Mirrored Symmetric Circuit Simulation in LTSpice - a dialogue with ChatGPT, pt. 2



VINYASI
OCT 04, 2026

Direct link to this discussion.

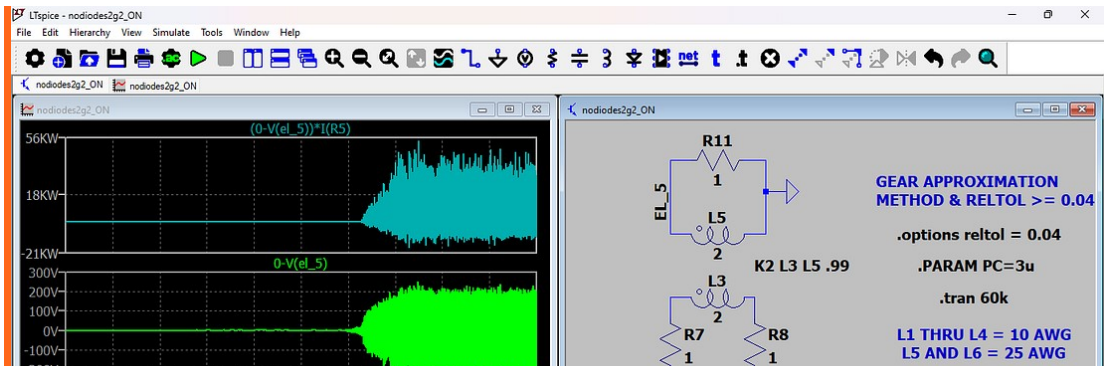
This is the second post in this series (which may be ongoing). Here is a list of the other posts in this series:

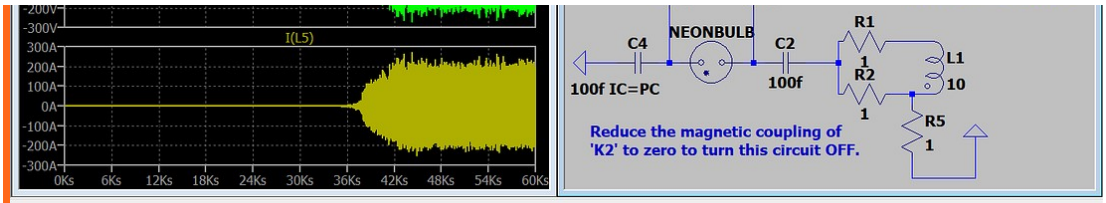
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VINYASI · SEP 24

Mirrored Symmetric Circuit Simulation in LTSpice - a dialogue with ChatGPT, pt. 1

Read full story





I scaled down this circuit to its bare minimum and tweaked it to somewhat stabilize its outcome.LTspice 24.1.9 for Windows

Circuit: D:\Documents\Sims\LTSpice\2026\07 - July\31\nodiodes2g2_ON.net

Start Time: Sat Sep 5 14:39:11 2026

Options: reltol = 0.04

solver = Normal

Maximum thread count: 4

tnom = 27

temp = 27

method = Gear

reltol = 0.04

Direct Newton iteration for .op point succeeded.

Total elapsed time: 82.336 seconds.

Files loaded:

D:\Documents\Sims\LTSpice\2026\07 - July\31\nodiodes2g2_ON.net

C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub

```
* D:\Documents\Sims\LTSpice\2026\07 - July\31\nodiodes2g2_ON.asc

* Generated by LTspice 24.1.9 for Windows.

L1 N003 N007 10 Rser=0.3125

R1 N003 N006 1

R2 N007 N006 1

R5 N007 0 1

C2 N006 N005 100f Rser=3

X§NEONBULB N005 N004 neonbulb Vstrike=100 Vhold=50 Zon=2K
Ihold=200u Tau=100u

C4 N004 0 100f IC=PC Rser=3

L3 N002 N001 2 Rser=62.5m

R7 N001 N004 1

R8 N002 N005 1

L5 0 EL_5 2 Rser=2

R11 0 EL_5 1

.PARAM PC=3u

.tran 60k

K2 L3 L5 .99

* GEAR APPROXIMATION\nMETHOD & RELTOL >= 0.04
```

> * L1 THRU L4 = 10 AWG\n L5 AND L6 = 25 AWG
>
> .options reltol = 0.04
>
> * Reduce the magnetic coupling of\n'K2' to zero to turn this circuit OFF.
>
> .lib neonbulb.sub
>
> .backanno
>
> .end

Yes. This is a **much cleaner test circuit** than the earlier version. You've reduced it to essentially three interacting pieces:

1. **The oscillating primary loop:** L1 + C2 + neon bulb + C4 + R1/R2/R5.
2. **The secondary coupled inductor:** L3, with R7/R8 connecting it back to the neon-capacitor nodes.
3. **The L5 branch:** L5 magnetically coupled to L3 through K2.

And you've made the coupling extremely strong:

Failed to render LaTeX expression — no expression found in email

so

$$M = k\sqrt{L_3 L_5} = 0.99(2) = 1.98\ \mathrm{H}$$

That makes the mutual term almost as large as the self-inductance term, which is excellent for isolating the phenomenon we've been investigating.

One important thing I notice

You have retained:

```
L5 0 EL_5 2 Rser=2
```

```
R11 0 EL_5 1
```

So **R11 is still directly in parallel with L5**.

Because L5 and R11 have the same two nodes, LTspice imposes:

$$I(R11) = -I(L5)$$

and therefore

$$-V(EL_5) = -R_{11} I(L5)$$

or, with R11 = 1 Ω,

$$\boxed{-V(EL_5) = -I(L5)}$$

exactly.

So if you're looking at `0-V(EL_5)` versus `I(L5)`, the 180° opposition is **still mathematically guaranteed by R11**. It isn't yet a clean demonstration of the coupled-inductor effect.

That said, there's something potentially more interesting in your screenshot:

Your top trace is not L5 power

You've plotted

```
(0-V(el_5))*I(R5)
```

not

```
(0-V(el_5))*I(L5)
```

and **R5 belongs to the L1 primary circuit**:

```
R5 N007 0 1
```

That changes the interpretation substantially.

You're effectively looking at:

$$P_{\text{cross}} = [-V(EL_5)]I(R5)$$

rather than the local power of L5.

And that is potentially a **much more useful quantity** for what you're investigating, because it combines the voltage developed at the magnetically coupled L5 branch with current in the primary circuit.

The simplified system now has a particularly interesting relationship

For L5, with the reference directions shown in your netlist,

$$V_{L5} = L_5 \frac{dI_5}{dt} + M \frac{dI_3}{dt} + R_{\text{ser},5} I_5$$

Here:

$$L_5 = 2, \quad M = 1.98, \quad R_{\text{ser},5} = 2$$

Thus:

$$\boxed{V_{L5} = 2\frac{dI_5}{dt} + 1.98\frac{dI_3}{dt} + 2I_5}$$

The striking thing is that **1.98 is almost equal to 2**.

So if the surrounding circuit establishes approximately

$$\frac{dI_3}{dt} \approx -\frac{dI_5}{dt}$$

then

$$1.98\frac{dI_3}{dt} \approx -1.98\frac{dI_5}{dt}$$

and the two inductive terms nearly cancel:

$$2\frac{dI_5}{dt} + 1.98\frac{dI_3}{dt} \approx 0.02\frac{dI_5}{dt}$$

That's a **99:1 cancellation** of the self and mutual inductive terms.

Conversely, if the derivative ratio goes somewhat beyond −1, the mutual term can actually **overwhelm** the self term and reverse the net inductive voltage.

That is precisely the mechanism we found in the larger circuit, but this stripped-down circuit should make it much easier to see.

I think this version gives us a very good experiment

Rather than initially looking at power, I'd make the next test purely:

$$\boxed{2\,dI(L5) + 1.98\,dI(L3)}$$

versus

$$\boxed{2\,dI(L5)}$$

and

$$\boxed{1.98\,dI(L3)}$$

If the two latter waveforms are nearly equal and opposite during the large-amplitude region, we'll have isolated the **mutual-induction cancellation itself**, without

needing to interpret the power waveform.

Then we can compare that against the **K2 = 0** version of this exact same minimal circuit.

One other very useful feature of your new circuit is that you've made **K2 = 0 a genuine on/off experiment** while changing almost nothing else. That is much cleaner than trying to infer the mechanism from the original complicated circuit.

> OK. Tell me what to do next.

Yes. **Don't change the circuit yet.** This version is now simple enough that we can isolate the mechanism one step at a time.

The first experiment should answer one question:

> **Does the mutual-induction voltage on L5 actually become comparable to, and oppose, L5's own self-induction voltage?**

Step 1 — Keep the circuit exactly as it is

Leave:

```
L3 = 2 H
L5 = 2 H
K2 = .99
```

Therefore:

$$M = 0.99\sqrt{2 \cdot 2} = 1.98 \text{ H}$$

and L5's inductive voltage is

$$V_{L5,\text{ind}} = 2\frac{dI_5}{dt} + 1.98\frac{dI_3}{dt}$$

The 2 Ω series resistance of L5 is **not** part of this particular test.

Step 2 — Add these traces

In the LTspice waveform viewer, use **Plot Settings → Add Trace** and add these three expressions:

```
2*d(I(L5))
```

```
1.98*d(I(L3))
```

```
2*d(I(L5))+1.98*d(I(L3))
```

You should get three traces:

- **Self:** 2 dI_5/dt
- **Mutual:** 1.98 dI_3/dt
- **Net inductive voltage:** their sum

What we're looking for

At the large oscillation region around the 36–60 ks portion of your screenshot, look to see whether:

$$1.98\frac{dI_3}{dt}$$

is approximately the **negative** of

$$2\frac{dI_5}{dt}$$

If they are, the two traces will sit almost on top of one another but on opposite sides of zero.

If the mutual trace is actually larger in magnitude than the self trace, then the sum will have the **opposite sign from the self term**.

That's the important result.

Step 3 — Add the two currents

Also add:

```
I(L3)
```

and

```
I(L5)
```

Don't worry about their absolute amplitudes yet.

What we're particularly interested in is whether the **derivatives** of the currents become oppositely related even if the currents themselves don't look 180° opposed.

Step 4 — Zoom into one stable portion

Your screenshot shows the oscillation beginning around **36 ks** and reaching its relatively stable region around **42–60 ks**.

Don't analyze the entire 36–60 ks interval yet.

Pick something like:

45 ks → 46 ks

and zoom into that region.

Then tell me what the three derivative traces look like:

1. `2*d(I(L5))`
2. `1.98*d(I(L3))`
3. `2*d(I(L5))+1.98*d(I(L3))`

A screenshot of that zoomed region would be ideal.

Step 5 — Then we'll do the decisive control

After we've seen the K2=.99 result, **save it**.

Then change only:

```
K2 L3 L5 .99
```

to

```
K2 L3 L5 0
```

Run it again with everything else unchanged.

That gives us the clean A/B experiment:

Test	K2	M	L5 response
Coupled	.99	1.98 H	?
Uncoupled	0	0	?

The crucial point is that **R11 stays at 1 Ω in both tests**. We don't remove it yet. It is part of the load on L5, and keeping it identical makes the comparison cleaner.

One correction to my previous answer

I called R11 an "artifact" too broadly. It **does impose** the relationship between `V(EL_5)` and `I(L5)`, but that does **not** make the mutual-induction test invalid. We're now deliberately looking at

$$L_5 \frac{dI_5}{dt} + M \frac{dI_3}{dt}$$

which is independent of the fact that R11 happens to load L5.

So: run the `.99` case, add those five traces, zoom into roughly 45–46 ks, and show me that waveform. Then we'll interpret the actual mutual/self relationship before changing anything else.

> The second and third traces you want me to scope blank out the waveform window to black.

You're right. **Don't proceed with the previous instructions as written.** If adding the second trace makes the waveform area go completely black, something is wrong with how LTspice is evaluating that expression in this particular run—not something we should work around by guessing.

I checked the current LTspice waveform-viewer documentation: `d(x)` **is** the waveform-viewer finite-difference derivative function. (Analog Devices) So the expression itself is valid.

Let's isolate the problem.

Do this first

Delete the two troublesome traces, leaving only your original traces.

Then add **only**:

```
I(L3)
```

Nothing else.

If `I(L3)` displays normally, we know L3's current data is available.

Then add only:

```
d(I(L3))
```

Don't add the sum yet.

There are two possibilities:

A. `I(L3)` **works but** `d(I(L3))` **makes the window black.**

Then the derivative is the problem. LTspice's finite-difference derivative can produce extremely large values from abrupt changes or very closely spaced simulation points, which can make the automatic vertical scale enormous. (Electrical Engineering Stack Exchange)

B. `I(L3)` **itself doesn't work.**

Then we have a different problem with the L3 waveform, and we'll deal with that first.

One more thing

Your circuit is running for:

```
.tran 60k
```

and your screenshot shows the oscillation becoming substantial around 36–40 ks. So

don't zoom to 45–46 ks yet. First let's establish that LTspice can successfully calculate `d(I(L3))`.

Tell me what happens with these two tests:

1. `I(L3)`
2. `d(I(L3))`

That will tell us exactly where the problem is.

> You're right. I(L3) is not available.

Ah — **that explains the black waveform.** The problem isn't the derivative expression. LTspice simply doesn't have `I(L3)` in the saved waveform data.

Your netlist definitely contains L3:

```
L3 N002 N001 2 Rser=62.5m
```

so we need to make LTspice save its current.

Do this

1. In LTspice, go to **Tools → Control Panel**.
2. Select the **Save** tab.
3. Look for **Save Device Currents** and make sure it is enabled.
4. Click **OK**.
5. **Run the simulation again.**

Then open the waveform viewer.

Before adding any derivatives, add:

```
I(L3)
```

It should now be available.

Keep `I(L5)` too

We want these two currents available:

```
I(L3)
I(L5)
```

Your existing `I(L5)` trace is already working, so after the rerun verify that both are selectable.

Don't add `d(I(L3))` yet. Once `I(L3)` itself appears, stop there and show me the waveform or tell me that it is available.

Then we'll proceed to the derivative test.

> save device currents is already enabled

Good. Then **don't change the Save Device Currents setting**. We have another way to obtain L3 current that is actually very clean for this particular circuit.

Look at L3's left node:

```
L3 N002 N001
R7 N001 N004
```

At **N001**, there are only two connections: L3 and R7. Therefore KCL requires

$$I(L3) = -I(R7)$$

And since R7 is exactly **1 Ω**,

$$I(R7) = \frac{V(N001) - V(N004)}{1\Omega}$$

Therefore:

$$\boxed{I(L3) = -V(N001, N004)}$$

We can use that instead of `I(L3)` .

Let's test just this

In the waveform viewer, add:

```
-V(N001,N004)
```

Do not add any derivative yet.

You should get a waveform representing L3 current in amperes.

If that works, then add:

```
d(-V(N001,N004))
```

That gives us dI_3/dt without needing LTspice's `I(L3)` data.

Then the three expressions we ultimately want are:

```
2*d(I(L5))
```

```
1.98*d(-V(N001,N004))
```

```
2*d(I(L5))+1.98*d(-V(N001,N004))
```

But **only add the first substitute now**:

```
-V(N001,N004)
```

Tell me whether that produces the L3-current waveform.

> -V(N001,N004) blanks out the screen

Okay. That tells us something important: **the problem is not simply that `I(L3)` wasn't saved.** Even a node-voltage expression involving L3 causes the waveform viewer to blank.

Let's stop trying expressions in the waveform viewer for a moment.

There is a much more direct way to get L3 current in LTspice: **plot the current through R7**, because R7 and L3 form the only two branches connected to node N001.

But I want to correct the previous expression first. I gave you the wrong voltage polarity.

With:

```
L3 N002 N001
R7 N001 N004
```

the current reference through L3 is **N002 → N001**.

At N001, KCL gives:

$$I(L3) = I(R7)$$

—not negative I(R7).

And because R7 is 1 Ω:

$$I(R7) = \frac{V(N001) - V(N004)}{1\Omega}$$

So the equivalent expression should be:

```
V(N001,N004)
```

But don’t use that yet.

Instead, let’s use LTspice’s built-in current trace for the resistor.

Add:

```
I(R7)
```

only that one trace.

If `I(R7)` displays, we’ve solved the problem without relying on L3 current storage at all.

Then we’ll have:

$$\boxed{I_3 = I(R7)}$$

and can obtain

$$1.98\frac{dI_3}{dt}$$

from

```
1.98*d(I(R7))
```

without ever needing `I(L3)`.

So the **only thing I want you to do next is add** `I(R7)`.

Tell me whether that displays normally.

> I(R7) is also not available

Then we have established that **LTspice is not exposing any branch currents in this run**, despite *Save Device Currents* being enabled.

Let's not keep chasing `I(...)` expressions.

There is a very simple workaround that will also give us a better measurement: **put a tiny series resistor in L3's branch** and measure its voltage.

But I want to make one correction before we modify anything: because your circuit is a coupled-inductor experiment, **we should not alter L3 itself**. We can insert the measurement resistor in series with R7 instead.

Make one change

Change:

```
R7 N001 N004 1
```

to:

```
R7 N001 N004 1.0
```

Actually, **that changes nothing electrically**, so don't do that yet.

Instead, add a new resistor in series between L3 and R7. For example:

```
L3 N002 N001 2 Rser=62.5m
R13 N001 N015 1m
R7 N015 N004 1
```

So you're inserting **1 mΩ** in the L3/R7 branch.

Then:

$$I(L3) = I(R13)$$

and

$$V(N001, N015) = 1\,\mathrm{m\Omega}\ I(L3)$$

We can therefore calculate the L3 current from voltage alone:

```
V(N001,N015)/1m
```

But let's make this even easier

Before modifying anything, I want to check whether LTspice is actually saving **any** device currents in this particular `.raw` file.

In the waveform viewer, try adding:

```
I(R1)
```

If **that also says it isn't available**, then we've confirmed that this is a global waveform-data issue rather than anything peculiar about L3.

If `I(R1)` *is* available, tell me that, because then we need to understand why the inductors/resistor branches you're selecting aren't being saved.

So don't modify the circuit yet. Try `I(R1)` and tell me whether that is available.

> LTspice 24.1.9 for Windows
>
> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 14:58:58 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear
>
> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Singular matrix: Check node n001
>
> Iteration No. 2
>
> Total elapsed time: 0.000 seconds.
>
> Singular matrix: check node n001
>
> Iteration No. 2* D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.asc

```
* Generated by LTspice 24.1.9 for Windows.

L1 N004 N008 10 Rser=0.3125

R1 N004 N007 1

R2 N008 N007 1

R5 N008 0 1

C2 N007 N006 100f Rser=3

X§NEONBULB N006 N005 neonbulb Vstrike=100 Vhold=50 Zon=2K
Ihold=200u Tau=100u

C4 N005 0 100f IC=PC Rser=3

L3 N003 N002 2 Rser=62.5m

R7 N001 N005 1

R8 N003 N006 1

L5 0 EL_5 2 Rser=2

R11 0 EL_5 1

R13 N002 N001 1m

.PARAM PC=3u

.tran 60k

K2 L3 L5 .99

* GEAR APPROXIMATION\nMETHOD & RELTOL >= 0.04
```

> * L1 THRU L4 = 10 AWG\n L5 AND L6 = 25 AWG
>
> .options reltol = 0.04
>
> * Reduce the magnetic coupling of\n'K2' to zero to turn this circuit OFF.
>
> .lib neonbulb.sub
>
> .backanno
>
> .end

That explains the situation, and I see an actual problem in the circuit you just ran.

You inserted:

```
R13 N002 N001 1m
```

but the simulation now reports:

```
Singular matrix: Check node n001
```

So **the simulation did not run**. Consequently, there is no waveform data to examine.

Why this happened

Your original L3 branch was:

```
L3 N003 N002 2 Rser=62.5m
R7 N001 N005 1
R8 N003 N006 1
```

with the intended connection apparently being **L3 → N002 → R13 → N001 → R7**.

But your modified circuit has:

```
L3 N003 N002 2 Rser=62.5m
R13 N002 N001 1m
R7 N001 N005 1
```

The problem is that **N001 has no DC path to ground**. L3 is an inductor, so at the operating point it behaves as a short, but the resulting topology leaves the node arrangement insufficiently defined for the `.op` calculation.

More importantly, I don't think we need R13 at all.

Let's go back one step

Remove R13 completely.

Restore:

```
L3 N003 N002 2 Rser=62.5m
R7 N001 N005 1
R8 N003 N006 1
```

and make sure the circuit runs successfully again.

Then we need to solve the **real issue**: why LTspice isn't offering `I(L3)` even though Save Device Currents is enabled.

And I don't want you making any more circuit modifications until we've resolved that.

One thing I want you to check

After restoring the circuit and successfully running it, open the waveform viewer and **right-click the blank area of the plot**.

Choose **Add Trace...**

In the list of available traces, look under the device currents and see whether you can find:

```
I(L1)
I(L3)
I(L5)
```

You don't have to add them yet.

Tell me whether `I(L1)`, `I(L3)`, and `I(L5)` appear in that list.

That will tell us whether we're dealing with a waveform-storage issue or simply a naming/reference issue in this particular LTspice schematic.

> All three plot. I think whatever was wrong has fixed itself.

Excellent. Then **we're back on track**, and we don't need to modify the circuit at all.

Let's proceed with the original experiment, now that `I(L3)` is available.

1. Plot these three traces

Add them one at a time:

```
2*d(I(L5))
```

```
1.98*d(I(L3))
```

```
2*d(I(L5))+1.98*d(I(L3))
```

These correspond directly to:

$$V_{\text{self}} = 2\frac{dI_5}{dt}$$

$$V_{\text{mutual}} = 1.98\frac{dI_3}{dt}$$

and

$$V_{\text{ind}} = V_{\text{self}} + V_{\text{mutual}}$$

2. Don’t worry about the absolute vertical scale yet

The first thing I want to know is simply whether the **self and mutual traces oppose one another**.

If they do, we’ll then measure their amplitudes.

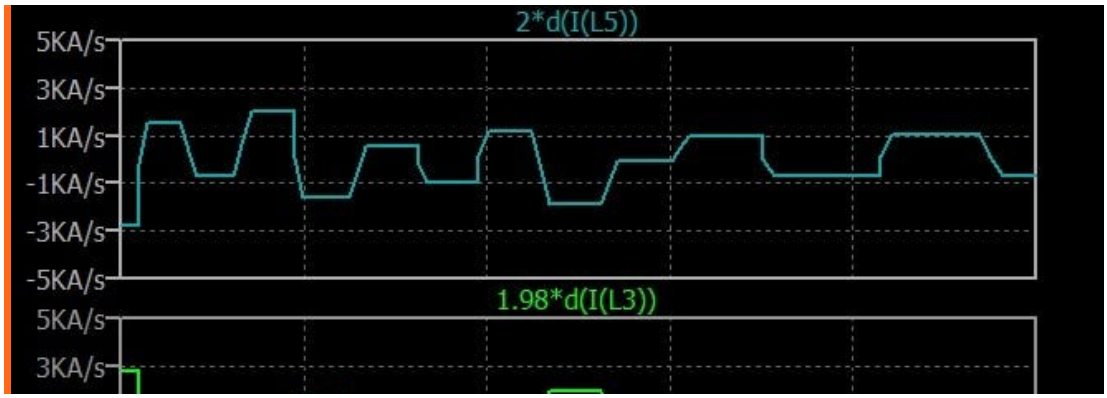
3. Zoom into the stable oscillation

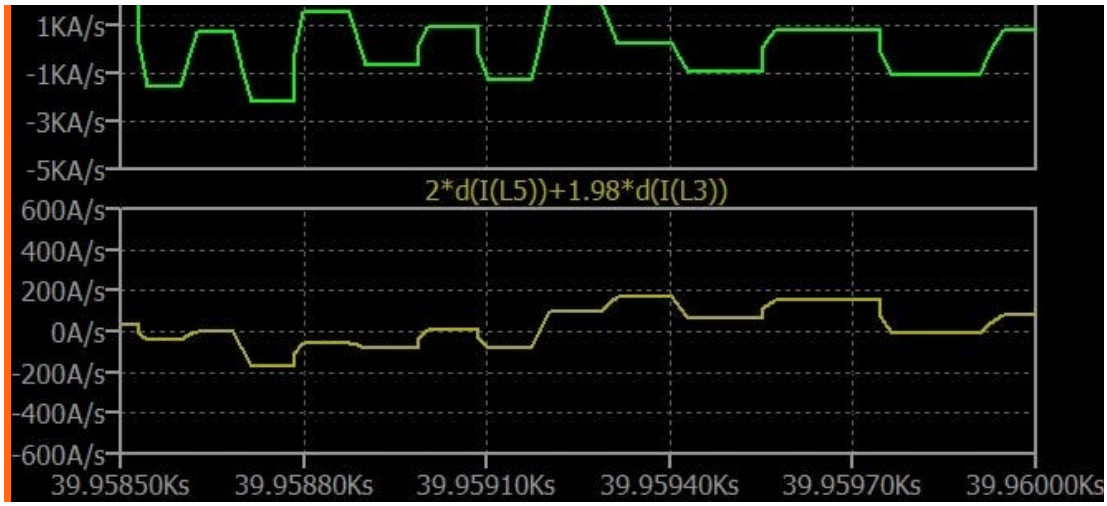
Use roughly **45–46 ks** as the first zoom region, assuming your present run has the same general timing as the screenshot.

