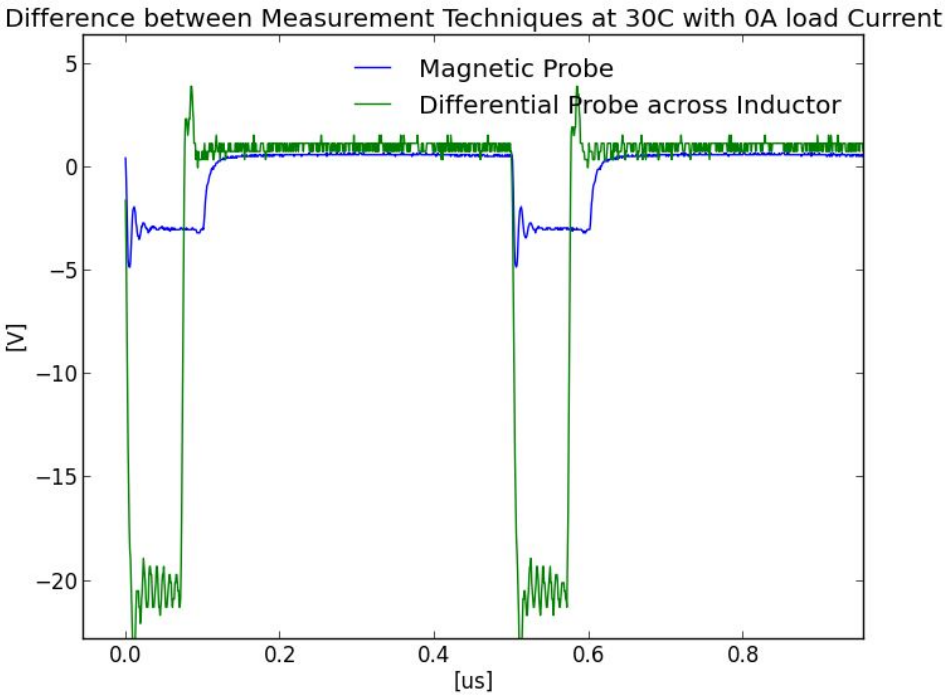
$$\frac{dB}{dt} \propto V_L$$

However...



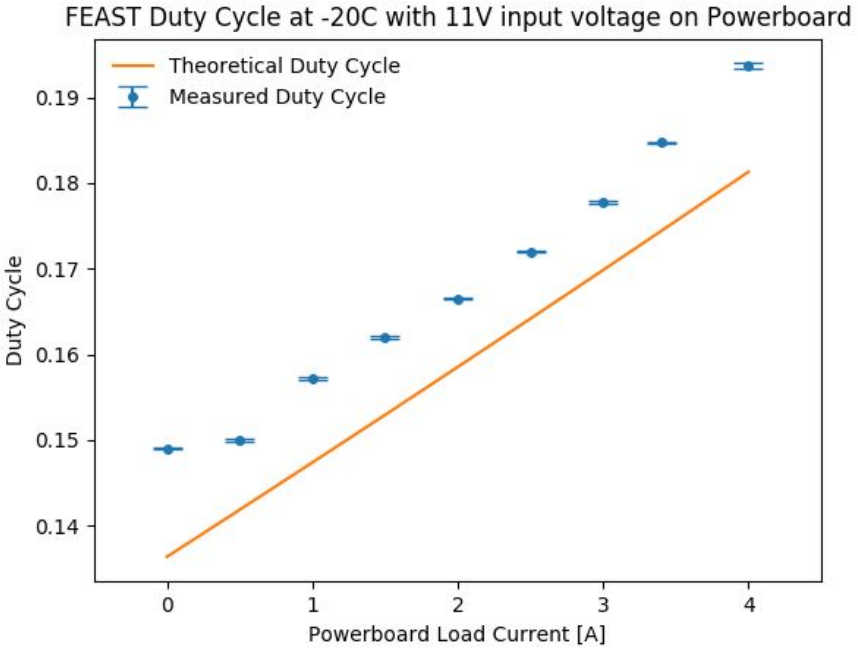
- The response of the magnetic probe is dependent on frequency and magnetic field strength.
- This leads to a shift in the on time/pulse width as the strength of different frequencies of the changing magnetic field are attenuated differently.

