[sdiy] Moog sequencer 960 analysis.. further DETAILED questions..

Answers from Dave Brown & Scott Loiselle

Dave Brown:

I have only repaired 960s so these answers are from examination of the schematics and what scope images I saved. Errors in my analysis are certainly possible.

question#1

Suppose you have the following setup on the Moog 960

The internal low freq oscillator is stopped,
All the 9 columns are at rotary switch 'normal' position (NORMAL for column 9 is SKIP)
but the 4th which is at 'skip'
What happens if I push the 4rth column SET pushbutton ?
Will it select the 4rth or the 5th column ?
And if the 4th column is selected anyway
and I start the oscillator, will it skip this 4rth column
at the very start and go to the next 'normal' column
or execute the 4rth anyway ?

The set button clears all stages and then sets the appropriate stage. The stage 4 flip flop has both the clear and set asserted, but the one shot pulse for clear is shorter so that stage is reset. The output is inverted so stage 4 is set. If that stage is set to skip, there are no inputs to the NOR gate. This is RTL logic so an unconnected input is a low. On the next clock stage 4 will then be reset. The “all stages off” circuitry will detect no stages are set and will set stage 1. The clock will continue running from stage 1. But this raises the issue of what if stage 1 is set to skip? I think if you manually set stage 1 and set it to skip, the other stages remain off when you start the oscillator and it simply stays on stage 1. This would be worth verifying.

question#2

I suppose that (when reached) any 'stop' selected columns will stop the internal oscillator
and turn its 'oscillator ON' light off ?
The same way as if I connect a column's OUT jack
to the oscillator 'OSC OFF' jack ?

Stop simply isolates a stage (1 to 8) by feeding the output of the flip flop back to the input. Only stage 9 out does turn off the oscillator but for stages 1 to 8 the oscillator stays enabled but the stage stops advancing. Hold is a more accurate term.

Any pulse to the oscillator stop jack will disable the internal oscillator.

question#3

It seems that the possible CV voltages on each row
are 0-2vdc (x1), 0-4vdc (x2), 0-8vdc (x4) ?

Regarding question#3
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are 0-2vdc (x1), 0-4vdc (x2), 0-8vdc (x4) ?

In the Moog system 55 service manual, in the 960 sequencer schematic,
Looking at the ‘transistorized’ OPAMP made of Q31,32,37,38

It looks like a non–inverting amplifier that can have 3 different gains:
X1: ((R162+R167)/R64)+1 => (3,55k+10k/1k)+1 => **gain of 14,55**
X2: ((R163+R167)/R64)+1 => (16,7k+10k/1k)+1 => **gain of 27,7**
X4: ((R164+R167)/R64)+1 => (43,3k+10k/1k)+1 => **gain of 54,3**

The columns CV switching PNP's 2N3702 (ex:Q1)
Each column supplies around +12v to each 5kB pots trios.
So 0-12v divided by the summer's separate resistors (100k and 1.3k (R165))
Gives around 12v X (1.3/(100 + 1.3)) = 0.12v X 0,012 = 0,153v max on each pot at the OPAMP input.
This maximum pot voltage is amplified and gives 3 possible amplified voltages:
X1: 0,153v x 14,55 = **2,23v max**
X2: 0,153v x 27,7 = **4,24v max**
X4: 0,153v x 54,3 = **8,31v max**
The specification for the 960 is 0-2V, 0-4V, and 0-8V.

question#4

When the oscillator is ON,
The main oscillator output jack is always giving a +5vpeak 90% duty cycle pulse right ? (for ADSR reason ??)
But each individual column out jacks give a positive pulse which duration is the actual column time ?

The clock is trimmed for a 90% duty cycle. My oscilloscope image shows a 4V amplitude.
The output stage gates are driven from RTL so are 3.6V amplitude and are high for the duration of the stage time.

question#5

The internal oscillator:
What are the actual min/max frequencies on each possible 6 positions ?

The oscillator is a unijunction driven from a constant current source that has been calibrated to 1V/Oct. The timing capacitors are of the following values so the ranges will differ by their multiple.

1: 27 uF
2: 5.6 uF
3: 1.5 uF
4: 0.39 uF
5: 0.04 (hard to read and maybe wrong)
6: 0.022 uF.

If 27 uF was x frequency then 0.022 would be 1350x, so a range of over 10 octaves.

The capacitors would have some tolerance, the largest likely +/-20%. The ratio of each stage to the next is close to 4 so these seem to be 2 octave increments. However, #5 looks wrong.

If you assume the coarse control had a range of 2 octaves, then you would want the step ratios to be multiples of 4:
1, 4, 16, 64, 256, 1024. The capacitor ratios are just a bit more (except for #5):
1, 4.8, 18, 69, 675, 1350 so all relatively close for standard capacitor values except that 675. If I chose #5 to be 256 exactly, the capacitor would be 0.1. It clearly is a 0.0? which looks like a 4 but could be a 9 which would be close to the right value, but not a standard value.

