Capacitor Energy Transfer Experiments

Poynt99 – 2008/Dec/06-07

V1.0

INTRODUCTION – What's this about?

Among Free Energy enthusiasts, two of the more popular methods of apparent free energy extraction arise from Inductive Kickback experiments with coils, and capacitor to capacitor charge/energy transfers through a load. This document looks at the latter.

The purpose of this document is not to debate whether free energy is obtainable from simple capacitor-to-capacitor energy transfers, but rather to show a few experiments and results with simulations as a means to learn more about the subject. The reader is left to make his own conclusions about the potential for free energy.

This document was inspired by **captainpecan's** (CP) thread and videos here at the overunity forum:
http://www.overunity.com/index.php?topic=6090.0;topicseen

A note about the values used in the experiments

From the videos, CP used two **4700u**F electrolytic capacitors, where the first one **C1** is charged to a starting voltage of **18.33V** with two 9V batteries in series. These are the values I will use.

Through a personal message, I have obtained the DC resistance values of CP's inductors/coils used in the videos, and they are as follows: 1.7, 1.8, and 1.8 Ohms, for a total of **5.3 Ohms** when added in series as per the videos.

As for the coil inductance, this is not available, and so I have made an educated guess. A nominal value of **30mH** was chosen, and the reason will be explained later. Larger inductor values to as high as 30H are tried as well to compare results and see the effects and changes that occur.

In all tests, the switch is closed after 10ms and remains closed to the end of the simulation run time.

CHAPTER 1 – The "Basic" Experiment

In Figure 1 is shown the most basic circuit for testing cap-to-cap energy transfer. Ignore the 100 MEG Ohm resistors as they are for simulation purposes only and do not affect the results. The only resistance present in this circuit is that of the switch itself, and is 0.01 Ohms. C1 is pre-charged to 18.33V and C2 to 0V as shown (IC=Initial Condition).

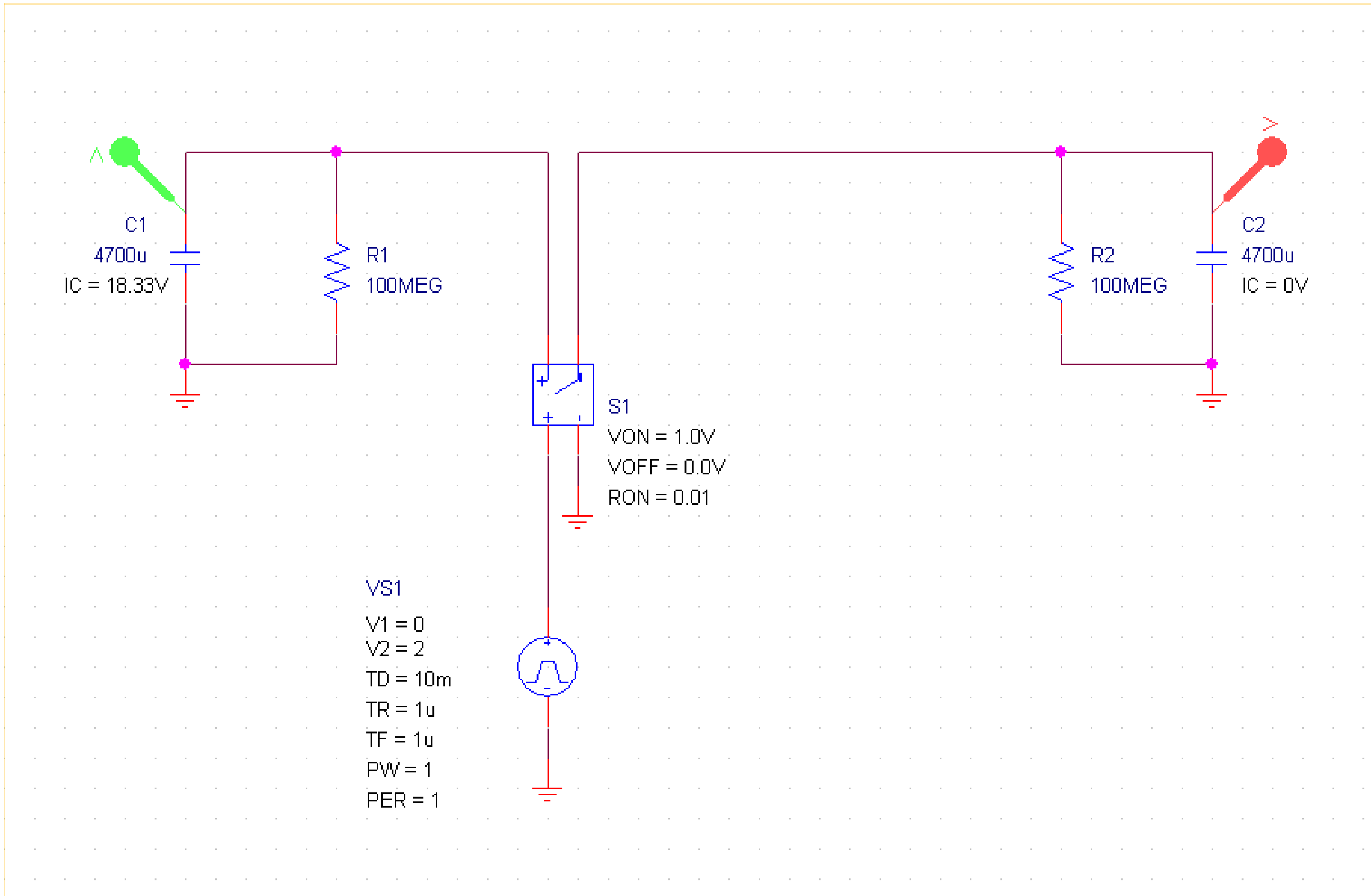

Figure 1 – Basic Circuit

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The following Figure 2 is the scope results of the Figure 1 circuit:

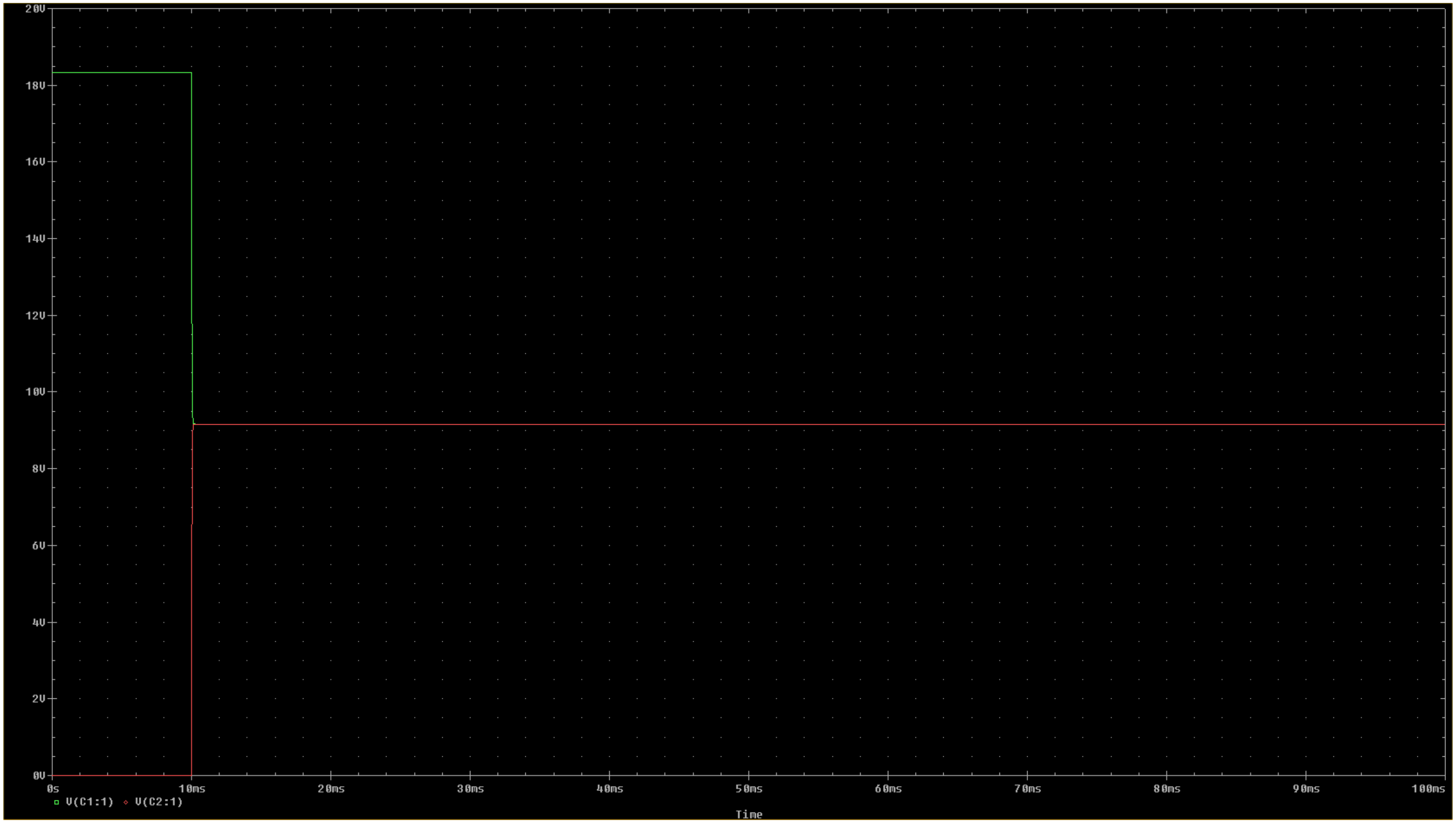

Figure 2 – Basic Circuit Scope Results

The energy transfer occurs very rapidly and both C1 and C2 settle at exactly **9.165V** each. This is exactly ½ of 18.33V. The simulation ran for 100ms (one-tenth of a second). C1 is the green trace, and C2 the red trace.

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Now let's introduce CP's coil resistance in the circuit as shown in Figure 3 below and observe the results:

