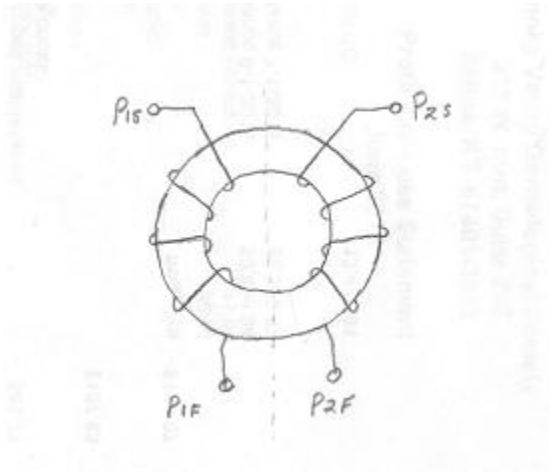
Common Mode Coil Tests 3_23_16 jmf

The following tests were performed on the following common mode toroid coil/core arrangement. The windings are counter-wound as shown and the specs are as follows:

Primary 1 and 2 wound with 92T each in 26ga magnet wire w/dcr = .71 ohm .

Pri 1 inductance = 44.8mh, Pri2 inductance = 47.8mh, Bucking inductance = 765uh

Core = Arnold P7070 ferrite, 2”OD x 1.25”ID x .75”Ht



Various connections will be made with the coil wiring. The scope connections will always be CH1(yel) to P1s, CH2(blu) to P2s, CH3(pnk) to output, CH4(grn) input current to P1s, and Math is CH1 x CH4 or input power in mean watts.

It should be obvious to those in the art that if a signal is applied to P1s while P2s is grounded with P1f connected to P2f, the coils would be operating in a bucking mode with relatively low inductance as compared to each individual coil. What is not obvious at least not to this author, is the voltage available at the junction of P1f and P2f. This is the subject of this paper.

The first test is with two separate in-phase 15v peak ac waveforms at 7kHz feeding P1s and P2s respectively with the output measured at the junction of P1f and P2f . Scope pix CM1 shows the results and as would be expected, the output peak on CH3(blu) is ~ equal to the inputs. The traces are slightly offset for clarity.

CM2 now shows the results when Ps1 and Ps2 are 180’ out-of-phase with the input levels and frequency same as above. Note the ~96v peak on the output on the P1f and P2f tap along with the phase. Is this a result of the A field or magnetic vector potential? We know an H field exists in the center of the toroid core between the winding gaps.

CM3 has Ps2 grounded so the only signal feeding the coil assembly is the single ended voltage seen on CH1. Note the input/output ratio difference between the differential and single ended inputs.

The question now arises “can this be useful”?

CM4 shows the maximum peak output on CH3 of 216.5v at the P1f/P2f tap that is connected to a .01ufd film cap that is connected to ground forming a series resonance network. Calculating the port inductance with this resonance peak at 6kHz with the .01ufd cap results in 70.4mh. The rounding of the top of the output waveform is due to some saturation of the core at this induction level.

For comparison, CM5 shows a resonance peak at 5.7kHz with a lower level input of 10v peak vs 15v peak as in CM4. Note the cleaner output waveform that is lower in saturation than CM4. The port inductance now calculates to 77.9mh, an increase over CM4 due to less saturation of the core.

CM6 now shows the maximum saturation resonance at 10kHz just before a "snap over" occurs that is shown in CM9 at 10.3kHz where the output drops back out of saturation. This condition will exist until the frequency is lowered to 6.8kHz as seen in CM8 where the circuit snaps back into saturation. This circuit action is similar to the author's PSO or Pumped Saturating Oscillator which will not be discussed here.

CM13 shows the output of the P1f/P2f tap on CH3 with a Caddock 1.0K ohm, 1% non-inductive metal film as a load with an input frequency of 10kHz. No resonance cap is used. The power output is 563mw rms with a mean input power of 1.041 watts.

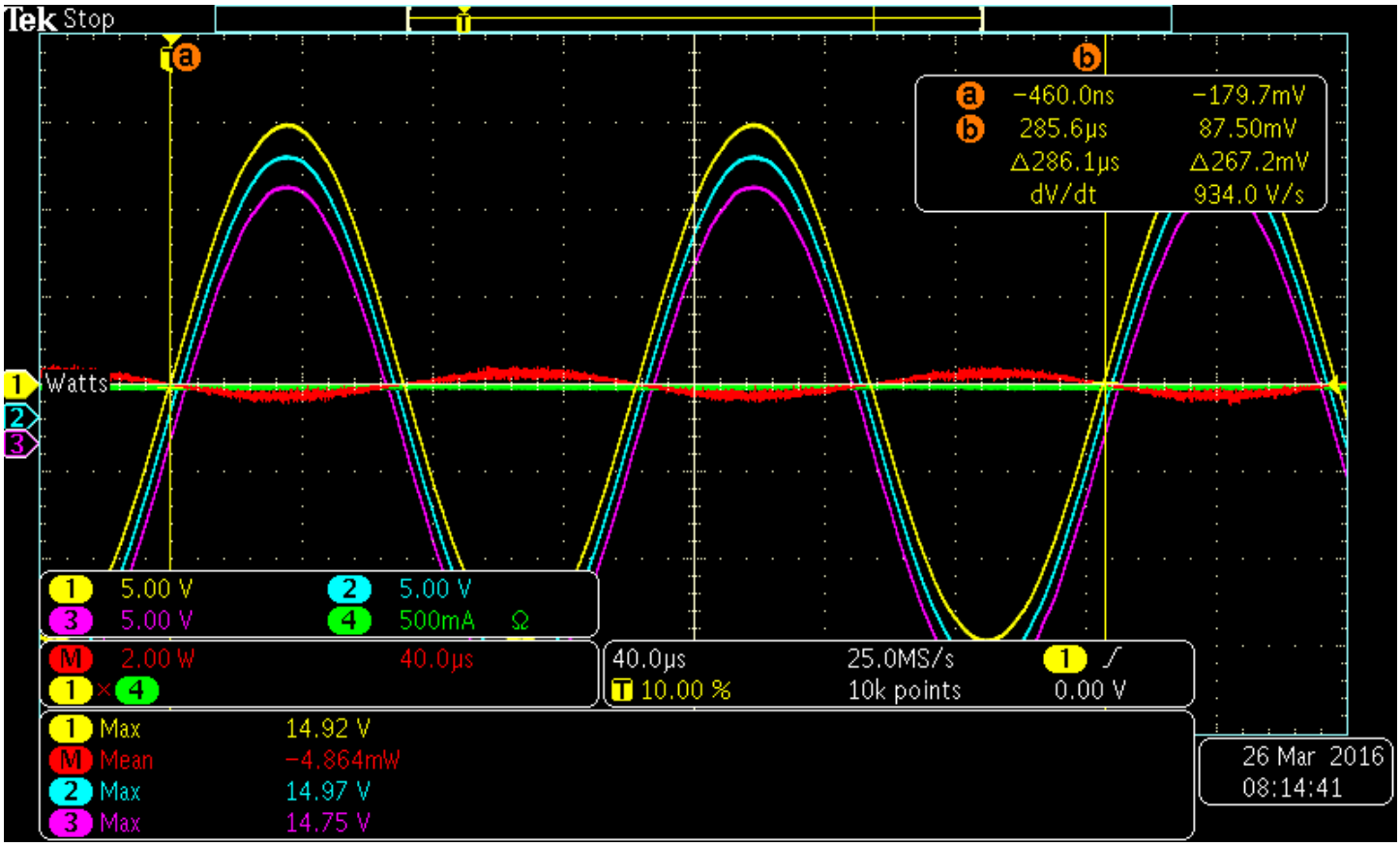
CM13A shows an input power of 604mw mean with no load which is basically the power to supply magnetizing current to the core. Since Xl = wL and the buck inductance = 765uh, the reactance at 10kHz = 48 ohm. The peak input current therefore would be 40.23/48 = .838A which is close to the peak current on CH4.