I only recorded measurements from one of the 960s I rebuilt which had a maximum of 400 Hz at #6 and maximum frequency control.

The CV input is 100K which is trimmed to 1V/Oct. The frequency control is 6V at 180K which is a bit over 3 octaves, so it looks like the 6 positions switch is setup for a 2 octave increment and the control is +/- 1.5 octaves. I did not check the values of the timing capacitors on the unit I repaired.

Assuming a 3 octave coarse frequency control, the minimum frequency for #6 would be 100 Hz, and #1 would make the lowest frequency 0.1 Hz. The specification for the 960 is 0.1 Hz to 500 Hz.

question#6

While the internal oscillator is running,
Pushing the 'shift' pushbutton would 'add' pulses
on the running pulse stream to all the shift registers ?

The output of the external shift input and the shift pushbutton one shot is or'd with the oscillator one shot. Both would produce a clock so would advance a stage. Note that if these events happen while the oscillator one shot is high, the output of the or is still high so no extra advance. The manual shift button one shot is longer, but would only advance the stage if the clock one shot was low. I don't know the one shot high time since it is an RC into a RTL gate, but the RC time constant is only 40 uS. I would say most of the time you would get an advance, but not guaranteed depending on the relationship to the clock high.

question#7

While a sequence is running on all the 8 columns
and the sequence has reached column#7
what happens if I push the column#3 SET button ?
Will this disturb the sequence and bring it back to column#3
then resume all the normal sequence ?

The set button clears the flip flops and sets that stage and that usually takes precedence over the clock. The datasheet doesn't actually specific set and clear inputs with respect to the clock but a look at the internal schematics for the 778 shows that it is the same as being clocked. So yes, irrespective of the oscillator, the set will change to that stage and then advance from there.

question#8

A:
If the sequencer oscillator is stopped (OSC-OFF pushbutton) at sequence#3 (column#3 light is lit)
And this sequence is in STOP position,
Then I click the OSC-ON pushbutton to restart the oscillator
Should I then hear the oscillator pulses (ADSR) an hear this
Column's 3 potentiometer pitches forever?

B:
And the same question but for sequence#1 at STOP ?
(Column's 1 potentiometer pitches forever?)

C:
And the same question but for sequence#9 at STOP ?
(Column's 8 potentiometer pitches forever?)

The oscillator output is directly from the oscillator, so whenever it is on the output is valid.

The oscillator output goes through a one-shot to shape the clock and that simply toggles all the flip/flops. As long as at least one stage is on their D inputs define what happens. Stop simply feeds the output of the flip flop back to the input so that is really a hold.

So, #1, yes it simply stays stopped on stage 3.
#2, yes, it stays stopped on stage 1.
#3, stage 9 is a valid stage, just like the others. There is simply no CV output from it, so yes, it stays stopped on stage 9.

A commentary on stage 9. Stage 8 is fed back to stage 1 on a skip. The schematics shows stage 9 skip/normal but the panel and wiring is skip/stop so an error there. Stop is just a hold on stage 9. However, stage 9 out does turn off the oscillator.

Note that if the sequencer is running, and you select STOP on stage 9, the oscillator does stop.