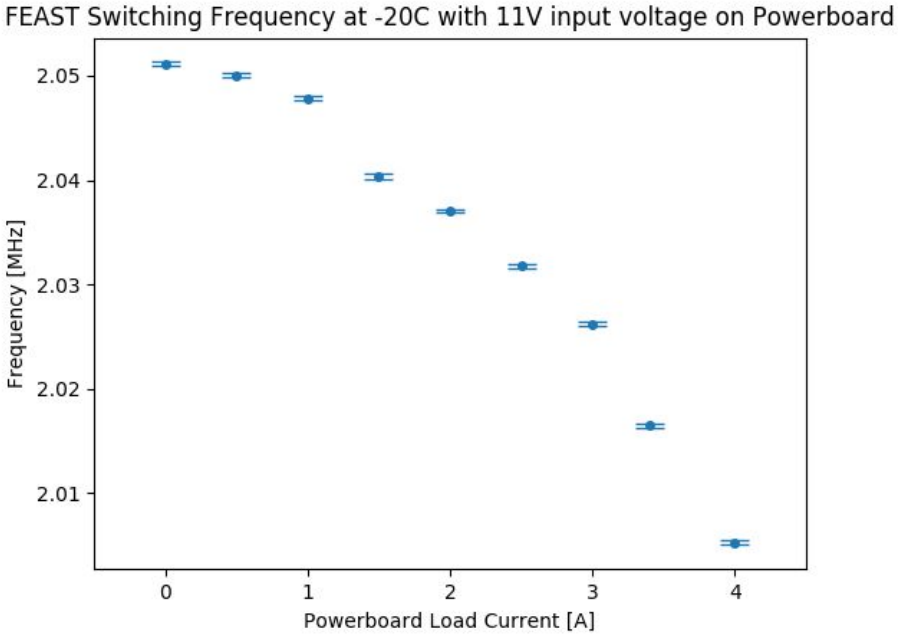




- **Left: blue pulse is the magnetic probe measurement taken using the small loop probe.**
- **Right: blue pulse is measured with the medium sized loop probe.**
- **The pulse width as measured by the small loop probe was in agreement with the differential probe reading for all measurements taken with it.**

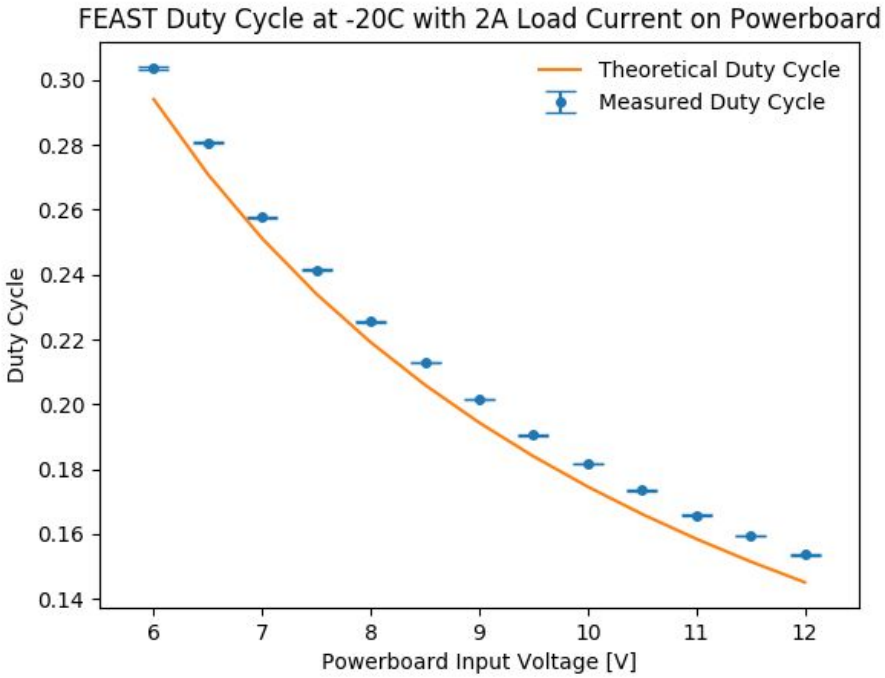
Constant input voltage of 11V with varying load current