What is interesting to note however, is the difference between the input power of 1.041 watts under load and the magnetizing power of 604mw which is 437mw. With an output power of 563mw this would appear to have a potential COP = 1.29. This potential COP increases with frequency but is not shown here for brevity.

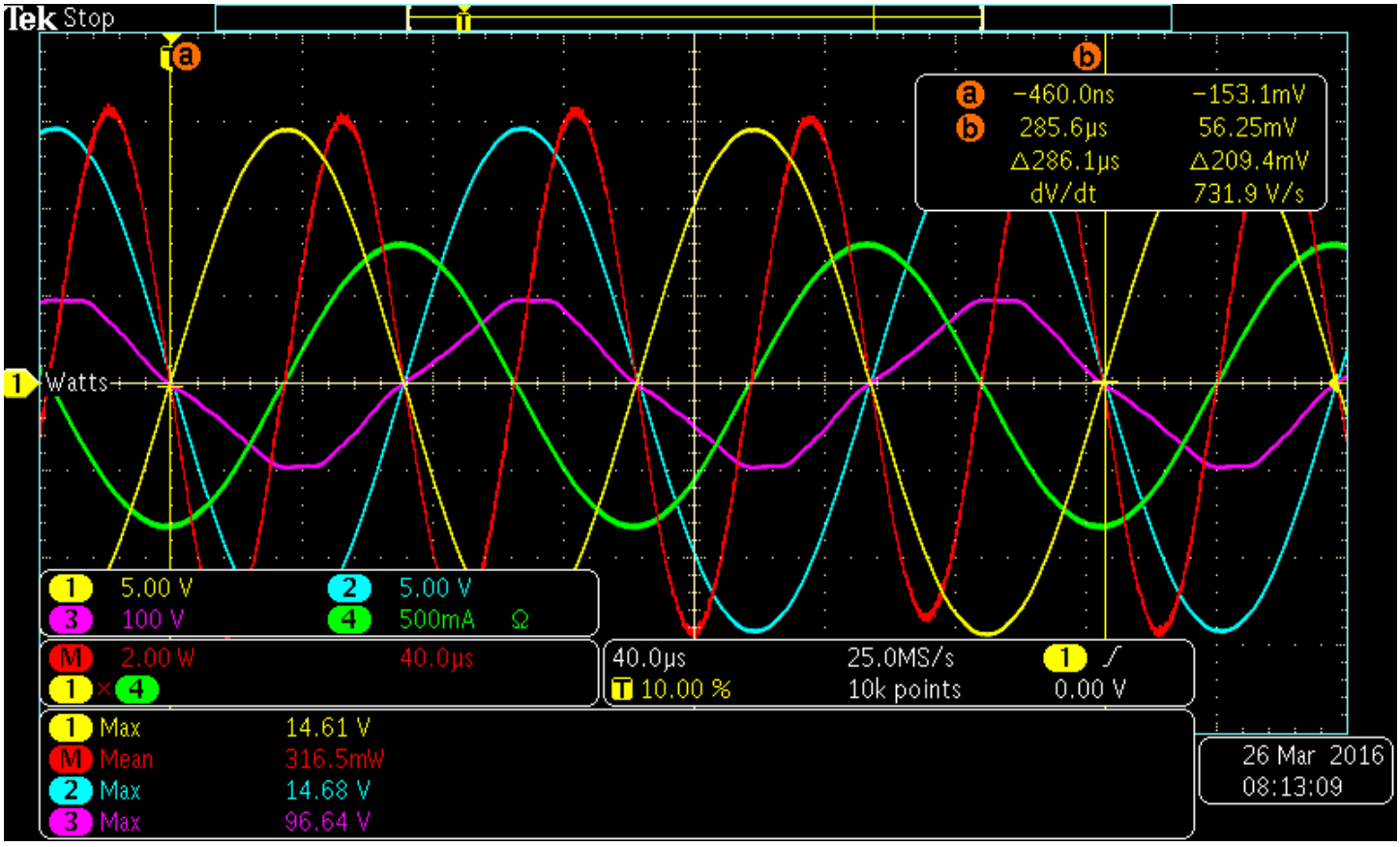
This utilization of this common mode choke or buck winding configuration leaves many questions to be answered. For example, is this circuit reciprocal? What if we drive the tap? What if we resonate the input? Why is the output ratio higher with higher inputs? Will this apply to air core windings? How, if at all, does this apply to the TPU?