question#9

From question#7..
While a sequence is running on all the 8 columns
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The datasheet doesn't actually specific set and clear inputs with respect to the clock but a look
at the internal schematics for the 778 shows that it is the same as being clocked.
So yes, irrespective of the oscillator, the set will change to that stage and then advance from there.
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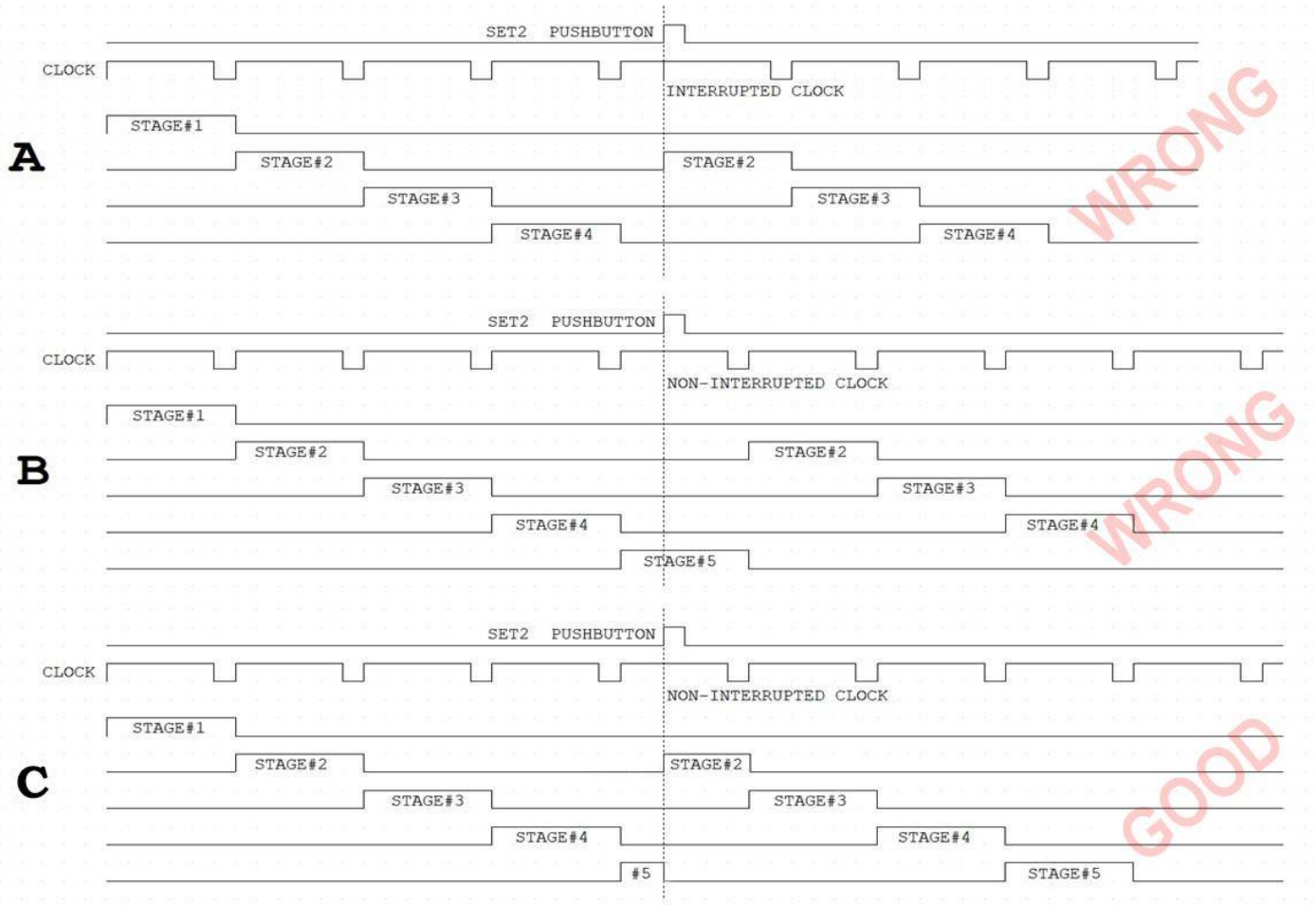
Ok.
But what about the running clock behaviour ?
I mean the clock timings ?
I put 2 possible behaviours on the below sketch..
Can you tell which one is the good one ? A or B ?
If A is the correct one there is some kind of feedback to the oscillator
to reset it if any SET buttons is pressed..
Otherwise pressing a SET button just 'prepares' for the next stage
And keep the timing of the sequence..

There is no feedback to the oscillator except Stage 9. A gate output on stage 9 stops the clock, so setting stage 9 will stop the clock. So set is independent of the clock, so there is NO interrupted clock.

Preset and Clear take precedent over the clock, so the clock will advance a stage after Preset or Clear are taken false. The Set button applies a preset to the flip flop and also triggers a one-shot that applies a clear. Clear resets the flip flops whose Q-0 output is inverted so all stages go off. However, the Set button has a longer pulse width than the one shot so preset is present after the clear, thus setting the flip flop. Q-0 goes low which is inverted so that stage goes on. The next clock will advance from this stage.

If this stage is skipped, then the next clock clears this stage, the circuitry detects that no stages are set, and sets stage 1.

Set is independent of the clock and the action is immediate. Neither A nor B is correct. On the clock following stage 4, stage 5 will occur. Set occurs during stage 5 which then immediately clears stage 5 and sets stage 2. The next clock continues on from stage 2 as shown in C. This assumes stage 2 is not skipped, which of course is the case since it is included in the sequence. I think. Timings on next page ..



Scott Loiselle:

Hi, I can answer most of the questions but ONLY about the Synthesizers.com 960 clone. I know that in general practice, using one is very much like using a Moog but I do not know about certain specific behaviors - they might be different between a Moog and the Synthesizers.com, or for that matter, the COTK clone, the Mos-Lab clones or any other clones.. That said, please see below.

question#1

Suppose you have the following setup on the Moog 960

The internal low freq oscillator is stopped,
All the 9 columns are at rotary switch 'normal' position
but the 4th which is at 'skip'
What happens if I push the 4rth column SET pushbutton ?
Will it select the 4rth or the 5th column ?