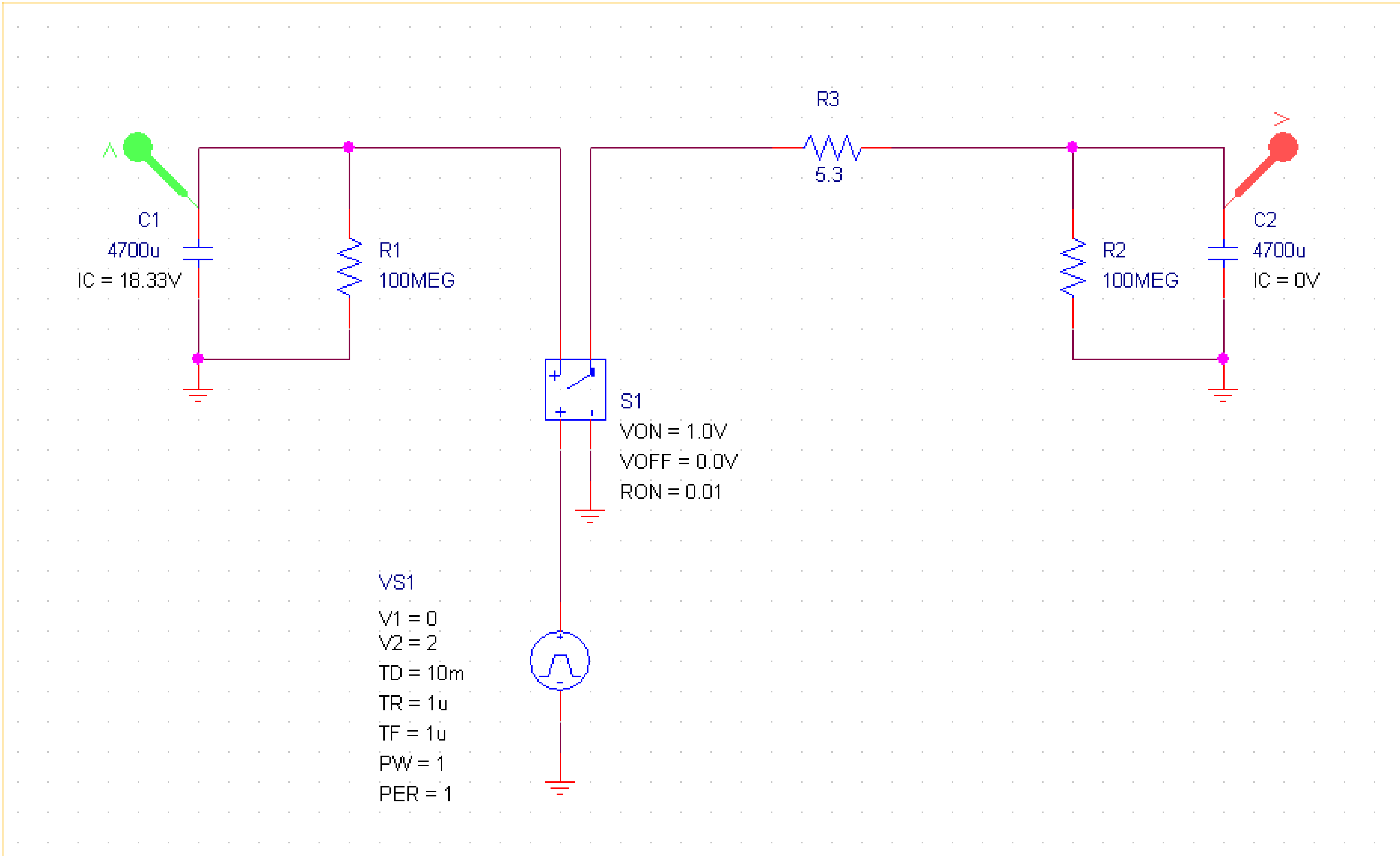

Figure 3 – Basic Circuit with CP's 5.3 Ohm Resistance Added

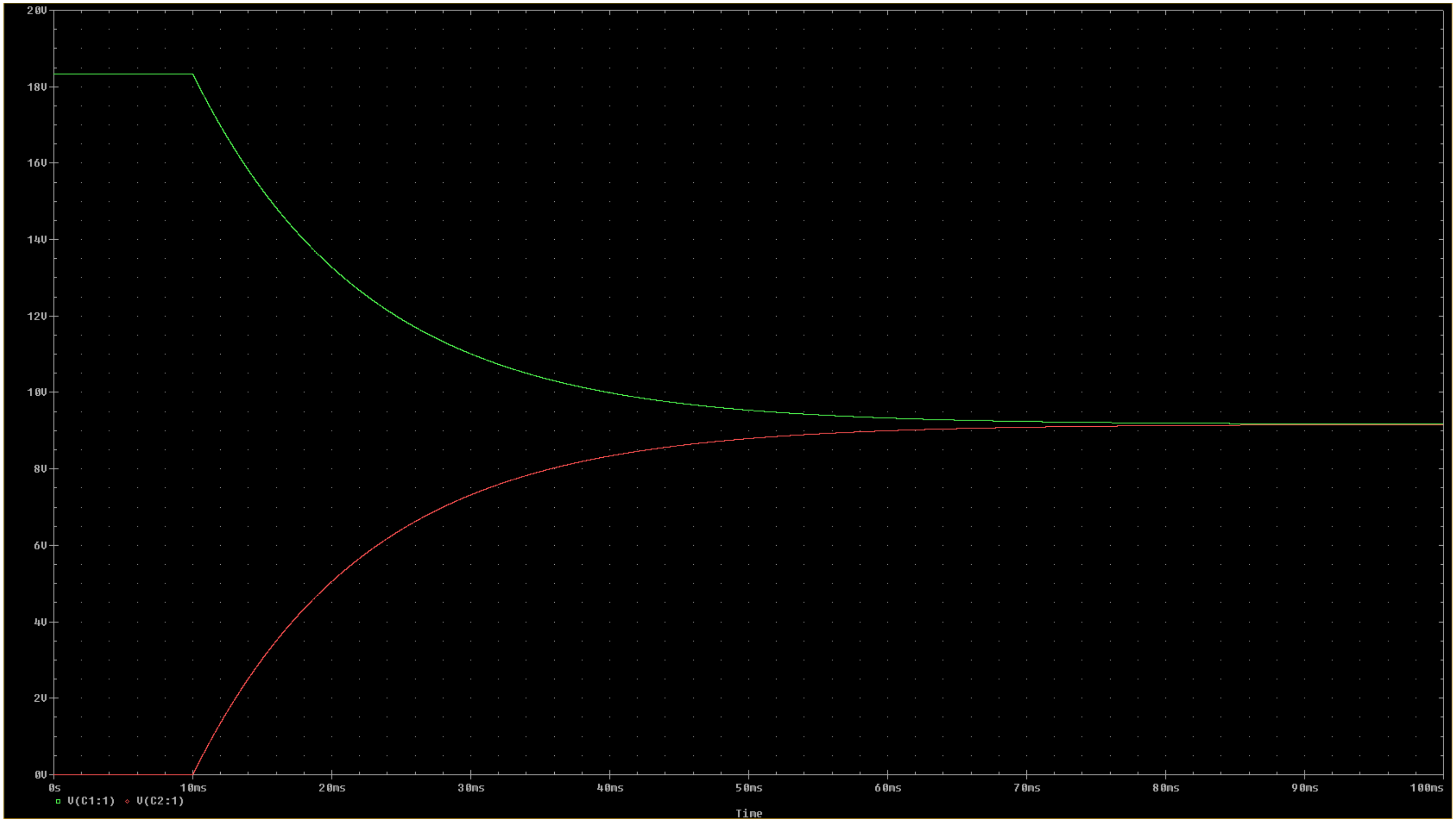

Figure 4 – Basic Circuit Scope Results With 5.3 Ohm Resistance

Notice the pronounced mirror-image charging/discharging curves as dictated by tau, RC and in this case is about 25ms. Five tau is what is normally used to describe the total time required for charging or discharging, and seems to correlate well here. The equation is somewhat skewed in this case because we actually have two 4700uF capacitors in series. The voltage on each cap still settles at the expected **9.165V** each.

We’ll now plot the power vs. time dissipated by R3 (CP’s coil resistance):

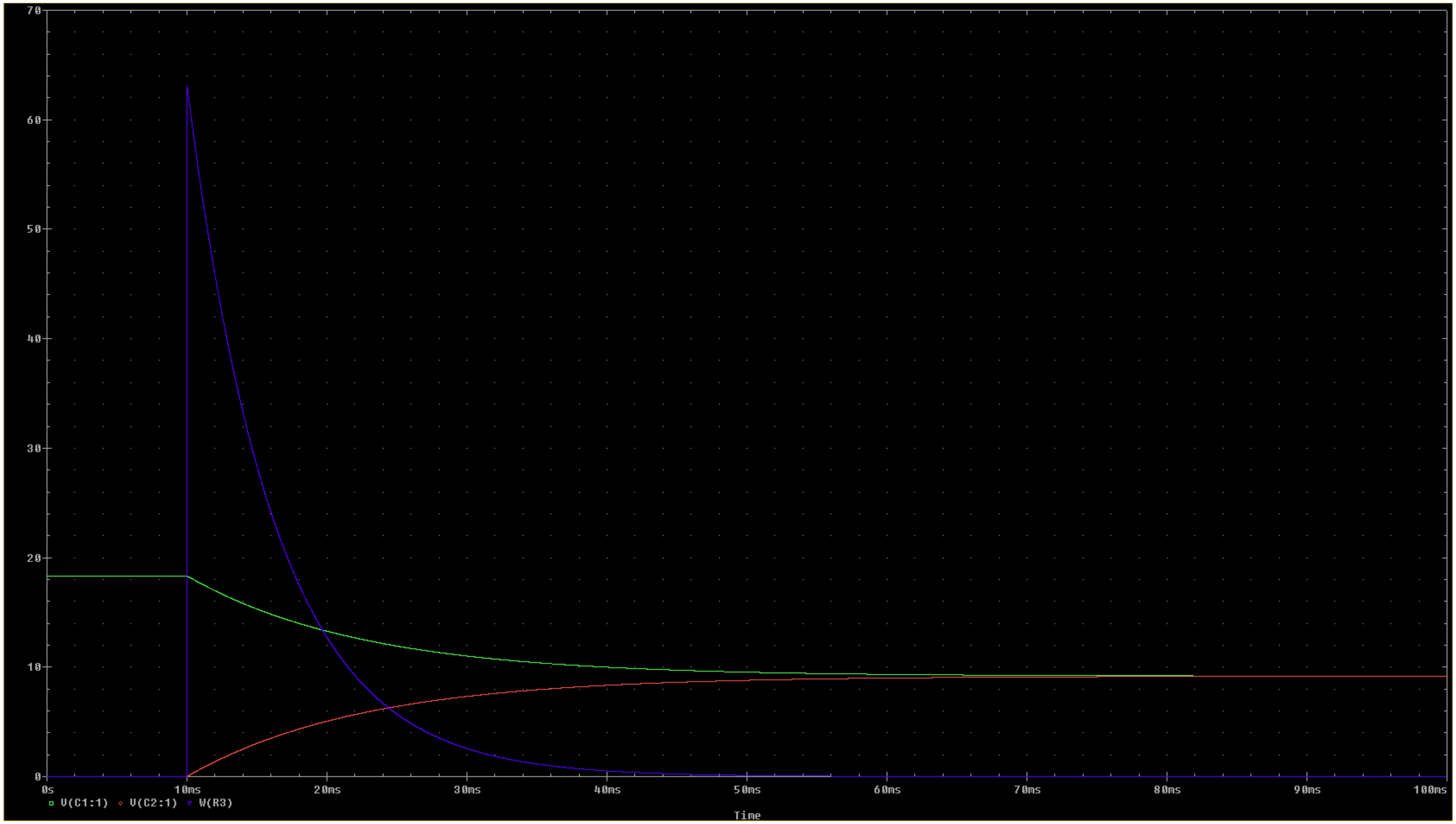

Figure 5 – Basic Circuit Scope Results with R3 Power in Blue

Here in Figure 5 we can see the R3 power (blue) peaks at about 65 Watts and effectively ends at 40ms. We can do a rough calculation of the Joules dissipated in R3 by folding over the wave form in half to form a square pulse from 10ms to 40ms. We draw a dividing horizontal line through the R3 wave form at a level that would result in roughly the same area under the curve for both halves. In this case 13 Watts appears to be fairly close.

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So 13 Watts over a 30ms time period yields 0.39 Watt-seconds, which is **0.39 Joules** of energy. Let's see if this holds up to the notion that half the energy is lost in these capacitor energy transfers, using of course our favorite **$E = ½ CV^2$** equation:

E = ½ 4700uF (18.33^2)
E = **0.7896 Joules** (our starting energy)
E/2 = **0.3948 Joules** (starting energy divided by 2)

It looks like the 0.39J is pretty close to 50% of the total energy we began with. Let's also double check this with a calculation of the energy left in each capacitor:

E = ½ 4700uF (9.165^2)
E = **0.1974 Joules each** (25%), and together amount to **0.3948 Joules** (50%).

So we have 0.7896J – 0.3948J – 0.394J = 0.0008 Joules remaining unaccounted for. Obviously we can only be accurate to a certain degree by eyeballing the wave form for the calculation, but we also have some small dissipation in the switch which we did not bother with because it is so small in comparison to the R3 value.