Jon Flickinger

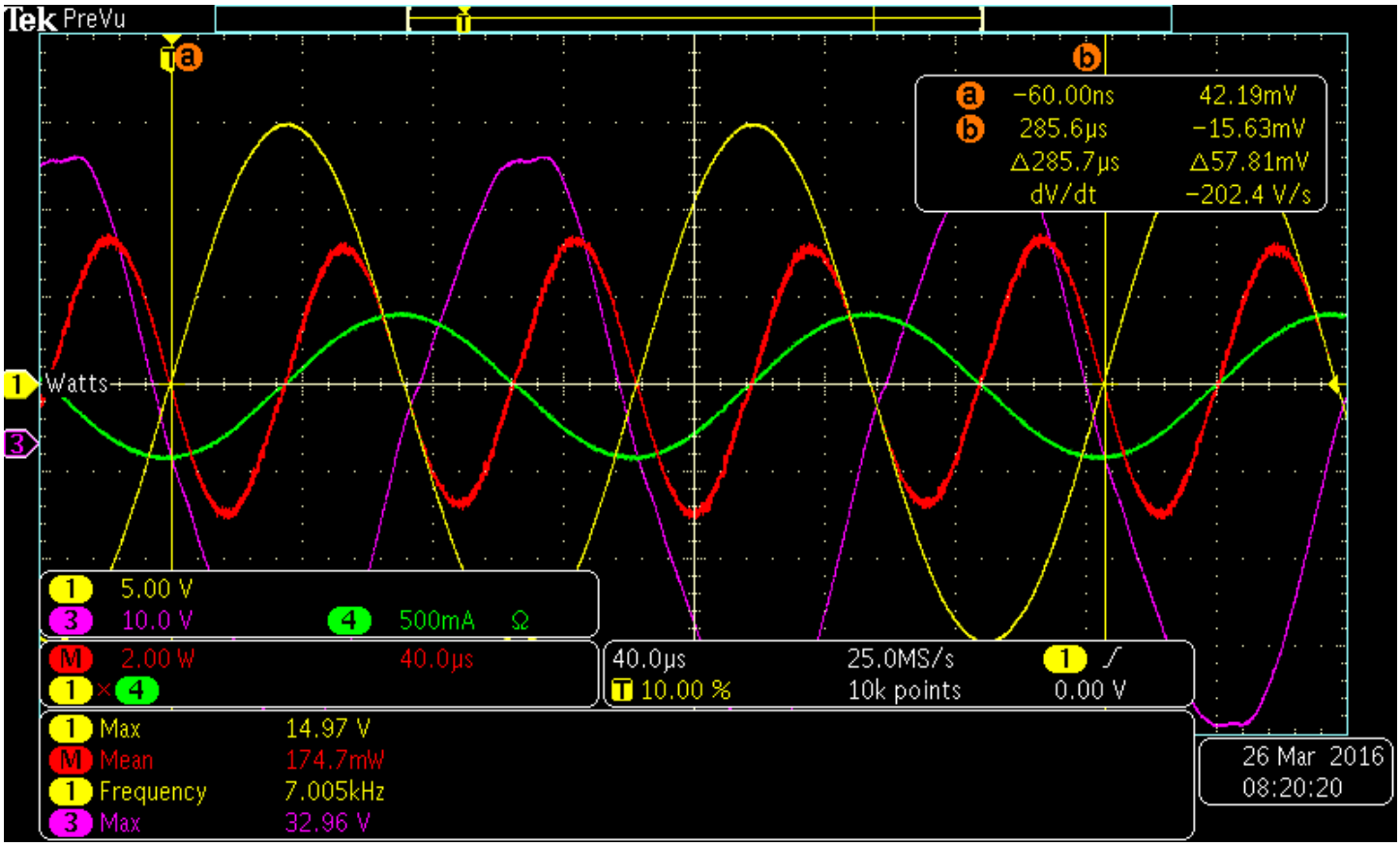
CM1


Tek Stop
a -460.0ns -179.7mV
b 285.6µs 87.50mV
Δ286.1µs Δ267.2mV
dV/dt 934.0 V/s
Watts
1 5.00 V 2 5.00 V
3 5.00 V 4 500mA Ω
M 2.00 W 40.0µs
1 × 4
40.0µs 25.0MS/s 1 ⎍
10.00 % 10k points 0.00 V
1 Max 14.92 V
M Mean −4.864mW
2 Max 14.97 V
3 Max 14.75 V
26 Mar 2016
08:14:41