It selects Stage 4

And if the 4th column is selected anyway
and I start the oscillator, will it skip this 4rth column

at the very start and go to the next 'normal' column
or execute the 4rth anyway ?

If a stage is in skip but you manually select it and then start the internal oscillator, it immediately goes to stage 1 and plays all stages except that it skips stage-4. If you manually select a stage that is in “normal” and then start the oscillator, it plays from that stage forward. The thing to remember is that regardless of whether or not the internal VCO is running, for whatever given stage is active, the 3 row outputs will be outputting whatever voltage the pots for the three rows of that particular stage are set to (unless it is in stage 9 in which case all three row outputs send out 0 volts).

question#2

I suppose that (when reached) any 'stop' selected columns will stop the internal oscillator
and turn its 'oscillator ON' light off ?

No, if the sequencer is playing and you set a stage to stop, the sequencer stops at that stage with that stage light lit and the internal oscillator light still lit. If you then turn the mode switch from stop to normal, it immediately begins playing again, from the stage it had been stopped at. But if you turn the mode switch from stop to either skip or the unmarked reset available on the Synthesizers.com units, it immediately goes to stage 1 one and starts playing again from there.

The same way as if I connect a column's OUT jack
to the oscillator 'OSC OFF' jack ?

This is correct.

question#3

It seems that the possible CV voltages on each row
are 0-2vdc (x1), 0-4vdc (x2), 0-8vdc (x4) ?

This is correct.

question#4

When the oscillator is ON,
The main oscillator output jack is always giving a +5vpeak 90% duty cycle pulse right ? (for ADSR reason ??)
But each individual column out jacks give a positive pulse which duration is the actual column time ?

This is correct.

question#5

The internal oscillator:
What are the actual min/max frequencies on each possible 6 positions ?

I do not know. The dotcom data sheet says the internal VCO goes from .1Hz to 2kHz+ but I do not know if that’s correct.

question#6

While the internal oscillator is running,
Pushing the 'shift' pushbutton would 'add' pulses
on the running pulse stream to all the shift registers ?

This is correct. Also, if feeding in an internal gate/trigger pulse into the SHIFT input, it sums the internal clock along with any external signal.

question#7

While a sequence is running on all the 8 columns
and the sequence has reached column#7
what happens if I push the column#3 SET button ?
Will this disturb the sequence and bring it back to column#3
then resume all the normal sequence ?

This is correct.

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If the sequencer oscillator is stopped (OSC-OFF pushbutton) at sequence#3 (column#3 light is lit)
And this sequence is in STOP position,
Then I click the OSC-ON pushbutton to restart the oscillator
Should I then hear the oscillator pulses (ADSR) an hear this
Column's 3 potentiometer pitches forever?

B:
And the same question but for sequence#1 at STOP ?
(Column's 1 potentiometer pitches forever?)

C:
And the same question but for sequence#9 at STOP ?
(Column's 8 potentiometer pitches forever?)

It is the same answer for all three. If

- the internal VCO is not running
- a stage is manually selected
- that stage mode is set to "STOP"

during this time, at all times, the row output will send out whatever voltage that the stage is set at, and the gate output of that stage will be held high.

When you then push START for the internal VCO, nothing changes except that "Oscillator On" lamp lights up. If you then reset the stage mode switch to normal (or skip, for stage-9), the 960 immediately starts playing at the *next* stage.

So if you are:

- at stage 3 with the internal VCO not running
- stage 3 mode switch is set to STOP

the stage 3 gate output will be high, putting out 5 volts and each row output will be putting out whatever voltage is set by each of the row pots for that stage.