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As a final test with the basic circuit, let's insert a series diode D1 as in Figure 6 to see the effect it has:

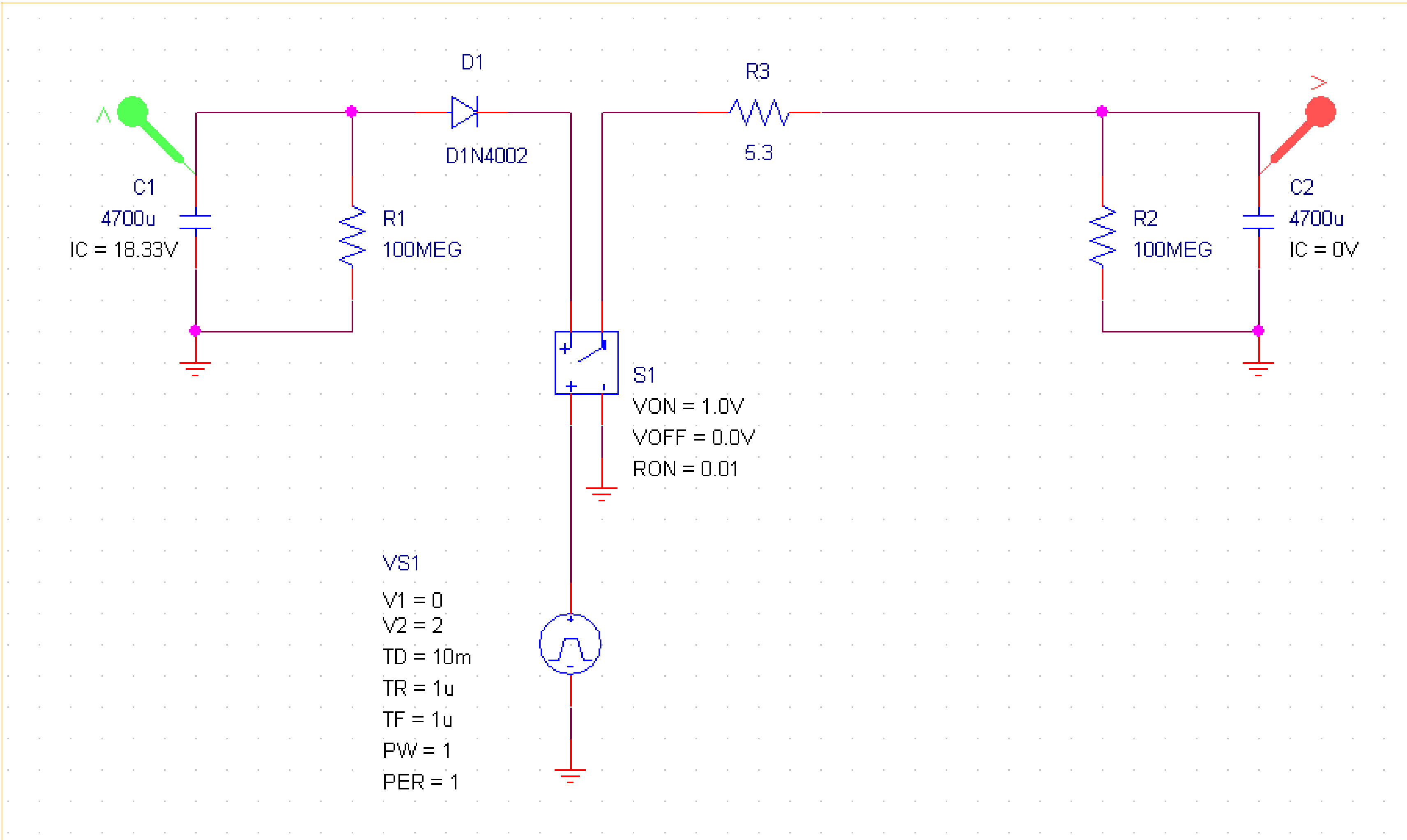

Figure 6 – Basic Circuit with R3 and 1N4002 Diode

It does not matter where the diode is placed after C1, as long as it is in series.

From Figure 7 below, we can see that D1 causes a separation of the final voltages for each capacitor. Some may assume that 0.7V was lost due to the diode drop, but in fact the sum of the two voltages still equals 18.33V. In this case we have C1= 9.529V, and C2= 8.801, for a total of 18.33V. Without the diode we were getting 9.165V on each capacitor, which is exactly half of our starting voltage. 9.529V – 8.801V = 0.728V, which corresponds with a 1N4002 diode drop. So C1 was raised by ½ a diode drop, and C2 was lowered by ½ a diode drop.

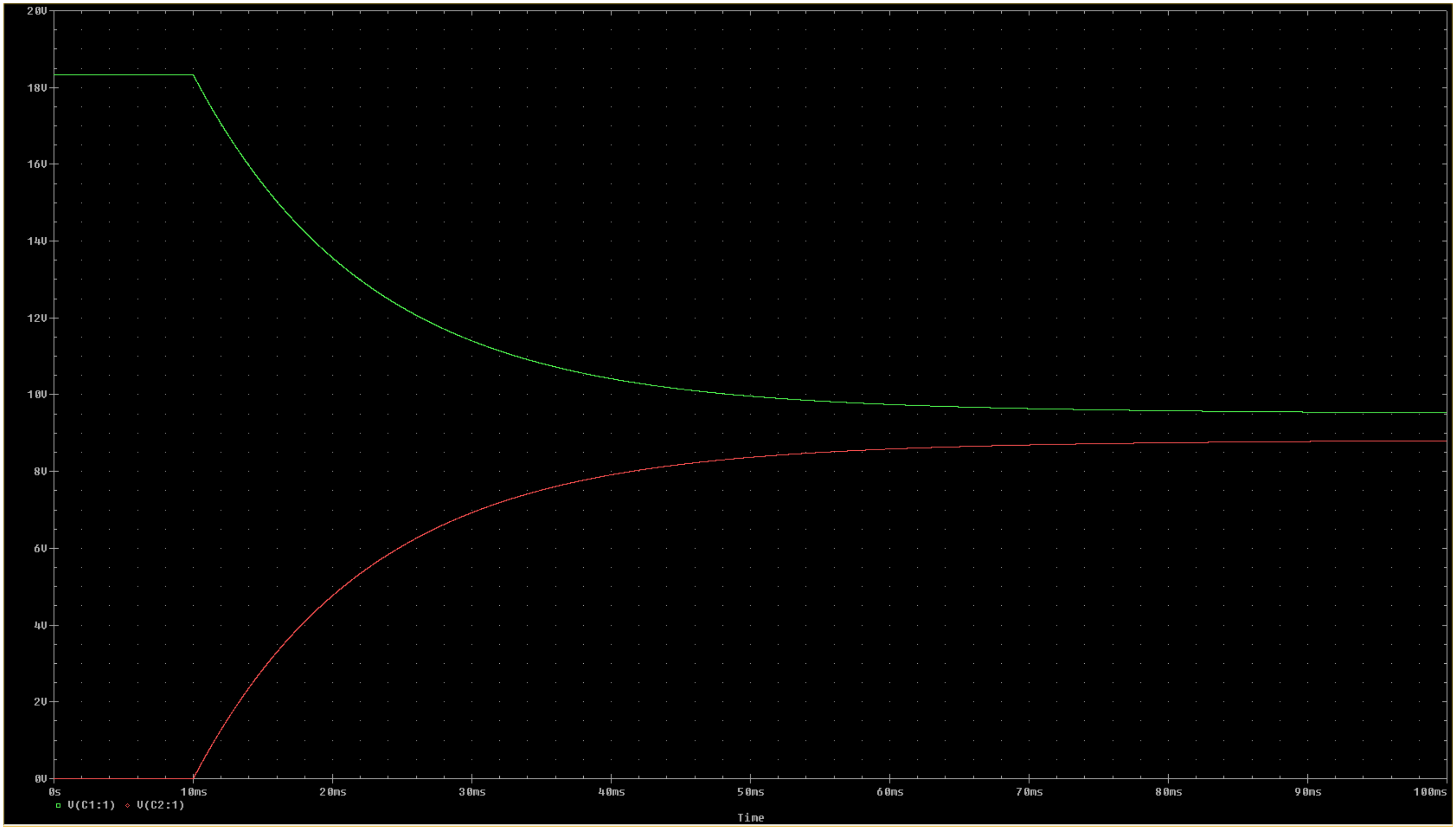

Figure 7 – Basic Circuit Scope Results with R3 and 1N4002 Diode

CHAPTER 2 – Transfer Through an Inductance

Below in Figure 8 is the circuit incorporating an inductor (3 coils) in series with the two capacitors. This is CP's actual setup and includes the DC resistance of the coils lumped into a single value of 5.3 Ohms, as before.