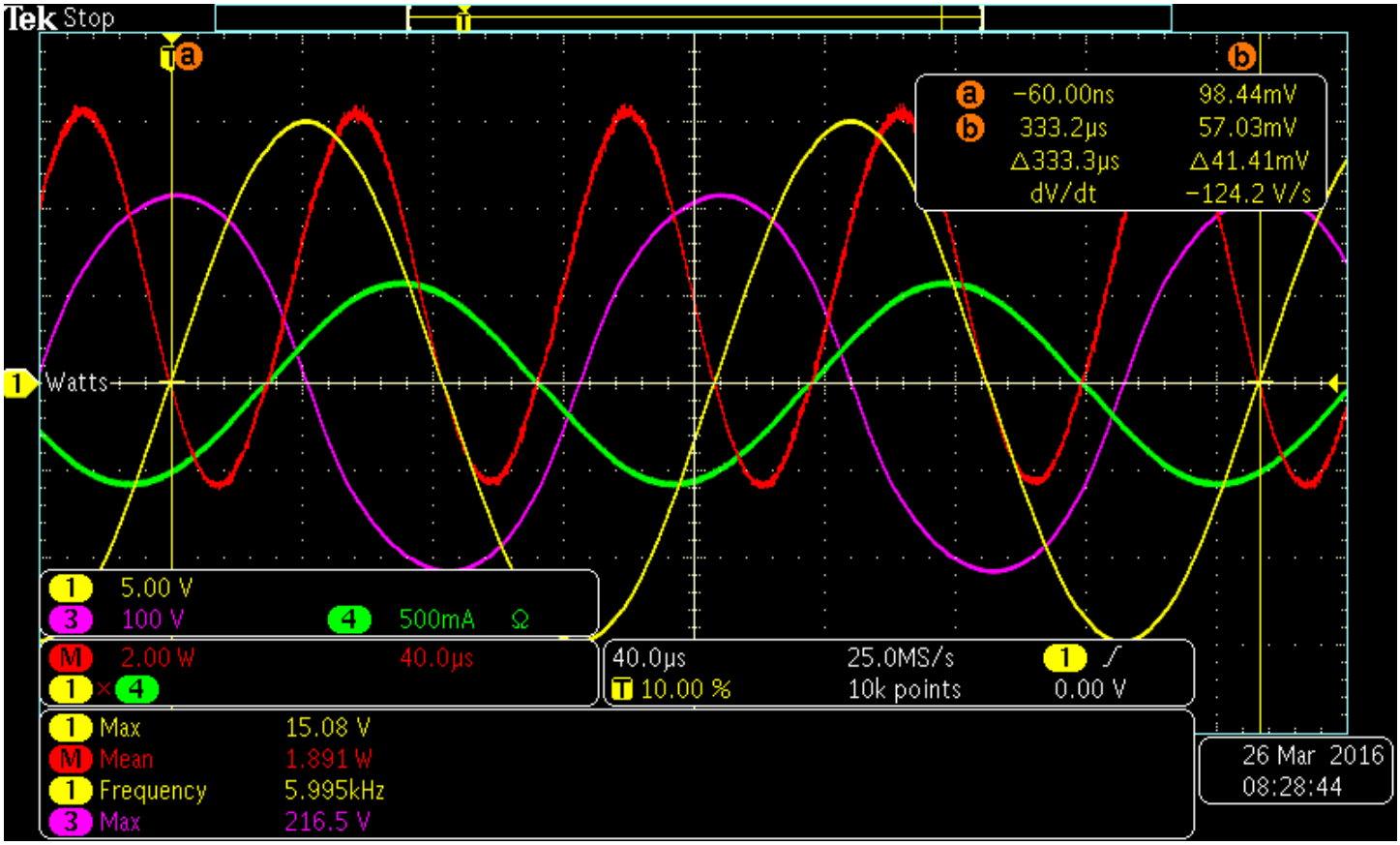
CM2


Tek Stop
a -460.0ns -153.1mV
b 285.6µs 56.25mV
Δ286.1µs Δ209.4mV
dV/dt 731.9 V/s
Watts
1 5.00 V 2 5.00 V
3 100 V 4 500mA Ω
M 2.00 W 40.0µs
1 × 4
40.0µs 25.0MS/s 1 ⎍
10.00 % 10k points 0.00 V
1 Max 14.61 V
M Mean 316.5mW
2 Max 14.68 V
3 Max 96.64 V
26 Mar 2016
08:13:09