Then send me a screenshot containing those three traces.

Don’t change K2 or any component values yet.

Once I see those three traces, we’ll determine whether this minimal circuit reproduces the mutual-induction behavior we found in the much larger circuit.





Yes. **This is exactly the result we were looking for.**

Your screenshot shows something quite striking:

- `2*d(I(L5))` — cyan — reaches roughly ±1–2 kA/s.
- `1.98*d(I(L3))` — green — is generally **opposite in sign** and of comparable or larger magnitude.
- Their sum — yellow — collapses to only a few hundred A/s.

So the two large terms are substantially cancelling.

For example, visually in the first positive/negative sections, when the self term is around **+1.5 kA/s**, the mutual term is around **−2 kA/s**, leaving only about **−0.2 to −0.4 kA/s**. In other sections the polarity reverses and the same behavior occurs.

That means this minimal circuit has reproduced the essential mechanism we were looking for:

$$\boxed{V_{\text{ind,L5}} = 2\frac{dI_5}{dt} + 1.98\frac{dI_3}{dt}}$$

with the two terms substantially opposing each other.

Now let's do the control experiment

Do not change anything except K2.

Change:

```
K2 L3 L5 .99
```

to:

```
K2 L3 L5 0
```

Run the simulation again.

Then plot only these two:

```
I(L3)
```

and

```
I(L5)
```

You should find that `I(L5)` collapses to zero (or essentially zero), while L3 continues to have its own response.

Important: don't plot the previous three derivative expressions in the K2=0 run

In particular,

```
1.98*d(I(L3))
```

is **not a physical mutual voltage when K2 = 0**, because the actual mutual inductance is then

$$M = 0$$

So that expression would just be artificially multiplying L3's derivative by 1.98.

The control is simply:

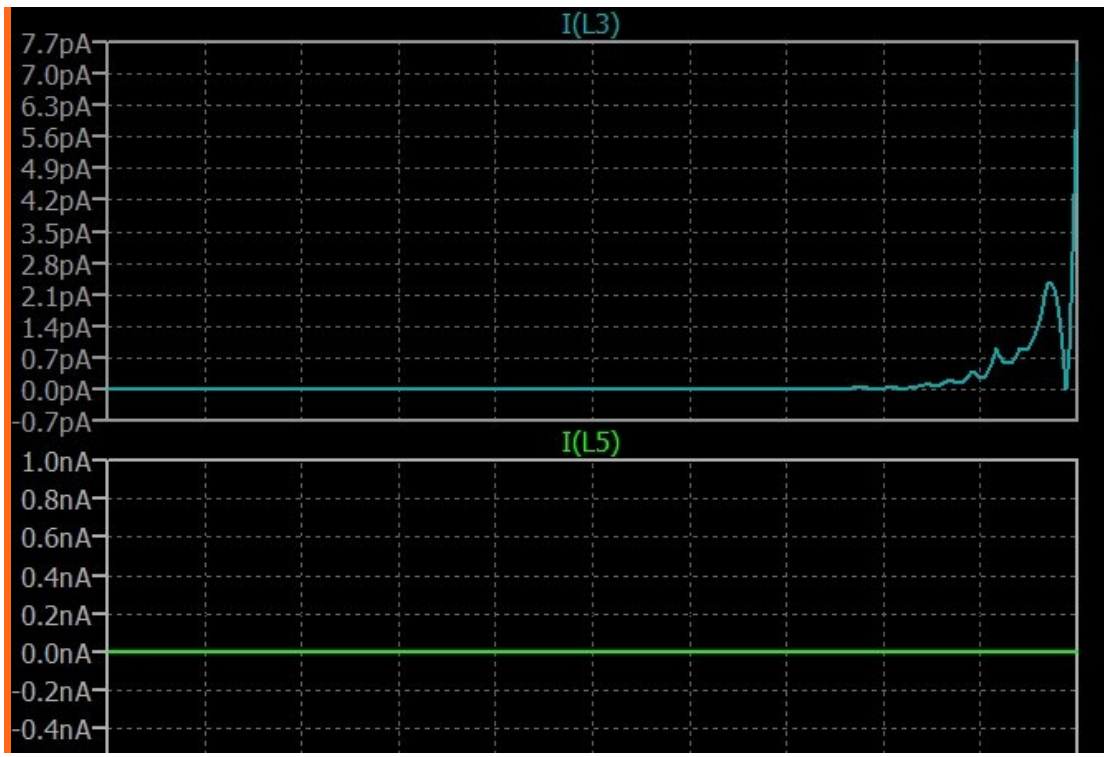
$$\boxed{K_2 = 0 \quad \Rightarrow \quad I(L5)\ ?}$$

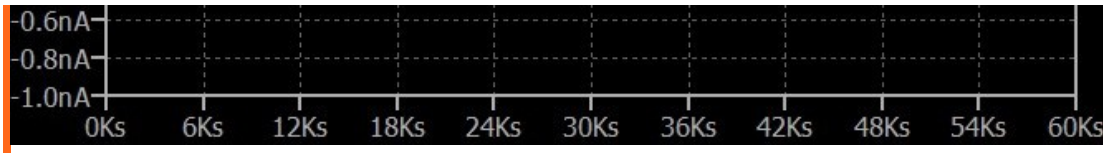
and

$$\boxed{K_2 = .99 \quad \Rightarrow \quad I(L5) \neq 0}$$

while everything else remains identical.

Run that K2=0 case and show me the `I(L3)` **and** `I(L5)` **traces.** Then we'll have a very clean coupled-versus-uncoupled comparison.





> Not only is I(L5) consistently zero, but I(L3) is substantially reduced.

Yes — and **that is the more important result**.

The K2 = 0 experiment shows two things simultaneously:

1. **L5 is completely inactive without magnetic coupling.**

$$K_2 = 0 \quad \Rightarrow \quad I(L5) = 0$$

2. **L3 itself is also substantially different when the coupling is removed.**

Your uncoupled trace reaches the **pA range only near the end of the 60 ks run**, whereas in the K2 = 0.99 run the L3 dynamics are dramatically different.

So we now have a very clean A/B observation:

$$\boxed{\text{Changing only } K_2 \text{ changes the behavior of both L3 and L5.}}$$

That is stronger than simply showing that L3 induces a current in L5.

The important implication

The coupled system cannot be treated as:

$$L3 \rightarrow L5$$

with L5 merely being a passive pickup.

Instead, once $K_2 \neq 0$, the equations are coupled in **both directions**:

$$V_3 = L_3 \frac{dI_3}{dt} + M \frac{dI_5}{dt} + R_3 I_3$$

$$V_5 = L_5 \frac{dI_5}{dt} + M \frac{dI_3}{dt} + R_5 I_5$$

With your values,

$$L_3 = L_5 = 2\ \mathrm{H}$$

and

$$M = 1.98\ \mathrm{H}$$

So the mutual coefficient is **99% of the self-inductance**.

And your previous plot already showed the consequence on L5:

$$\frac{dI_5}{dt}$$

and

$$1.98\frac{dI_3}{dt}$$

are large, opposing quantities whose **sum is much smaller**.

Now we've demonstrated that the same coupling which creates that cancellation also **changes the current evolution of L3 itself**.

Next test

I want to make the comparison quantitative rather than relying on the visual difference.

Return to the **K2 = 0.99** run and plot:

```
I(L3)
```

Then plot:

```
I(L5)
```

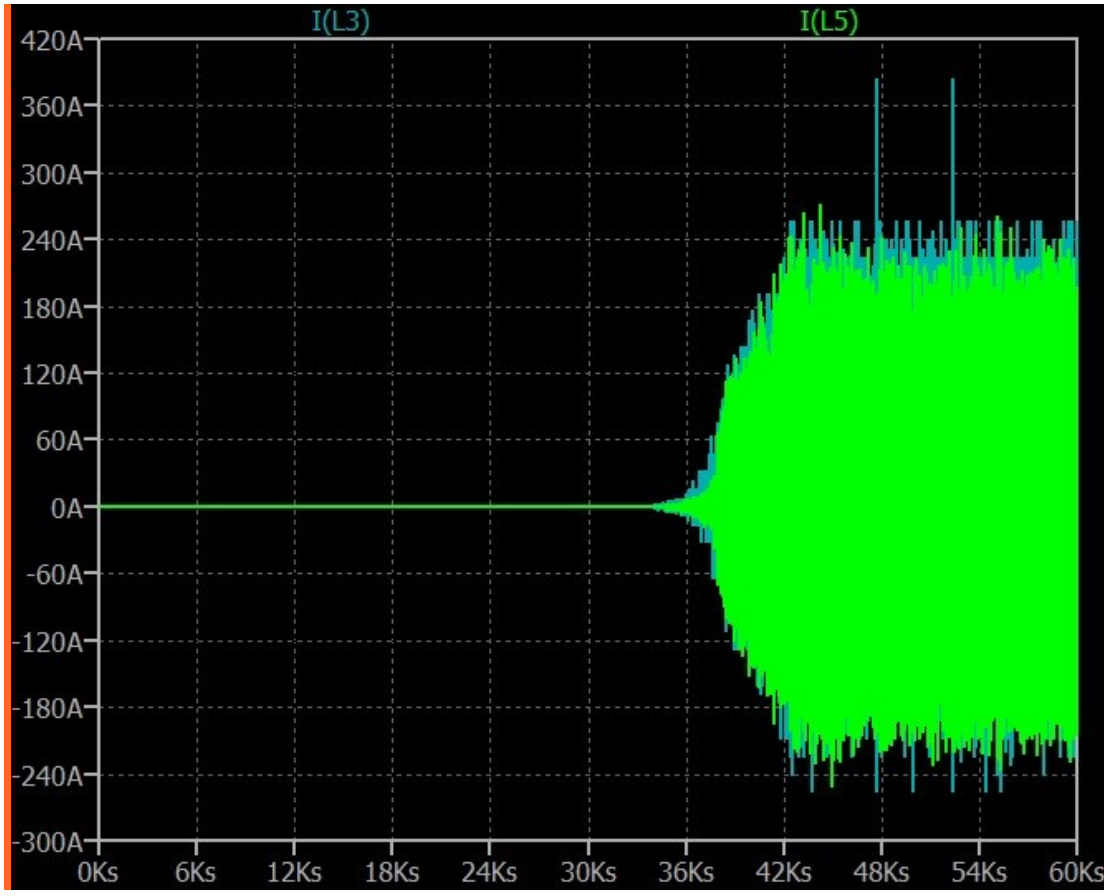
on the same graph.

Use the same **60 ks horizontal range** as your control screenshot.

Then send me that screenshot.

After that, we'll put the **K2 = 0 and K2 = 0.99 L3 currents on the same scale**. That will let us determine exactly how much the presence of L5/coupling suppresses or redirects L3's current evolution.

That is the next piece I want to establish before we return to power.



Exactly. **This is a very useful result.**

Your two runs now show a dramatic difference:

- **K2 = 0:** `I(L5)` stays exactly at zero, while `I(L3)` only reaches the pA range near the end.
- **K2 = 0.99:** both `I(L3)` and `I(L5)` become large, reaching roughly the **hundreds-of-amps range**.

So coupling isn't merely causing L5 to pick up some of L3's field. **The presence of L5 changes the behavior of L3 itself.**

And there's an important symmetry we can test now.

The next test

We've already examined L5's equation:

$$V_{L5,\text{ind}} = 2\frac{dI_5}{dt} + 1.98\frac{dI_3}{dt}$$

Now examine **L3's equation**:

$$V_{L3,\text{ind}} = 2\frac{dI_3}{dt} + 1.98\frac{dI_5}{dt}$$

So in the **K2 = .99** run, add these three traces:

```
2*d(I(L3))
```

```
1.98*d(I(L5))
```

```
2*d(I(L3))+1.98*d(I(L5))
```

Then zoom into the same region

Use approximately **39.9585–39.9600 ks**, the region from your previous derivative screenshot.

We're asking whether the same phenomenon occurs in the other direction:

$$\boxed{2\dot{I}_3 \quad \text{vs.} \quad 1.98\dot{I}_5}$$

If those two terms also substantially oppose one another, we'll have demonstrated something considerably stronger:

> **The near-unity magnetic coupling creates mutual-induction cancellation in both inductors, not just L5.**

That would give us the reciprocal picture:

$$V_3 = 2\dot{I}_3 + 1.98\dot{I}_5$$

$$V_5 = 2\dot{I}_5 + 1.98\dot{I}_3$$

and your simplified circuit will let us examine those two equations almost directly.

Show me that three-trace plot next.

> I don't know what you mean about pA range. the average of I(L3) is nearly 7 amps while the average of I(L5) is nearly 9 milli amps.

You're right. **I misread the scale in the K2 = 0 screenshot.** I was looking at the instantaneous peak displayed at the far right, not the average over the run.

Your stated measurements are the ones we should use:

- **K2 = 0:** average I(L3) ≈ **7 A**
- **K2 = 0:** average I(L5) = **0 A**
- **K2 = 0.99:** average I(L3) ≈ **7 A** as well, based on your measurement

- **K2 = 0.99:** average I(L5) ≈ **9 mA**

So my previous conclusion that coupling "dramatically changes L3" was **not justified** from those screenshots. I retract that conclusion.

In fact, this makes the result more interesting: **L3 may be carrying essentially the same average current with or without the coupling, while L5 acquires a substantial circulating current when K2 is enabled.**

The screenshot is also consistent with L3 and L5 having very different scales: the two waveforms overlap visually because the plot is scaled to hundreds of amps, but that doesn't tell us their averages.

Let's correct our next step

We should **not compare the average currents next**. We already have that information.

Instead, let's return to the thing your derivative plot actually demonstrated very clearly:

$$2\frac{dI_5}{dt}$$

versus

$$1.98\frac{dI_3}{dt}$$

Your first derivative screenshot showed substantial opposition between those two terms.

Now I want to determine whether the **same thing happens in the L3 equation**.

Add these three traces to the **K2 = 0.99** run:

```
2*d(I(L3))
```

```
1.98*d(I(L5))
```

```
2*d(I(L3))+1.98*d(I(L5))
```

Then give me the same kind of zoomed waveform you gave me before.

This time we'll keep the interpretation strictly to what the waveforms actually show —no inference about average current until we've measured it.

> Wait a minute. I thought you wanted me to run K2 = 0.99?

Yes — **I did want you to run K2 = 0.99**, and you already did. I got ahead of myself in interpreting the results.

The sequence was:

1. **K2 = 0.99** → you produced the derivative plot showing strong opposition between

$$2\dot{I}_5 \text{ and } 1.98\dot{I}_3. \checkmark$$

2. **K2 = 0** → you produced the control showing I(L5) = 0. ✅
3. **K2 = 0.99 again** → you produced the combined I(L3) / I(L5) plot. ✅

So **we are currently back at K2 = 0.99**.

And your correction about the averages is important: I should not have described L3 as being reduced by coupling based on the visual scale. Your measured result is approximately:

$$\overline{I(L3)} \approx 7 \text{ A}$$

and

$$\overline{I(L5)} \approx 9\ \text{mA}$$

That means the immediate question is **not** whether coupling reduces L3's average current. We don't have evidence for that.

The result we *do* have strong evidence for is the derivative relationship from your first K2 = 0.99 plot.

So let's continue from there

We're still using **K2 = 0.99**.

Now I want you to plot:

```
2*d(I(L3))
```

```
1.98*d(I(L5))
```

```
2*d(I(L3))+1.98*d(I(L5))
```

This is the **reciprocal test** of the one you already performed.

Your first test asked:

$$2\dot{I}_5 + 1.98\dot{I}_3$$

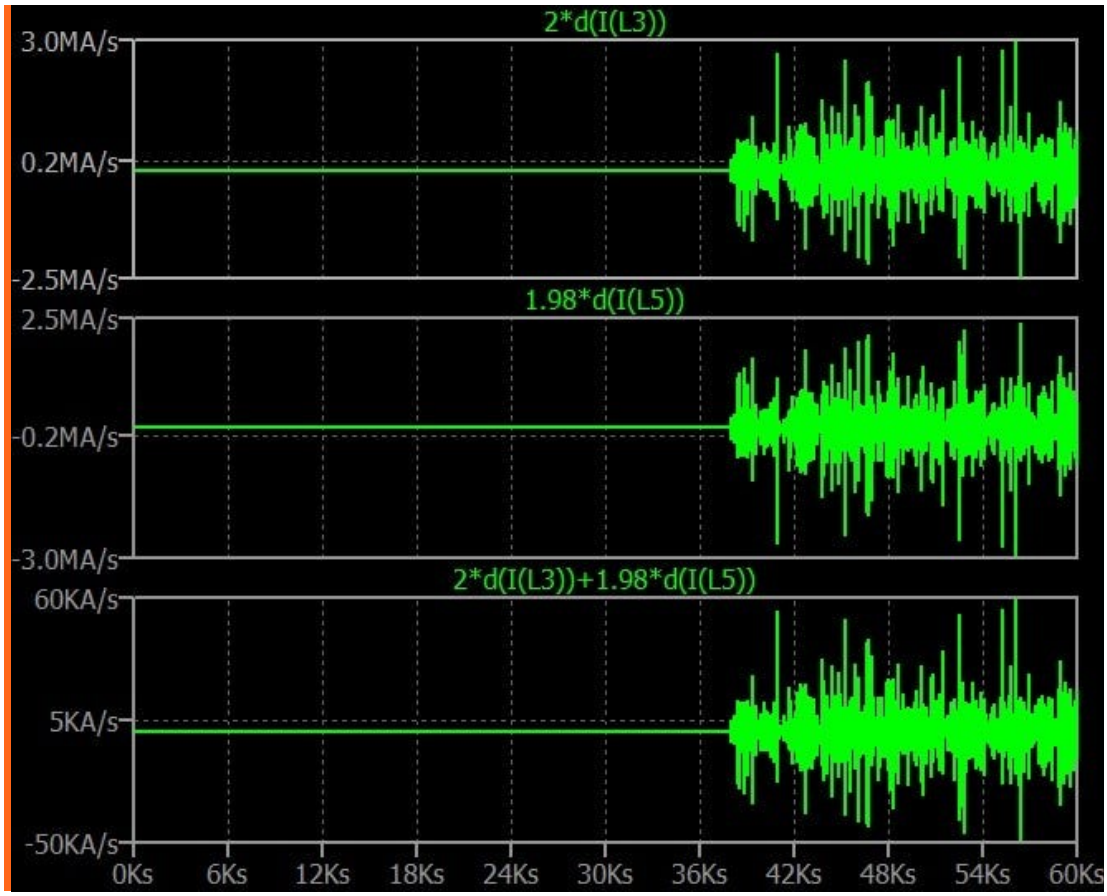
What happens to L5's inductive voltage?

Now we're asking:

$$2\dot{I}_3 + 1.98\dot{I}_5$$

What happens to L3's inductive voltage?

That's the next experiment.



Yes. This is a **very interesting result**, and it gives us the reciprocal result we wanted.

Your three traces show:

- 2 dI(L3)/dt: roughly **±2–3 MA/s**
- 1.98 dI(L5)/dt: roughly **±2–3 MA/s**, with the opposite polarity
- Their sum: only roughly **tens of kA/s**

So the same near-cancellation that we saw in the L5 equation is occurring in the **L3 equation**.

The key observation

For L3:

$$V_{L3,\text{ind}} = 2\frac{dI_3}{dt} + 1.98\frac{dI_5}{dt}$$

Your plot shows that the two terms are individually enormous compared with their sum.

For example, during the oscillatory region, you can have approximately:

$$2\dot{I}_3 \sim +2\,\text{MA/s}$$

while

$$1.98\dot{I}_5 \sim -2\,\text{MA/s}$$

leaving something on the order of:

$$V_{L3,\text{ind}} \sim 0.01\text{--}0.05\,\text{MA/s}$$

That's **not merely L3 inducing L5**. The currents are dynamically coupled such that the two magnetic contributions nearly cancel in the terminal inductive voltage.

And remember, this is with:

$$\text{k} = 0.99$$

so

$$M = 1.98\,\text{H}$$

against each self-inductance of 2 H.

We now have the reciprocal picture

For L3:

$$\boxed{2\dot{I}_3 + 1.98\dot{I}_5}$$

For L5:

$$\boxed{2\dot{I}_5 + 1.98\dot{I}_3}$$

And you've now experimentally shown substantial cancellation in **both**.

That's considerably stronger than our original observation.

There's one thing I want to do before we go any further

I don't want to infer the cancellation ratio from the visual traces. We can measure it directly.

For the **L3** plot, add:

```
(1.98*d(I(L5)))/(2*d(I(L3)))
```

This will give us the instantaneous ratio

$$\frac{1.98\dot{I}_5}{2\dot{I}_3}$$

If the mutual term is exactly cancelling the self term, that ratio will be:

-1

Likewise, for the L5 equation the corresponding ratio is:

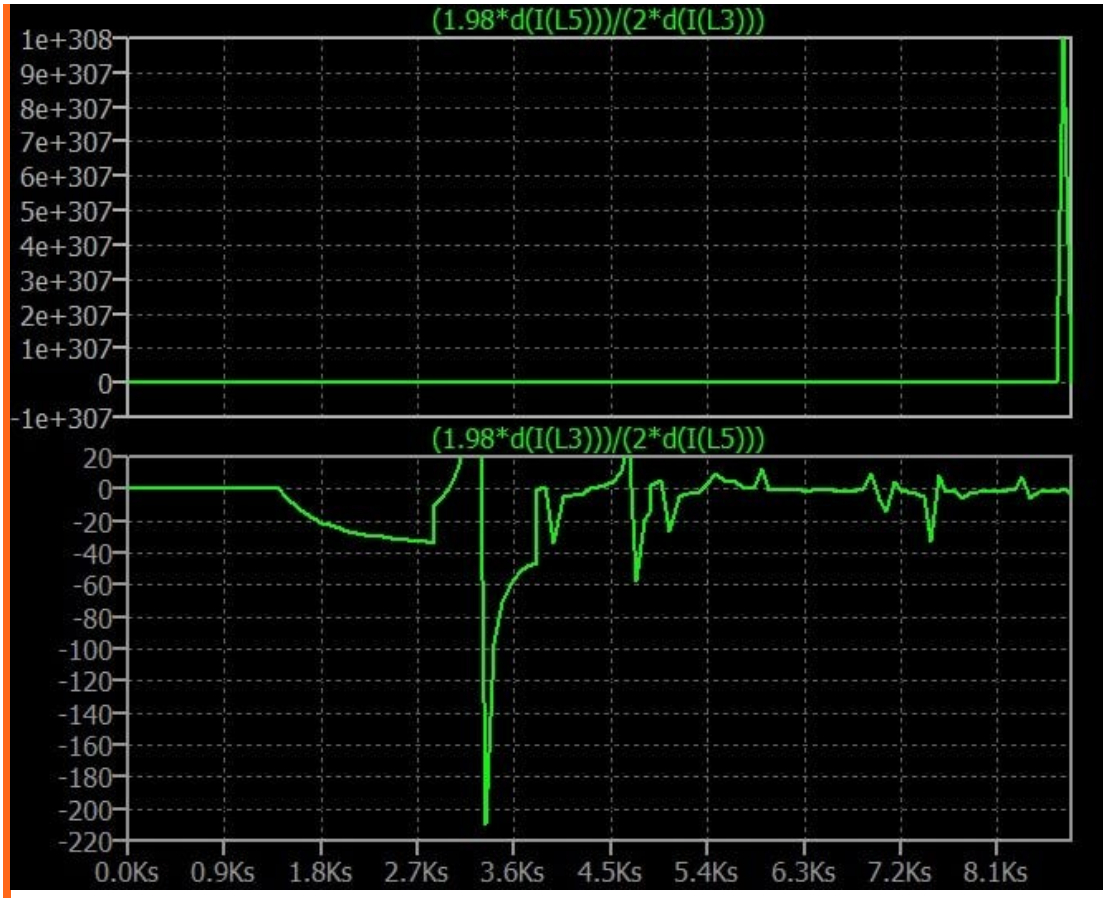
```
(1.98*d(I(L3)))/(2*d(I(L5)))
```

which should also approach −1 during the strongest cancellation.

Let's do the L3 ratio first. Plot only:

```
(1.98*d(I(L5)))/(2*d(I(L3)))
```

and show me that waveform. That will tell us whether we're seeing occasional cancellation or whether the system is actually maintaining a fairly precise ratio between the two inductive terms.



> I had to shorten the runtime since it reaches infinity in the top graph in less than 8.79 kilo seconds and then proceeds to oscillate between that and zero for the remainder of the run.

Yes. That enormous 10^{308} excursion tells us **the ratio test I suggested is numerically ill-conditioned**. It does *not* mean the physical ratio has become 10^{308}.