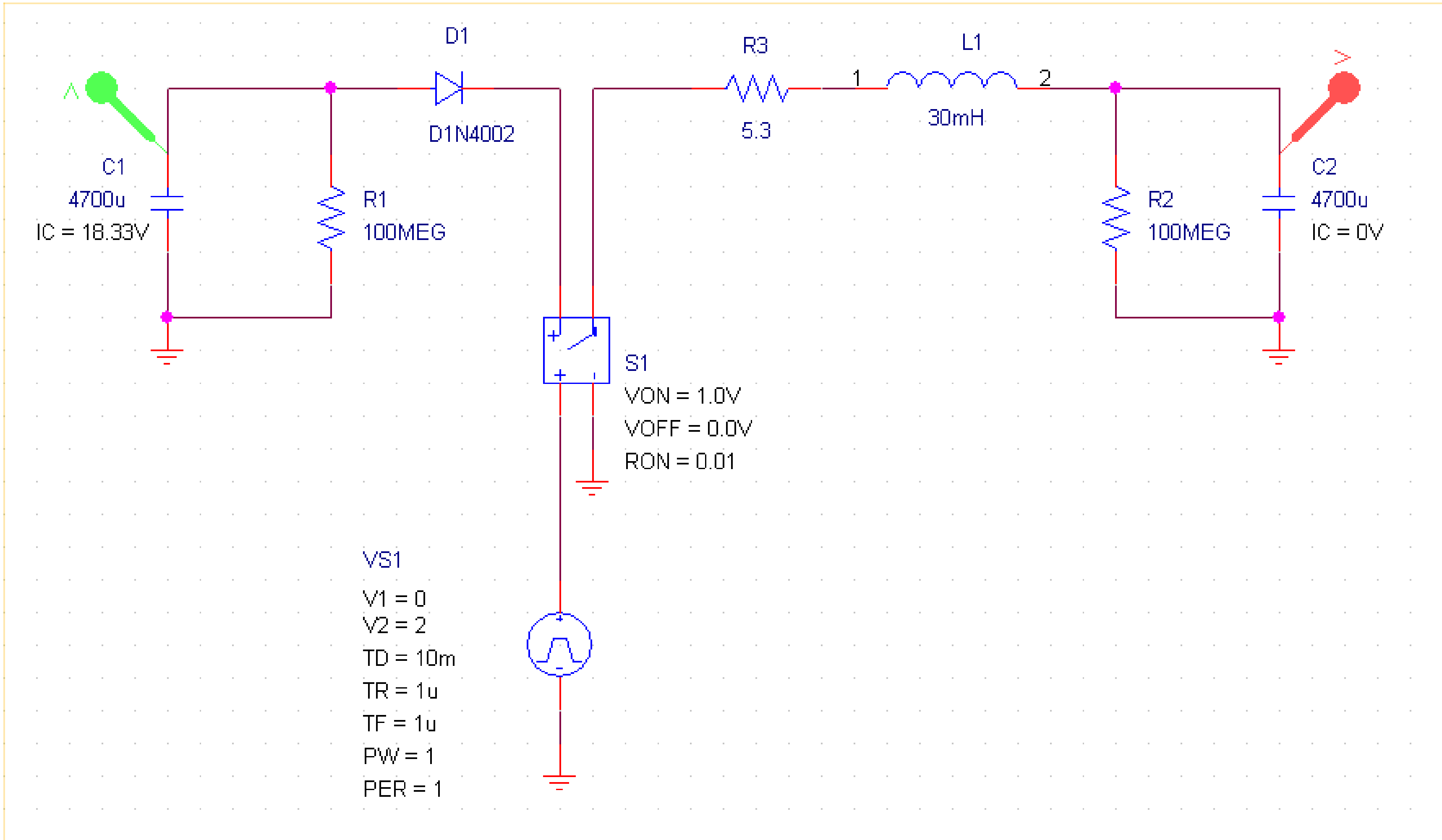

Figure 8 – Coil Circuit as per CP's Setup

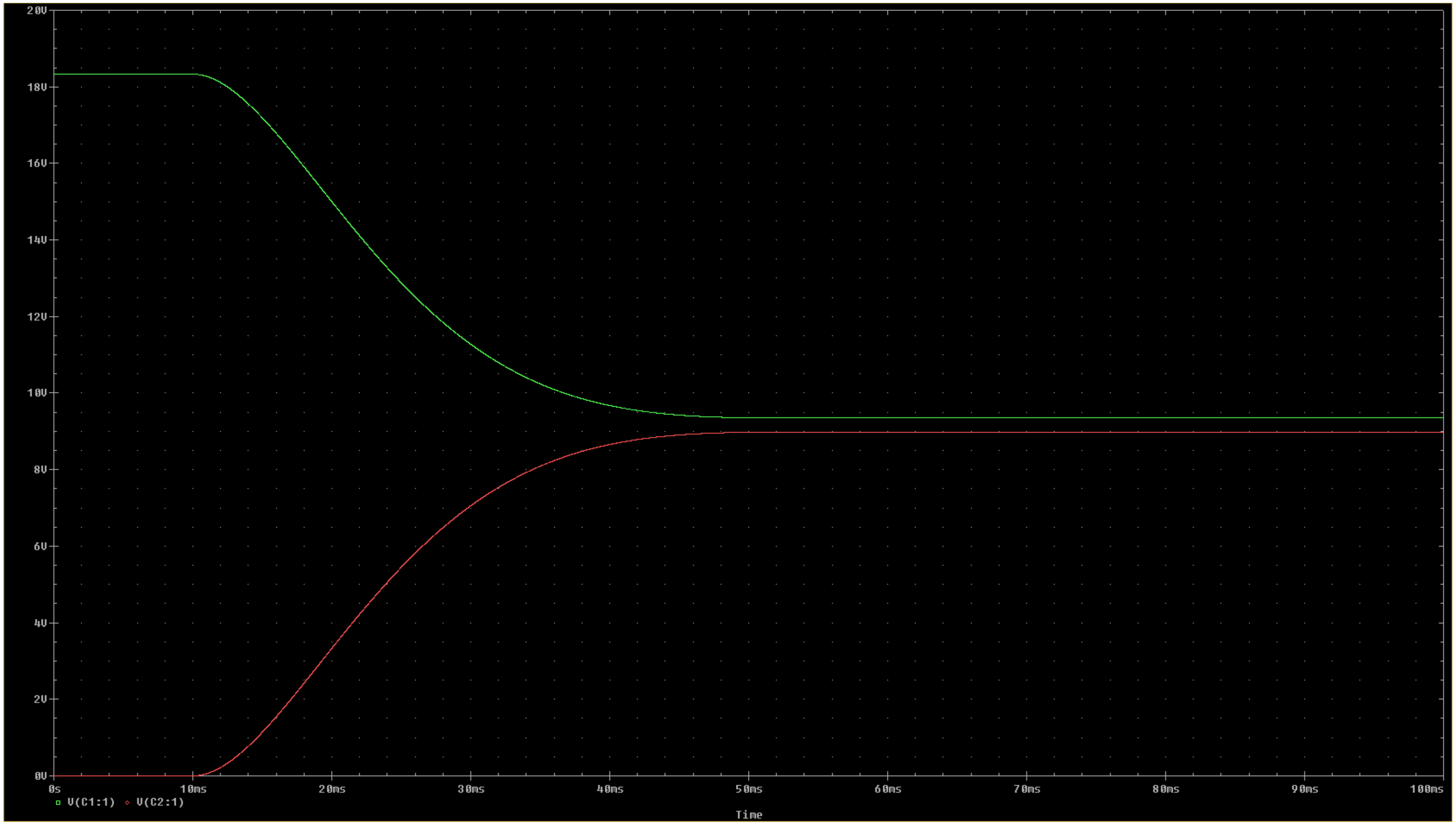

Figure 9 – Coil Circuit Scope Results

Figure 9 above shows the results of CP's circuit shown in Figure 8. Notice the similarity between Figure 9 and Figure 7. However, it appears the addition of L1 has linearized the charge and discharge curves somewhat. Notice also that the final voltage settles much quicker in Figure 9. C1 is 9.3541V and C2 is 8.9759V for a total of 18.33V as before. From the two voltages we can see that about **24%** of the energy was transferred to C2, **26%** remains on C1, and therefore about **50%** was dissipated in R3 and D1 combined, similar to what we saw in Figure 5.

Figure 10 below illustrates the coil circuit again, but this time includes the R3 and D1 power dissipation traces as shown similarly before in Figure 5. R3 power is the blue trace, and D1 power is the yellow trace.

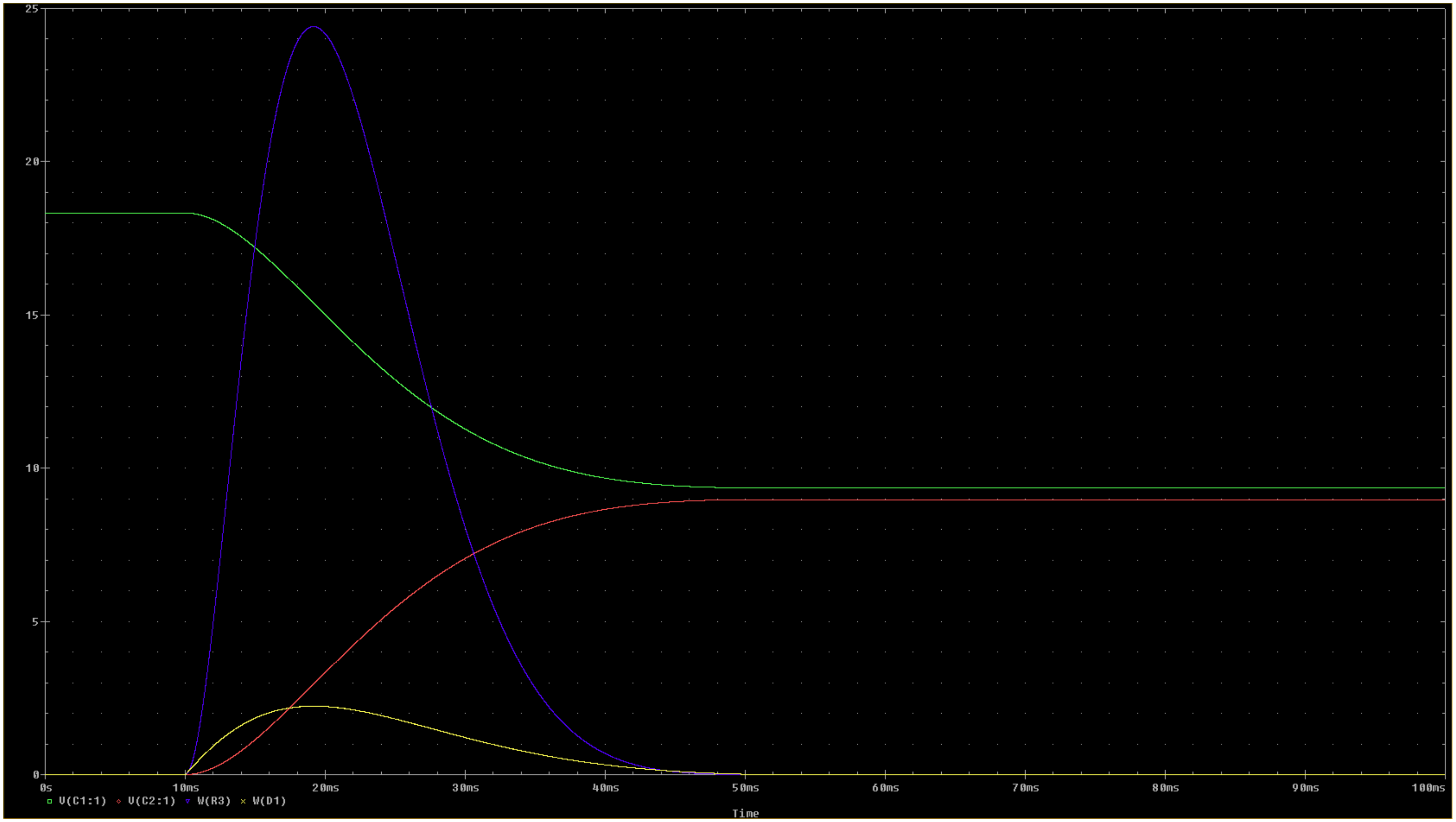

Figure 10 – Coil Circuit Scope Results of Figure 8 with R3 (blue) and D1 (yellow) Power Losses

Notice the smoothing action on the R3 power from L1. Applying a similar technique to roughly estimate the Joules dissipated, I calculate R3 contributed 43% of the loss, and D1 the remaining 7%.

The value for L1 was chosen to be **30mH** (it may be lower in reality) because this was the highest value that still resulted in the final voltage for C1 to be higher than C2. I believe this is true in all cases demonstrated in CP's videos. If we increase L1 to a higher value, C1 will actually turn out to be *lower* in voltage than C2, meaning more of the initial energy is transferred between the two capacitors. Figure 11 below illustrates what happens if we increase L1 by a factor of 10 times to **300mH**. The simulation run time was increased to 200ms from 100ms.

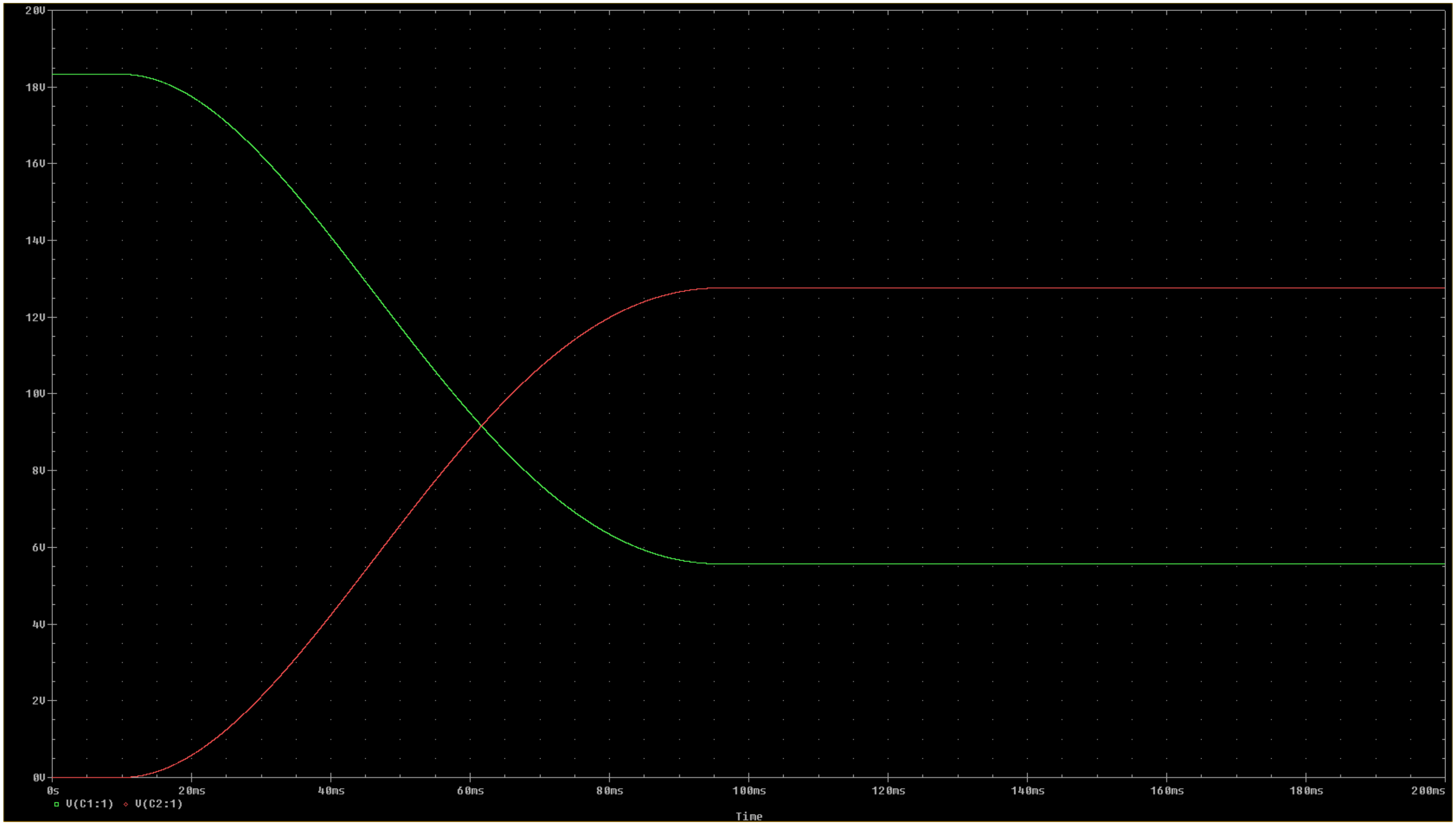

Figure 11 – Coil Circuit with L1 Set to 300mH

C1 ended up at 5.5683V and C2 at 12.762V, for a total of 18.33V once again. In this case, about **48.5%** of the energy was transferred from C1 to C2, a substantial improvement from 25%. C1 has **9.2%** of the energy remaining. Let's see what happened to our R3 and D1 losses in Figure 12 below.