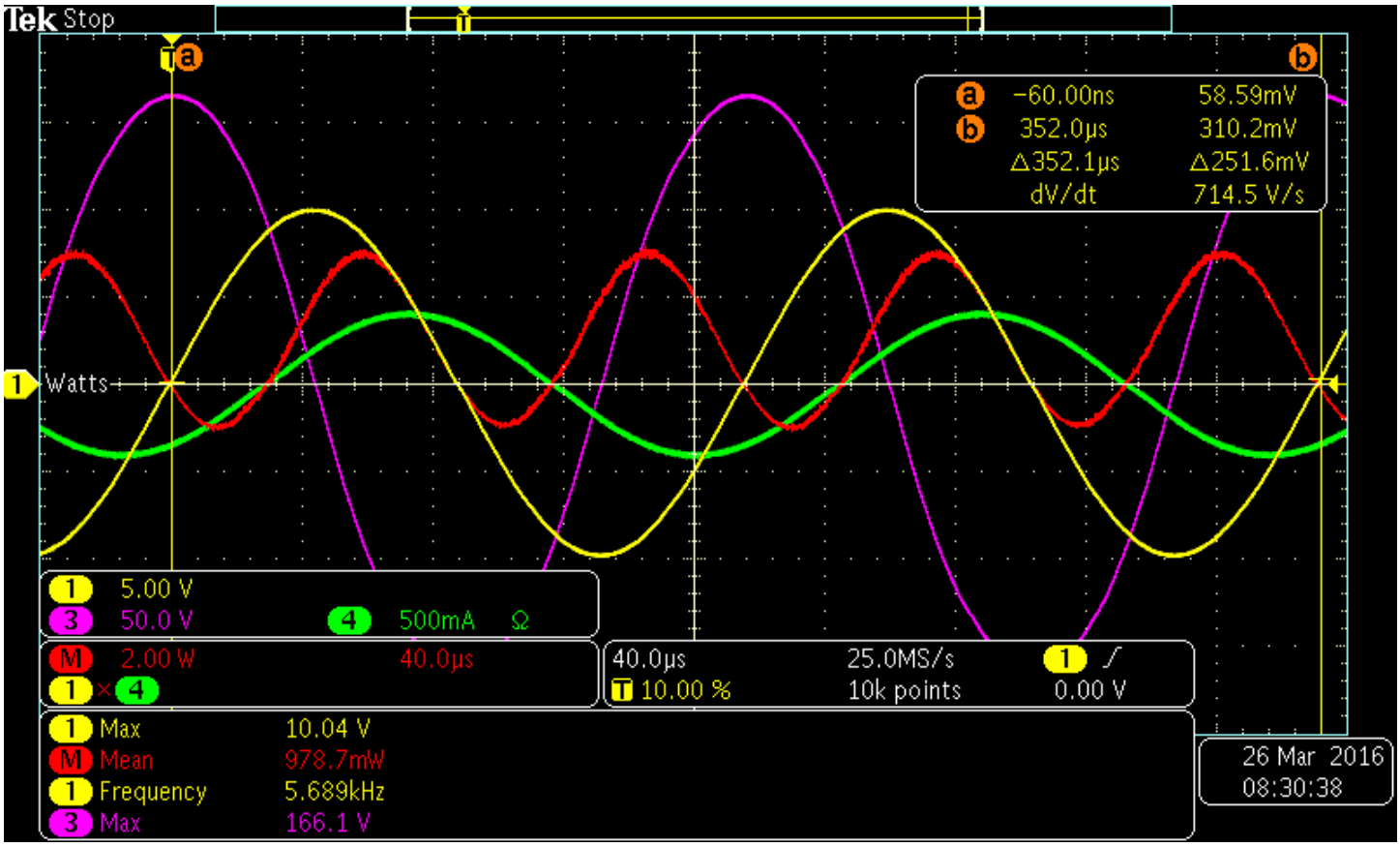
CM3


Tek PreVu
a -60.00ns 42.19mV
b 285.6µs -15.63mV
Δ285.7µs Δ57.81mV
dV/dt -202.4 V/s
Watts
1 5.00 V
3 10.0 V
4 500mA Ω
M 2.00 W 40.0µs
1 × 4
40.0µs 25.0MS/s 1 ⎍
10.00 % 10k points 0.00 V
1 Max 14.97 V
M Mean 174.7mW
1 Frequency 7.005kHz
3 Max 32.96 V
26 Mar 2016
08:20:20

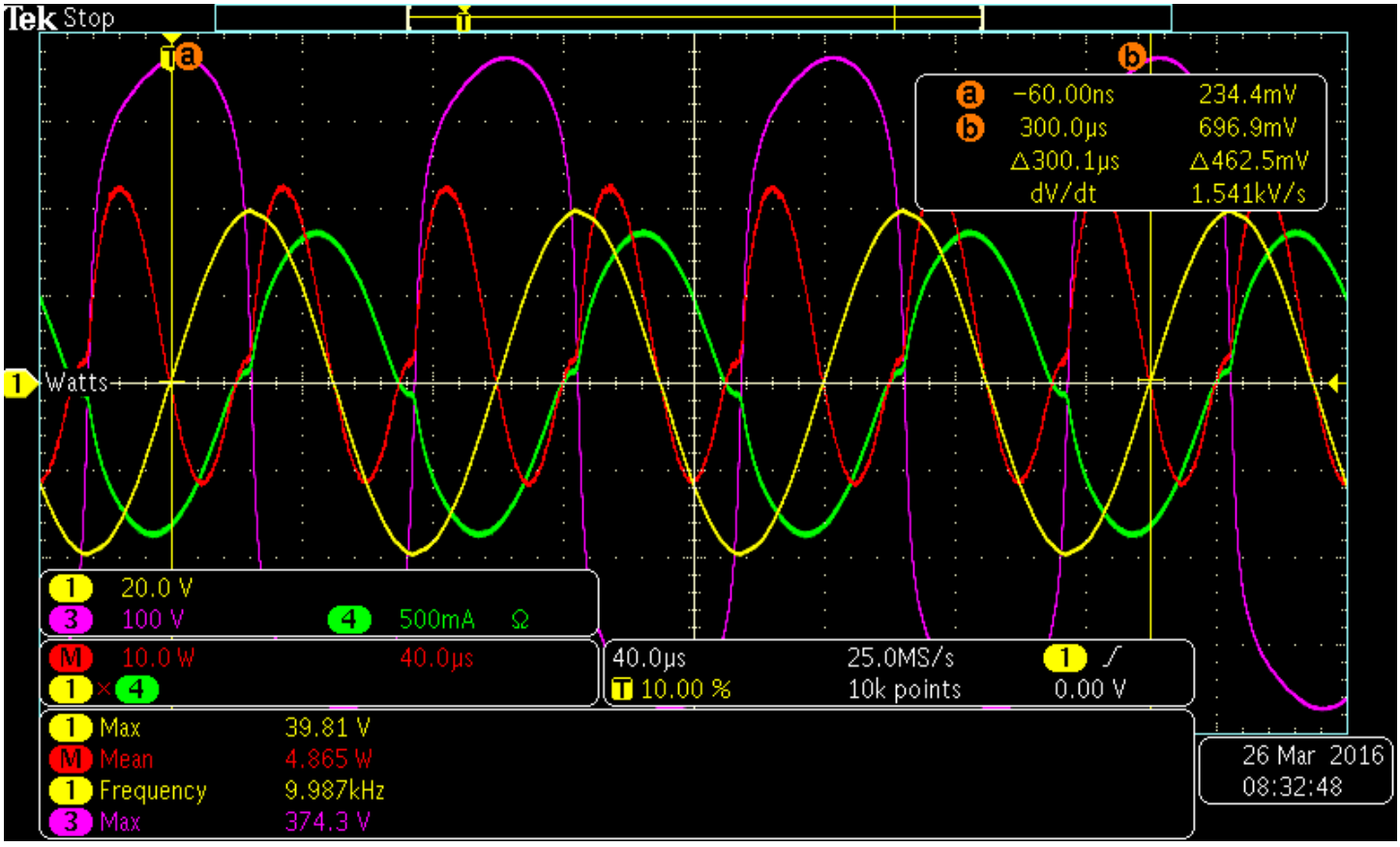
CM4


Tek Stop
a -60.00ns 98.44mV
b 333.2µs 57.03mV
Δ333.3µs Δ41.41mV
dV/dt -124.2 V/s
Watts
1 5.00 V
3 100 V
4 500mA Ω
M 2.00 W 40.0µs
1 × 4
40.0µs 25.0MS/s 1 ⎍
10.00 % 10k points 0.00 V
1 Max 15.08 V
M Mean 1.891 W
1 Frequency 5.995kHz
3 Max 216.5 V
26 Mar 2016
08:28:44