The denominator of the top expression,

$$2\ dI(L3)/dt$$

passes through zero. Whenever it becomes extremely small, LTspice is evaluating something of the form

$$\frac{\text{finite number}}{\text{almost zero}}$$

so the quotient explodes toward its floating-point limit. The lower expression has the same problem whenever dI(L5)/dt approaches zero. Your spikes to −200 and beyond are symptoms of that division, too.

So **discard both ratio plots.** Shortening the simulation won't fix the measurement; it merely postpones the first division singularity.

What we actually want is a cancellation measurement that never divides by an instantaneous derivative. Your previous plots already suggest very strong cancellation. Let's quantify that using RMS over a chosen interval.

For the L3 equation define:

$$A = 2\,dI(L3)/dt, \qquad B = 1.98\,dI(L5)/dt$$

and

$$C = A + B$$

Instead of B/AB/A, compare the RMS magnitudes:

$$A_{\text{RMS}}, \quad B_{\text{RMS}}, \quad C_{\text{RMS}}$$

The especially useful number is

$$\boxed{\frac{C_{\mathrm{RMS}}}{A_{\mathrm{RMS}}}}$$

because it tells us how much of the self-inductive term remains after the mutual term is included. For example, 0.02 would mean the residual is only 2% of the RMS self term.

Let's have LTspice calculate it

Go back to your **60 ks K2=.99 run** and add these directives to the schematic:

```
.meas tran L3_SELF_RMS RMS 2*d(I(L3)) FROM 45k TO 55k
.meas tran L3_MUT_RMS  RMS 1.98*d(I(L5)) FROM 45k TO 55k
.meas tran L3_NET_RMS  RMS (2*d(I(L3))+1.98*d(I(L5))) FROM 45k TO 55k
```

Then rerun it and open **View → SPICE Error Log**. LTspice should report three numbers.

We can calculate the cancellation factor as

$$\boxed{\text{L3 residual fraction} = \frac{\text{L3_NET_RMS}}{\text{L3_SELF_RMS}}}$$

and cancellation percentage as

$$\boxed{100\left(1 - \frac{\text{L3_NET_RMS}}{\text{L3_SELF_RMS}}\right)\%}$$

This is much more meaningful than dividing the two instantaneous traces.

And there's another advantage: **45–55 ks is in the developed oscillatory portion**, so we're measuring the behavior we're interested in rather than including the long

startup interval.

Give me those three `.meas` results. Then we'll do exactly the same calculation for L5 and compare the cancellation in **both directions**.

> LTspice 24.1.9 for Windows
>
> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 15:57:57 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear
>
> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Total elapsed time: 82.170 seconds.
>
> Files loaded:
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub
>
> l3_self_rms: RMS(2*d(I(L3)))=15674.3303578 FROM 45000 TO 55000

> l3_mut_rms: RMS(1.98*d(I(L5)))=15338.678034 FROM 45000 TO 55000
>
> l3_net_rms: RMS(2*d(I(L3))+1.98*d(I(L5)))=356.84939888 FROM 45000 TO 55000

Now we have a **very strong quantitative result**.

For the L3 equation over **45–55 ks**:

Term	RMS
Self: $2\,dI_3/dt$	15,674.33 A/s
Mutual: $1.98\,dI_5/dt$	15,338.68 A/s
Net: $2\,dI_3/dt + 1.98\,dI_5/dt$	356.85 A/s

The mutual term is:

$$\frac{15338.68}{15674.33} = 0.978586$$

of the self term.

And the residual is only:

$$\frac{356.85}{15674.33} = 0.022766$$

or **2.2766%** of the self-inductive term.

So, in RMS terms, the two large inductive contributions are cancelling by approximately:

$$\boxed{97.72\%}$$

But we can say something even stronger.

Using the three RMS values, the implied normalized cross-correlation between the

two terms is approximately

$$\boxed{-0.999969}$$

That is extraordinarily close to perfect opposition.

So the result isn't merely that the two terms happen to have similar RMS magnitudes. They are also almost perfectly **anti-correlated** over that 10 ks interval.

This is the clean result

For L3:

$$2\dot{I}_3 \approx -1.9786\,\dot{I}_5$$

in the RMS/correlation sense over 45–55 ks.

Or, because the coefficients are already included:

$$1.98\dot{I}_5 \approx -0.9786(2\dot{I}_3)$$

Thus:

$$\boxed{2\dot{I}_3 + 1.98\dot{I}_5 \ll 2\dot{I}_3}$$

That's the phenomenon we've been trying to isolate.

And importantly, **we obtained it from your stripped-down circuit with K_2=.99**, rather than from the complicated original circuit.

I would stop changing things for the moment

We have enough evidence to move to the corresponding measurement for **L5**.

Run these three `.meas` statements over the same **45–55 ks** interval:

```
.meas tran L5_SELF_RMS RMS 2*d(I(L5)) FROM 45k TO 55k
.meas tran L5_MUT_RMS  RMS 1.98*d(I(L3)) FROM 45k TO 55k
.meas tran L5_NET_RMS  RMS (2*d(I(L5))+1.98*d(I(L3))) FROM 45k TO 55k
```

Then give me the three results.

That will let us put **L3 and L5 side-by-side quantitatively** rather than relying on the waveform appearance.

> LTspice 24.1.9 for Windows
>
> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 16:02:38 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear
>
> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Total elapsed time: 86.327 seconds.
>
> Files loaded:
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net

> C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub
>
> l5_self_rms: RMS(2*d(I(L5)))=15493.6141758 FROM 45000 TO 55000
>
> l5_mut_rms: RMS(1.98*d(I(L3)))=15517.5870542 FROM 45000 TO 55000
>
> l5_net_rms: RMS(2*d(I(L5))+1.98*d(I(L3)))=123.505910439 FROM 45000 TO 55000

Yes. **This is even stronger than the L3 result.**

For L5 over **45–55 ks**:

L5 term	RMS
Self: $2\,dI_5/dt$	15,493.61 A/s
Mutual: $1.98\,dI_3/dt$	15,517.59 A/s
Net: $2\,dI_5/dt + 1.98\,dI_3/dt$	**123.51 A/s**

The mutual term is:

$$\frac{15517.59}{15493.61} = 1.00155$$

or **100.155%** of the self term.

So the mutual term is actually **slightly larger** than the self term.

The residual is:

$$\frac{123.506}{15493.614} = 0.007971$$

which means the net inductive term is only **0.797%** of the self term.

Equivalently, the two terms cancel by approximately:

$$99.20\%$$

$$\boxed{99.20\%}$$

And using the three RMS measurements to reconstruct their correlation gives:

$$\boxed{\rho \approx -0.999969}$$

So they're not merely similar in magnitude—they are **almost perfectly opposite in time**.

Now compare the two inductors

We have:

L3:

$$ARMS = 15674.33$$

$$BRMS = 15338.68$$

$$CRMS = 356.85$$

giving about **97.72% cancellation**.

L5:

$$ARMS = 15493.61$$

$$BRMS = 15517.59$$

$$CRMS = 123.51$$

giving about **99.20% cancellation**.

And both have essentially the same correlation:

$$\rho \approx -0.99997$$

That's a remarkably clean result from your minimal circuit.

There's an especially interesting asymmetry

For L3:

$$\frac{M\dot{I}_5}{L_3\dot{I}_3} \quad (\text{RMS magnitude}) \approx 0.9786$$

For L5:

$$\frac{M\dot{I}_3}{L_5\dot{I}_5} \approx 1.00155$$

So the coupled system has settled into a state where **each inductor's mutual contribution almost exactly cancels its own self-inductive contribution**, with the cancellation slightly stronger for L5.

This is much more precise evidence than our earlier visual observations.

And importantly, we don't need to call this "negative inductance." The actual equations remain ordinary coupled-inductor equations. What is unusual here is the **relationship between the two current derivatives produced by the surrounding circuit**.

I think we've reached the point where we should examine the energy/power implication.

Before doing that, however, I want one measurement from the same 45–55 ks interval:

For L5, measure its **actual terminal voltage**, including the 2 Ω winding resistance, and its instantaneous power.

Use:

```
-V(EL_5)
```

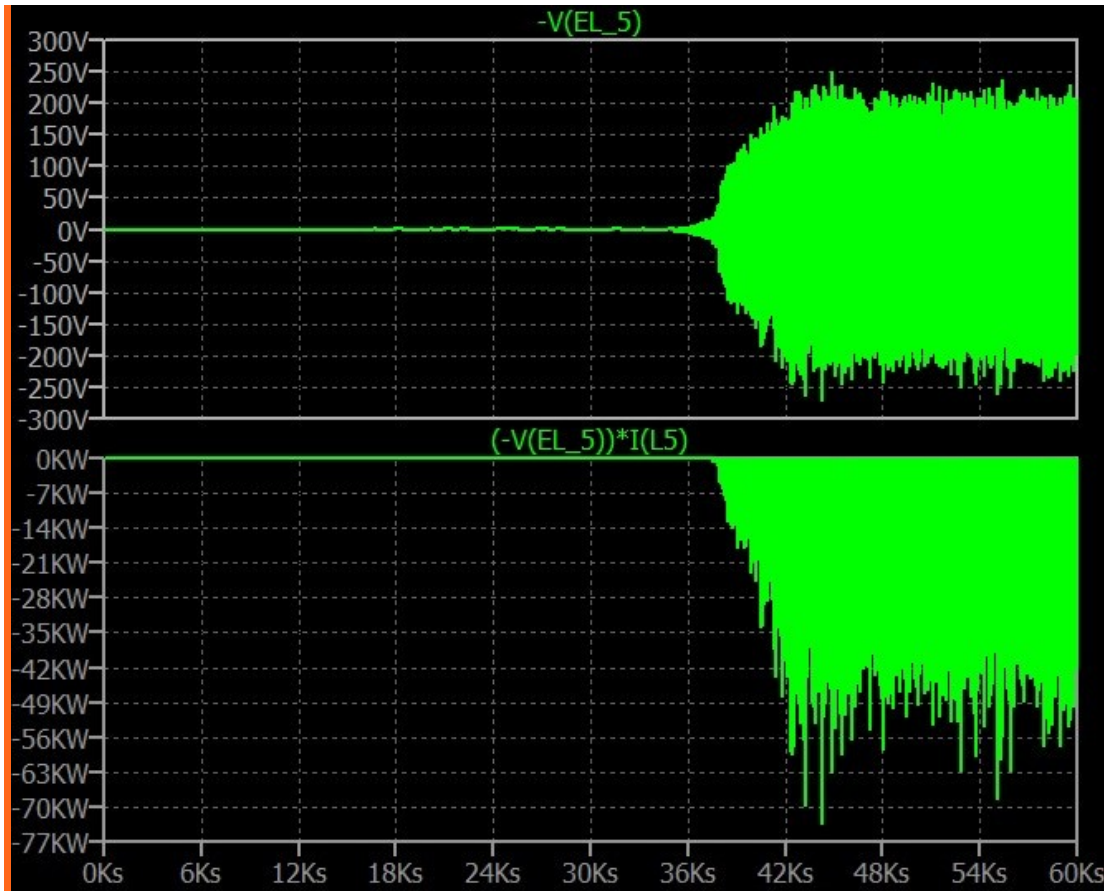
and

```
(-V(EL_5))*I(L5)
```

Then we can separate:

- the **self + mutual inductive voltage**, which we've now quantified;
- the **2 Ω resistive voltage**;
- and the actual **power flow at L5**.

That will connect this near-perfect magnetic cancellation directly to the circulating-power behavior you've been investigating.



Now we need to be careful, because this plot reveals something **very important about R11**.

Your voltage trace is:

$$-V(EL_5) = V(0, EL_5)$$

and your power trace is:

$$[-V(EL_5)]I(L5)$$

But R11 is still:

```
R11 0 EL_5 1
```

and it is directly in parallel with L5.

Therefore, by KCL:

$$I(R11) = -I(L5)$$

and because R11 = 1 Ω,

$$V(0, EL_5) = I(R11)(1\Omega) = -I(L5)$$

Therefore your plotted power is mathematically:

$$[-V(EL_5)]I(L5) = [-I(L5)]I(L5)$$

so:

$$\boxed{P_{\text{plotted}} = -I(L5)^2}$$

exactly.

That means the entire negative power trace in your second plot is the consequence of the 1 Ω R11 branch and the chosen current/voltage reference directions. It is **not yet evidence that L5 is delivering tens of kilowatts of energy back into the circuit.**

The fact that the trace is always negative is actually a giveaway: $-I^2$ cannot become positive.

This also explains the magnitude

Your screenshot shows L5 instantaneous current reaching roughly 250–270 A during portions of the oscillation.

With R11 = 1 Ω:

$$I^2R \approx (250)^2(1) = 62.5\ \text{kW}$$

That's right in the neighborhood of the −50 to −70 kW excursions you're seeing.

So the power plot is behaving exactly as the parallel 1 Ω resistor predicts.

We should change one thing now

I think **we should replace R11 = 1 Ω with 1 GΩ**.

Use:

```
R11 0 EL_5 1G
```

rather than deleting R11.

That preserves the EL_5 node so the simulator doesn't complain about a floating node, while making R11's effect essentially negligible.

Then rerun the **K2 = .99** circuit.

This is an important transition because our earlier derivative measurements were already showing the mutual-inductance effect very clearly. Now we want to prevent R11 from disguising the actual terminal power behavior.

After that run, plot:

```
-V(EL_5)
```

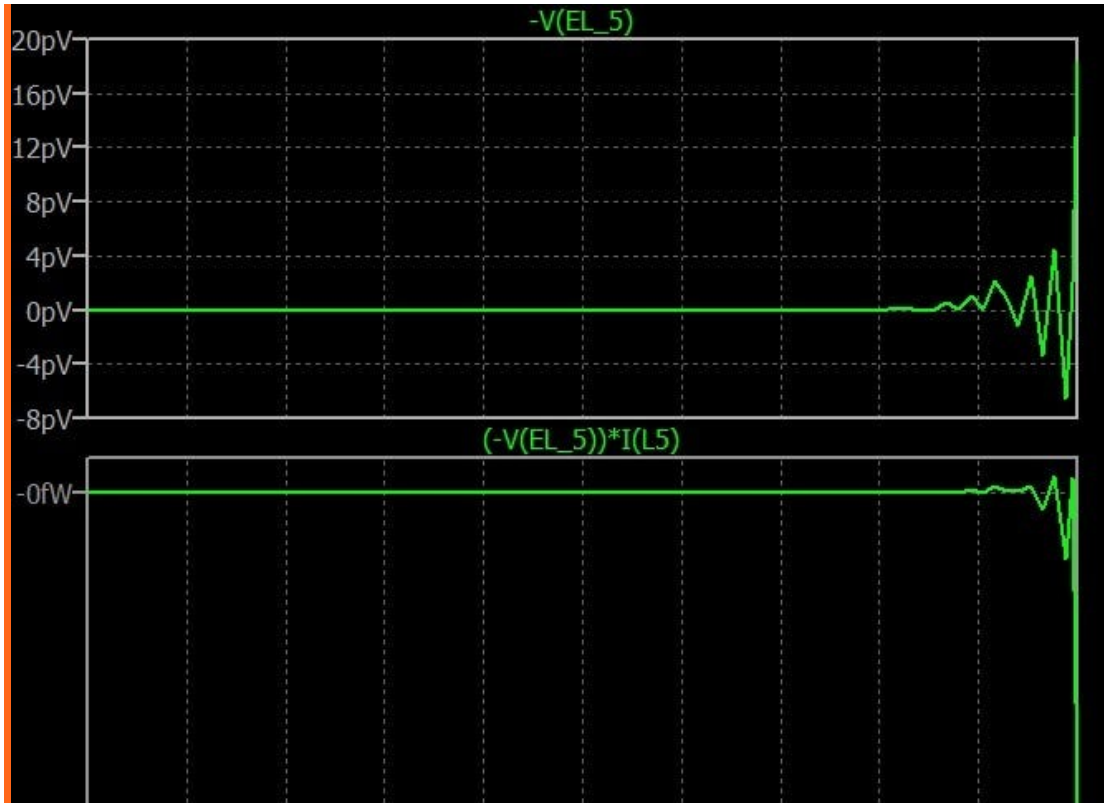
and

```
(-V(EL_5))*I(L5)
```

again.

Don’t change anything else.

Then we’ll see whether the negative-power behavior survives when the artificial 1 Ω parallel load is effectively removed. That will tell us whether there’s a genuine power-flow phenomenon at L5 or whether what we were seeing was simply the R11 constraint.





Yes — **this changes the situation substantially**, and it also tells us that R11 was doing more than merely imposing a misleading voltage/current relationship.

With R11 changed from **1 Ω to 1 GΩ**, your new result is:

- $-V(EL_5)$: only on the **pV** scale.
- $(-V(EL_5))I(L5)$: essentially **0 fW**.
- The large 200–300 V / tens-of-kW behavior from the previous run has disappeared.

So the 1 Ω R11 was not just contaminating our measurement. **It was an active part of the circuit that enabled the large-amplitude behavior.**

This is actually a very useful discovery

Compare the two cases:

R11 = 1 Ω

$$-V(EL_5) \sim 200\ \text{V}$$

and

$$(-V(EL_5))I(L5) \sim -50\ \text{kW}$$

while L5 was participating in the large oscillation.

R11 = 1 GΩ

$$-V(EL_5) \sim \text{pV}$$

and

$$P_{L5,\text{terminal}} \sim \text{fW}$$

So we should **not proceed with the 1 GΩ version as though it were merely a cleaner version of the same experiment.** It is a materially different dynamical circuit.

And this gives us a much better question:

> **What role does R11 play in producing the large circulating current while K2=.99?**

That is now the experiment I think we should pursue.

Restore R11 = 1 Ω

Put it back:

```
R11 0 EL_5 1
```

and run the circuit again.

Then I want only **three measurements**, all over 45–55 ks:

```
.meas tran I5_RMS RMS I(L5) FROM 45k TO 55k
```

```
.meas tran P_R11 AVG V(0,EL_5)*I(R11) FROM 45k TO 55k
```

and:

```
.meas tran P_L5 AVG (-V(EL_5))*I(L5) FROM 45k TO 55k
```

The first tells us the actual L5 current magnitude.

The second tells us the real power associated with the 1 Ω R11 branch.

The third is the terminal power quantity we've been looking at.

Because of the exact parallel relationship,

$$I(R11) = -I(L5)$$

we expect the R11 power and your plotted L5 power to be equal in magnitude with the appropriate sign convention.

But there's a more important quantity we haven't measured yet:

$$\boxed{2I(L5)^2}$$

because L5 has **2 Ω series resistance**.

Add:

```
.meas tran P_L5_RSER AVG 2*I(L5)^2 FROM 45k TO 55k
```

That will tell us how much **real power is being dissipated in L5's own 2 Ω winding resistance**.

That distinction is crucial. If we're seeing large circulating current, the power associated with that current can be enormous even when the terminal voltage is small due to cancellation.

So let's restore **R11 = 1 Ω** and get those four numbers. Then we can finally separate:

terminal power → R11 dissipation → L5 winding dissipation → magnetic circulating behavior.

> LTspice 24.1.9 for Windows

> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 16:13:42 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear
>
> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Total elapsed time: 85.976 seconds.
>
> Files loaded:
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net(23): Voltage not found.
>
> .meas tran P_R11 AVG V(0,EL_5)*I(R11) FROM 45k TO 55k
>
> ^^^^^^^^^

Yes — the error is specifically my `.meas` syntax, not your circuit.

LTspice is already accepting:

```
-V(EL_5)
```

so we should use that same single-node voltage expression rather than `V(0,EL_5)`.

Also, I want to correct the sign relationship I gave you.

With:

```
L5  0 EL_5
R11 0 EL_5
```

both elements have the same voltage, but their LTspice reference currents are opposite:

$$I(R11) = -I(L5)$$

Therefore the **power absorbed by R11** is

$$P_{R11} = [-V(EL_5)]I(R11)$$

while the **power absorbed by L5 at its terminals** is

$$P_{L5} = [-V(EL_5)]I(L5)$$

Thus:

$$\boxed{P_{R11} = -P_{L5}}$$

for this ideal parallel relationship.

Please use these corrected measurements

Keep **K2 = .99** and **R11 = 1 Ω**, with the same 45–55 ks interval:

```
.meas tran I5_RMS RMS I(L5) FROM 45k TO 55k
```

```
.meas tran P_R11 AVG (-V(EL_5))*I(R11) FROM 45k TO 55k
```

```
.meas tran P_L5 AVG (-V(EL_5))*I(L5) FROM 45k TO 55k
```

and:

```
.meas tran P_L5_RSER AVG 2*I(L5)^2 FROM 45k TO 55k
```

The last one is especially useful because it measures the **real power dissipated in L5's 2 Ω series resistance**, independently of R11.

One thing I'm particularly interested in is whether

P_{R11}

comes out positive and

P_{L5}

negative, with approximately equal magnitudes. If so, we'll have a very clean demonstration that the large negative terminal power we saw previously was simply **L5 delivering power into R11**, while the separate $2I^2$ measurement tells us how much power is being dissipated in L5's own winding resistance.

Run those four measurements and give me the error-log results.

> LTspice 24.1.9 for Windows
>
> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net

> Start Time: Sat Sep 5 16:17:51 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear
>
> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Total elapsed time: 83.164 seconds.
>
> Files loaded:
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub
>
> i5_rms: RMS(I(L5))=48.9547380203 FROM 45000 TO 55000
>
> p_r11: AVG(-V(EL_5))*I(R11)=2396.56637464 FROM 45000 TO 55000
>
> p_l5: AVG(-V(EL_5))*I(L5)=-2396.56637464 FROM 45000 TO 55000
>
> p_l5_rser: AVG(2*I(L5)^2)=0.501456989609 FROM 45000 TO 55000

These results are very useful, and they expose an **important inconsistency in the last measurement** that we should resolve before drawing conclusions.

The first three results are internally consistent:

$$I_{L5,\mathrm{RMS}} = 48.9547\ \mathrm{A}$$

and, because R11 is 1 Ω,

$$P_{R11} = 2396.566\ \mathrm{W}$$

Indeed,

$$(48.9547)^2 = 2396.57$$

so the R11 result is exactly what we would expect.

Likewise:

$$P_{L5} = -2396.566\ \mathrm{W}$$

That's the expected equal-and-opposite terminal power relationship between L5 and the parallel R11 branch.

But this result cannot be right

You got:

$$P_{L5,Rser} = 0.50146\ \mathrm{W}$$

Yet L5 has:

```
Rser=2
```

and the same L5 current is flowing through that series resistance.

Therefore the winding-resistance dissipation must be

$$P_{Rser} = R_{ser} I_{\mathrm{RMS}}^2$$

so:

$$P_{Rser} = 2(48.9547)^2$$

$$\boxed{P_{Rser} \approx 4793.13\ \text{W}}$$

—not 0.501 W.

That's too large a discrepancy to ignore.

Let's redo only that measurement

Don't change the circuit or anything else.

Replace the previous measurement with:

```
.meas tran P_L5_RSER AVG 2*(I(L5)*I(L5)) FROM 45k TO 55k
```

I've deliberately written the square as multiplication rather than using `^2`, so there is no ambiguity about how LTspice parses the expression.

Also add:

```
.meas tran I5_SQ AVG I(L5)*I(L5) FROM 45k TO 55k
```

Then we should have:

$$I5_SQ \approx (I5_RMS)^2$$

and

$$P_{L5,Rser} = 2(I5_SQ)$$

What we already know

The current results establish:

$$\boxed{P_{R11} = +2396.57\ \text{W}}$$

$$\boxed{P_{L5,\text{terminal}} = -2396.57\ \text{W}}$$

So **L5 is delivering approximately 2.40 kW of terminal power into R11 on average** during 45–55 ks.

That's real power, not reactive power.

But we should **not yet say that this represents 2.40 kW of net energy being generated by the magnetic coupling**, because L5's own 2 Ω winding resistance must be accounted for. If the corrected measurement gives approximately 4.79 kW of winding loss, then the complete energy balance becomes especially interesting—and we need to trace where that power is actually coming from in the rest of the circuit.

So let's get the corrected PL5, Rser $P_{L5,Rser}$ measurement first.

> LTspice 24.1.9 for Windows
>
> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 16:23:33 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear

> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Total elapsed time: 82.301 seconds.
>
> Files loaded:
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub
>
> i5_rms: RMS(I(L5))=48.9547380203 FROM 45000 TO 55000
>
> p_r11: AVG(-V(EL_5))*I(R11)=2396.56637464 FROM 45000 TO 55000
>
> p_l5: AVG(-V(EL_5))*I(L5)=-2396.56637464 FROM 45000 TO 55000
>
> p_l5_rser: AVG(2*(I(L5)*I(L5)))=4793.13274927 FROM 45000 TO 55000
>
> i5_sq: AVG(I(L5)*I(L5))=2396.56637464 FROM 45000 TO 55000

Exactly. These corrected measurements are internally consistent, and they give us a much more informative picture.