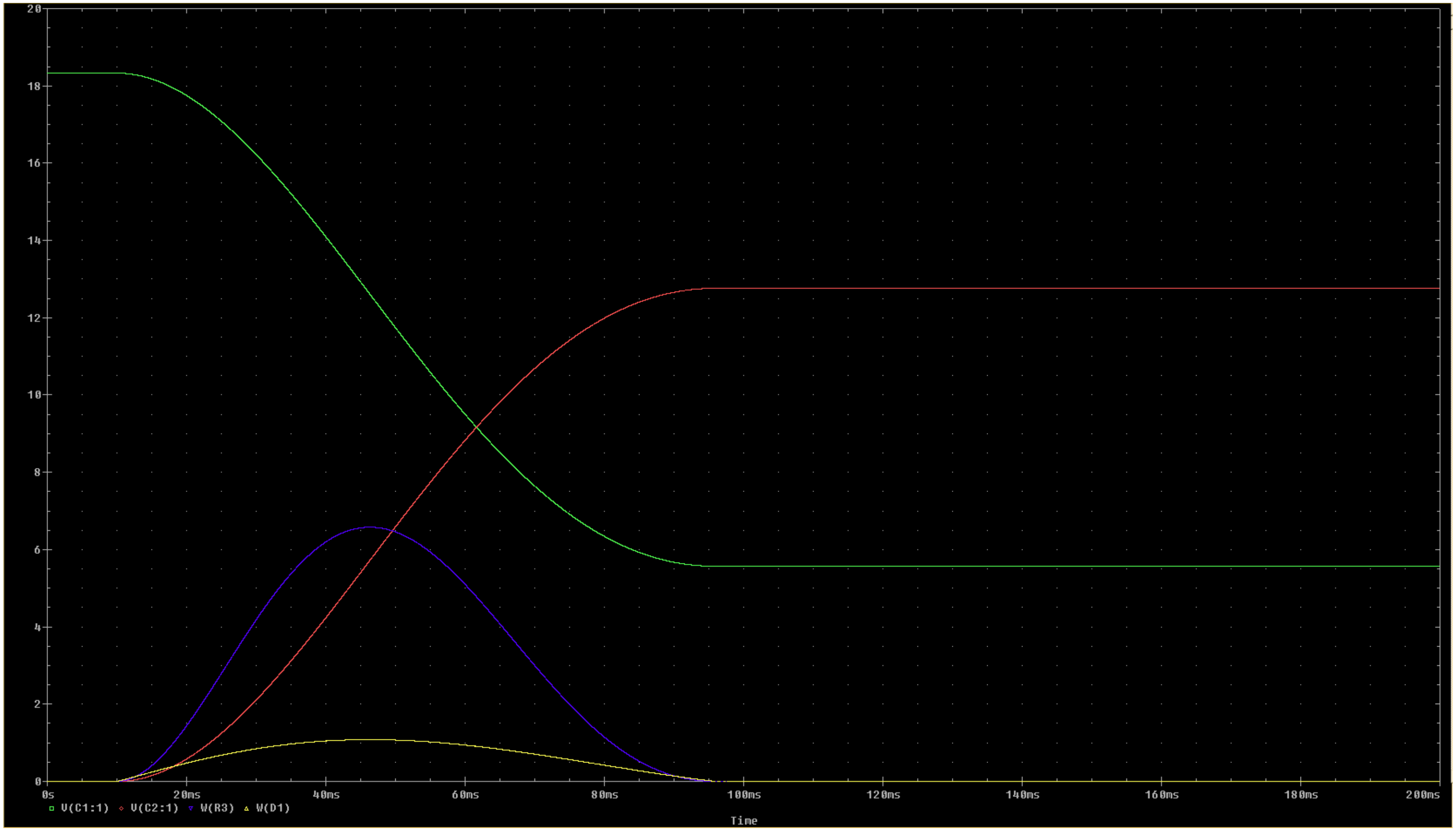

Figure 12 – Coil Circuit Scope Results with L1 at 300mH. R3 (blue) and D1 (yellow) Power Losses

Using the techniques as before, the R3 loss is about **36%** of the energy, and the D1 loss about **6.3%**. So with a much larger inductor we were able to transfer more energy from C1 to C2, AND do it with less loss in R3 and D1.

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There is a direct inverse correlation here between energy transferred and energy lost. Are there any limits? Let's push the value of L1 yet another magnitude to **3000mH** and see what happens in Figure 13 below.

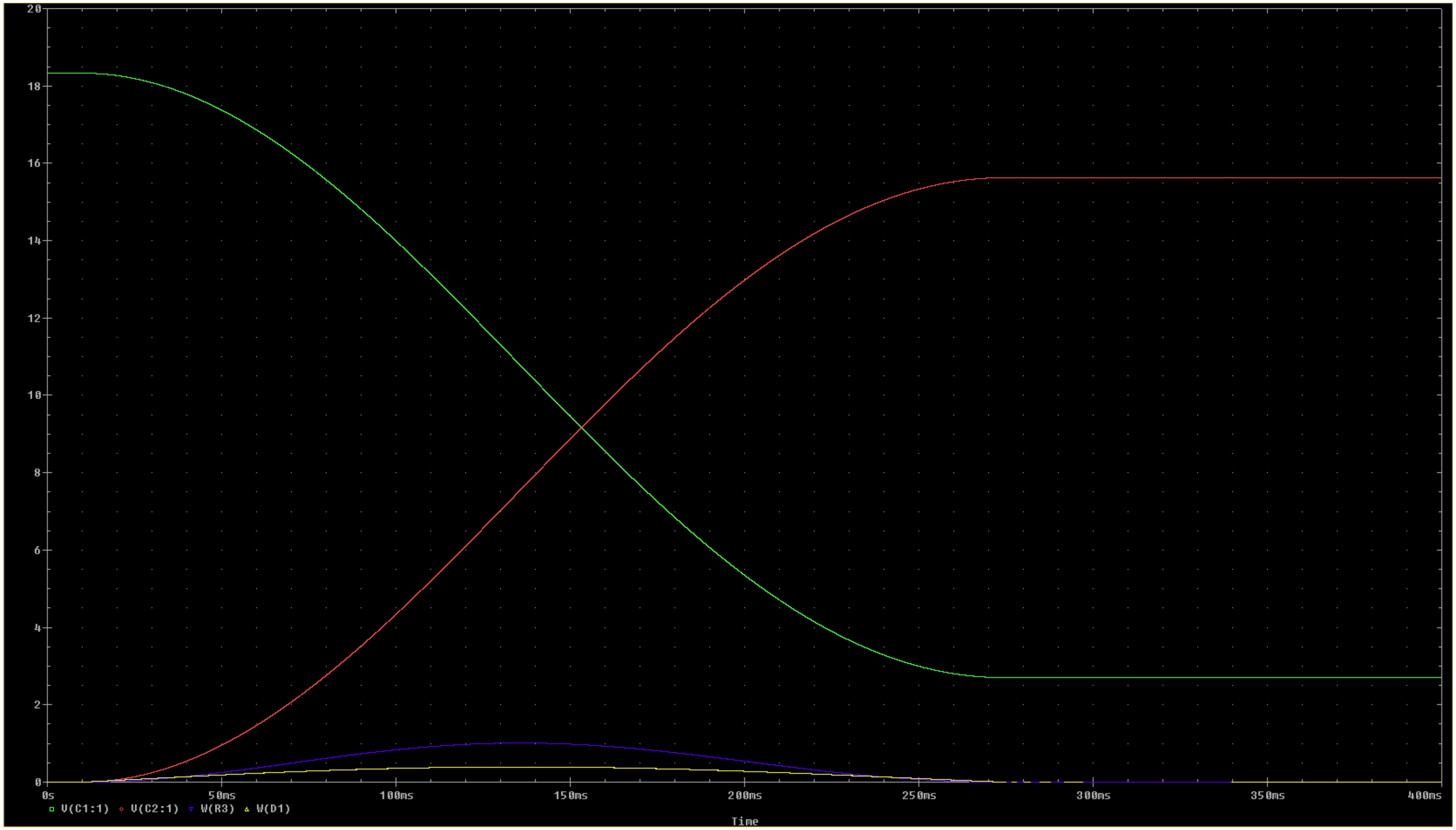

Figure 13 – Coil Circuit Scope with L1 at 3000mH Showing Reduce Losses, Better Energy Transfer

C1 is at 2.7013V and C2 at 15.629V. This corresponds to **2.17%** and **72.70%** of the energy respectively. This leaves **25.13%** lost in R3 and D1.

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The test was carried to an extreme with L1 set to **30 Henries**, and as expected the efficiency of energy transfer increased once again. C2 contained **84.89%** of the starting energy, and C1 had **0.62%** remaining. The last **14.49%** is lost in R3 and D1.

The increase in inductance slows the charging/discharging process down thus limiting the current through the R3 resistor and D1 diode. As power is I^2R, the lower the current, the less power dissipated or lost in these components. This explains why larger inductance values for L1 increases the energy transfer efficiency from C1 to C2.

In all the tests up to this point, the R3 resistance value was never changed and remained at 5.3 Ohms. It should be apparent that R3 is a big factor in allowing energy to transfer from one capacitor to another. There is another rather large problem; how do we obtain coils with such high inductance and with such little DC resistance? In all practicality, we don't. To obtain even a 3000mH air core coil with only 5.3 Ohms resistance would require a wire gauge of at least #10 and its size would probably rival that of a small car.

One researcher I am aware of wound an air-core coil using a lot of #30 wire. The inductance was 3.12H and DC resistance was a whopping 740 Ohms. This is realistic for an air-core coil.

To obtain higher coil inductances with much less wire and hence resistance, we need to incorporate proper core materials that will concentrate the flux. There are losses associated with cores as well, but using them brings us much closer to the realm of high inductances without mammoth-sized coils.

As an example, here are the specifications I found for a microwave oven transformer (MOT) on the web:

Primary: R= 0.35 Ohms; L= 44.4mH (a 15 times improvement in the DC resistance)
Secondary: R= 88 Ohms; L= 19.3H

Let’s see how a 3.12H coil with 740 Ohms DC resistance affects our energy transfer results in Figure 14 below:

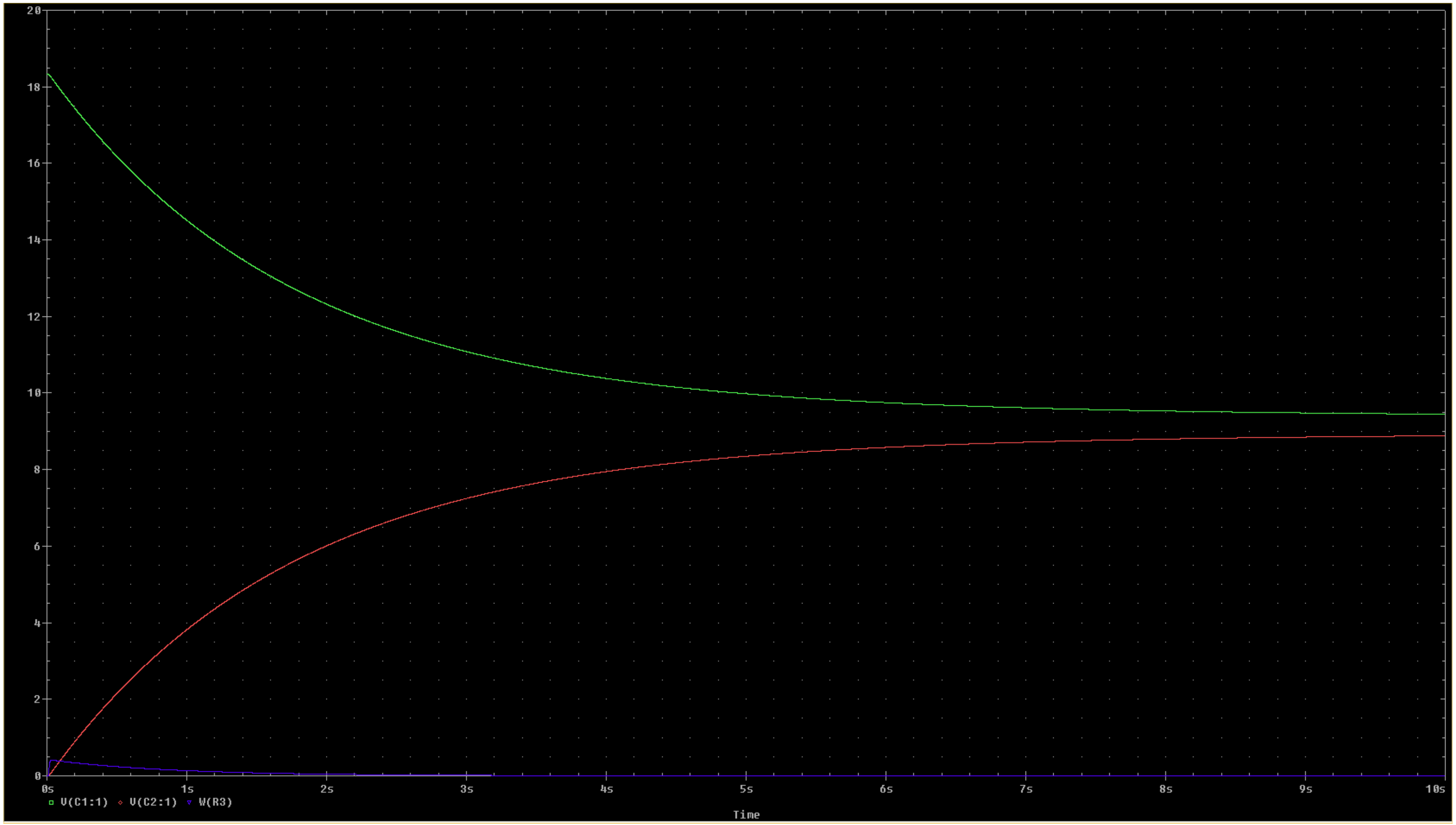

Figure 14 – Coil Circuit Scope with L1 set to 3H and R3 to 740 Ohms

It appears that our results are very similar to those in Figure 7 with just R3 present and no coil. The simulation run time is 10 seconds due to the much longer time constant of 4700uF and 740 Ohms. So although the coil inductance is quite high, it’s ability to aid in transferring the energy between C1 and C2 is minimized because of the swamping out effect from its own DC resistance R3. The tau is now about 3.5s and 5 tau is 17.5 seconds.