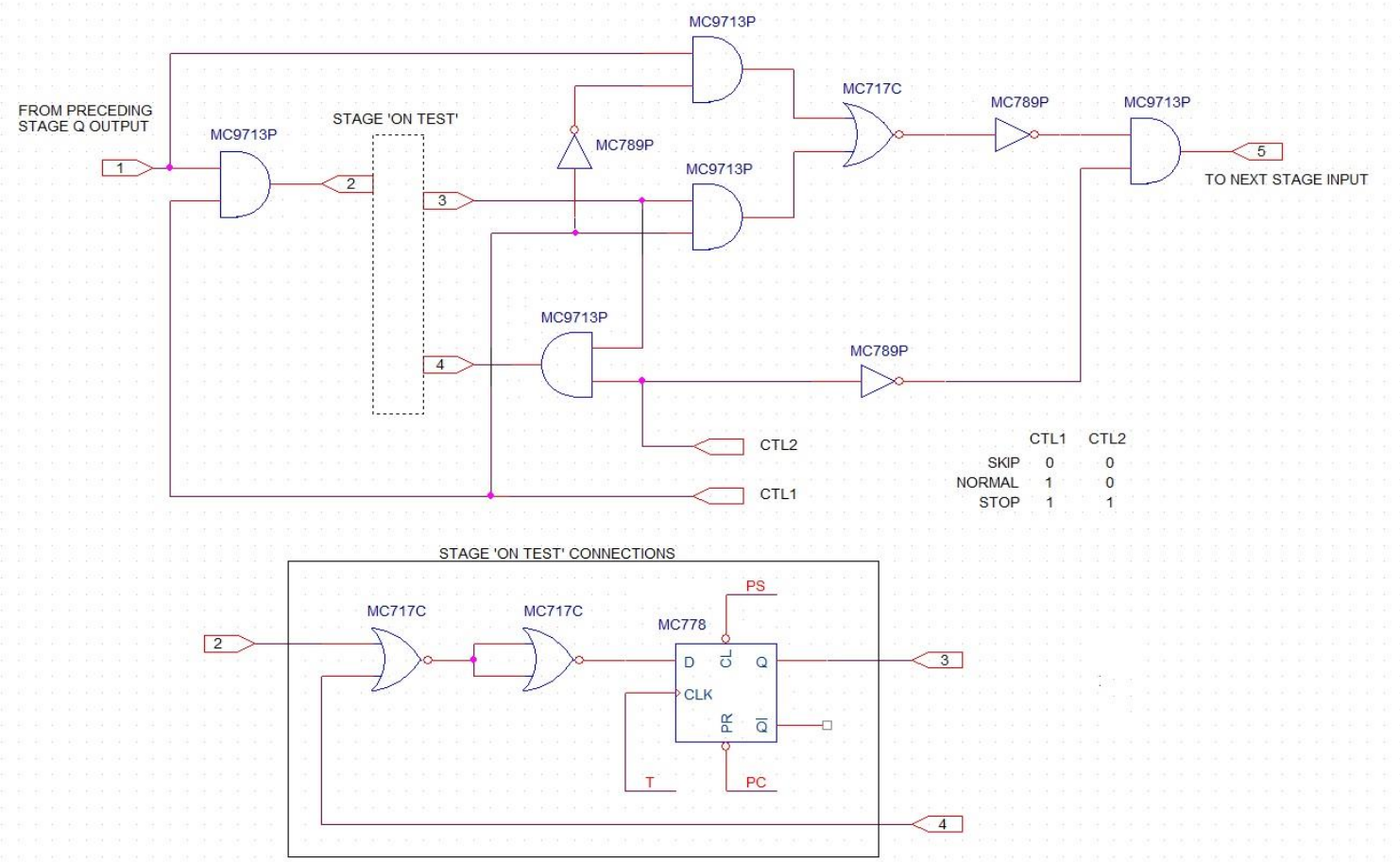
- you then press START on the internal VCO

nothing happens or changes except that the "oscillator on" lamp lights up.

If you then turn the stage 3 mode switch from STOP to NORMAL, it immediately goes to stage-4 and plays all stages sequentially from there.