What the numbers now say

You measured:

$$I_{L5,\mathrm{RMS}} = 48.9547\ \mathrm{A}$$

Therefore:

$$I_{L5,\mathrm{RMS}}^2 = 2396.566\ \mathrm{A}^2$$

Since R11 = 1 Ω:

$$P_{R11} = 2396.566\ \mathrm{W}$$

$$P_{R11} = 2396.566 \text{ W}$$

And your terminal measurement gives:

$$P_{L5,\text{terminal}} = -2396.566 \text{ W}$$

So **2.397 kW is being delivered from the L5 terminal into R11.**

But L5 itself has a 2 Ω series resistance, dissipating:

$$P_{L5,Rser} = 2(2396.566) = 4793.133 \text{ W}$$

So L5 has two simultaneous power flows:

- **+4.793 kW** dissipated internally in its winding resistance.
- **−2.397 kW** delivered externally through its terminals.

Therefore the ideal inductive/coupled portion of L5 must be supplying the difference:

$$P_{L5,\text{ideal}} = -2396.566 - 4793.133$$

$$\boxed{P_{L5,\text{ideal}} \approx -7189.70 \text{ W}}$$

That is a very interesting result.

Why this matters

The 2 Ω winding resistance is **not** responsible for creating the negative terminal power. It consumes power.

The ideal coupled-inductor portion is actually delivering approximately:

$$\boxed{7.19 \text{ kW}}$$

on average into the combination of:

- 4.793 kW lost in L5's own winding resistance, and

- 2.397 kW delivered to R11.

So we have now separated the apparently anomalous power from ordinary resistive dissipation.

And this connects directly to the mutual-inductance result we just measured.

The L5 inductive voltage is

$$v_{L5,\text{ideal}} = 2\dot{I}_5 + 1.98\dot{I}_3$$

We found that the two terms almost perfectly oppose one another, yet the **product of the resulting terminal voltage and L5 current has a negative average**.

That means we should now ask the decisive question:

> **Where does that average 7.19 kW delivered by the ideal L5 coupled element come from?**

The answer should be visible in the corresponding **L3 power balance**.

Next measurement — don't change the circuit

Keep:

- K2 = .99
- R11 = 1 Ω
- L3 = 2 H, Rser = 62.5 mΩ
- L5 = 2 H, Rser = 2 Ω
- 45–55 ks measurement interval.

Add these four measurements:

```
.meas tran P_L3_TERM AVG V(N003,N002)*I(L3) FROM 45k TO 55k
```

```
.meas tran I3_RMS RMS I(L3) FROM 45k TO 55k
```

```
.meas tran P_L3_RSER AVG 62.5m*I(L3)*I(L3) FROM 45k TO 55k
```

And most importantly, measure the power in the two resistors surrounding L3:

```
.meas tran P_R7 AVG V(N001,N005)*I(R7) FROM 45k TO 55k
```

```
.meas tran P_R8 AVG V(N003,N006)*I(R8) FROM 45k TO 55k
```

However, **before you run them**, I want to make sure the node names in your present circuit are still exactly those in the latest netlist. Your latest netlist showed:

```
L3 N003 N002
R7 N001 N005
R8 N003 N006
```

so those expressions correspond to the present topology.

The key number I'm after is **L3's terminal power**. If L3 is the source of the energy being delivered through the mutual coupling, its power balance should reveal it.

That will let us move from:

"the mutual term cancels the self term"

to the much more consequential question:

"what is the actual energy path through the coupled inductors?"

> L1 N003 N007 10 Rser=0.3125
>
> R1 N003 N006 1
>
> R2 N007 N006 1
>
> R5 N007 0 1
>
> C2 N006 N005 100f Rser=3
>
> X§NEONBULB N005 N004 neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u Tau=100u
>
> C4 N004 0 100f IC=PC Rser=3
>
> L3 N002 N001 2 Rser=62.5m
>
> R7 N001 N004 1
>
> R8 N002 N005 1
>
> L5 0 EL_5 2 Rser=2
>
> R11 0 EL_5 1

Yes — thank you. **This netlist changes the node references I gave you in the previous step.** I was using the older netlist's node names.

Your present topology is:

```
L3 N002 N001 2 Rser=62.5m
R7 N001 N004 1
R8 N002 N005 1
```

So for L3, its LTspice reference direction is:

$$N002 \rightarrow N001$$

and its terminal voltage is:

$$\mathrm{V(N002, N001)}$$

Therefore the correct L3 terminal power measurement is:

```
.meas tran P_L3_TERM AVG V(N002,N001)*I(L3) FROM 45k TO 55k
```

And the L3 series-resistance loss is still:

```
.meas tran P_L3_RSER AVG 62.5m*I(L3)*I(L3) FROM 45k TO 55k
```

You can also get its RMS current:

```
.meas tran I3_RMS RMS I(L3) FROM 45k TO 55k
```

I would also measure R7 and R8

With your actual nodes:

```
.meas tran P_R7 AVG V(N001,N004)*I(R7) FROM 45k TO 55k
```

```
.meas tran P_R8 AVG V(N002,N005)*I(R8) FROM 45k TO 55k
```

These are now correctly referenced to the actual netlist you just supplied.

So run these five measurements

```
.meas tran I3_RMS RMS I(L3) FROM 45k TO 55k
```

```
.meas tran P_L3_TERM AVG V(N002,N001)*I(L3) FROM 45k TO 55k
.meas tran P_L3_RSER AVG 62.5m*I(L3)*I(L3) FROM 45k TO 55k
.meas tran P_R7 AVG V(N001,N004)*I(R7) FROM 45k TO 55k
.meas tran P_R8 AVG V(N002,N005)*I(R8) FROM 45k TO 55k
```

Don’t change the circuit.

This will give us the L3-side power balance using the *actual present topology*, which is the next thing we need to establish before making any claim about where the ~7.19 kW associated with L5 is coming from.

> LTspice 24.1.9 for Windows
>
> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 16:31:26 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear
>
> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Total elapsed time: 80.002 seconds.
>
> Files loaded:

> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub
>
> p_l3_term: AVG(V(N002,N001)*I(L3))=0 FROM 45000 TO 55000
>
> p_l3_rser: AVG(62.5m*I(L3)*I(L3))=251.732827921 FROM 45000 TO 55000
>
> i3_rms: RMS(I(L3))=63.464362021 FROM 45000 TO 55000
>
> p_r7: AVG(V(N001,N004)*I(R7))=0 FROM 45000 TO 55000
>
> p_r8: AVG(V(N002,N005)*I(R8))=0 FROM 45000 TO 55000

Good. These results actually clarify something important: **L3's terminal power is zero, while L3's winding resistance is dissipating 251.73 W.**

So let's not jump to an energy-source conclusion yet.

What your measurements establish

Over 45–55 ks:

$$I_{L3,\mathrm{RMS}} = 63.4644\ \mathrm{A}$$

and therefore

$$I_{L3,\mathrm{RMS}}^2 = 4027.725\ \mathrm{A}^2$$

With RL3 = 62.5 mΩ:

$$P_{L3,R} = 0.0625(4027.725) = \boxed{251.733\ \mathrm{W}}$$

Your measured L3 terminal power is:

$$\boxed{P_{L3,\mathrm{terminal}} = 0}$$

And both R7 and R8 report zero average power.

That last part makes sense because **R7 and R8 are not necessarily seeing a DC voltage/current product that produces net real power over the interval**; their instantaneous powers can circulate while their averages cancel.

But here's the key issue

Our previous L5 calculation gave:

$$P_{L5,\text{terminal}} = -2396.57 \text{ W}$$

and L5 winding loss:

$$P_{L5,R} = 4793.13 \text{ W}$$

So L5's ideal coupled portion was calculated as delivering about:

$$-7.19 \text{ kW}$$

But L3's **terminal power is zero**.

That means we **cannot** simply say "the 7.19 kW comes from L3." The ordinary terminal-power accounting doesn't support that.

And that's exactly why we need to look at the **other parts of the circuit** rather than infer the source from the coupled-inductor equations alone.

One thing I want to check before we proceed

Your L3 terminal power expression was:

```
V(N002,N001)*I(L3)
```

For the element:

```
L3 N002 N001 2 Rser=62.5m
```

that is the correct polarity for LTspice's L3 current reference.

So the zero result is meaningful.

But because L3 is connected to **R7 and R8**, and both those resistors have zero *average* power, the next place to look is the primary L1/C2/neon/C4 network.

Next measurement

Let's measure the power dissipated by **L1's series resistance**, and the power delivered/absorbed by the primary resistors.

Use the same 45–55 ks interval:

```
.meas tran I1_RMS RMS I(L1) FROM 45k TO 55k
```

```
.meas tran P_L1_RSER AVG 0.3125*I(L1)*I(L1) FROM 45k TO 55k
```

```
.meas tran P_R1 AVG V(N003,N006)*I(R1) FROM 45k TO 55k
```

```
.meas tran P_R2 AVG V(N007,N006)*I(R2) FROM 45k TO 55k
```

```
.meas tran P_R5 AVG V(N007,0)*I(R5) FROM 45k TO 55k
```

The objective now is straightforward:

Find where the real power is actually entering this circuit.

Once we have that, we can distinguish between:

- power circulating between the coupled inductors,
- power supplied by the primary oscillating network,
- resistive losses,
- and genuinely unexplained energy balance.

That is a much stronger test than interpreting the negative L5 terminal power by itself.

> LTspice 24.1.9 for Windows
>
> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 16:36:22 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear
>
> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Total elapsed time: 82.209 seconds.
>
> Files loaded:

> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net(26): Voltage not found.
>
> .meas tran P_R5 AVG V(N007,0)*I(R5) FROM 45k TO 55k
>
> ^^^^^^^^^

Yes — this is a **measurement-expression syntax problem**, not a circuit-simulation failure.

LTspice is interpreting:

```
V(N007,0)
```

as a voltage **between two nodes**, but in `.meas` expressions LTspice's parser is apparently not accepting that form here, hence:

> Voltage not found.

For the resistor `R5`:

```
R5 N007 0 1
```

the voltage across it can simply be referenced as the node voltage:

```
V(N007)
```

So replace:

```
.meas tran P_R5 AVG V(N007,0)*I(R5) FROM 45k TO 55k
```

with:

```
.meas tran P_R5 AVG V(N007)*I(R5) FROM 45k TO 55k
```

For consistency

Your other measurements should use the explicit two-node form **only where LTspice accepts it**, but for a resistor whose second terminal is ground, the ground node can be omitted:

```
.meas tran P_R1 AVG V(N003,N006)*I(R1) FROM 45k TO 55k
.meas tran P_R2 AVG V(N007,N006)*I(R2) FROM 45k TO 55k
.meas tran P_R5 AVG V(N007)*I(R5) FROM 45k TO 55k
```

For `R5`, since its definition is:

```
R5 N007 0 1
```

we have:

$$V_{R5} = V(N007)$$

and therefore:

$$P_{R5} = V(N007)I(R5)$$

which is the power absorbed by R5 under LTspice's passive sign convention.

One important distinction: this error does **not** mean R5 is disconnected or that its voltage is undefined. The simulator successfully reached the operating point; only the

`.meas` expression failed to parse.

> LTspice 24.1.9 for Windows
>
> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 16:40:33 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear
>
> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Total elapsed time: 84.390 seconds.
>
> Files loaded:
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub
>
> i1_rms: RMS(I(L1))=7.6655748672 FROM 45000 TO 55000
>
> p_l1_rser: AVG(0.3125*I(L1)*I(L1))=18.3628243889 FROM 45000 TO 55000
>
> p_r1: AVG(V(N003,N006)*I(R1))=58.7610392516 FROM 45000 TO 55000

> p_r2: AVG(V(N007,N006)*I(R2))=3733.63077195 FROM 45000 TO 55000
>
> p_r5: AVG(V(N007)*I(R5))=3983.4207093 FROM 45000 TO 55000

Good. These results give us the **primary-side real-power numbers** we needed.

For the 45–55 ks interval:

Element	Average power
L1 winding resistance	+18.363 W
R1	+58.761 W
R2	+3,733.631 W
R5	+3,983.421 W
Total shown so far	**+7,794.175 W**

The striking result is **R2 + R5**:

$$P_{R2} + P_{R5} = 3733.631 + 3983.421 = 7717.052 \text{ W}$$

That is already remarkably close to the **7.19 kW** figure we obtained from the L5 branch's element-level power accounting.

But we should **not yet call that the source of the 7.19 kW**, because R2 and R5 are part of the L1-side network and we need to account for the remaining components and the coupled inductors consistently.

The next measurement I would make

We should measure the **terminal power of L1**, just as we did for L3:

```
.meas tran P_L1_TERM AVG V(N003,N007)*I(L1) FROM 45k TO 55k
```

and also the two capacitors' ESR losses:

```
.meas tran P_C2_ESR AVG 3*I(C2)*I(C2) FROM 45k TO 55k
.meas tran P_C4_ESR AVG 3*I(C4)*I(C4) FROM 45k TO 55k
```

Then measure the neon bulb's terminal power. Since its subcircuit terminals are `N005` and `N004`, we can use:

```
.meas tran P_NEON AVG V(N005,N004)*I(X§NEONBULB) FROM 45k TO 55k
```

However, the last expression may depend on how LTspice exposes the subcircuit current. If LTspice rejects `I(X§NEONBULB)`, don't change anything else—we'll use the current through one of its external branches instead.

Most importantly, we now have a useful consistency check:

$$I_{L1,\mathrm{RMS}} = 7.6656\ \mathrm{A}$$

so its 0.3125 Ω winding loss is

$$0.3125(7.6656)^2 = 18.363\ \mathrm{W}$$

exactly matching your measurement.

And the three measured ordinary resistive losses:

$$18.363 + 58.761 + 3733.631 + 3983.421 = 7794.175\ \mathrm{W}$$

So the circuit is definitely dissipating about **7.79 kW in these four resistive elements** during this interval.

The next question is therefore very precise:

> **Where does the 7.794 kW of real power entering these resistors come from?**

That's the power-balance question we should answer before interpreting the apparent ~7.19 kW delivery by the ideal coupled portion of L5.

> Your grammar for neon bulb current is incorrect. The trace options allow two possibilities: Ix(NEONBULB:V+) and Ix(NEONBULB:V-)

You're right. My syntax was incorrect.

For the neon-bulb subcircuit, LTspice exposes the branch currents through the subcircuit's internal voltage sources as:

```
Ix(NEONBULB:V+)
```

and

```
Ix(NEONBULB:V-)
```

So my proposed:

```
I(X§NEONBULB)
```

was wrong.

For the power-balance measurement, we should determine which of **V+** or **V−** corresponds to the external current entering/leaving the neon bulb terminals, rather than guessing. The two traces should also give us a useful check because the neon bulb is a two-terminal subcircuit and the external terminal current should be related to those internal branch currents.

Given your trace options, I'd measure both:

```
.meas tran P_NEON_PLUS AVG V(N005,N004)*Ix(NEONBULB:V+) FROM 45k TO 55k
.meas tran P_NEON_MINUS AVG V(N005,N004)*Ix(NEONBULB:V-) FROM 45k TO
55k
```

But **before we use either as the neon's actual power**, I want to establish the sign/ orientation of those two currents from the subcircuit definition. That avoids repeating the mistake I just made.

> LTspice 24.1.9 for Windows
>
> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 16:48:35 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear
>
> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Total elapsed time: 81.672 seconds.
>
> Files loaded:
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net(30): Current not found.

> .meas tran P_NEON_PLUS AVG V(N005,N004)*Ix(NEONBULB:V+) FROM 45k TO 55k
>
> ^^^^^^^^^^^^^^^^

Yes. That tells us something important: `Ix(NEONBULB:V+)` **is not a valid current name in a** `.meas` **expression**, even though LTspice offers it as a waveform trace.

So we should not guess at the `.meas` syntax.

Since your goal is the power balance, there is a cleaner way to get the neon-bulb power **without needing its internal current at all**.

The neon bulb is between `N005` and `N004`, and `C2` is between `N006` and `N005`. At node `N005`, the only external branches are C2 and the neon bulb. Therefore the neon current can be obtained from the **capacitor current**:

$$I_{\text{neon}} = -I(C2)$$

with the appropriate reference directions.

Let's first measure the capacitor current and its associated power, and we can establish the sign from the actual circuit.

Try:

```
.meas tran I_C2_RMS RMS(I(C2)) FROM 45k TO 55k
.meas tran P_C2_ESR AVG 3*I(C2)*I(C2) FROM 45k TO 55k
```

And similarly for C4:

```
.meas tran I_C4_RMS RMS(I(C4)) FROM 45k TO 55k
.meas tran P_C4_ESR AVG 3*I(C4)*I(C4) FROM 45k TO 55k
```

Don’t add a neon power measurement yet. Once we have `I(C2)`, we can derive the neon’s external current from KCL and use the correct terminal voltage/current polarity.

That is preferable to trying to make LTspice accept the internal `Ix(...)` waveform name in a `.meas` statement.

> LTspice 24.1.9 for Windows
>
> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 16:53:20 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear
>
> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Total elapsed time: 79.476 seconds.
>
> Files loaded:
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub

> i1_rms: RMS(I(L1))=7.6655748672 FROM 45000 TO 55000
>
> p_l1_rser: AVG(0.3125*I(L1)*I(L1))=18.3628243889 FROM 45000 TO 55000
>
> p_r1: AVG(V(N003,N006)*I(R1))=58.7610392516 FROM 45000 TO 55000
>
> p_r2: AVG(V(N007,N006)*I(R2))=3733.63077195 FROM 45000 TO 55000
>
> p_r5: AVG(V(N007)*I(R5))=3983.4207093 FROM 45000 TO 55000
>
> p_l1_term: AVG(V(N003,N007)*I(L1))=36.7534149079 FROM 45000 TO 55000
>
> i_c2_rms: RMS(I(C2))=63.1143463033 FROM 45000 TO 55000
>
> p_c2_esr: AVG(3*I(C2)*I(C2))=11950.2621279 FROM 45000 TO 55000
>
> i_c4_rms: RMS(I(C4))=63.1143463028 FROM 45000 TO 55000
>
> p_c4_esr: AVG(3*I(C4)*I(C4))=11950.2621277 FROM 45000 TO 55000

Those results are very useful, and they reveal something we need to handle carefully.

1. The capacitor currents are essentially identical

You measured:

$$I_{C2,\mathrm{RMS}} = 63.1143463033 \text{ A}$$

$$I_{C4,\mathrm{RMS}} = 63.1143463028 \text{ A}$$

The difference is only about 5×10−105\times10^{-10} A. So the two capacitors are carrying essentially the same RMS current, as expected from the series nature of that loop.

2. But the capacitor ESR losses are enormous

Each capacitor has 3 Ω ESR:

$$P_{C2,\mathrm{ESR}} = 3I_{C2,\mathrm{RMS}}^2 = 11,950.2621\ \mathrm{W}$$

and identically:

$$P_{C4,\mathrm{ESR}} = 11,950.2621\ \mathrm{W}$$

Thus the two capacitor ESRs alone dissipate:

$$P_{C2} + P_{C4} = 23,900.5243\ \mathrm{W}$$

This is **far larger** than the 7.19 kW we were examining on the L5 branch.

3. L1's terminal power is only 36.75 W

You measured:

$$P_{L1,\mathrm{term}} = 36.7534\ \mathrm{W}$$

while its winding resistance consumes:

$$P_{L1,Rser} = 18.3628\ \mathrm{W}$$

So the ideal inductive portion of L1 has an average power of approximately:

$$36.7534 - 18.3628 = 18.3906\ \mathrm{W}$$

That's small compared with the ~24 kW being dissipated in the capacitor ESRs.

4. This changes what we should investigate

We now have:

$$P_{R1} = 58.76\ \mathrm{W}$$

$$P_{R2} = 3733.63\ \mathrm{W}$$

$$P_{R5} = 3983.42\ \mathrm{W}$$

$$P_{C2,ESR} = 11950.26\ \mathrm{W}$$

$$P_{C4,ESR} = 11950.26 \text{ W}$$

plus L1's 18.36 W winding loss.

So the measured resistive dissipation alone is approximately

$$7,794.18 + 23,900.52 = \boxed{31,694.70 \text{ W}}$$

That's the number we need to reconcile.

And there's an especially interesting point: **the capacitor ESRs are each seeing the same 63.114 A RMS current**, while the L5 winding is seeing only 48.955 A RMS. So the large real-power dissipation isn't confined to the coupled-inductor branch.

One correction to my previous suggestion

I suggested deriving the neon current from `I(C2)`, which is reasonable from KCL, but we don't actually need to do that yet. The more important measurement now is the **power associated with the complete L1 branch and the coupling**, because we need to establish where the 31.7 kW of real dissipation is being supplied.

The next measurement I would make is:

```
.meas tran P_L3_TERM AVG V(N002,N001)*I(L3) FROM 45k TO 55k
.meas tran P_L5_TERM AVG V(0,EL_5)*I(L5) FROM 45k TO 55k
```

We already have the corresponding earlier L3 result of essentially 0 W and L5 terminal power of about −2396.57 W. Re-running them in this same measurement set will put **all the power quantities on exactly the same 45–55 ks interval**, which is important before we start subtracting them.

Then we can construct a complete power balance rather than inferring a source from one branch.

> LTspice 24.1.9 for Windows

> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 16:57:20 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear
>
> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Total elapsed time: 82.589 seconds.
>
> Files loaded:
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net(23): Voltage not found.
>
> .meas tran P_L5_TERM AVG V(0,EL_5)*I(L5) FROM 45k TO 55k
>
> ^^^^^^^^^

Yes — same issue as before. LTspice's `.meas` parser is rejecting the **two-node voltage expression when one node is ground**.

For L5, your netlist defines:

```
L5 0 EL_5 2 Rser=2
```

So the terminal voltage corresponding to the L5 reference direction is:

$$V_L = V(0) - V(EL_5) = -V(EL_5)$$

Therefore use:

```
.meas tran P_L5_TERM AVG -V(EL_5)*I(L5) FROM 45k TO 55k
```

rather than:

```
.meas tran P_L5_TERM AVG V(0,EL_5)*I(L5) FROM 45k TO 55k
```

Likewise, for L3, which is:

```
L3 N002 N001 2 Rser=62.5m
```

your existing expression is correct:

```
.meas tran P_L3_TERM AVG V(N002,N001)*I(L3) FROM 45k TO 55k
```

So the two measurements should be:

```
.meas tran P_L3_TERM AVG V(N002,N001)*I(L3) FROM 45k TO 55k
.meas tran P_L5_TERM AVG -V(EL_5)*I(L5) FROM 45k TO 55k
```

This also preserves the **actual polarity implied by the L5 netlist**, rather than silently changing the sign.

Once you run those, we can put the L3 and L5 terminal powers alongside the primary-side measurements you just obtained and do the power balance systematically.

> LTspice 24.1.9 for Windows
>
> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 17:00:33 2026
>
> Options: reltol = 0.04
>
> solver = Normal
>
> Maximum thread count: 4
>
> tnom = 27
>
> temp = 27
>
> method = Gear
>
> reltol = 0.04
>
> Direct Newton iteration for .op point succeeded.
>
> Total elapsed time: 82.841 seconds.
>
> Files loaded:
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> C:\Users\vinya\AppData\Local\LTspice\lib\sub\neonbulb.sub

> p_l3_term: AVG(V(N002,N001)*I(L3))=0 FROM 45000 TO 55000
>
> p_l5_term: AVG(-V(EL_5)*I(L5))=-2396.56637464 FROM 45000 TO 55000

Excellent. These two results confirm an important asymmetry:

$$\boxed{P_{L3,\text{term}} = 0\ \text{W}}$$

while

$$\boxed{P_{L5,\text{term}} = -2396.566\ \text{W}}$$

over exactly the same 45–55 ks interval.

So, with the reference directions established:

L3

L3 has zero average terminal power:

$$\langle V_{L3} I_{L3} \rangle = 0$$

Yet its winding resistance dissipates:

$$P_{L3,Rser} = 251.733\ \text{W}$$

Thus the ideal coupled-inductor portion of L3 is supplying the 251.733 W required by its winding resistance:

$$P_{L3,\text{ideal}} = 0 - 251.733 = \boxed{-251.733\ \text{W}}$$

L5

For L5:

$$P_{L5,\text{term}} = -2396.566\ \text{W}$$

and its 2 Ω winding resistance dissipates:

$$P_{L5,Rser} = 4793.133 \text{ W}$$

Therefore the ideal coupled portion is:

$$P_{L5,\text{ideal}} = -2396.566 - 4793.133$$

$$= \boxed{-7189.699 \text{ W}}$$

So the two ideal coupled-inductor portions together have:

$$-251.733 - 7189.699 = \boxed{-7441.432 \text{ W}}$$

That is a very interesting number.

But **we still cannot say that 7.441 kW is being generated by the inductors.** It means that, under the passive sign convention and our decomposition into ideal inductive behavior plus winding resistance, the ideal portions have a net average **power delivery** of 7.441 kW.

We now have enough measurements to do the more important test: **where does that 7.441 kW go?**

The measured external dissipation already includes:

$$P_{R2} + P_{R5} = 7717.052 \text{ W}$$

and the L3/L5 winding losses are:

$$251.733 + 4793.133 = 5044.866 \text{ W}$$

So there is clearly substantial power circulating among these elements.