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This large RC tau dominates any effects the coil and capacitors have in combination and explains why we are back to square 1 in terms of energy transfer efficiency using a high inductance high DC resistance coil.

CHAPTER 2 – Getting Work From the Transfer

In an attempt get obtain meaningful work output from the setup, the coil is replaced with a transformer. The goal is to shuttle the initial energy back and forth between C1 and C2 with as little loss as possible, and to tap the energy flowing through the series inductance in order to make it do some work for us.

We will use the MOT for which we have the specifications.

First we will run a test to see how much energy is transferred in one shot from C1 to C2 as before through a diode D1. L1 will be the MOT primary, and we will ignore the MOT secondary for now. See Figure 15 below for the circuit.

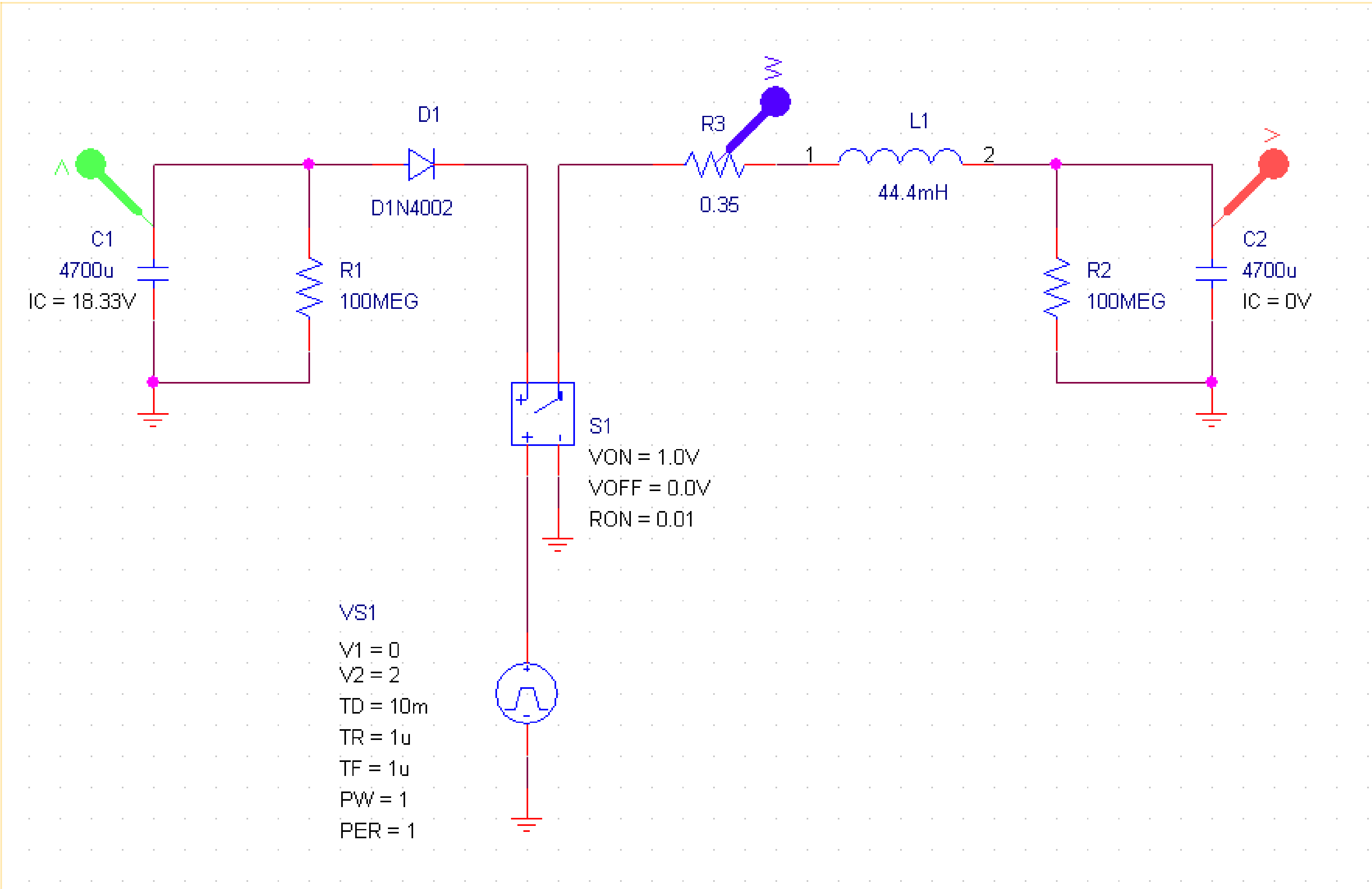

Figure 15 – Coil Circuit with MOT Primary to Test One Shot Energy Transfer

Now let's see the results of our much lowered R3 value and slightly increased L1 value in Figure 16 next page.

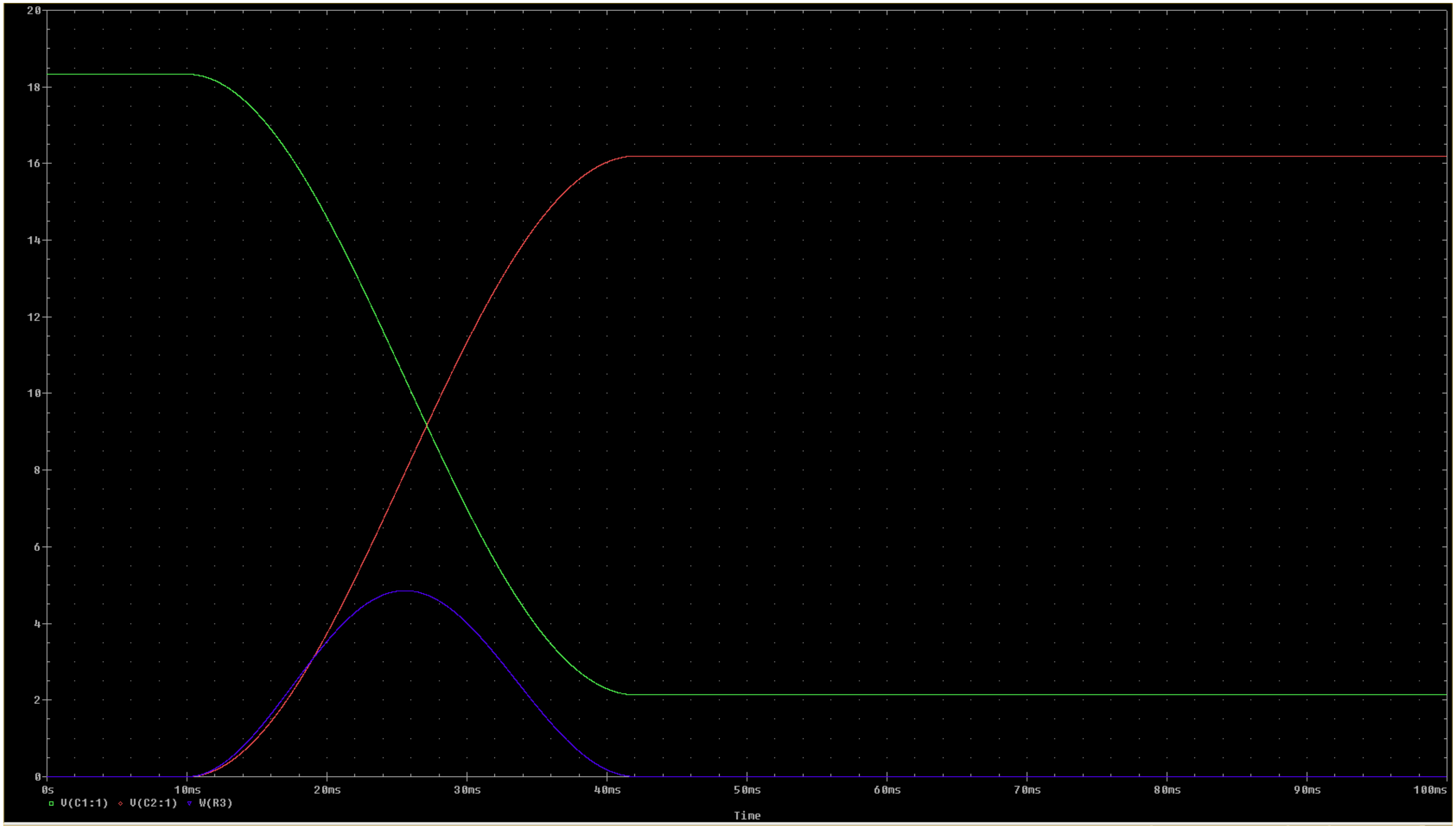

Figure 16 – Scope Results for Figure 15

With this change we have obtained a good energy transfer. C1 voltage is **2.1317V** and C2 is **16.198V**. This correlates to energies of **1.35%** and **78.088%** respectively. The remaining **20.56%** of the energy is lost in R3 (blue trace), D1, and the switch resistance. The energy lost in D1 and the switch is not shown in Figure 16.

Now let's remove diode D1 and make a damped oscillator as shown in Figure 17 below:

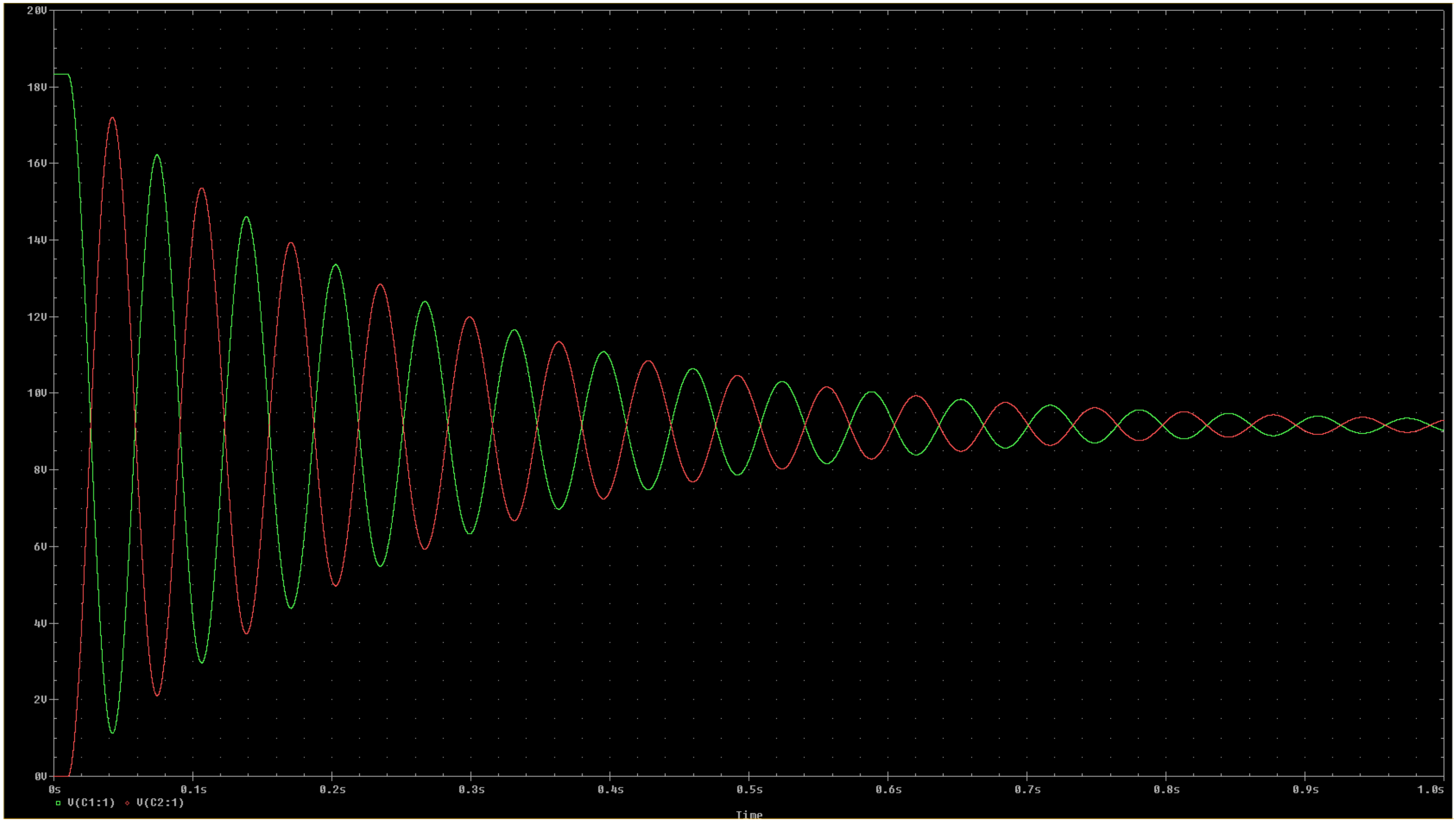

Figure 17 – D1 Removed Allowing Damped Oscillation of Energy from C1 to C2 and Back

The simulation time was set to 1 second, but the oscillations go beyond this. The idea should be clear though. The oscillations are damped due to the **11.5%** energy loss still remaining in R3 and the switch resistance. Removal of D1 has clearly improved the energy transfer efficiency; now **88.15%** (17.21V) was transferred to C2 and **0.37%** (1.12V) left on C1 after the first half-cycle. The final voltage for C1 and C2 will be 9.165V once the oscillation settles.