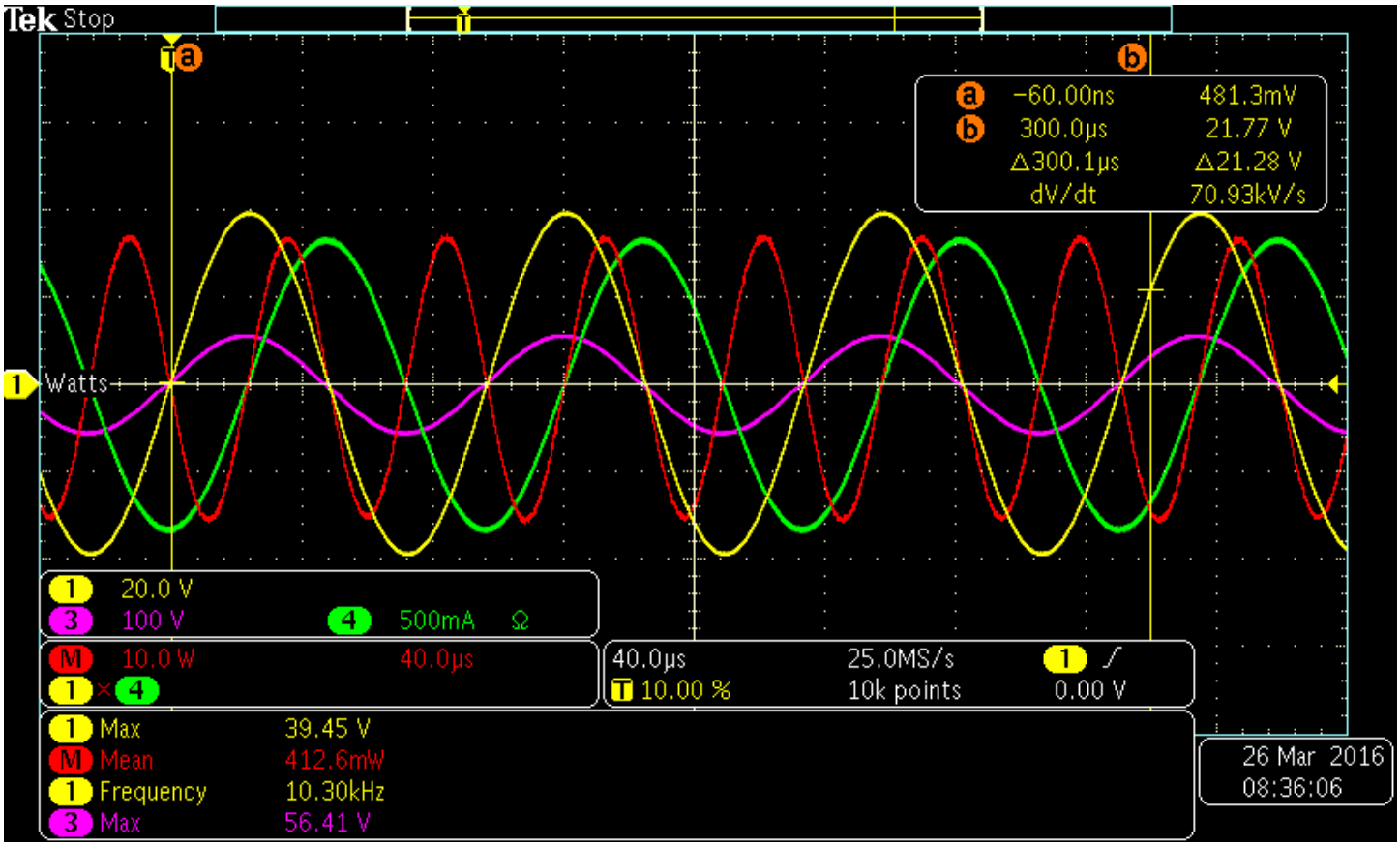
CM5


Tek Stop
a -60.00ns 58.59mV
b 352.0µs 310.2mV
Δ352.1µs Δ251.6mV
dV/dt 714.5 V/s
Watts
1 5.00 V
3 50.0 V
4 500mA Ω
M 2.00 W 40.0µs
1 × 4
40.0µs 25.0MS/s
10.00 % 10k points
0.00 V
1 Max 10.04 V
M Mean 978.7mW
1 Frequency 5.689kHz
3 Max 166.1 V
26 Mar 2016
08:30:38