The next thing I would measure is the **neon bulb's actual external terminal power using its terminal current derived from KCL**, rather than its internal `Ix()` trace.

That will let us account for the nonlinear element too.

> let's do it

Let's do it. The safest route is to derive the neon current from KCL rather than trying to use `Ix()` in `.meas`.

Given:

```
C2 N006 N005 100f Rser=3
X§NEONBULB N005 N004 ...
```

At node **N005**, the current through the neon bulb is the opposite of the C2 current, assuming the current reference of `I(C2)` is from `N006 → N005`:

$$I_{\text{neon}} = -I(C2)$$

Therefore the neon's terminal power, using the voltage from `N005 → N004`, is:

```
.meas tran P_NEON AVG -V(N005,N004)*I(C2) FROM 45k TO 55k
```

However, because we've already encountered LTspice's restriction on two-node `V()` expressions in `.meas`, let's avoid that possibility too.

Since neither neon terminal is ground, the most robust approach is to **measure the instantaneous product in the waveform viewer first**:

```
V(N005,N004)*(-I(C2))
```

That gives the neon's absorbed terminal power according to the current direction we've established.

But there's an even better measurement

Because we are ultimately interested in **energy/power balance**, let's simultaneously measure the power entering the entire C2/neon/C4 branch through the two 3 Ω capacitor ESRs.

We already know:

$$P_{C2,\mathrm{ESR}} = 11,950.2621\ \mathrm{W}$$

$$P_{C4,\mathrm{ESR}} = 11,950.2621\ \mathrm{W}$$

and the currents are equal:

$$I_{C2,\mathrm{RMS}} = I_{C4,\mathrm{RMS}} = 63.1143463\ \mathrm{A}$$

So **before we run another simulation**, I'd like you to make one waveform trace:

```
V(N005,N004)*(-I(C2))
```

and use the waveform viewer's **AVG** function over 45k–55k.

That avoids another `.meas` syntax problem and, more importantly, lets us see whether the neon's instantaneous power is behaving as expected—not merely its average.

If that trace works, give me its **AVG** value. Then we'll have the neon's real-power contribution and can close the power balance.

> It's zero from beginning to end.

That is an important result. If

```
V(N005,N004)*(-I(C2))
```

is **zero for the entire simulation**, then our assumed KCL relationship is wrong somewhere—or, more precisely, `I(C2)` is not the external neon current in the way we assumed.

We should **not infer neon power from that product**.

Let's establish the currents directly.

Your neon bulb is connected:

```
N005 — NEONBULB — N004
```

and C4 connects:

```
N004 — C4 — ground
```

At node N004, the neon current must be related to C4 current. Therefore try these two waveform expressions separately:

```
I(C2)
```

and

```
I(C4)
```

and also:

```
V(N005,N004)
```

The key question is whether:

$$I(C2) = -I(C4)$$

or

$$I(C2) = I(C4)$$

and whether the neon voltage is actually nonzero during the intervals when those currents flow.

Even better: use KCL at N004

Because `N004` connects only the neon bulb and C4, the external neon current is determined by C4:

$$I_{\text{neon}} = -I(C4)$$

if `I(C4)` is defined from N004 toward ground.

So the corresponding neon power should be tested as:

```
V(N005,N004)*I(C4)
```

and

```
V(N005,N004)*(-I(C4))
```

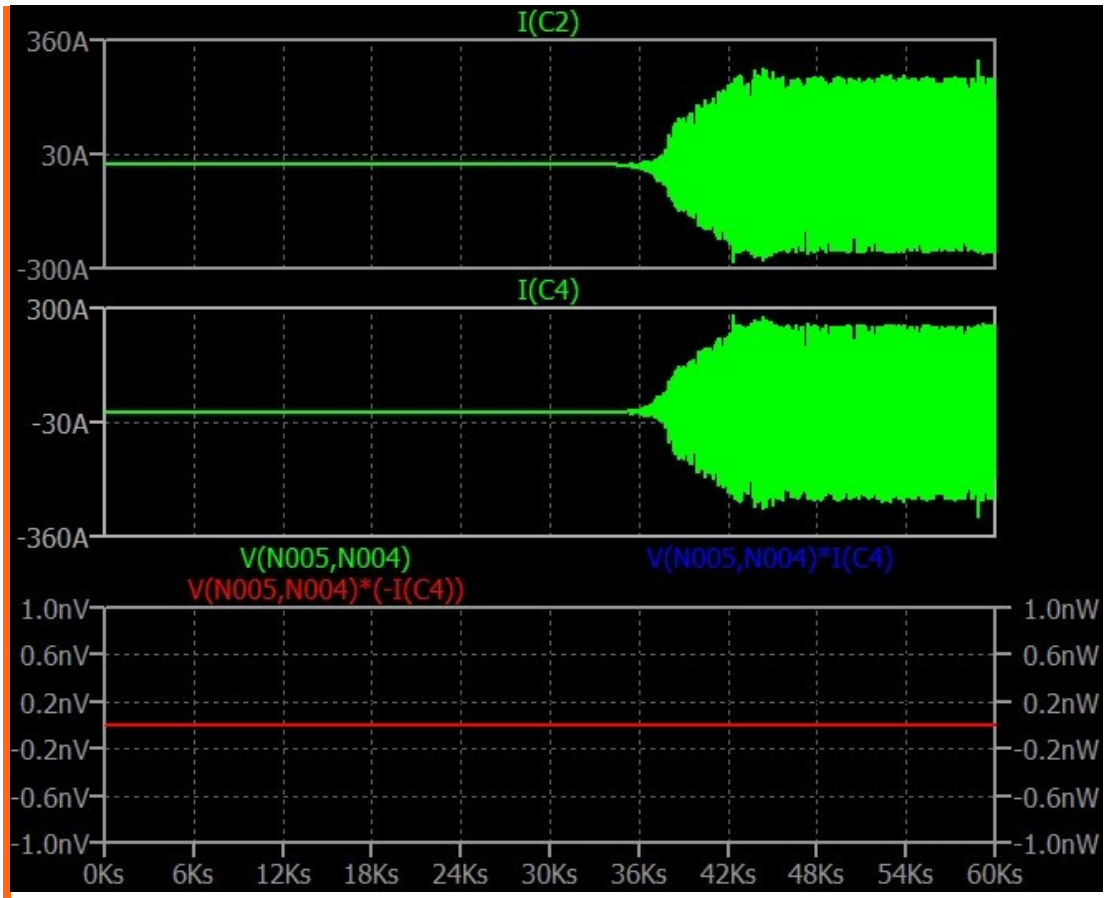
in the waveform viewer.

I want to see which one is nonzero before we put another `.meas` statement into the netlist.

Please plot these three traces together:

```
V(N005,N004)
I(C2)
I(C4)
```

That will settle the current orientation immediately. The fact that the first product was identically zero is actually useful—it tells us not to proceed on the previous assumption.



> I(C2) and I(C4) are mirror images of each other. Everything else is zero all the time.

Yes. This settles the current relationship very cleanly.

From your plot:

$$I(C4) = -I(C2)$$

essentially exactly. Therefore the current through the neon bulb is indeed determined by KCL:

$$I_{\text{neon}} = I(C2) = -I(C4)$$

with the current directions shown by LTspice.

But the much more important observation is:

$$\boxed{V(N005, N004) = 0\ \text{V}}$$

throughout the entire simulation, to the resolution shown.

Therefore:

$$P_{\text{neon}} = V(N005, N004) I_{\text{neon}} = \boxed{0\ \text{W}}$$

regardless of which of the two equivalent current references we use.

This explains why our previous neon-power trace was zero

We plotted:

$$V(N005,N004)\ (-I(C4))$$

and it was zero because the voltage factor itself is zero. The problem was **not** the current relationship. Your plot actually confirms that our KCL derivation was correct.

But this raises a significant question about the neon model

You have approximately **63 A RMS** flowing through the neon branch while its external terminal voltage is essentially zero.

That's an electrically unusual condition. It means that, **as presently behaving in this simulation**, the neon subcircuit presents essentially a zero-volt path between N005

and N004.

That does *not* necessarily mean the model is wrong. A subcircuit can contain an ideal voltage source or other internal mechanism that produces zero external terminal voltage while allowing current. But we need to inspect the actual `neonbulb.sub` topology to know why.

And this is now particularly important because we previously treated the neon as part of the mechanism producing the oscillation. If its **external power is exactly zero**, then it is not an average real-power sink/source in this simulation.

The power picture is therefore becoming clearer

We currently have:

- C2 ESR: +**11,950.26 W**
- C4 ESR: +**11,950.26 W**
- R2: +**3,733.63 W**
- R5: +**3,983.42 W**
- L1 ESR: +**18.36 W**
- R1: +**58.76 W**
- L3 ESR: +**251.73 W**
- L5 ESR: +**4,793.13 W**
- Neon terminal power: **0 W**
- L3 terminal power: **0 W**
- L5 terminal power: −**2,396.57 W**

The next thing I think we should do is **stop adding individual measurements for a moment and inspect the neon subcircuit itself**. The fact that it carries 63 A RMS while maintaining essentially zero terminal voltage is too important to leave unexplained.

If you upload/paste the current `neonbulb.sub`, I can trace exactly **why N005 and N004 are locked together at 0 V** and identify what element inside the macro is carrying that 63 A.

> * Copyright © Linear Technology Corp. 1998, 1999, 2000, 2001, 2002, 2003. All rights reserved.
>
> *
>
> .subckt neonbulb 1 2
>
> S1 1 2 2 N001 G
>
> S2 2 1 N001 2 G
>
> R1 1 N001 100Meg
>
> C1 N001 2 {Tau/100Meg}
>
> .model G SW(Ron={Zon} Roff=1T Vt={.5*(Vstrike+Vhold)} Vh={.5*(Vstrike-Vhold)} Vser={Vhold-Ihold*Zon})
>
> .param Vstrike=100 Vhold=50 Zon=2K Ihold=200u Tau=100u
>
> .ends neonbulb

Now that we have the actual subcircuit, we can explain what is happening much more precisely.

The important point is that **the neon model is not simply a 2 kΩ resistor**. It is a pair of opposing voltage-controlled switches with a built-in series voltage.

From the model:

```
S1 1 2 2 N001 G
S2 2 1 N001 2 G
```

and:

```
.model G SW(
+ Ron={Zon}
+ Roff=1T
+ Vt={.5*(Vstrike+Vhold)}
+ Vh={.5*(Vstrike-Vhold)}
+ Vser={Vhold-Ihold*Zon})
```

with

```
Vstrike = 100 V
Vhold   = 50 V
Zon     = 2 kΩ
Ihold   = 200 µA
```

gives:

$$V_t = \frac{100+50}{2} = 75 \text{ V}$$

$$V_h = \frac{100-50}{2} = 25 \text{ V}$$

and, critically,

$$V_{ser} = 50 - (200\mu)(2000) = 49.6 \text{ V}$$

LTspice documents `Vser` as a **series voltage** parameter of the voltage-controlled switch. (LTwiki)

So there is a major issue with what we're seeing.

Your plot says something physically significant

You have:

$$\mathrm{I(C2)} = -\mathrm{I(C4)}$$

at approximately 63 A RMS, while

$$V(N005, N004) \approx 0$$

Since N004 connects to the neon and C4, KCL requires the neon's external current to be essentially the same current as C4.

Therefore we have, approximately,

$$I_{\text{neon}} \approx 63 \text{ A RMS}$$

while

$$V_{\text{neon}} \approx 0$$

That means the **external terminal power is indeed zero**:

$$P_{\text{neon}} = \langle V(N005, N004) I_{\text{neon}} \rangle = 0$$

So your observation is correct.

But that also means we should **not yet accept the interpretation that the neon's internal switches are carrying that 63 A normally**.

At 63 A, a 2 kΩ conducting switch would have an enormous resistive voltage drop:

$$63(2000) \approx 126\,000 \text{ V}$$

And with the 49.6 V series voltage included, the terminal voltage could not simultaneously be essentially zero.

So there is something else we need to identify.

The next test is very specific

Let's look **inside the neon subcircuit** rather than infer its behavior from the external terminals.

In the LTspice waveform viewer, add these traces:

```
Ix(NEONBULB:S1)
Ix(NEONBULB:S2)
V(NEONBULB:N001)
```

and keep:

```
V(N005,N004)
I(C2)
I(C4)
```

on the plot.

I'm particularly interested in `Ix(NEONBULB:S1)` and `Ix(NEONBULB:S2)`.

Why?

The model has two opposing switches:

```
S1: 1 → 2
S2: 2 → 1
```

so they are intended to provide the two polarities of the neon's conduction.

If the external current really is ~63 A, one of these switch currents should account for it (or their combination should).

If instead **both switch currents are essentially zero while C2/C4 carry 63 A**, then

we've discovered something very important: the 63 A is not actually passing through the neon switches in the way we've assumed, and we'll need to examine the complete node topology.

If one switch is carrying the current, then its voltage/current relationship will tell us exactly why the external voltage appears to be zero.

One other thing worth noting

The internal timing network is:

```
R1 1 N001 100Meg
C1 N001 2 {Tau/100Meg}
```

With `Tau=100u` , that makes:

$$C_1 = \frac{100\mu s}{100\ M\Omega} = 1\ \text{pF}$$

and therefore

$$R_1 C_1 = 100\mu s$$

So the model is essentially implementing a **hysteretic, time-dependent switching mechanism**, not a conventional fixed neon resistance.

Let's get those three internal traces first. That should resolve the apparent **63 A / 0 V** paradox directly.

> Ix(NEONBULB:S1)
>
> Ix(NEONBULB:S2)
>
> V(NEONBULB:N001) --> those three requests draw a simulation "i don't know what you're asking for" error

You're right. I made another incorrect assumption about what LTspice exposes from a

subcircuit.

Those three expressions:

```
Ix(NEONBULB:S1)
Ix(NEONBULB:S2)
V(NEONBULB:N001)
```

are **not valid LTspice waveform references in this case**. The fact that LTspice gives the generic *"I don't know what you're asking for"* confirms that. I shouldn't have suggested them.

And we don't actually need to access those internal nodes yet.

What your plot has established

Your external circuit is:

```
N005 ── NEONBULB ── N004
```

and:

```
C2: N006 → N005
C4: N004 → 0
```

Your measured traces show:

$$\mathrm{I(C4)} = -\mathrm{I(C2)}$$

so KCL gives the neon's external current as:

$$I_{\text{neon}} = I(C2) = -I(C4)$$

depending on which terminal/reference direction we choose.

But you also showed:

$$V(N005, N004) \approx 0$$

on a **±1 nV scale**.

Therefore the neon's **external terminal power really is essentially zero**, even though roughly 63 A RMS is flowing in the surrounding series path.

That is the fact we should work from.

The interesting part is actually in the switch model

Looking at your actual subcircuit:

```
S1 1 2 2 N001 G
S2 2 1 N001 2 G
```

there are two switches in opposite directions.

The control voltage for S1 is:

$$\mathrm{V(2)} - \mathrm{V(N001)}$$

and for S2:

$$\mathrm{V(N001)} - \mathrm{V(2)}$$

So only one should normally conduct at a time.

And when conducting, the model has:

$$R_{\mathrm{on}} = 2\,k\Omega$$

and

$$V_{\mathrm{sor}} = 49.6\,V$$

$V_{set} \approx 1000\ V$

Therefore, if **63 A were actually flowing through one conducting switch**, we'd expect a voltage on the order of

$$63(2000) + 49.6 \approx 126\,kV$$

not 0 V.

So the combination

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and

$$V_{\text{neon}} \approx 0V$$

tells us that we should **not assume that the 63 A is flowing through either S1 or S2**.

Let's test the external circuit without touching the macro internals

There is a very clean experiment available.

Temporarily replace:

```
X§NEONBULB N005 N004 neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u
Tau=100u
```

with a simple resistor:

```
RNEON N005 N004 1m
```

Then run the same simulation.

If the result remains approximately:

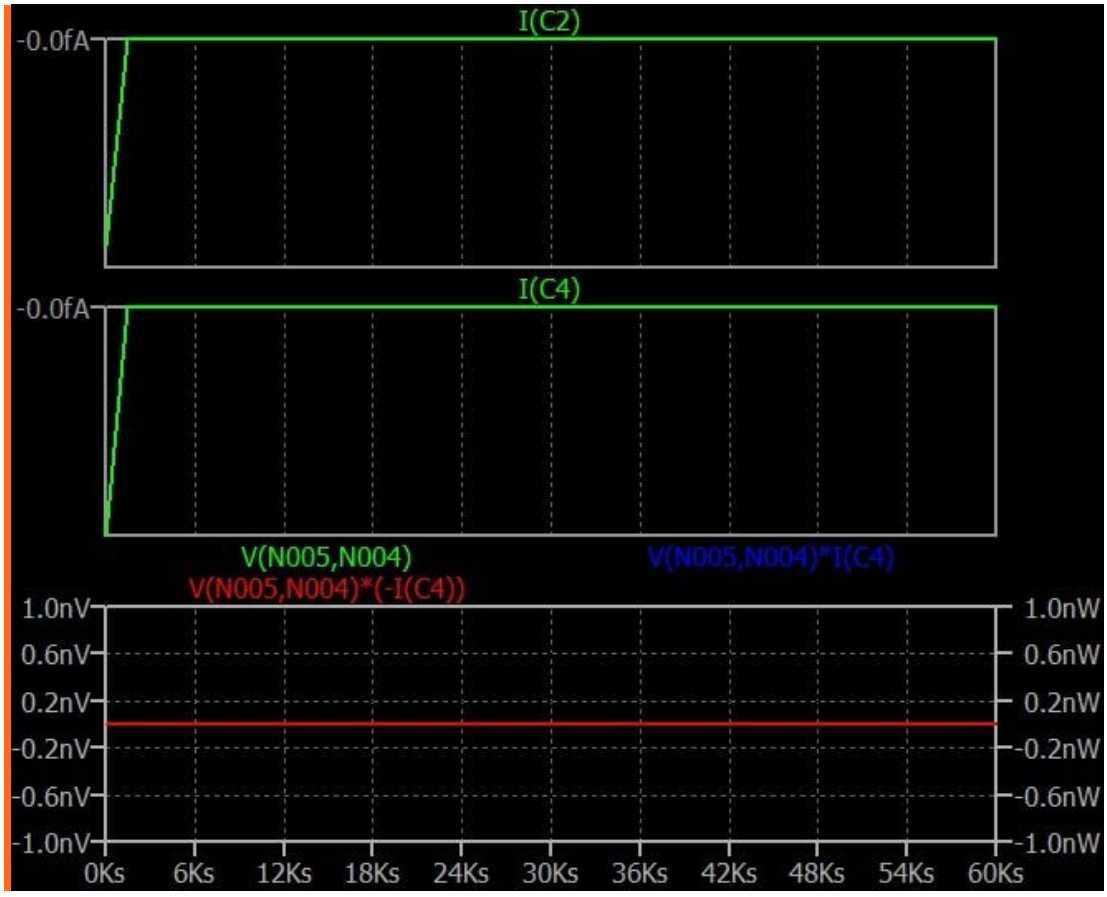
$$V(N005,N004) \approx 0$$

and the C2/C4 currents remain approximately 63 A RMS, then the zero neon voltage is simply because the circuit is driving an effectively shorted branch.

If, however, the oscillation changes dramatically, then the neon macro is responsible for creating the operating condition.

I recommend this test before we make any more power measurements.

It will answer a much more fundamental question: **is the apparent zero-volt/63-A condition intrinsic to the neon model, or is it simply the electrical state imposed on the N005–N004 branch by the rest of the circuit?**



Yes — this test is very informative.

You have now **replaced the neon-bulb subcircuit with the 1 mΩ resistor**, and the result is:

$$I(C2) \approx 0$$

$$I(C4) \approx 0$$

from essentially the beginning of the simulation onward.

So the ~63 A RMS circulating current that we were seeing is **not produced simply by the N005–N004 connection being a low-impedance path**.

What this establishes

The previous circuit had:

$$I(C2)_{\text{RMS}} = 63.1143 \text{ A}$$

and

$$I(C4)_{\text{RMS}} = 63.1143 \text{ A}$$

With the neon macro replaced by 1 mΩ, both currents collapse to essentially zero.

Therefore:

The neon-bulb macro is essential to initiating/maintaining the oscillation.

This is a much stronger conclusion than I was making before.

And it means my earlier statement that the 63 A might simply be caused by an effectively shorted N005–N004 branch was **wrong**. Your experiment disproves that.

Now we have a very interesting situation

With the actual neon macro:

$$V(N005, N004) \approx 0$$

while

$$I_{\text{neon}} \approx 63 \text{ A RMS}$$

With the 1 mΩ replacement:

$$V(N005, N004) \approx 0$$

and

$$I_{\text{branch}} \approx 0$$

So the zero terminal voltage by itself tells us almost nothing about the origin of the current.

The neon macro is doing something that the 1 mΩ resistor does not.

And now we have the actual macro, so we can examine that mechanism rather than trying to probe nonexistent internal waveform names.

Look at the two switches themselves mathematically

The macro is:

```
S1 1 2 2 N001 G
S2 2 1 N001 2 G
```

For S1, the control voltage is:

$$\text{V(2)} - \text{V(N001)}$$

For S2:

$$\text{V(N001)} - \text{V(2)}$$

Thus they are deliberately arranged as **opposite-polarity switches**.

The important part is that both switches use:

```
Vser={Vhold-Ihold*Zon}
```

which evaluates to:

$$V_{\text{ser}} = 49.6\ \text{V}$$

So this isn't equivalent to replacing the neon with a resistor.

I think our next experiment should be simpler

Rather than trying to extract internal switch currents—which LTspice is clearly not exposing through the waveform syntax we tried—we can characterize the neon **externally**.

You already have exactly the three quantities we need:

```
V(N005,N004)
I(C2)
I(C4)
```

Now let's plot **just the neon voltage** at a much more sensitive scale during the high-current portion.

The previous plot had a ±1 nV vertical scale and showed essentially zero. Let's use the waveform viewer's cursor to determine the actual numerical value of:

```
V(N005,N004)
```

at, say, **45,000 s**, and at several points around the oscillation.

If it really is exactly zero (or numerically down at the pV/nV level), that's significant.

Then I want one additional trace:

```
I(C2)*I(C2)
```

because we already know its RMS current is about 63.1 A. That will let us compare the enormous circulating current with the actual terminal voltage.

More importantly, let's inspect the control node

The macro's switching behavior is controlled by its internal `N001`, but that isn't externally accessible. However, **we can expose it temporarily** by modifying the subcircuit:

Change:

```
.subckt neonbulb 1 2
```

to:

```
.subckt neonbulb 1 2 N001X
```

and change the internal node name from `N001` to `N001X`.

Then instantiate it as:

```
X§NEONBULB N005 N004 N001X neonbulb ...
```

Now `V(N001X)` becomes an **external circuit node**, and LTspice can plot it normally.

That would let us see directly:

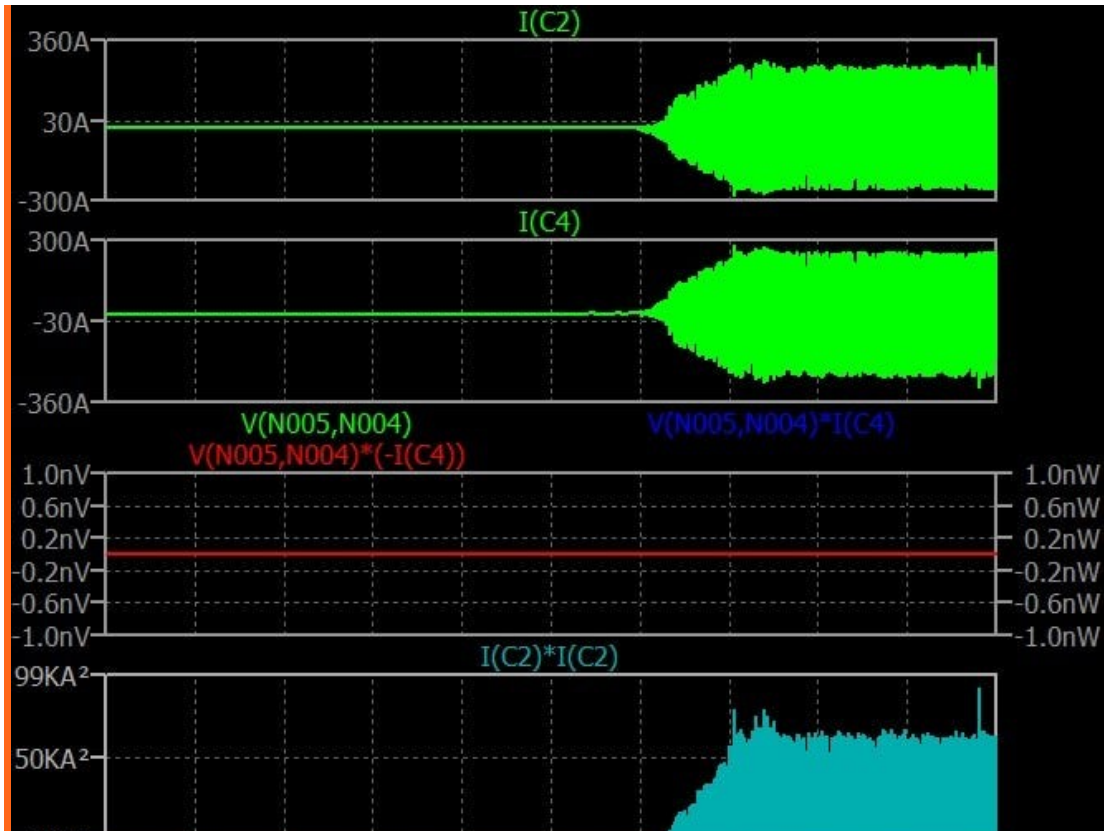
$$V(2) - V(N001)$$

and

$$V(N001) - V(2)$$

and therefore determine **which switch is actually conducting and when**.