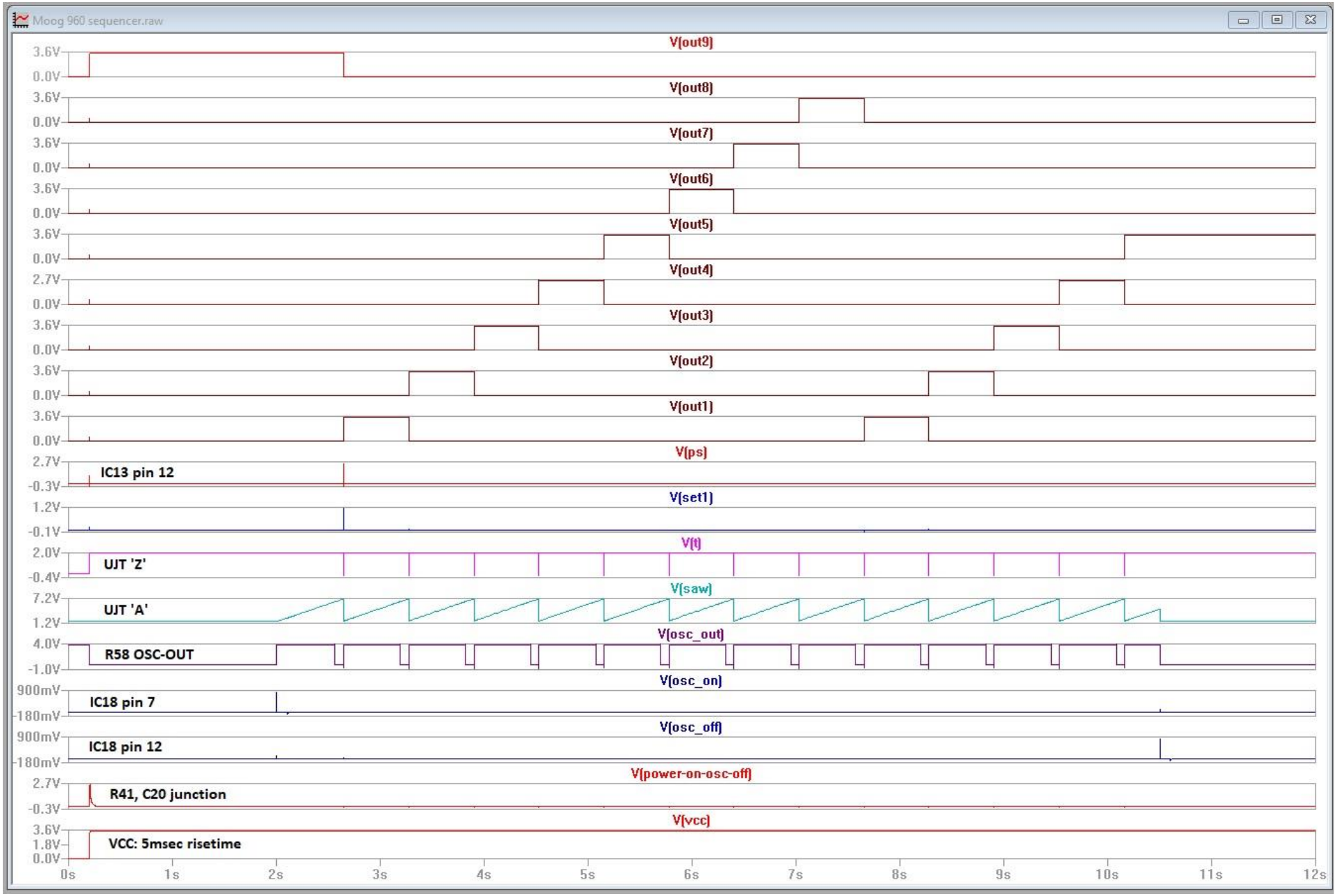
One thing to make clear: when stage-9 is active, all row outputs send out 0 volts, there are no voltage pots for stage-9, it is simply a stage for the sequencer to come to rest at, so that **when you push play, it starts correctly on stage 1.**