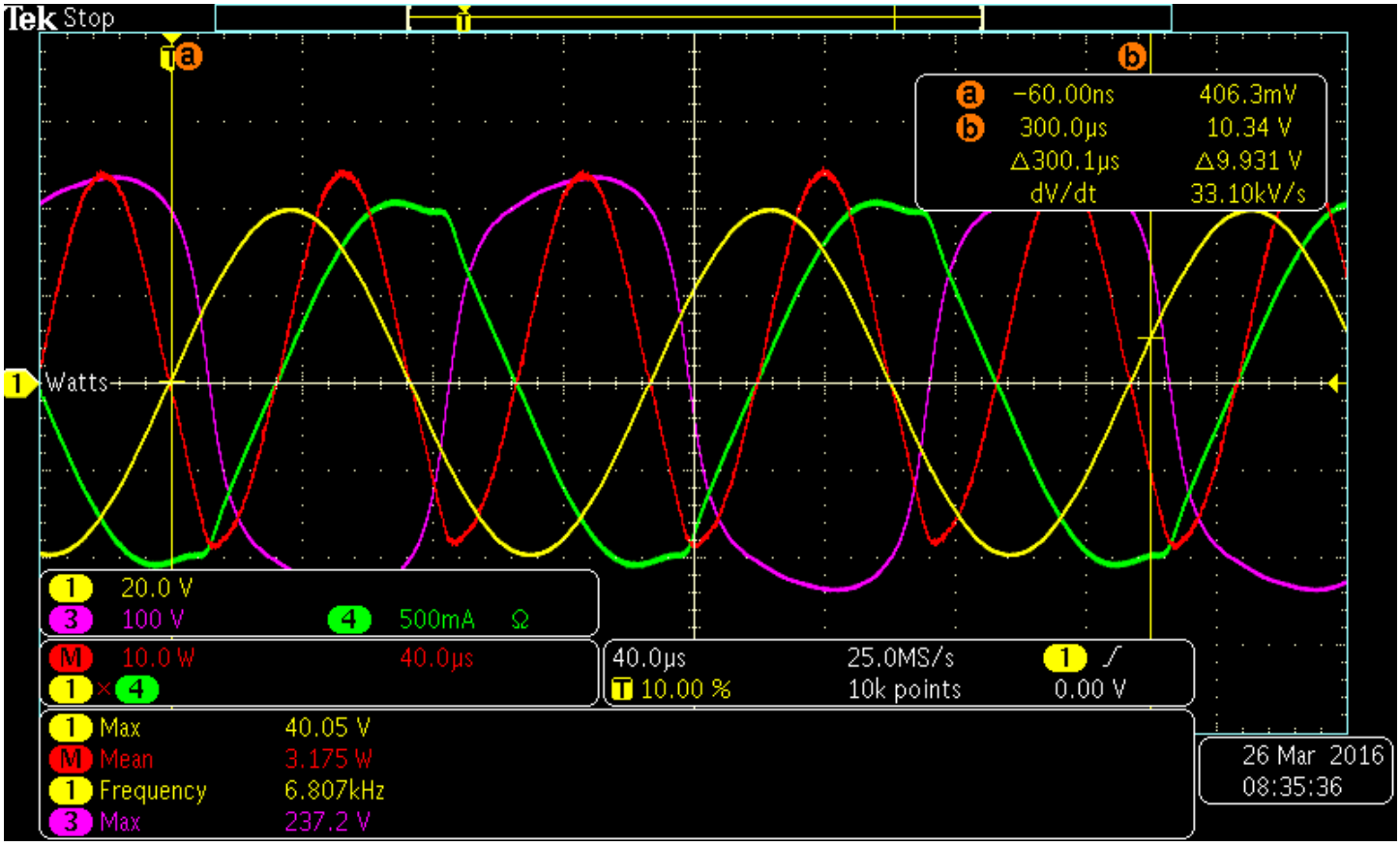
CM6


Tek Stop
a -60.00ns 234.4mV
b 300.0µs 696.9mV
Δ300.1µs Δ462.5mV
dV/dt 1.541kV/s
Watts
1 20.0 V
3 100 V
4 500mA Ω
M 10.0 W 40.0µs
1 × 4
40.0µs 25.0MS/s
10.00 % 10k points
0.00 V
1 Max 39.81 V
M Mean 4.865 W
1 Frequency 9.987kHz
3 Max 374.3 V
26 Mar 2016
08:32:48

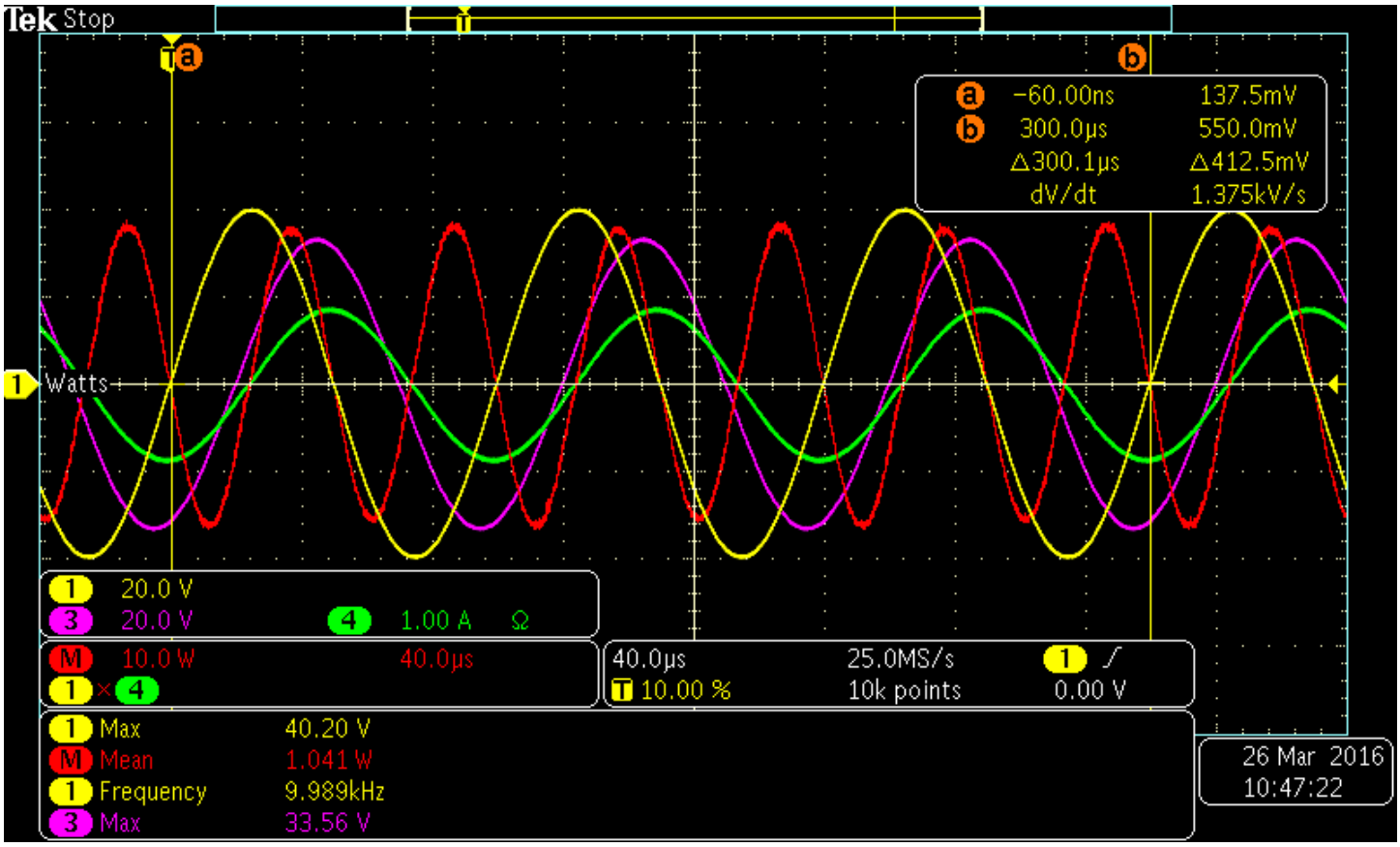
CM9


Tek Stop
a -60.00ns 481.3mV
b 300.0µs 21.77 V
Δ300.1µs Δ21.28 V
dV/dt 70.93kV/s
Watts
1 20.0 V
3 100 V
4 500mA Ω
M 10.0 W 40.0µs
1 × 4
40.0µs 25.0MS/s
10.00 % 10k points
0.00 V
1 Max 39.45 V
M Mean 412.6mW
1 Frequency 10.30kHz
3 Max 56.41 V
26 Mar 2016
08:36:06