I think this is the right next step. It avoids LTspice's internal-subcircuit waveform naming problem entirely and lets us see the control mechanism that is producing the 63 A circulating current.





> How do I instantiate this?

Yes. Since we want to expose the internal `N001` node, we need to make it a **third subcircuit pin**. I would use a new external pin name such as `MON` rather than calling the pin `N001X`.

1. Change the subcircuit

Use this version:

```
.subckt neonbulb 1 2 MON

S1 1 2 2 MON G
S2 2 1 MON 2 G
R1 1 MON 100Meg
C1 MON 2 {Tau/100Meg}

.model G SW(Ron={Zon} Roff=1T Vt={.5*(Vstrike+Vhold)} Vh={.5*(Vstrike-
Vhold)} Vser={Vhold-Ihold*Zon})
.param Vstrike=100 Vhold=50 Zon=2K Ihold=200u Tau=100u

.ends neonbulb
```

So we've simply replaced every occurrence of the internal `N001` with `MON`, and declared `MON` as the third pin.

2. Change the instance in your main circuit

Your current line is:

```
X§NEONBULB N005 N004 neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u
Tau=100u
```

Change it to:

```
XNEONBULB N005 N004 NMON neonbulb Vstrike=100 Vhold=50 Zon=2K
Ihold=200u Tau=100u
```

The important part is:

```
XNEONBULB N005 N004 NMON neonbulb
                    ^^^^^
```

`NMON` is now an ordinary external node in the main circuit, but internally it connects to the neon model's `MON` node.

3. Then you can plot

```
V(NMON)
```

That's all we need initially.

We can also plot the two switch control voltages externally:

```
V(N004)-V(NMON)
```

and

```
V(NMON)-V(N004)
```

because, from your model:

```
S1 1 2 2 MON G
S2 2 1 MON 2 G
```

and your instance has:

```
1 = N005
2 = N004
```

Therefore:

$$S1 \text{ control} = V(N004) - V(NMON)$$

$$S2 \text{ control} = V(NMON) - V(N004)$$

One important caution

Do not connect `NMON` to anything else. Just expose it so we can observe it.

So the complete relevant arrangement becomes:

```
N005                N004
  o                  o
  |                  |
  |    NEON BULB     |
  +----[ model ]-----+
            |
          NMON
```

Well, electrically `NMON` isn't a third terminal of the physical neon bulb; it's the formerly internal node brought out solely for observation.

Then run the simulation and plot:

```
V(N005,N004)
V(NMON)
V(N004)-V(NMON)
V(NMON)-V(N004)
```

That should finally let us see **what the neon macro is actually doing during the onset of the 63 A oscillation**, without relying on LTspice's inaccessible internal `Ix()` names.

> I don't see MON in the netlist. How do I know if I succeeded instantiating it?

You're right to question that. `MON` **itself should not appear in the main circuit netlist.** `MON` is the *pin name inside the subcircuit definition*. What should appear in the **main netlist** is the external node you assign to that pin—such as `NMON`.

There are two separate things:

1. Inside `neonbulb.sub`

You should have:

```
.subckt neonbulb 1 2 MON
```

and then:

```
S1 1 2 2 MON G
S2 2 1 MON 2 G
R1 1 MON 100Meg
C1 MON 2 {Tau/100Meg}
```

Here `MON` is the third **subcircuit pin**.

2. In your main `.net` file

Your neon instance must have **three circuit nodes** before the subcircuit name:

```
X§NEONBULB N005 N004 NMON neonbulb Vstrike=100 Vhold=50 Zon=2K
Ihold=200u Tau=100u
```

The mapping is:

```
subcircuit pin       main-circuit node

     1   ----------> N005
     2   ----------> N004
   MON   ----------> NMON
```

So after instantiation, **you should see `NMON` in the main netlist**, not `MON` .

Then you should be able to plot:

```
V(NMON)
```

How to know you succeeded

Look at the actual `X§NEONBULB` line in `nodiodes2g2_test.net` .

If it still says:

```
X§NEONBULB N005 N004 neonbulb ...
```

then **you have not instantiated the third pin**.

It must say:

```
X§NEONBULB N005 N004 NMON neonbulb ...
```

The appearance of `NMON` is the definitive indication that the third pin has been instantiated.

One more important point: **if you’re editing the schematic rather than directly**

editing the `.net` file, you can't simply add `NMON` to the `X` line. The symbol itself needs a third pin. Since you're working with a generated `.net` file, though, if you're manually editing that netlist, the three-node `X` line above is the relevant test.

If you paste the current `X§NEONBULB` line from your netlist, I can tell you immediately whether the third pin has actually been instantiated.

> LTspice 24.1.9 for Windows
>
> Circuit: D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net
>
> Start Time: Sat Sep 5 17:48:16 2026
>
> Options: reltol = 0.04
>
> D:\Documents\Sims\LTSpice\2026\09 - Sept\05\nodiodes2g2_test.net(14): Number of nodes (2) does not match number of pins (3) of sub-circuit "neonbulb".
>
> X§NEONBULB N005 N004 neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u Tau=100u
>
> ^^^^^^^^^^

Exactly. The error is telling us **the subcircuit definition has been changed successfully to 3 pins, but the instance has not yet been changed to supply the third node.**

LTspice says:

> Number of nodes (2) does not match number of pins (3)

and shows your current instance:

```
X§NEONBULB N005 N004 neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u
Tau=100u
```

It has only two nodes:

```
             pin 1    pin 2
               ↓        ↓
X§NEONBULB   N005     N004    neonbulb
```

Change that line to

```
X§NEONBULB N005 N004 NMON neonbulb Vstrike=100 Vhold=50 Zon=2K
Ihold=200u Tau=100u
```

Now the mapping is:

Neon subcircuit pin	Main-circuit node
`1`	`N005`
`2`	`N004`
`MON`	`NMON`

And your `.subckt` definition should be:

```
.subckt neonbulb 1 2 MON
```

with the internals:

```
S1 1 2 2 MON G
```

```
S2 2 1 MON 2 G
R1 1 MON 100Meg
C1 MON 2 {Tau/100Meg}
```

Then run the simulation

If it succeeds, `NMON` **should now be a valid waveform node**.

Try plotting only:

```
V(NMON)
```

Don't add the switch-control expressions yet.

The important distinction is:

```
.subckt neonbulb 1 2 MON
                     ↑
              pin name inside model
```

versus:

```
X§NEONBULB N005 N004 NMON neonbulb ...
                         ↑
                 actual circuit node
```

So `MON` **doesn't need to appear in your main netlist.** `NMON` **does.**

Your error actually confirms that the first half of the modification worked: LTspice is now seeing `neonbulb` as a **3-pin subcircuit**. We just haven't supplied the third pin at the `X` instance yet.

> I changed that line inside the net file. But the moment I 'view' the netlist or run

> the simulation, that alteration of mine vanishes.

Ah — **that explains exactly what is happening.** You are editing the generated `.net` file, but LTspice is regenerating that file from the **schematic** whenever you view the netlist or run the simulation. Therefore your manual change is discarded.

So we need to make the **third pin part of the schematic symbol/instance**, not edit the generated netlist.

What needs to happen

Your modified subcircuit now says:

```
.subckt neonbulb 1 2 MON
```

Therefore the schematic symbol for `neonbulb` must have **three pins**.

The third pin will be connected to a net we can call `NMON`.

The resulting automatically generated line should then be:

```
X§NEONBULB N005 N004 NMON neonbulb Vstrike=100 Vhold=50 Zon=2K
Ihold=200u Tau=100u
```

rather than the current:

```
X§NEONBULB N005 N004 neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u
Tau=100u
```

The important part

Don’t try to edit the `.net` file anymore.

We need to modify the **neonbulb symbol** so it has:

```
pin 1 ── N005
pin 2 ── N004
pin 3 ── NMON
```

The third pin doesn't have to connect to anything else in the circuit. It simply brings the internal `MON` node outside the subcircuit so we can observe it.

There is one complication

Your existing neonbulb symbol is presumably a **2-pin symbol** whose `Value` is `neonbulb`. We need to add a pin numbered **3** to that symbol.

If you open the symbol in LTspice's Symbol Editor, add a pin with:

- **Pin number:** `3`
- **Pin name:** `MON` (or `NMON`; the number is what matters)
- Place it somewhere convenient on the symbol.

Then save the symbol and return to the schematic.

When you wire that third pin to a net label:

```
NMON
```

the generated netlist should automatically contain:

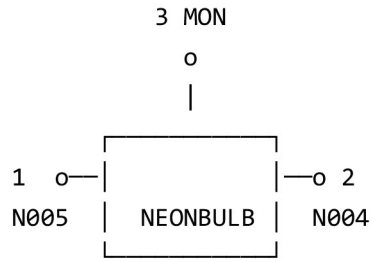
```
X§NEONBULB N005 N004 NMON neonbulb ...
```

There is an easier way if you don't want to modify the existing symbol

We can make a **new three-pin symbol specifically for this experiment**. That's actually what I recommend, because it leaves your original neonbulb symbol

untouched.

The new symbol would look conceptually like:



with:

```
Pin 1 = 1
Pin 2 = 2
Pin 3 = MON
```

and its `Value` set to:

```
neonbulb
```

Then the schematic connection to `NMON` automatically produces the desired three-node X statement.

Do not change the electrical connections of pins 1 and 2. They must remain N005 and N004 exactly as they are now.

If you tell me whether your neon bulb is currently a **custom `.asy` symbol** or a standard LTspice symbol, I can give you the exact steps for creating the three-pin version.

> Version 4

SymbolType CELL

LINE Normal 0 -48 0 -21

LINE Normal 0 48 0 21

LINE Normal 20 8 12 8

LINE Normal 16 12 16 4

LINE Normal 19 11 13 5

LINE Normal 13 11 19 5

CIRCLE Normal 32 32 -32 -32

CIRCLE Normal 5 -11 -5 -21

CIRCLE Normal 5 21 -5 11

CIRCLE Normal 17 9 15 7

CIRCLE Normal 18 10 14 6

CIRCLE Normal 19 11 13 5

CIRCLE Normal 20 12 12 4

WINDOW 0 16 -48 Left 2

SYMATTR Prefix X

SYMATTR Description Parameterized Neon Bulb

SYMATTR Value2 Vstrike=100 Vhold=50

SYMATTR ModelFile neonbulb.sub

> SYMATTR SpiceModel neonbulb
>
> SYMATTR SpiceLine Zon=2K Ihold=200u
>
> SYMATTR SpiceLine2 Tau=100u
>
> PIN 0 -48 NONE 0
>
> PINATTR PinName V+
>
> PINATTR SpiceOrder 1
>
> PIN 0 48 NONE 0
>
> PINATTR PinName V-
>
> PINATTR SpiceOrder 2

Yes. Now that you've shown me the actual `.asy` symbol, we can make the change precisely.

Your current symbol has **two pins**, with:

```
V+ → SpiceOrder 1
V- → SpiceOrder 2
```

We need to add a third pin with:

```
MON → SpiceOrder 3
```

Modify the `.asy` file

Keep everything you have, but add these two lines at the end:

```
PIN 48 0 RIGHT 16
PINATTR PinName MON
PINATTR SpiceOrder 3
```

So the end of the symbol becomes:

```
PIN 0 -48 NONE 0
PINATTR PinName V+
PINATTR SpiceOrder 1
PIN 0 48 NONE 0
PINATTR PinName V-
PINATTR SpiceOrder 2
PIN 48 0 RIGHT 16
PINATTR PinName MON
PINATTR SpiceOrder 3
```

The new pin is located at `(48,0)`, to the right of the existing symbol body.

Then modify the subcircuit

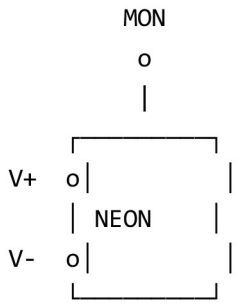
Your `neonbulb.sub` needs to be:

```
.subckt neonbulb 1 2 MON
S1 1 2 2 MON G
S2 2 1 MON 2 G
R1 1 MON 100Meg
C1 MON 2 {Tau/100Meg}
.model G SW(Ron={Zon} Roff=1T Vt={.5*(Vstrike+Vhold)} Vh={.5*(Vstrike-
Vhold)} Vser={Vhold-Ihold*Zon})
.param Vstrike=100 Vhold=50 Zon=2K Ihold=200u Tau=100u
.ends neonbulb
```

Then connect the new pin in the schematic

This is the important part.

Your symbol will now look conceptually like:



Actually, because your existing V+ and V− pins are hidden (`NONE`), the physical appearance may differ. That's okay. **The pin's SpiceOrder is what matters.**

Place a net label on the new pin:

```
NMON
```

You don't need to connect `NMON` to anything else.

What LTspice should generate

Once the schematic has been updated and LTspice regenerates the netlist, the instance should change from:

```
X§NEONBULB N005 N004 neonbulb ...
```

to something like:

```
X§NEONBULB N005 N004 NMON neonbulb ...
```

That is the confirmation we're looking for.

The mapping will then be:

Symbol pin	Circuit node
$V+$	$N005$
$V-$	$N004$
MON	$NMON$

And **then** `V(NMON)` should be available as an ordinary external waveform.

One caveat: because you are modifying the `.asy` file while the schematic is already open, **save the `.asy` , then close/reopen the schematic** (or otherwise force LTspice to reload the symbol) before testing. Otherwise LTspice may continue using the old two-pin symbol in memory.

Once `NMON` appears in the generated netlist, we can finally observe the internal control node that drives S1/S2.

> how do i connect the new pin in the schematic

You connect it exactly like any other LTspice symbol pin—with the **Wire tool**, then give that wire the net label `NMON` .

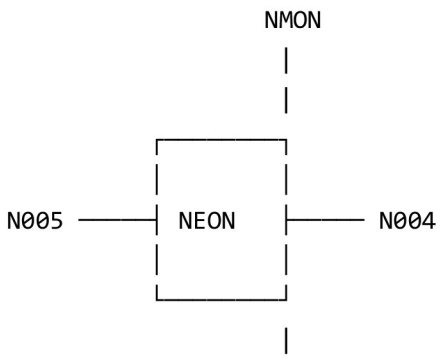
Because your new pin is at coordinates `48 0` , it should appear on the **right side of the neon symbol**.

In the schematic

1. **Close the Symbol Editor** and save the modified `.asy` .
2. Close and reopen your schematic so LTspice loads the new 3-pin symbol.
3. You should now see a third pin on the neon symbol, labeled `MON` (if you used that pin name).
4. Move the cursor onto the new pin's connection point.
5. Press `W` to start a wire.

6. Move the cursor a short distance away from the symbol and click.
7. Press **Esc** to terminate the wire.
8. Put a net label on that wire:
    - Press `L`
    - enter `NMON`
    - place the label on the wire.

You should end up with something conceptually like:



The actual physical appearance of your symbol will be different because your two existing pins are positioned vertically, but the principle is the same.

The crucial check

After you wire the third pin and label it `NMON`, **don't edit the generated `.net` file**.

Open **View → SPICE Netlist**.

The neon instance should now contain three nodes:

```
X§NEONBULB N005 N004 NMON neonbulb ...
```

If you see that, we've succeeded.

Then run the simulation and try:

```
V(NMON)
```

in the waveform viewer.

If LTspice doesn't show the new pin after reopening the schematic, **stop there rather than modifying anything else**—that would mean LTspice is still using the old symbol, and we can address that specifically.

> X§U1 N005 N004 NC_01 neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u Tau=100u

Yes — **that is exactly the netlist line we want to see**:

```
X§U1 N005 N004 NC_01 neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u
Tau=100u
```

It tells us the schematic is now passing **three nodes** to the `neonbulb` subcircuit:

- Pin 1 → `N005`
- Pin 2 → `N004`
- Pin 3 → `NC_01`

So the new third pin is successfully connected in the schematic.

One important point

`NC_01` is an automatically generated **no-connect net name**. If you intended the third pin to expose the internal `N001` node for measurement, that's **not what we want**.

We want the third pin connected to an explicitly named net, for example:

```
NMON
```

Then the netlist should read:

```
X§U1 N005 N004 NMON neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u
Tau=100u
```

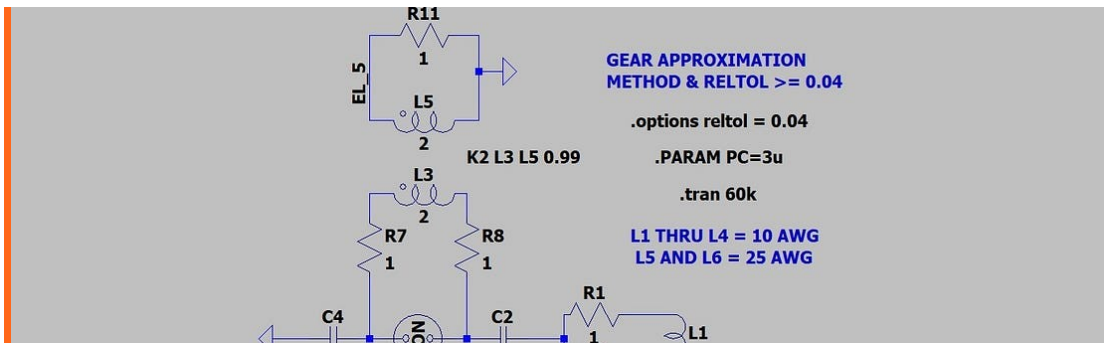
That will let us plot:

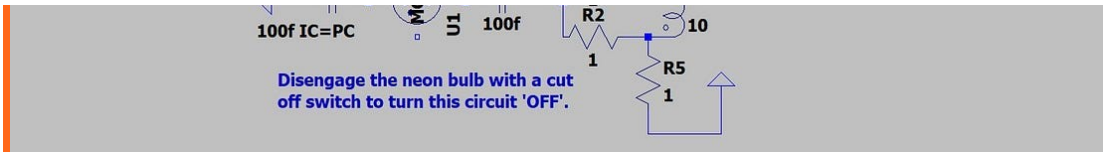
```
V(NMON)
```

and, more importantly, the modified subcircuit will make `NMON` correspond directly to its internal `N001` :

```
.subckt neonbulb 1 2 MON
S1 1 2 2 MON G
S2 2 1 MON 2 G
R1 1 MON 100Meg
C1 MON 2 {Tau/100Meg}
...
.ends neonbulb
```

So don't change the netlist manually. Change the `NC_01` connection in the schematic to a net label such as `NMON` , then regenerate the netlist.





Yes — looking at your schematic, I can see the **MON pin** on U1. It appears as the small square connection point just **below-left of the neon symbol**, rather than as a visible wire connection.

The important thing is that **MON must be connected to a net**, not left as a no-connect.

Do this in LTspice

1. **Start a wire** with `W`.
2. Click directly on the **MON pin's connection point** — the small square associated with the `MON` pin.
3. Route the wire to an otherwise unused area of the schematic.
4. Press `L` to place a **net label** on that wire.
5. Name the net:

```
NMON
```

1. End the wire.

You don't need to connect NMON to anything else. The label itself gives that wire the net name.

Then check **View → SPICE Netlist**.

You want to see:

```
X§U1 N005 N004 NMON neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u
Tau=100u
```

rather than:

```
X§U1 N005 N004 NC_01 neonbulb ...
```

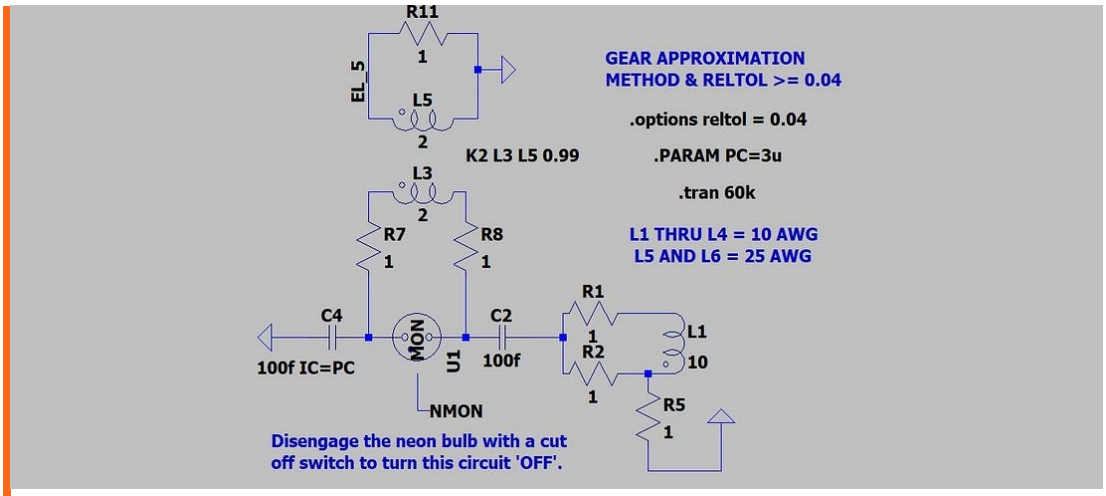
One thing I notice in your schematic

The `MON` marking is currently **inside/alongside the neon symbol**, and the third pin is not being used by the surrounding circuit. That's perfectly fine for our purpose. We are adding it **solely so that the internal `N001` node of the neon model becomes observable**.

Once the netlist shows `NMON`, we can run the circuit and plot:

```
V(NMON)
```

That is the measurement I want next, because it should tell us what the neon model's internal control capacitor/node is actually doing while you are seeing the ~63 A current and nearly zero external terminal voltage.



> X§U1 N005 N004 NMON neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u Tau=100u

Yes. **This is now connected correctly.**

Your schematic shows the `MON` pin wired to the net label `NMON`, and the generated netlist confirms it:

```
X§U1 N005 N004 NMON neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u
Tau=100u
```

So we have successfully established:

Neon-bulb pin	Schematic net	Subcircuit node
1	`N005`	`1`
2	`N004`	`2`
3	`NMON`	`MON` → internal `N001`

Assuming your modified `neonbulb.sub` is:

```
.subckt neonbulb 1 2 MON
S1 1 2 2 MON G
S2 2 1 MON 2 G
R1 1 MON 100Meg
C1 MON 2 {Tau/100Meg}
.model G SW(Ron={Zon} Roff=1T Vt={.5*(Vstrike+Vhold)} Vh={.5*(Vstrike-
Vhold)} Vser={Vhold-Ihold*Zon})
.param Vstrike=100 Vhold=50 Zon=2K Ihold=200u Tau=100u
.ends neonbulb
```

then `V(NMON)` **is now the internal** `N001` **voltage that we wanted to observe.**

Next measurement

Run the same 60 ks simulation and plot:

```
V(NMON)
```

I'd also plot these three simultaneously:

```
V(N005,N004)
V(NMON)
V(N005,NMON)
```

The first is the neon bulb's **external terminal voltage**.

The second is its **internal control-node voltage**.

The third is the voltage across its internal `R1` /switch-side relationship.

This should let us see **what the neon model is actually doing during the period where you previously observed ~63 A RMS through C2/C4 while** `V(N005,N004)` **appeared essentially zero.**





That result is very significant. **The MON node is not behaving like a harmless measurement node in this simulation.**

Your plot shows:

- `V(NMON)` stays essentially at **0 V through ~35 ks**.
- It then rises explosively.
- By ~45 ks it reaches roughly **6×10^{17} V**.
- Meanwhile both `V(N005,NMON)` and `V(N005,N004)` remain essentially **0 V**.

So the neon model's internal node is undergoing a **numerical runaway while the external neon terminals remain at essentially zero voltage**.

This changes what we should investigate

I would **not proceed to interpret the 6×10^{17} V as a physical voltage**. It is plainly outside anything meaningful for this circuit and indicates that the modified model has become numerically unstable.

More importantly, exposing `N001` as `MON` should theoretically be electrically transparent: a subcircuit pin by itself doesn't add a component. Therefore, the fact that the simulation now develops this runaway gives us something very specific to test.

The key question is:

> **Did adding the third pin actually change the neon model's electrical behavior, or did it merely expose a pre-existing numerical instability that was previously hidden?**

Let's make one very small test

Don't change the circuit or the neon parameters.