LTSPICE timings 21 - SKIP-NORMAL-STOP test circuit

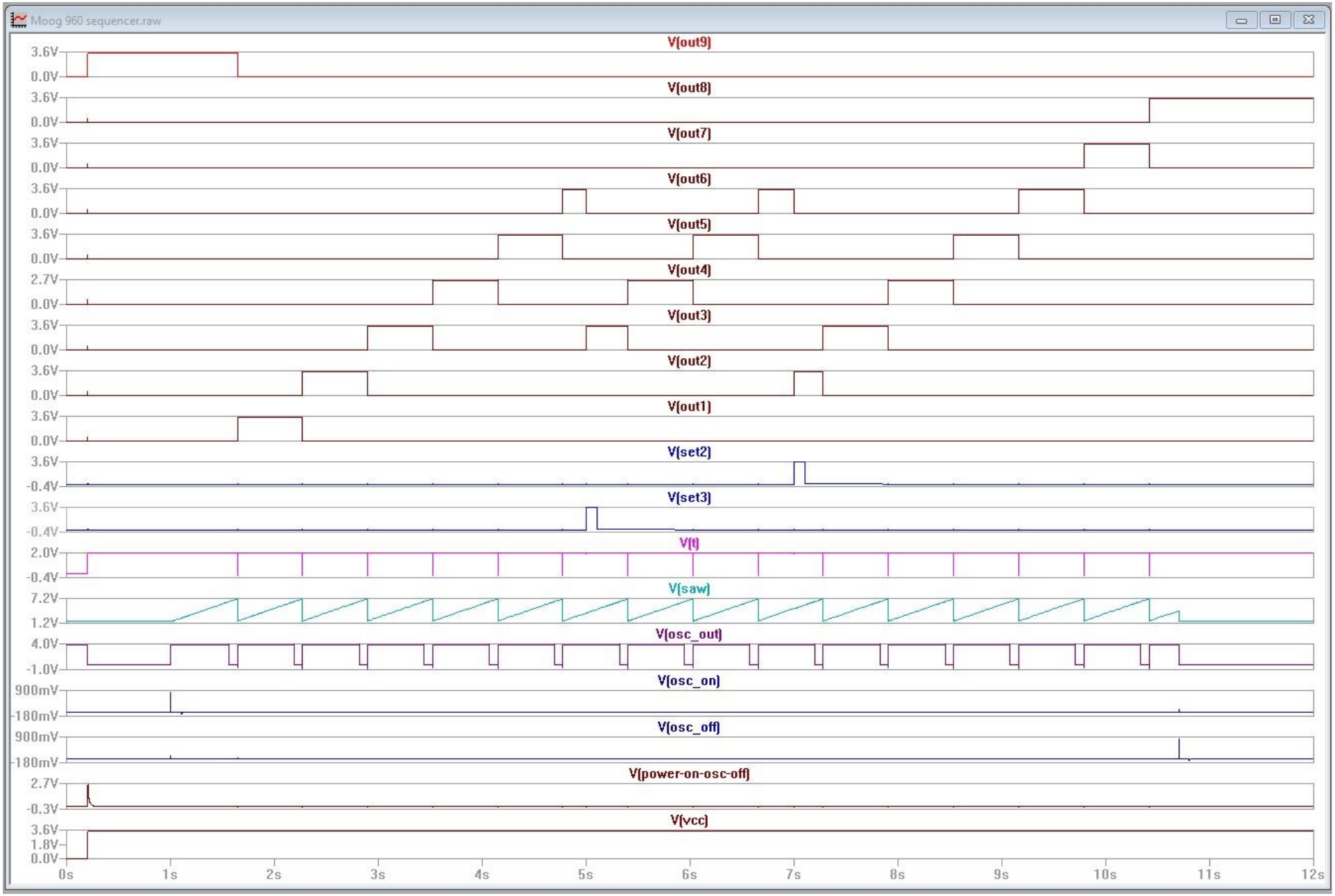


LTSPICE timings next page..