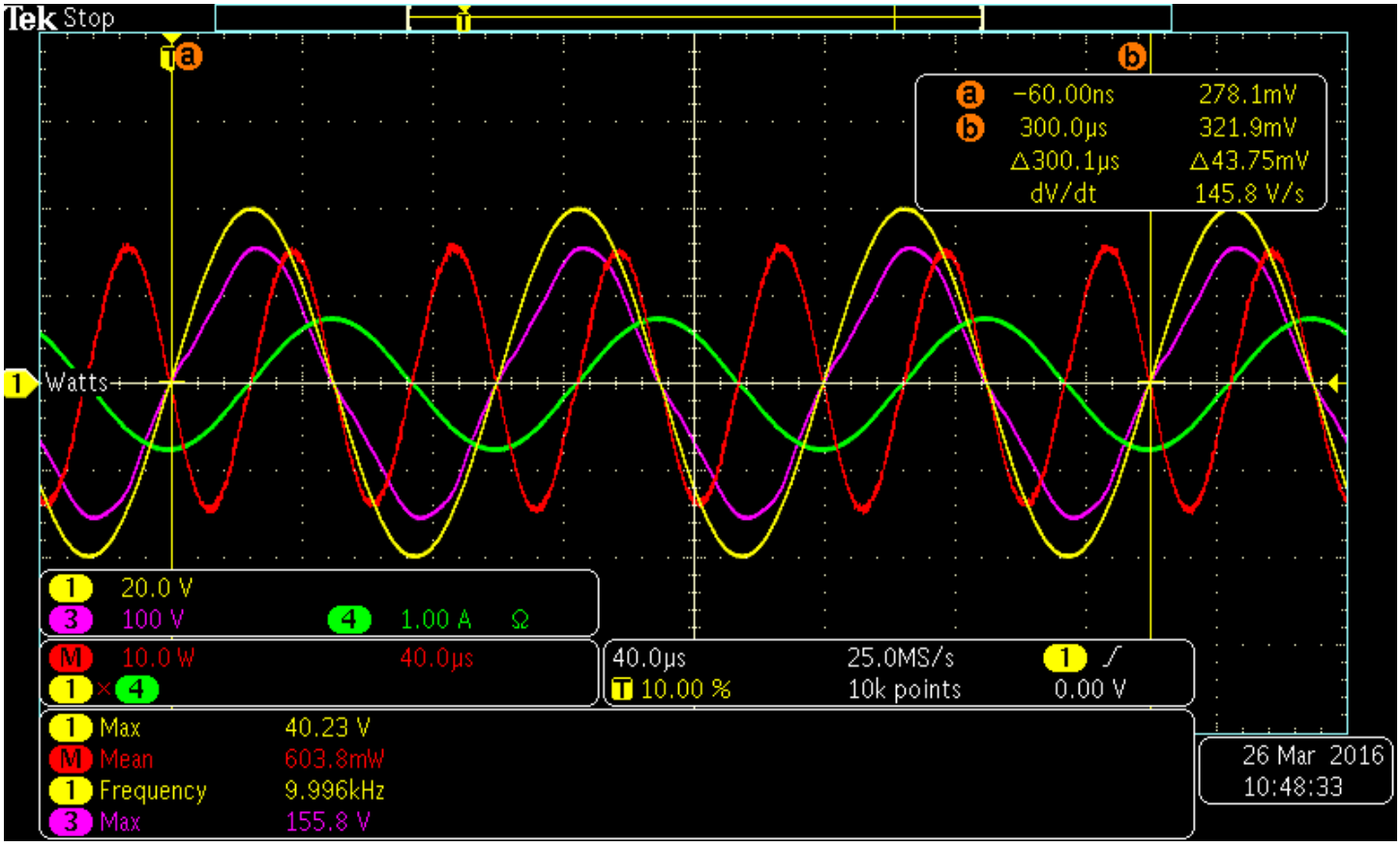
CM8


Tek Stop
a -60.00ns 406.3mV
b 300.0µs 10.34 V
Δ300.1µs Δ9.931 V
dV/dt 33.10kV/s
Watts
1 20.0 V
3 100 V
4 500mA Ω
M 10.0 W 40.0µs
1 × 4
40.0µs 25.0MS/s
10.00 % 10k points
0.00 V
1 Max 40.05 V
M Mean 3.175 W
1 Frequency 6.807kHz
3 Max 237.2 V
26 Mar 2016
08:35:36

CM13


Tek Stop
a -60.00ns 137.5mV
b 300.0µs 550.0mV
Δ300.1µs Δ412.5mV
dV/dt 1.375kV/s
Watts
1 20.0 V
3 20.0 V
4 1.00 A Ω
M 10.0 W 40.0µs
1 × 4
40.0µs 25.0MS/s 1 ⎍
10.00 % 10k points 0.00 V
1 Max 40.20 V
M Mean 1.041 W
1 Frequency 9.989kHz
3 Max 33.56 V
26 Mar 2016
10:47:22

CM13A


Tek Stop
a -60.00ns 278.1mV
b 300.0µs 321.9mV
Δ300.1µs Δ43.75mV
dV/dt 145.8 V/s
Watts
1 20.0 V
3 100 V
4 1.00 A Ω
M 10.0 W 40.0µs
1 × 4
40.0µs 25.0MS/s 1 ⎍
10.00 % 10k points 0.00 V
1 Max 40.23 V
M Mean 603.8mW
1 Frequency 9.996kHz
3 Max 155.8 V
26 Mar 2016
10:48:33