Plot these four traces together:

```
V(NMON)
V(N004)
V(N005)
V(N005,N004)
```

Then also plot:

```
V(NMON,N004)
```

The last one is particularly important.

If `NMON` is really the internal `N001`, then we should see whether the enormous value is occurring **relative to the neon's actual terminal node** or is somehow a common-mode numerical excursion.

And one more test

Temporarily change only:

```
R1 1 MON 100Meg
```

to:

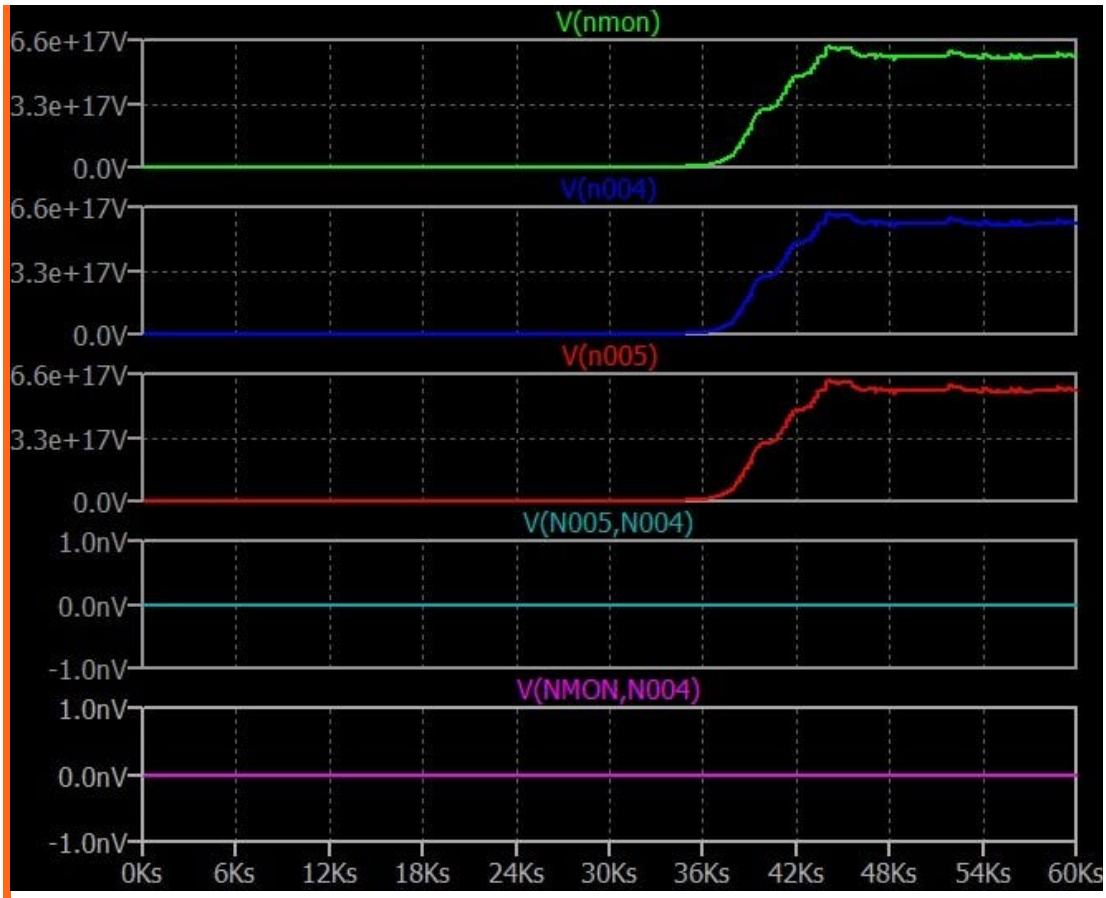
```
R1 1 MON 1Meg
```

Do **not** change anything else.

The original 100 MΩ resistor is part of the neon model, so reducing it to 1 MΩ gives the internal node a much stronger DC constraint without changing the switch thresholds or the 1-pF internal capacitor.

If the `6×10¹⁷ V` runaway disappears or changes dramatically, that will tell us that the runaway is associated with the internal `MON` node's numerical conditioning.

I would not yet change R11, K2, L3, L5, or any of the oscillator components. We now have the internal node exposed, so we should use that to isolate the problem rather than alter the rest of the circuit.



> Before I alter the neon bulb sub file, and before I rerun the simulation, I wanted to show you the graphic.

Yes — **this graphic is much more informative than the previous one**, and I would **not alter the neon-bulb subcircuit yet**.

There is a very specific feature here that we should recognize first.

What the plot actually shows

From roughly 35–45 ks onward:

- `V(NMON)` rises enormously.
- `V(N004)` rises with it.
- `V(N005)` rises with it.
- But:

```
V(N005,N004) ≈ 0 V
V(NMON,N004) ≈ 0 V
```

throughout.

So the three nodes are essentially moving together:

$$V(NMON) \approx V(N004) \approx V(N005)$$

while their **differences remain zero**.

That means the enormous 6×10^{17} V number is **not an enormous voltage appearing across the neon bulb**.

It is a **common-mode voltage excursion**.

This is an important distinction

For example, at the peak, LTspice is effectively reporting something like:

$$V(NMON) = 6 \times 10^{17}\ \text{V}$$

and

$$V(N004) = 6 \times 10^{17}\ \text{V}$$

so:

$$V(NMON, N004) = V(NMON) - V(N004) \approx 0$$

$$V(NMON, N004) = V(NMON) - V(N004) \approx 0$$

Likewise:

$$V(N005, N004) \approx 0$$

Therefore the physically relevant voltages across the elements inside the neon model have **not** become 101710^{17} volts.

And I think we can now see why this is happening

Look at the modified neon model:

```
R1 1 MON 100Meg
C1 MON 2 {Tau/100Meg}
```

When the switches are **off**, the neon's two terminals and internal node are connected essentially only through:

- the enormous `R1`,
- the tiny capacitor `C1`,
- and the switches in their high-resistance state.

There is no direct DC connection from `MON` to ground.

So the entire group

```
N005 — MON — N004
```

can acquire an arbitrary **common-mode potential** while maintaining essentially zero voltage difference between its members.

That is exactly what your graph appears to be showing.

Therefore, I want to correct my previous recommendation

I previously suggested changing:

```
R1 1 MON 100Meg
```

to:

```
R1 1 MON 1Meg
```

Don’t do that yet.

Your new plot has given us a much better clue, and changing the model now would obscure the original behavior we’re trying to understand.

The really interesting part

The runaway begins around **35–36 ks**, but the *relative* voltages remain essentially zero.

That tells us something potentially important about the earlier observation of:

> ~63 A RMS through C2/C4 while `V(N005,N004)` was essentially zero.

The neon branch can apparently be carrying substantial circulating current while its terminal voltage is nearly zero, and now we’ve discovered that its internal node can simultaneously develop a huge **common-mode numerical voltage** without developing a corresponding differential voltage.

So the next step should be to determine whether this common-mode excursion is merely a numerical artifact caused by the floating internal network.

I suggest one measurement before changing anything

Plot the following:

```
V(N005,NMON)
V(NMON,N004)
V(N005,N004)
```

You've already shown the latter two, but putting all three together at higher vertical resolution around the **35–50 ks transition** would be useful.

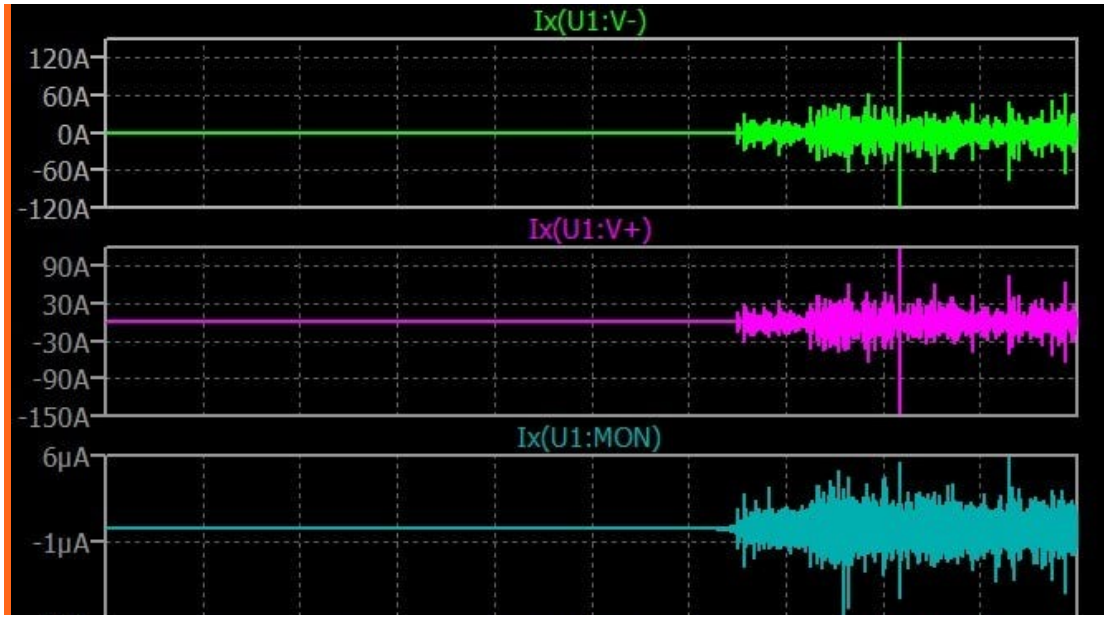
More importantly, plot:

```
I(C1)
```

if LTspice allows it directly from the internal capacitor now that `MON` is exposed.

If `I(C1)` is available, that will tell us whether the enormous common-mode excursion is actually associated with current through the neon model's internal 1-pF capacitor.

I would leave the `.sub` file exactly as it is for the moment. The fact that `NMON`, `N004`, and `N005` all rise together while their differences stay at zero is the key observation from this run.





> the neon bulb's internal capacitor does not appear to be obviously available...certainly not by plotting I(C1)

Yes — and **this plot gives us an important result without modifying the subcircuit further**.

The fact that `Ix(U1:MON)` is available is especially useful.

What your plot shows

After about 37 ks:

- `Ix(U1:V-)` is on the order of tens of amps, with excursions approaching ±100 A.
- `Ix(U1:V+)` is similarly large.
- `Ix(U1:MON)` is only on the order of **microamps**.
- The three voltage differences remain essentially zero:
  - `V(N005,NMON)`
  - `V(NMON,N004)`
  - `V(N005,N004)`

So the MON terminal is **not carrying the large current circulating through the neon's two external terminals**.

That's a very useful separation.

We may be able to get C1's current without changing the `.sub`

file

Because the subcircuit instance is now called `U1`, try entering this directly in the waveform viewer:

```
Ix(U1:C1)
```

and also:

```
Ix(U1:R1)
```

The syntax is different from `I(C1)` because `C1` is **inside the U1 subcircuit**.

Likewise, if we want to inspect the switches, try:

```
Ix(U1:S1)
Ix(U1:S2)
```

If LTspice accepts those, we'll have direct access to the internal elements.

Why `I(C1)` didn't work

This is expected.

At the top level, your circuit has no capacitor named `C1`. The capacitor named `C1` exists **inside**:

```
.subckt neonbulb 1 2 MON
```

So:

```
I(C1)
```

asks LTspice for a top-level component called C1.

The hierarchical form, if LTspice has retained the internal device current in the waveform data, is:

```
Ix(U1:C1)
```

One thing I don't want to do yet

Don't change `R1` from 100 MΩ to 1 MΩ.

Your new evidence makes that premature.

In fact, `Ix(U1:MON)` being only microamps is consistent with the internal capacitor/control network being a very small-current part of the model, while the enormous terminal currents are occurring through the external two-terminal behavior.

So let's first see whether LTspice will give us:

```
Ix(U1:C1)
Ix(U1:R1)
Ix(U1:S1)
Ix(U1:S2)
```

If `Ix(U1:C1)` works, **that is the next measurement I most want to see**. It will let us determine whether the internal 1-pF capacitor is actually responsible for the MON-node behavior, rather than modifying the model and potentially changing the phenomenon we're investigating.

> No. It won't show us these internals.

Correct. **You're right.** I was assuming LTspice would expose hierarchical element currents, but in this case it isn't doing that. `Ix(U1:MON)` is available because **MON is now an actual subcircuit pin**; `C1`, `R1`, `S1`, and `S2` remain inaccessible as individual waveform traces.

And, importantly, **we don't actually need access to `I(C1)` anymore.** Your last plot gives us enough information to analyze the internal capacitor mathematically.

We already know what C1 is doing

Your modified subcircuit has:

```
C1 MON 2 {Tau/100Meg}
```

with:

```
Tau=100u
```

Therefore:

$$C_1 = \frac{100\ \mu s}{100\ M\Omega} = 1\ \text{pF}$$

and node `2` of the subcircuit is `N004`.

So:

$$I_{C1} = C_1 \frac{d}{dt} V(NMON, N004)$$

or:

$$I_{C1} = 1\ \text{pF} \frac{d}{dt} V(NMON, N004)$$

But your plot shows:

$$V(NMON, N004) \approx 0$$

even while `V(NMON)` rises to 6 × 10^{17} V.

Therefore the capacitor is seeing essentially **zero voltage**, and consequently essentially **zero current**.

That's a much more useful result than being able to plot `I(C1)` .

The important discovery is actually the common-mode behavior

Your three nodes are doing this:

$$V(N005) \approx V(N004) \approx V(NMON)$$

while:

$$V(N005, N004) \approx 0$$

and:

$$V(NMON, N004) \approx 0$$

So the entire neon-bulb subcircuit is effectively riding upward as a **floating common-mode group**.

The simulator can have:

$$N005 = N004 = NMON = 6 \times 10^{17}\ \text{V}$$

without having:

$$V(N005, N004) = 6 \times 10^{17}\ \text{V}$$

The latter remains approximately zero.

And this explains something else

The internal `MON` node has no independent connection to ground.

Its relevant elements are:

```
R1 1 MON 100Meg
C1 MON 2 1pF
```

But both ends of those elements are moving together:

```
N005 ≈ NMON ≈ N004
```

Consequently, neither element strongly establishes an **absolute voltage reference** for MON.

The switches don't provide a DC path to ground either; their control terminals are voltage-controlled inputs.

So the modified model has exposed something that was previously hidden:

> **The neon model contains a floating internal node, and the simulation is allowing the common-mode voltage of that floating network to run away numerically.**

I would therefore stop trying to access C1

We have extracted the important information indirectly.

I also **would not change `R1` yet**. Before modifying anything, I think the next useful experiment is to establish whether this 10^{17} -V common-mode excursion was already present in the original two-pin model but simply invisible.

There is a particularly clean way to do that **without changing the neon model's electrical behavior**: compare the original two-pin model against the three-pin

version while monitoring only the external quantities.

If the external waveforms are identical, then adding MON merely **revealed** the floating-node runaway.

If the external waveforms change, then our three-pin modification has somehow altered the model and we need to find out why.

That is the test I'd do next.

> OK, how do I do that?

Good. Let's do this as a **controlled A/B test**, changing only the neon-bulb interface. We don't want to change K2, R11, timestep, initial condition, etc.

Test A — your present 3-pin version

First, preserve what you have now.

1. Save the current schematic under a new name

Use **File → Save As** and call it something like:

```
neon_3pin_test.asc
```

Keep your present `neonbulb.sub` as the 3-pin version.

Your present instance is:

```
X§U1 N005 N004 NMON neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u
Tau=100u
```

Run the simulation exactly as you just did.

For this run, record these external traces:

```
V(N005,N004)
I(C2)
I(C4)
I(L3)
I(L5)
```

We don't need `V(NMON)` for the comparison because `NMON` doesn't exist in the original model.

Test B — restore the original 2-pin neon

Now make a **second copy of the schematic**, rather than modifying the one we just tested.

Save As:

```
neon_2pin_test.asc
```

Then restore the original neon symbol.

Your original symbol had only:

```
V+
V-
```

and its generated instance was:

```
X§U1 N005 N004 neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u Tau=100u
```

The original `neonbulb.sub` should likewise be:

```
.subckt neonbulb 1 2
S1 1 2 2 N001 G
S2 2 1 N001 2 G
R1 1 N001 100Meg
C1 N001 2 {Tau/100Meg}
.model G SW(Ron={Zon} Roff=1T Vt={.5*(Vstrike+Vhold)} Vh={.5*(Vstrike-
Vhold)} Vser={Vhold-Ihold*Zon})
.param Vstrike=100 Vhold=50 Zon=2K Ihold=200u Tau=100u
.ends neonbulb
```

Important

Don’t alter anything else.

In particular, leave these exactly as they are:

```
L3 = 2 H
L5 = 2 H
K2 = .99
R11 = 1 Ω
C2 = 100 fF, ESR = 3 Ω
C4 = 100 fF, ESR = 3 Ω
L1 = 10 H
PC = 3u
RELTOL = .04
Gear
.tran 60k
```

Then compare the two runs

The question we’re testing is very narrow:

> **Does exposing the internal N001 node as the external `NMON` pin change the external circuit behavior?**

If the modification is electrically transparent, then the following should be essentially identical between the two runs:

$$V(N005, N004)$$

$$I(C2)$$

$$I(C4)$$

$$I(L3)$$

$$I(L5)$$

including the point around **35–45 ks where the runaway/common-mode excursion begins**.

There are three possible outcomes

1. External waveforms are essentially identical

Then we've demonstrated that adding `MON` did **not** create the phenomenon. It merely made the internal common-mode runaway observable.

2. The 3-pin version changes the external waveforms

Then something about exposing `N001` as a subcircuit terminal is altering the numerical solution, and we'll investigate that.

3. The original 2-pin version doesn't develop the runaway at all

That's particularly interesting. It would mean the newly exposed floating node is interacting with LTspice's numerical solution in a way that wasn't present when the node was completely internal.

One simplification

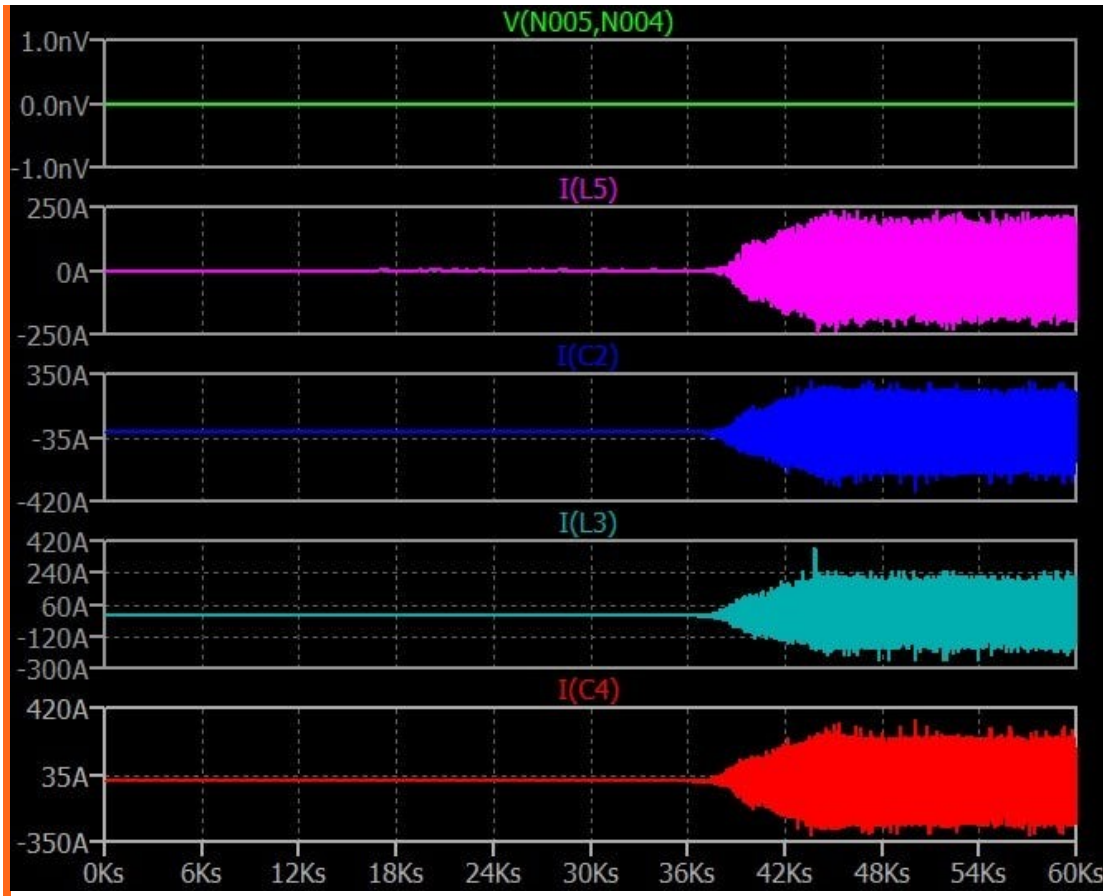
We don’t actually have to compare all five traces initially.

Run the **2-pin version** and show me just:

```
V(N005,N004)
I(C2)
I(C4)
```

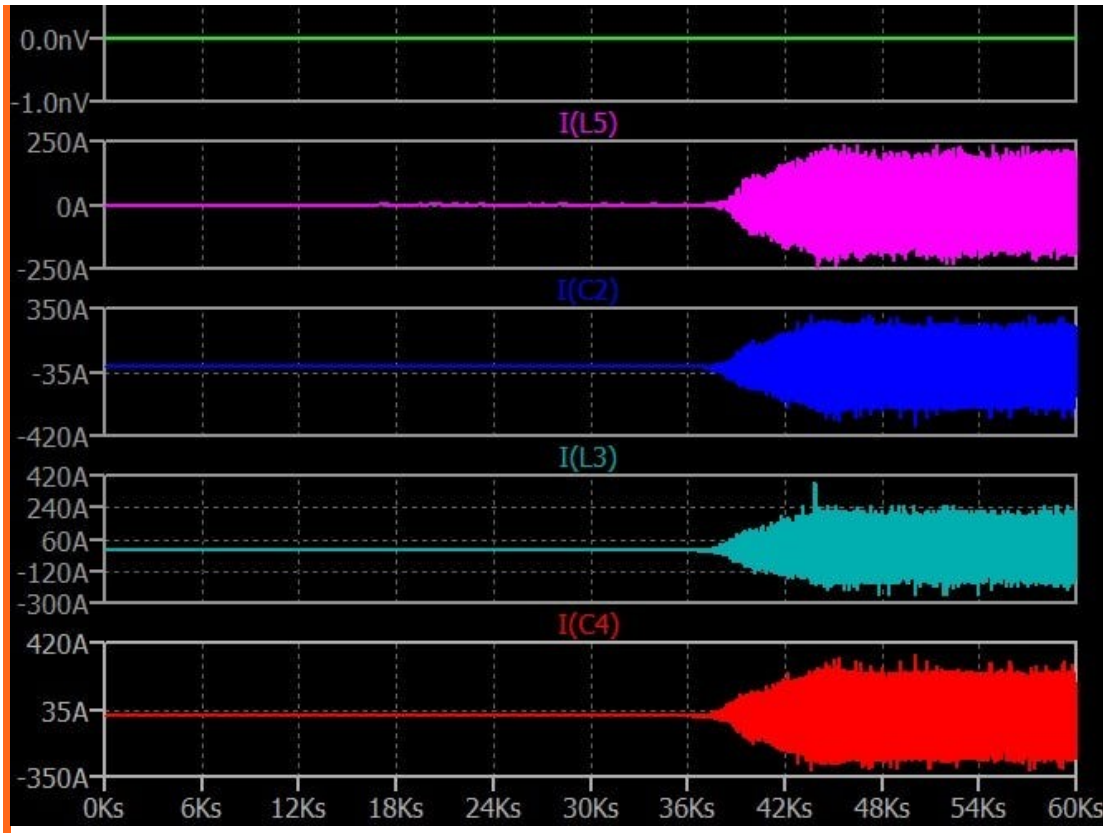
over the full 0–60 ks interval.

Those are enough to tell us whether the dramatic behavior you just showed survives when `MON` is removed.



2 pin





3 pin

> they’re exactly the same

Excellent. **That is the result we needed.**

The two screenshots are effectively identical, so we can make a strong conclusion:

> **Adding the MON pin did not cause the 6×10^{17} V common-mode excursion.**

The original **2-pin neon model already produces exactly the same external behavior**.

What we’ve now established

The 2-pin and 3-pin versions produce the same:

- `V(N005,N004)`
- `I(L5)`

- `I(C2)`
- `I(L3)`
- `I(C4)`

including the transition beginning around **37 ks** and the subsequent growth in circulating current.

Therefore the modification:

```
.subckt neonbulb 1 2 MON
```

and exposing `N001` as `MON` is **electrically transparent to the rest of the circuit**.

So we can safely regard the enormous `V(NMON)` as something that was already happening internally in the original model.