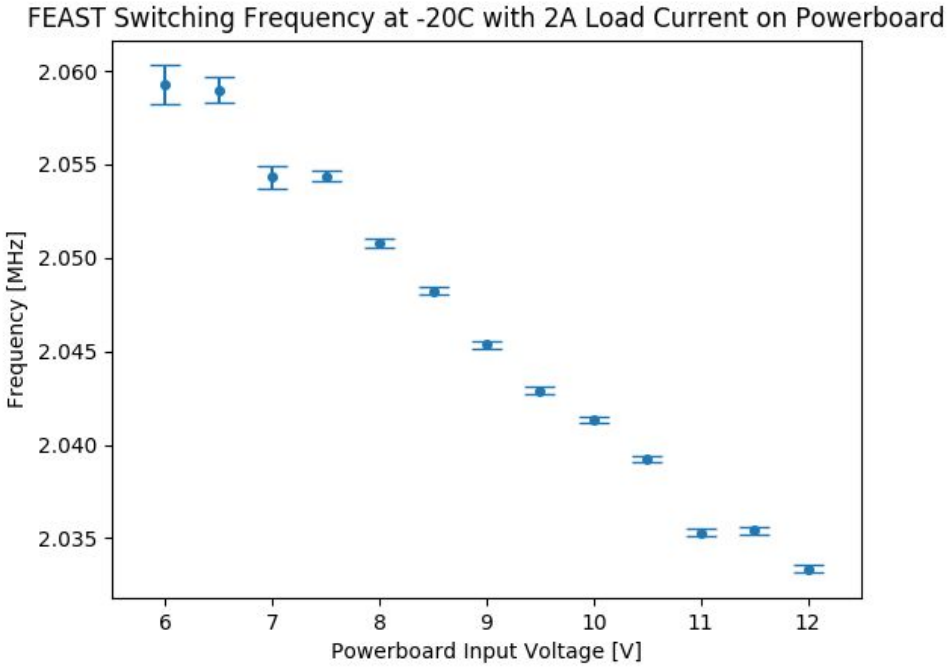




- **Measured using small loop probe**

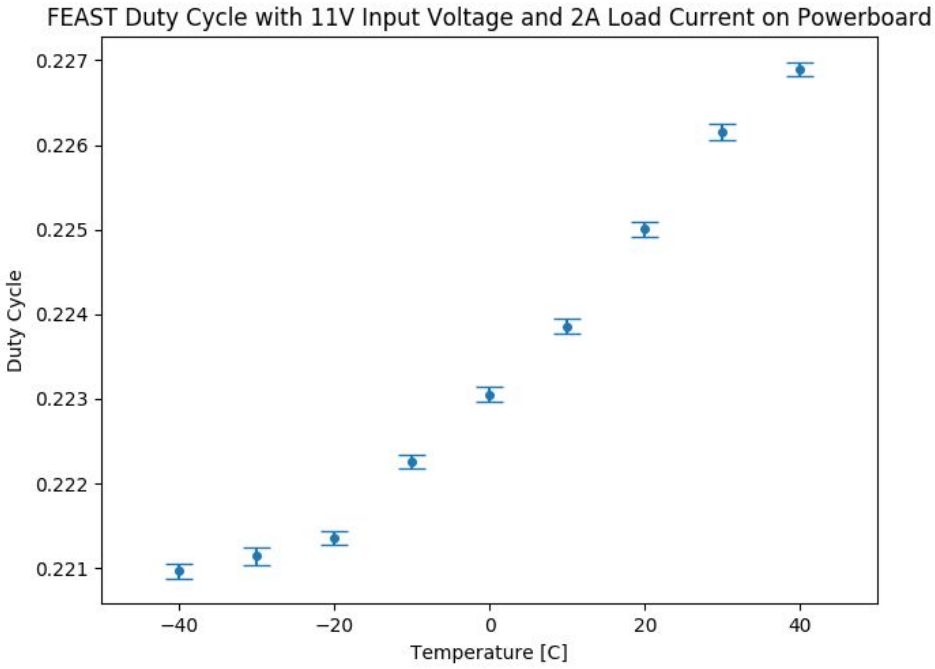
Constant load current of 2A with varying input voltage

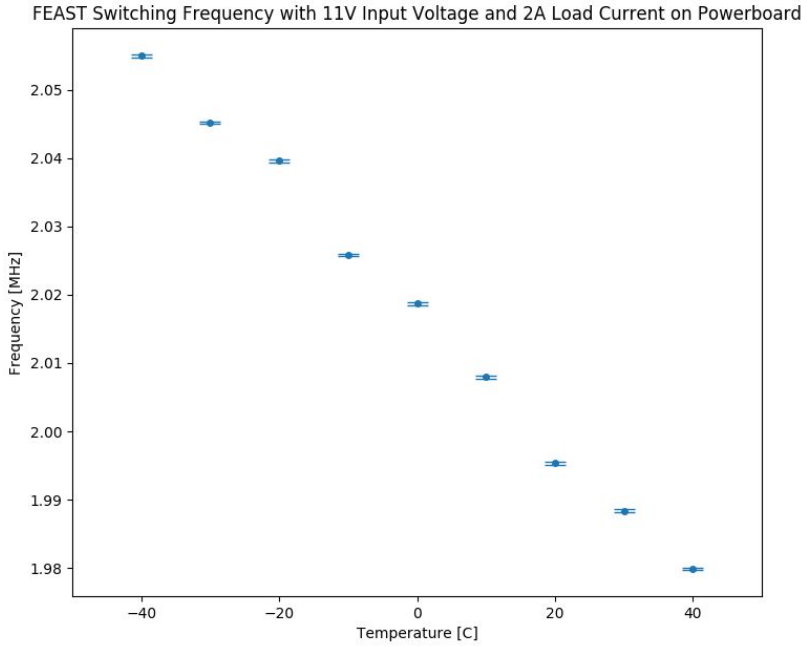




- **Measured using small loop probe**

Constant 11V input voltage and 2A load current with varying temperature





- **Measured using medium sized loop probe**