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So what can we now do to try and get this setup to do some work for us? Let's try using a full wave bridge across the MOT's primary inductor and charge another 4700uF capacitor (C3) with it. I believe CP did this in one video. See Figure 18 below. The MOT's secondary has been loaded with a 100MEG Ohm resistance, so it's more or less like the secondary isn't even present.

Later we'll try using the MOT secondary to supply the full wave bridge and observe the results.

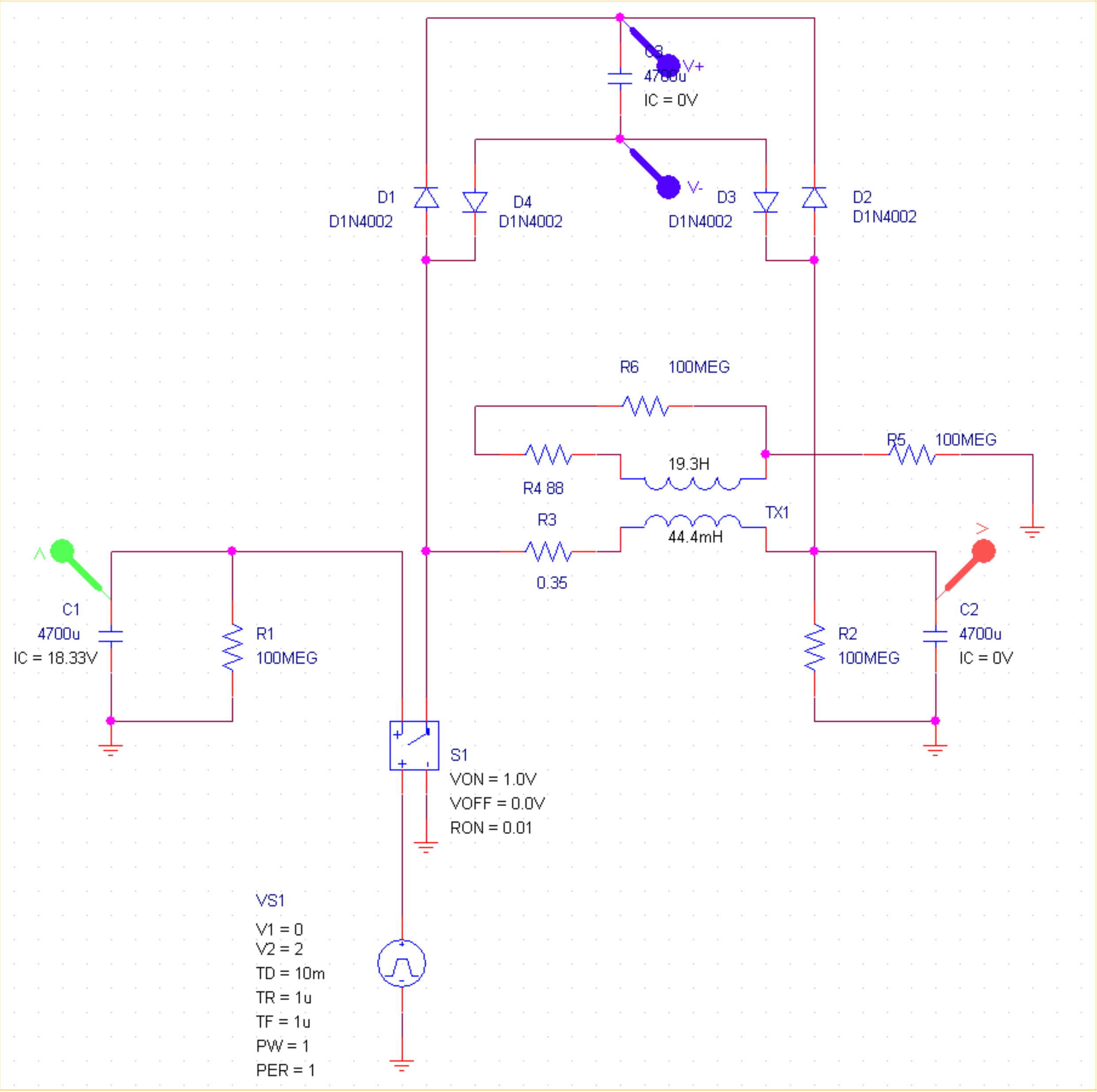

Figure 18 – Coil Circuit with MOT and FWB off Primary

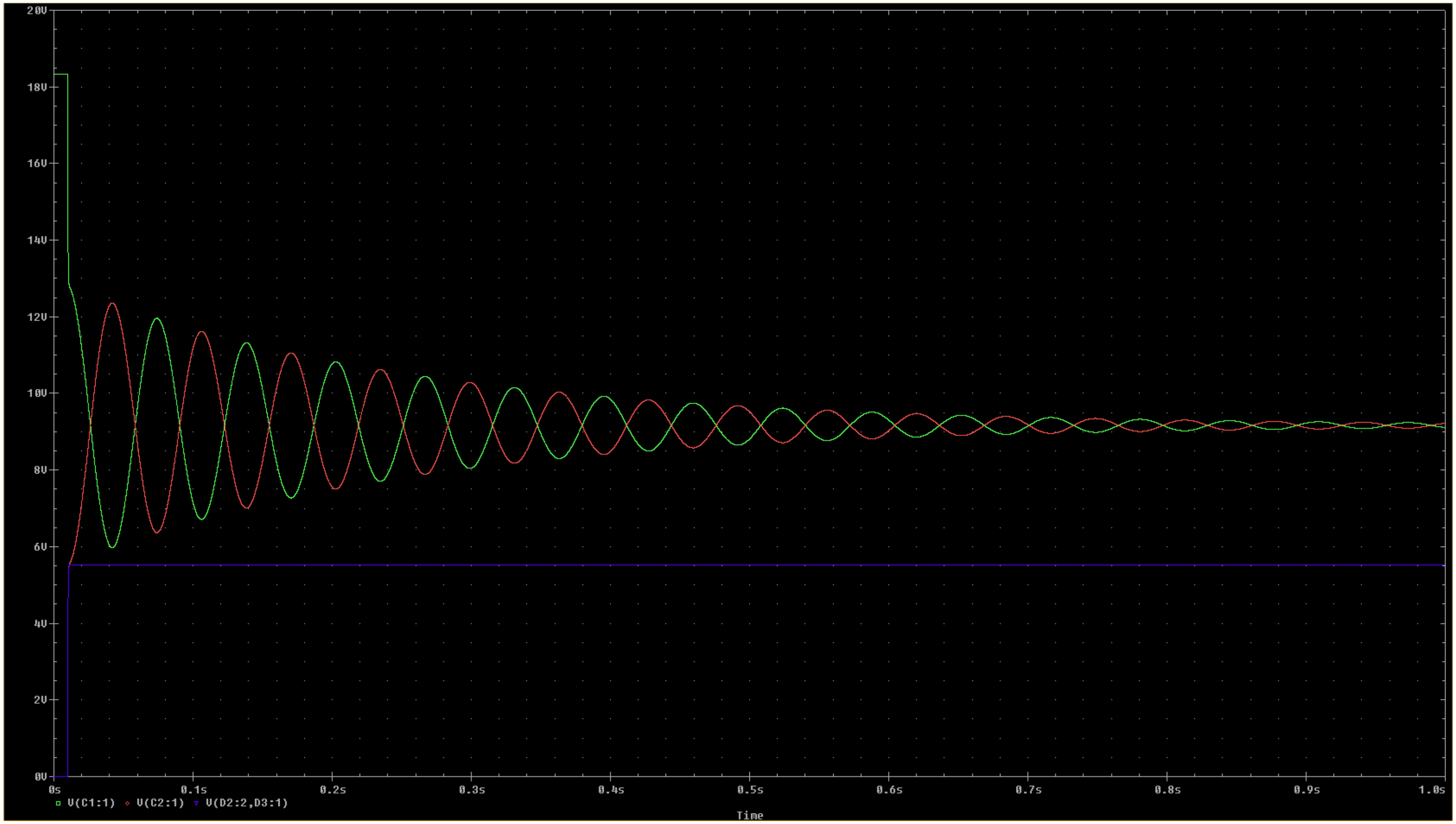

Figure 19 – Results from Figure 18 Circuit

In Figure 19 above we see that a substantial amount of energy was used immediately from C1 to partially charge C3 to **5.535V**. This was accomplished through D1 and D3 only which makes sense because at switch closure C1 discharges through the lowest impedance path directly into C3 via D1 and seeks a Ground path through D3 and C2 (C2 acts as a short circuit the instant the switch turns ON). Once the voltage on C1 and C3 have equalized, C1 continues its damped oscillation with C2 and back again as before, only starting out at a much lower energy level because of the transfer to C3. After the first half cycle, C1 had **5.977V** remaining on it and C2 charge up to **12.353V**.

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Using our favorite equation again, the energies on each capacitor after the first half cycle are:

C1= **10.63%**, C2= **45.41%**, and C3= **9.12%** for a total of **65.16%** of the energy. The remaining **34.84%** of the energy is lost as dissipation in D1, D3, R3, and the switch resistance. I have examined these losses to verify their amount.

What happens if we connect the full wave bridge to the MOT secondary? See figure 20 below.