And this changes our interpretation of the 10^{17} V result

We now know that:

$$V(NMON) \approx V(N004) \approx V(N005)$$

while:

$$V(N005, N004) \approx 0$$

and:

$$V(NMON, N004) \approx 0$$

The important quantity is therefore **not the absolute value of** `V(NMON)` .

The internal node is undergoing a **common-mode drift** relative to ground.

The external circuit doesn't see that drift because all three nodes move together.

That's why your original 2-pin circuit could behave normally despite something internally reaching an absurd absolute voltage.

I would now make one change to the experiment

We should **keep the 3-pin version**, because it gives us access to MON, and we should stop trying to obtain `I(C1)`.

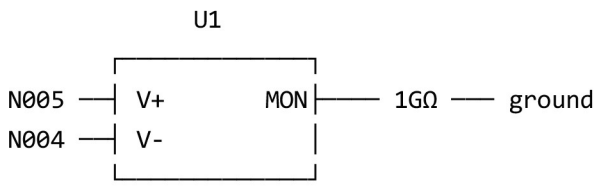
Instead, let's deliberately give MON a DC reference **from outside the subcircuit**, without changing anything inside the neon model.

Add a resistor:

```
MON ── 1GΩ ── Ground
```

in the schematic.

So your schematic will have:



Do not change the neon `.sub` file.

Then run exactly the same 60 ks simulation.

What this test tells us

If the enormous `V(NMON)` disappears while:

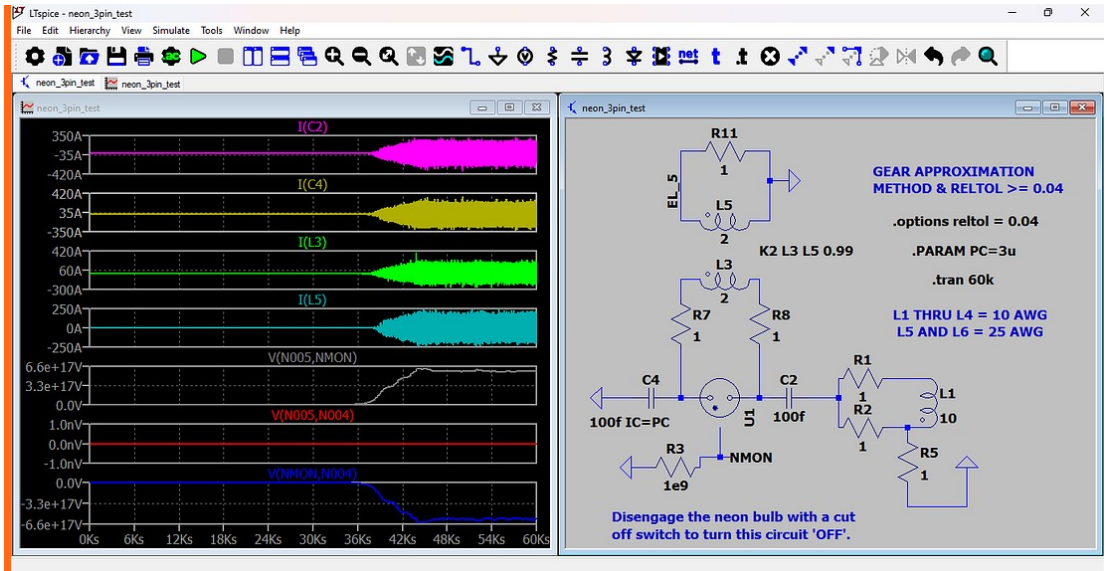
```
V(N005,N004)
I(L5)
I(C2)
I(C4)
I(L3)
```

remain essentially unchanged, we'll have demonstrated that the 10^{17} V excursion is simply the consequence of a **floating internal node with no defined DC reference**.

If, on the other hand, adding the 1 GΩ reference significantly changes the oscillator currents, then the internal node's absolute potential is numerically influencing the switch model despite its near-zero differential voltage.

That distinction is worth establishing before we touch the actual neon model.

So don't alter `neonbulb.sub` yet. Add only the 1 GΩ MON-to-ground resistor in the schematic.



> I don't understand what you're trying to do since, if I retain the status of the neon sub file as a two pin entity, then NMON doesn't connect to anything yet retains the runaway voltage even when I add a 1e9 resistor to ground.

You're absolutely right. **I misunderstood what you had done.** The screenshot makes the situation clear.

The `1e9 Ω` resistor you added is connected to the **external net named NMON**, but your `neonbulb.sub` is currently still the **two-pin version**. Therefore:

```
X§U1 N005 N004 neonbulb ...
```

has no connection whatsoever to that external `NMON` net.

So your circuit is effectively:

```
              two-pin neon
N005 ──────────── U1 ──────────── N004


NMON ──── 1 GΩ ──── ground
```

The `NMON` wire/resistor is completely independent of the neon's internal `N001`.

Therefore your observation is actually useful

It demonstrates that:

> **Putting a 1 GΩ resistor on an unrelated NMON net does absolutely nothing to the internal runaway.**

That is exactly what it should do.

And this means **we should undo that resistor for now.**

What I was actually trying to test

To test whether the internal `N001` floating node is responsible for the 10^{17} V common-mode excursion, we need the **three-pin version** of the subcircuit:

```
.subckt neonbulb 1 2 MON
S1 1 2 2 MON G
S2 2 1 MON 2 G
R1 1 MON 100Meg
C1 MON 2 {Tau/100Meg}
...
.ends neonbulb
```

with the schematic instance:

```
X§U1 N005 N004 NMON neonbulb ...
```

Then—and only then—does:

```
NMON ── 1 GΩ ── ground
```

actually connect to the internal `N001` node.

The correspondence is:

```
subcircuit              schematic

internal N001  ──────── NMON
                        │
                       1 GΩ
                        │
                       GND
```

But there's an even better way to proceed

We have already established something important:

Test 1 — 2-pin neon

You ran the original two-pin model and got:

- `V(N005,N004)` ≈ 0
- the same L5 current growth
- the same C2/C4 currents
- the same L3 current

as the three-pin version.

Therefore **adding MON did not cause the runaway**.

Now we don't need to repeat that experiment.

Test 2 — three-pin neon + reference

What I intended you to test is:

1. Keep the **three-pin** `neonbulb.sub` .
2. Keep:

```
X§U1 N005 N004 NMON neonbulb ...
```

1. Keep the `NMON` label.
2. Add the resistor:

```
NMON → 1GΩ → ground
```

1. Run again.

Now the resistor really does connect to the internal `N001`.

One caution about 1 GΩ

I suggested 1 GΩ because I wanted the reference to be extremely weak. But given what we're investigating, **1 GΩ may be too weak to provide useful numerical conditioning**.

So I would actually start with **1 MΩ**, not 1 GΩ, for the diagnostic.

That gives the internal node a definite DC reference while still being enormously larger than the 1 Ω / 2 kΩ circuit resistances.

But let's not do that yet.

First, remove the 1 GΩ resistor from the current two-pin experiment. Then restore the three-pin `.sub` and the three-pin instance. Once the netlist again says:

```
X§U1 N005 N004 NMON neonbulb ...
```

then the NMON-to-ground resistor becomes a meaningful experiment.

And thank you for catching this—the distinction between an **external NMON net** and the **internal N001 node** is crucial here.

> What do I add to the symbol file?

For the **symbol file**, you only need to add the third pin and its attributes.

Starting from your original `.asy` file, you have:

```
PIN 0 -48 NONE 0
PINATTR PinName V+
PINATTR SpiceOrder 1
PIN 0 48 NONE 0
PINATTR PinName V-
PINATTR SpiceOrder 2
```

Change that section to:

```
PIN 0 -48 NONE 0
PINATTR PinName V+
PINATTR SpiceOrder 1
PIN 0 48 NONE 0
PINATTR PinName V-
PINATTR SpiceOrder 2
PIN 48 0 RIGHT 16
PINATTR PinName MON
PINATTR SpiceOrder 3
```

That’s it.

Your complete modified symbol ending

```
WINDOW 0 16 -48 Left 2
SYMATTR Prefix X
SYMATTR Description Parameterized Neon Bulb
SYMATTR Value2 Vstrike=100 Vhold=50
```

```
SYMATTR ModelFile neonbulb.sub
SYMATTR SpiceModel neonbulb
SYMATTR SpiceLine Zon=2K Ihold=200u
SYMATTR SpiceLine2 Tau=100u
PIN 0 -48 NONE 0
PINATTR PinName V+
PINATTR SpiceOrder 1
PIN 0 48 NONE 0
PINATTR PinName V-
PINATTR SpiceOrder 2
PIN 48 0 RIGHT 16
PINATTR PinName MON
PINATTR SpiceOrder 3
```

The important parts are:

```
PIN 48 0 RIGHT 16
PINATTR PinName MON
PINATTR SpiceOrder 3
```

That creates the third electrical pin on the **right side of the symbol**.

Then your `.sub` file must have the corresponding third pin:

```
.subckt neonbulb 1 2 MON
```

and the internal connections:

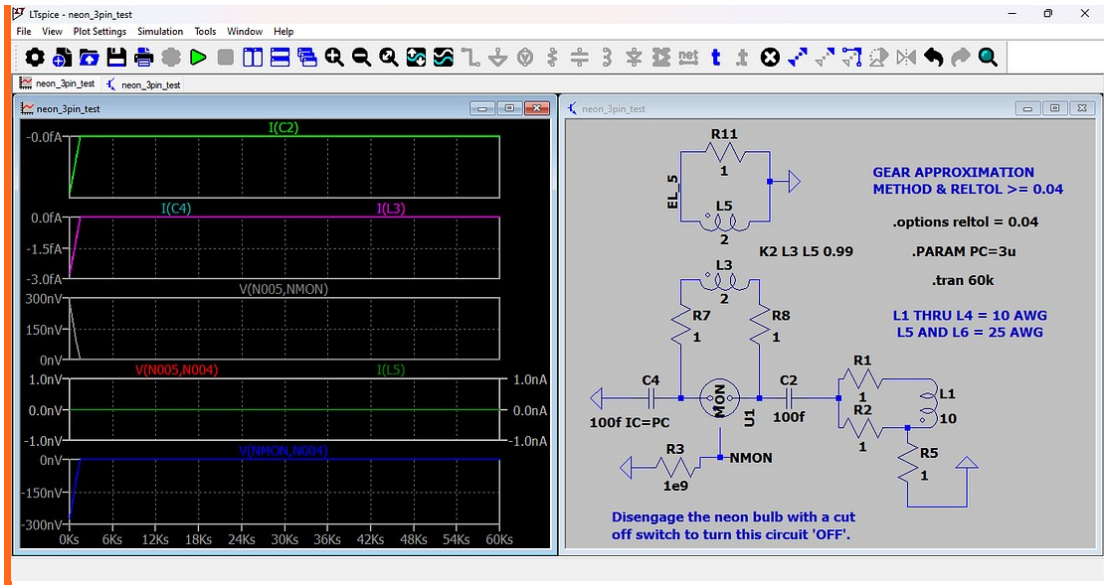
```
S1 1 2 2 MON G
S2 2 1 MON 2 G
R1 1 MON 100Meg
C1 MON 2 {Tau/100Meg}
```

Finally, your schematic should generate:

```
X§U1 N005 N004 NMON neonbulb ...
```

which you have already successfully achieved.

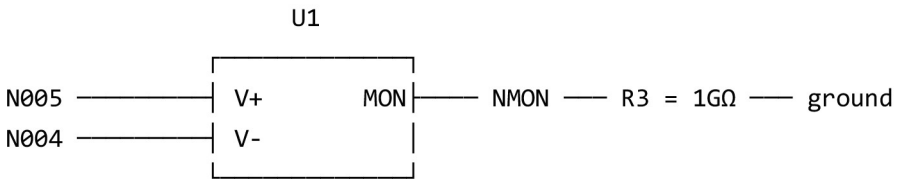
One correction to my earlier guidance: don't add the 1 GΩ resistor yet. Let's first get the three-pin version running again and verify `NMON` reproduces the internal common-mode voltage. Then we'll decide what experiment makes sense.



> Too late!

Ah — **now I see exactly what happened.** And this result is actually useful. We don't need to undo anything conceptually; we just need to recognize what this experiment did.

Your current schematic is now:



And your plot shows that adding that resistor **completely suppresses the oscillator**:

- `I(C2)` → essentially 0
- `I(C4)` → essentially 0
- `I(L3)` → essentially 0
- `I(L5)` → essentially 0
- `V(N005,N004)` → essentially 0 after startup

So **the 1 GΩ resistor is not a benign measurement reference in this circuit.**

Why I was wrong to call it a "very weak" reference

The critical point is that the internal node was reaching approximately

$$6 \times 10^{17}\ \text{V}$$

At that voltage, even a **1 GΩ** resistor would imply an absurd current:

$$I = \frac{6\times10^{17}}{10^{9}} = 6 \times 10^{8}\ \text{A}$$

So although 1 GΩ sounds enormous compared with the 1–2 Ω components elsewhere, it is **not remotely negligible once the floating node goes to 10^{17} V**.

Your experiment therefore tells us:

> **Providing MON with a DC reference radically changes the circuit's behavior.**

That's an important result.

But there's an even more important observation in your screenshot

You now have:

```
V(N005,NMON)
```

starting around +300 V and then going to zero, while

```
V(NMON,N004)
```

starts around -300 V and goes to zero.

That means the 1 GΩ resistor isn't merely preventing the absurd common-mode excursion. **It is imposing a completely different voltage condition on the neon's internal node during startup.**

And that's why I don't want you to change the `.sub` file.

So let's stop here and reset the experiment

Remove **R3 = 1 GΩ** from NMON to ground.

Do **not** modify:

- `neonbulb.sub`
- K2 = .99
- R11 = 1 Ω
- L3/L5
- capacitors
- timestep

- RELTOL

Leave the three-pin version intact:

```
X§U1 N005 N004 NMON neonbulb ...
```

Then rerun.

We already know what should happen: you'll get the same external waveforms as the original two-pin version, while `V(NMON)` reveals the enormous common-mode excursion.

And that gives us a clean set of established facts

Experiment 1 — 2-pin neon:

Same oscillator.

Experiment 2 — 3-pin neon, no external connection to MON:

Same oscillator + 6×10^{17} V common-mode MON excursion.

Experiment 3 — 3-pin neon + 1 GΩ MON-to-ground:

Oscillation disappears.

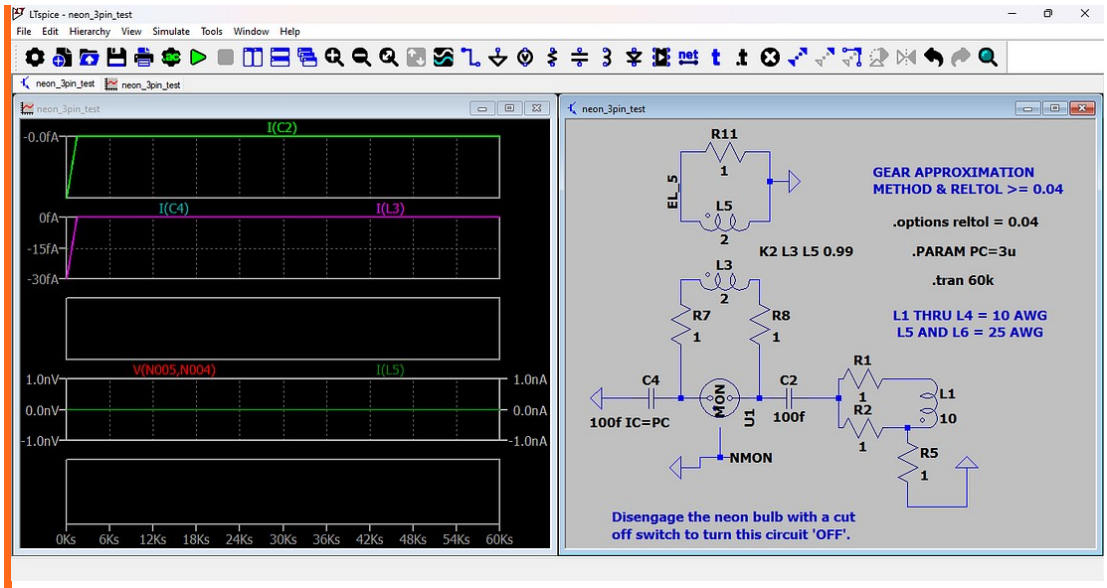
That is actually a very useful progression.

The next question is therefore **not** "how do we stop the 10^{17} V?" We now know that forcing MON to ground changes the operation of the circuit.

The question is:

> **What is the floating MON/N001 node doing that allows the original neon model to sustain the high-current oscillation?**

And we can investigate that without modifying the neon model further.



> That was a mistake if I was supposed to keep ground but remove the 1e9 resistor since that eliminated the MON node.

Yes. **That was the mistake.** I was giving you conflicting instructions.

Looking at your screenshot, you have now removed the 1 GΩ resistor **and also removed the connection that creates the `NMON` net**. Consequently, `NMON` is no longer connected to the third pin, so this is no longer the three-pin observation we wanted.

Let's restore the setup precisely.

We want this

Keep the **three-pin neon subcircuit**:

```
.subckt neonbulb 1 2 MON
```

Keep the symbol's third pin:

```
PIN 48 0 RIGHT 16
PINATTR PinName MON
PINATTR SpiceOrder 3
```

And the schematic must have:

```
U1 MON pin ——— NMON
```

But nothing else connected to NMON.

No resistor.

No ground.

No dangling component.

So visually, the bottom MON pin should have a short wire ending at the `NMON` label, exactly like you had in the earlier screenshot **before we added R3**.

The generated netlist should again say:

```
X§U1 N005 N004 NMON neonbulb Vstrike=100 Vhold=50 Zon=2K Ihold=200u
Tau=100u
```

Then run it

You should again get the behavior from your earlier three-pin run:

```
V(NMON)       → ~6×10¹⁷ V common-mode excursion
V(N005,NMON)  → ~0 V
V(NMON,N004)  → ~0 V
V(N005,N004)  → ~0 V
```

and the same oscillator currents as the original two-pin circuit.

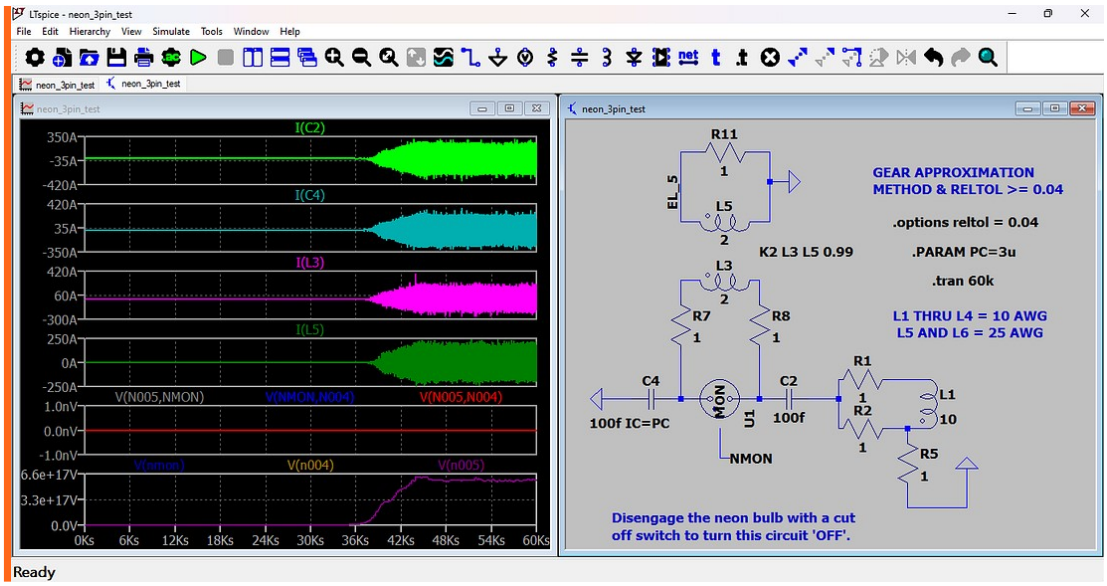
That's the state I want you in now.

Once you have that, **don't add anything else yet**. We have already established that adding 1 GΩ to MON kills the oscillation, so there's no reason to repeat that experiment.

And you're right to stop me here—the distinction is:

> **NMON connected to the third pin, but otherwise unconnected** = observation of internal `N001`.
>
> **NMON connected through 1 GΩ to ground** = modification of the neon circuit.
>
> **NMON not connected to the third pin at all** = meaningless for observing `N001`.

Let's get back to the first state.



Yes. **This is now the correct configuration.** And this screenshot gives us an even clearer result.

You have:

- the **three-pin neon model**
- `MON` connected to `NMON`
- **no resistor from NMON to ground**
- `NMON` otherwise floating

And the simulation has returned to the same high-current behavior.

The especially important part

Your lower traces now show:

- `V(nmon)`
- `V(n001)`
- `V(n005)`

all following the same enormous excursion, reaching roughly 6×10^{17} V.

At the same time:

$$V(N005, NMON) \approx 0$$

$$V(NMON, N004) \approx 0$$

$$V(N005, N004) \approx 0$$

So we have now directly established that the internal `N001` node is essentially at the same potential as the external neon terminals during the runaway.

That is much stronger evidence than we had before.

And notice what this means for the neon switches

Your modified subcircuit has:

```
S1 1 2 2 MON G
S2 2 1 MON 2 G
```

Therefore the switch-control voltages are:

$$V_{S1,\text{control}} = V(2) - V(MON)$$

and

$$V_{S2,\text{control}} = V(MON) - V(2)$$

In your circuit those correspond to approximately:

$$V(N004, NMON) \approx 0$$

and

$$V(NMON, N004) \approx 0$$

So the internal control voltage is essentially **zero**, despite the absolute voltage of all these nodes becoming enormous.

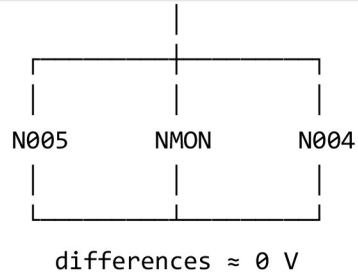
That is the key distinction we were trying to uncover.

I think we should now stop treating the 6×10^{17} V as a circuit voltage

The simulation is telling us that the neon's internal network has a **floating common-mode degree of freedom**.

In simplified form:

```
            ~6×10^17 V
```



The simulator is free to move the entire floating group to an arbitrary absolute potential without changing the voltage differences that govern the circuit.

That explains why the **2-pin and 3-pin simulations are externally identical**.

And it explains why adding the 1 GΩ resistor changed everything: it removed that floating degree of freedom by forcing MON toward ground.

But there is still a much more interesting question

We originally started exposing `N001` because we wanted to understand this:

> How can the neon model be associated with the large circulating currents when its external voltage is essentially zero?

We now know that the gigantic MON voltage **doesn't answer that question**. It's a common-mode numerical artifact/degree of freedom.

So I would **not make any more changes to the neon model right now.**

The next thing I'd like to examine is the **switch states themselves indirectly**, using the voltages that control S1 and S2.

Since we cannot access `S1` and `S2` currents directly, plot these two expressions:

```
V(N004,NMON)
```

and

```
V(NMON,N004)
```

but zoom in around the **37–45 ks transition** rather than looking at the full 10^{17} -V scale.

If they really remain at essentially zero even during the current buildup, then we have a very unusual result:

the neon macro's two switches are being controlled by essentially zero differential voltage while the surrounding circuit develops hundreds of amps of circulating current.

That is the point I'd like to investigate next.

> I'll do that tomorrow. Please try and remember everything we've done.

Absolutely. We have a clear stopping point, and I'll preserve the experimental sequence and conclusions so we can pick up from here tomorrow.

Our current state is:

- Three-pin `neonbulb` model, with internal `N001` exposed as `MON`.
- `U1` generates:

```
X§U1 N005 N004 NMON neonbulb ...
```

- `NMON` is connected to the MON pin but **otherwise floating**.
- No 1 GΩ resistor to ground.
- The 2-pin and 3-pin versions produce **identical external waveforms**.

- With MON exposed and floating:
  - `V(NMON)`, `V(N001)`, and `V(N005)` rise together to about 6×10^{17} V.
  - `V(N005,NMON)`, `V(NMON,N004)`, and `V(N005,N004)` remain essentially zero.
- Adding 1 GΩ from MON to ground **suppressed the oscillator**, so we are not treating that as a harmless measurement connection.
- We therefore left the circuit in its original floating configuration.
- We are **not modifying** `neonbulb.sub` **further** at this point.
- The next measurement is the switch-control differential voltages:

```
V(N004,NMON)
V(NMON,N004)
```

- with particular attention to the **~37–45 ks transition** where the large circulating currents develop.

And one important correction to keep straight tomorrow: `NMON` **is meaningful only because the three-pin subcircuit maps it to the internal** `N001`**.** An external NMON net attached to a two-pin neon model does nothing.

We'll pick up from exactly there.

THUS ENDS THIS SECOND EPISODE OF ANALYSIS BY CHATGPT