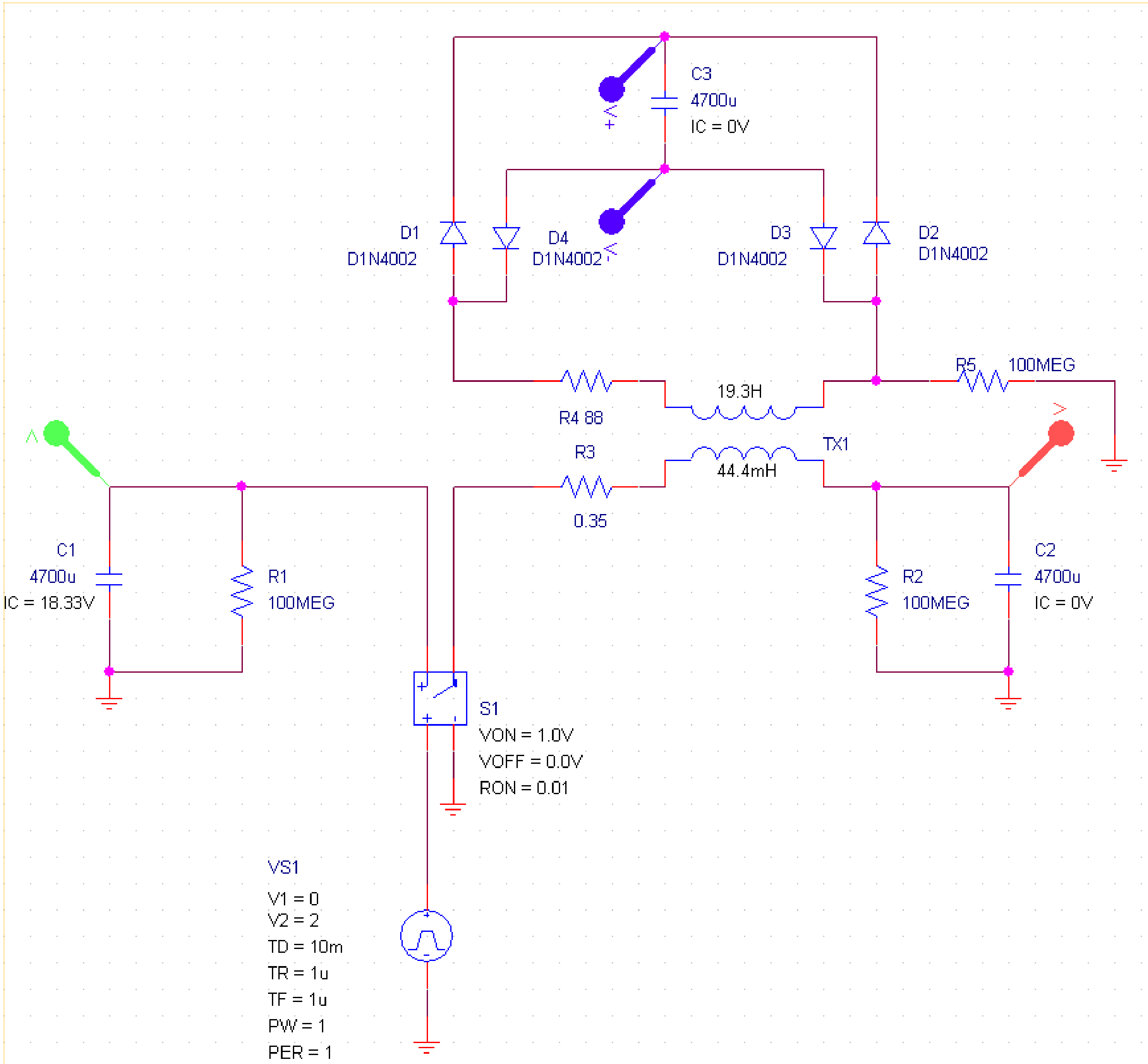

Figure 20 – Coil Circuit with MOT Sec Feeding FWB

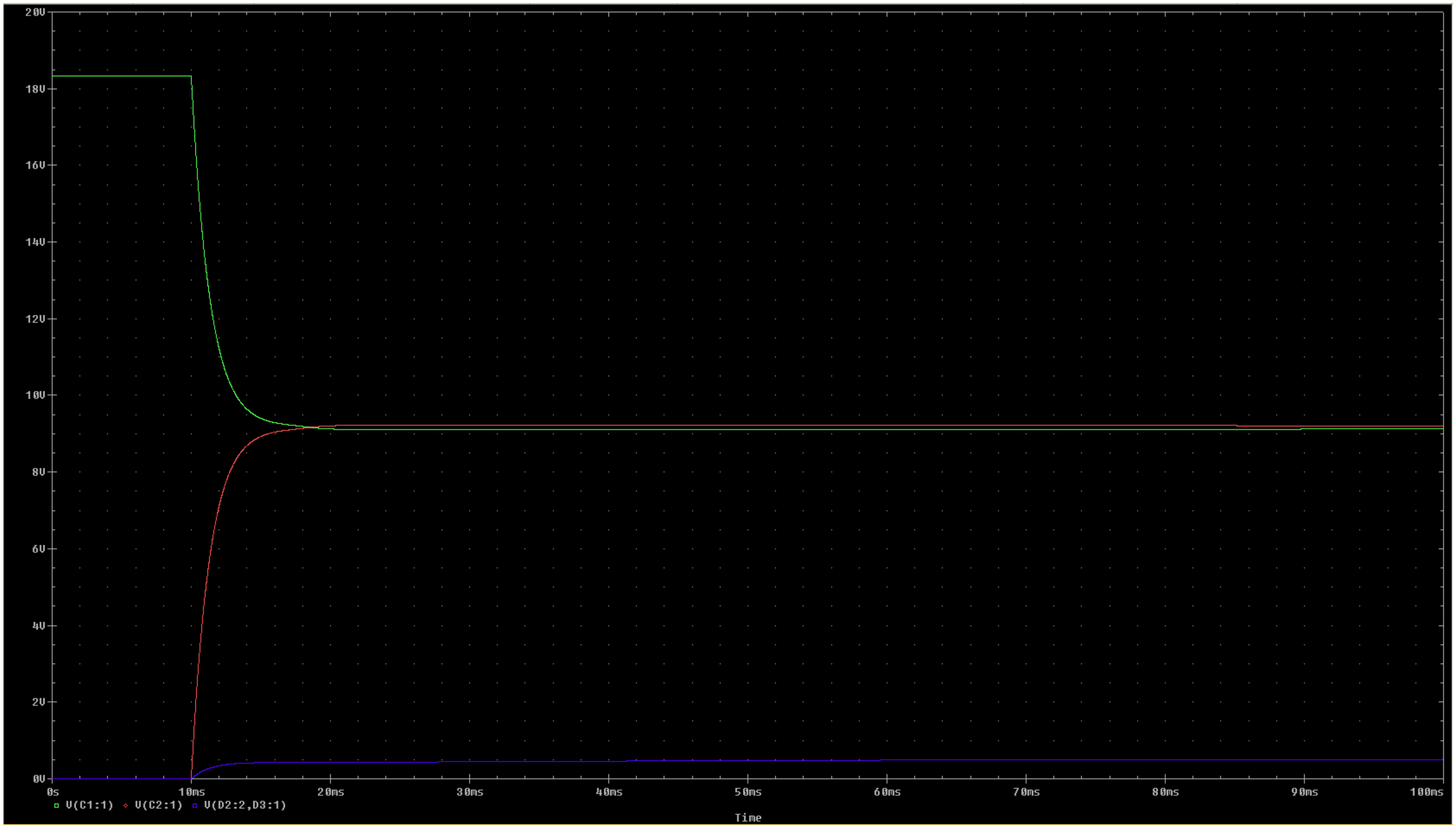

Figure 21 – Coil Circuit Scope Results with MOT Sec Feeding FWB

Here we see our energy transfer efficiency drop a substantial amount. C1's final voltage is **9.11V**, C2 is at **9.22V**, and C3 at **0.5V**. This corresponds to **24.7%**, **25.3%**, and **0.05%** for a total of **50.05%** of the starting energy. These results are very similar to what was obtained in Figure 2. I did confirm that the remaining 50% of the energy is lost in D1, D3, R3, R4, and S1's switch resistance. As before, D2, and D4 did not conduct at all and could be removed from the circuit.

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Why are the results so much worse when using the MOT secondary to drive the FWB? Again it comes down to resistance in the wiring. We do have a huge inductance of 19.3H, but the 88 Ohm DC resistance prohibits us from taking advantage of it, and instead introduces another wasteful dissipative element into the overall transfer process.

A quick word about Dielectric Absorption. This is an effect caused by the capacitor's dielectric not giving up all its charge when the terminals are shorted after the capacitor was charged. Observing the terminal voltage with a meter will show that it can slowly creep up from 0V to as much as 10% of the original charge before shorting. This is a nuisance in precision circuitry and is worst in cheap electrolytic capacitors. I feel fairly confident that the voltage creep seen in CP's experiments is a result of this phenomenon. It is especially suspicious when doing a direct cap to cap short without alligator leads and an inductor in between. This should always produce half the original voltage on the first capacitor assuming the capacitors are of equal value.

This has all been a somewhat grueling exercise, but I hope it's helpful to those curious about these energy transfers.

Regards,
Poynt99

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APPENDIX A – Energy Stored in a Capacitor and the Potential Difference Across the Plates

An interesting test with a thermocouple that can be found here:
http://www.iop.org/activity/education/Projects/Teaching%20Advanced%20Physics/Electricity/Capacitors/file_3324.doc

TAP 128- 3: Energy stored in a capacitor and the potential difference across the plates.

Introduction

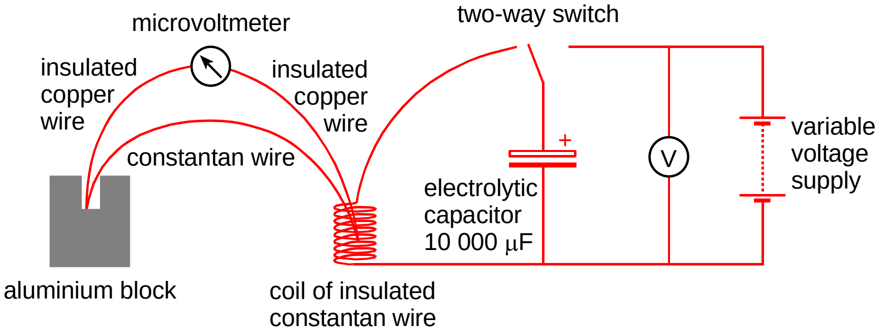
This demonstration is intended to make the link between the energy stored in a capacitor and the potential difference to which it has been charged. It relies on the heating effect of the current which flows when the capacitor is discharged resulting in a measurable rise in temperature. The rise in temperature is assumed to be proportional to the energy stored. It is possible to obtain a series of readings by charging the capacitor to different potential differences and determining the rise in temperature each time.

Requirements

- ✓ capacitor 10 000 μF, 30 V working
- ✓ resistance coil (about 1 m of 34 swg insulated eureka wire wound into a small coil which will tightly enclose the temperature probe/thermocouple), or thermally insulated carbon film resistor of a few ohms resistance.
- ✓ thermocouple, copper–constantan
- ✓ micro voltmeter
- ✓ spdt switch
- ✓ multimeter
- ✓ power supply, 0–25 V
- ✓ aluminium block
- ✓ leads, 4 mm

Set-up

1. Set up this apparatus.



Make sure that the capacitor is connected to the supply correctly otherwise it may suffer damage. You will need to use the thermocouple connected to a sensitive voltmeter, measuring in mV.

2. Adjust the output of the dc supply to (say) 5.0 V.
3. Connect the capacitor to the supply using the two-way switch so that it becomes charged. Record the reading on the voltmeter.
4. Discharge the capacitor through the resistance coil and record the reading on the sensitive voltmeter, the output from the thermocouple.

5. Charge the capacitor to a different potential difference and repeat the experiment. Obtain a series of values of potential difference V and sensitive voltmeter readings. Do not exceed the safe working voltage of the capacitor (30 V).

6. Plot a graph that will enable you to deduce a relationship between the energy stored in the capacitor and the potential difference across its plates.

You are assuming that the energy stored in the capacitor is equal to the change in internal energy of the resistance coil, which is proportional to the temperature rise of the coil. Note that the reading on the sensitive voltmeter is proportional to the rise in temperature of the thermocouple probe.

What you have learned

1. From the shape of your graph, you should be able to deduce the link between the pd across the capacitor and the energy stored in it, as measured by the temperature rise.

Practical advice

Care should be taken to ensure that electrolytic capacitors are connected with the correct polarity and that the working voltage is not exceeded.

It will be worth spending some time familiarising students with the thermoelectric effect. This provides an essential link to temperature rise and thus the energy stored by the capacitor. It is advisable to discuss in advance how to analyse the data recorded.

Be careful to shield the apparatus from draughts, as they affect the final temperature rise obtained. Ensure the ‘cold junction’ of the thermocouple is in thermal contact with the aluminium block – a few drops of glycerol may help, with a smack rubber bung to hold the wires still.

Try out the experiment first for yourself to decide whether or not it will yield quantitative information about the relationship $W = ½ C V^2$. If there is too much scatter in the points, there will be no justification for plotting a straight line graph. If it is not convincing quantitatively, it may still be worthwhile to carry out the experiment qualitatively.

The use of small bead resistor instead of the coil enables the thermocouple’s hot junction to be taped securely to its surface. As stated, shielding from draughts is important, as the hot junction assembly has small thermal inertia.

The apparatus can be calibrated by delivering short timed pulses of current at a known voltage from the power supply, to calibrate the output, in terms of temperature rise, against a known energy input ItV. As such the exercise has to be treated as an extended experiment, which will be carried out over 2 practical sessions.

Alternative approaches

A preliminary demonstration to show how a discharging capacitor can briefly light a bulb could be useful. Large value capacitors, used as backup power supplies for memory (5 V working, 1.0 F) are also available, and can light LEDs for considerable lengths of time.

You might use a temperature probe for the main experiment if you have a suitable one with a sufficiently small thermal capacity.

External references

This activity is adapted from Advancing Physics, Chapter 10, 130E