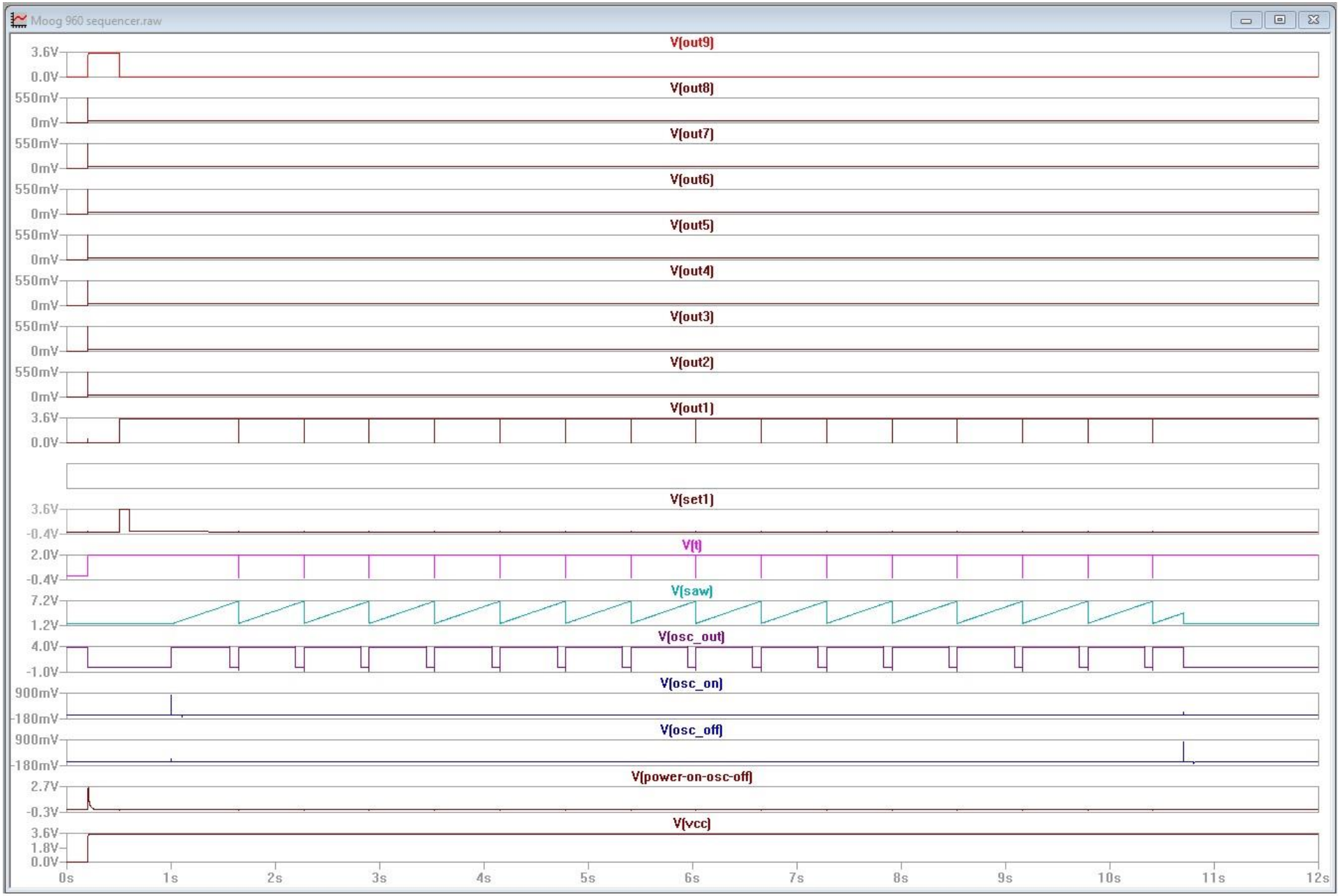
LTSPICE timings 1 - normal sequence



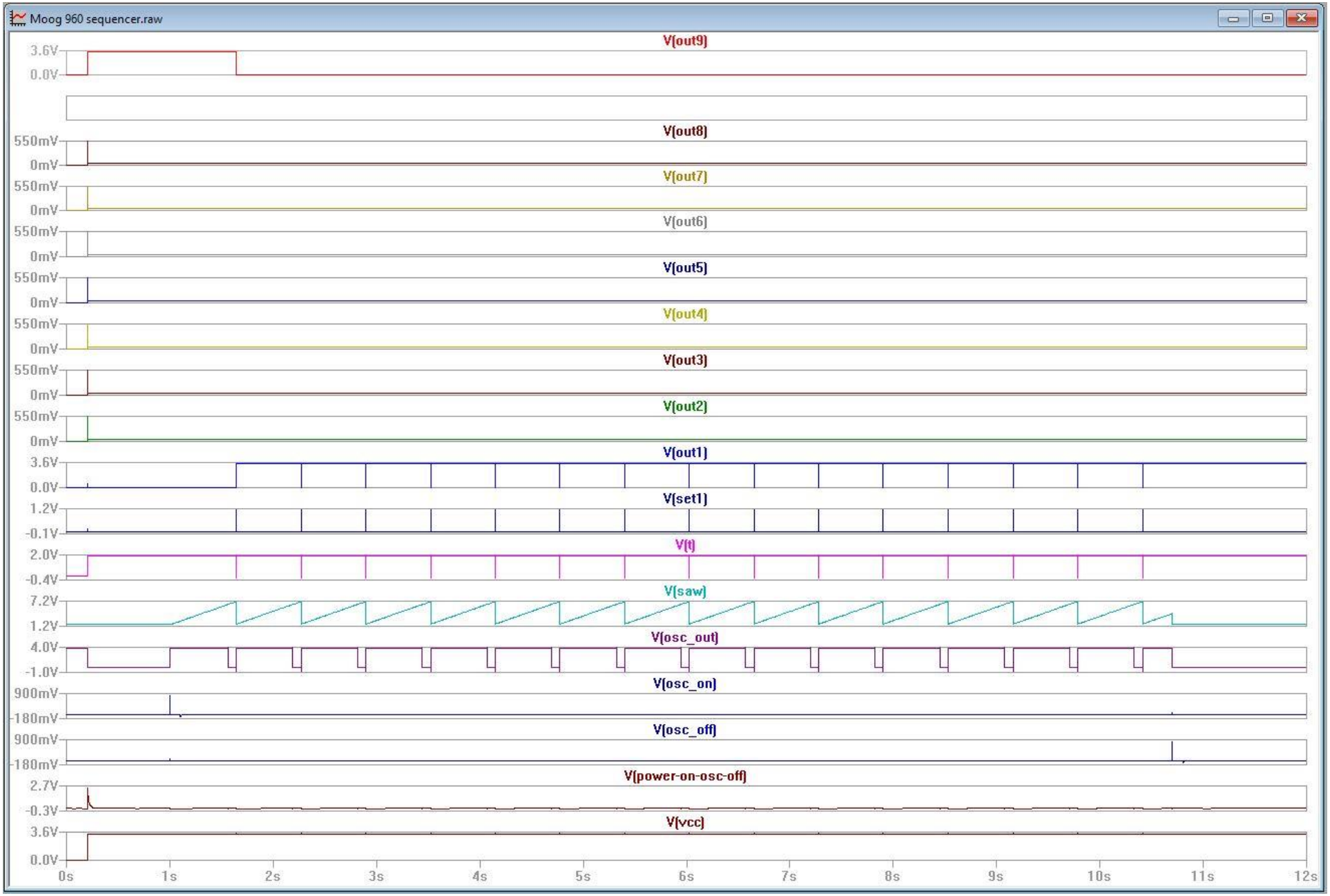
LTSPICE timings 2 - SET3 then SET2



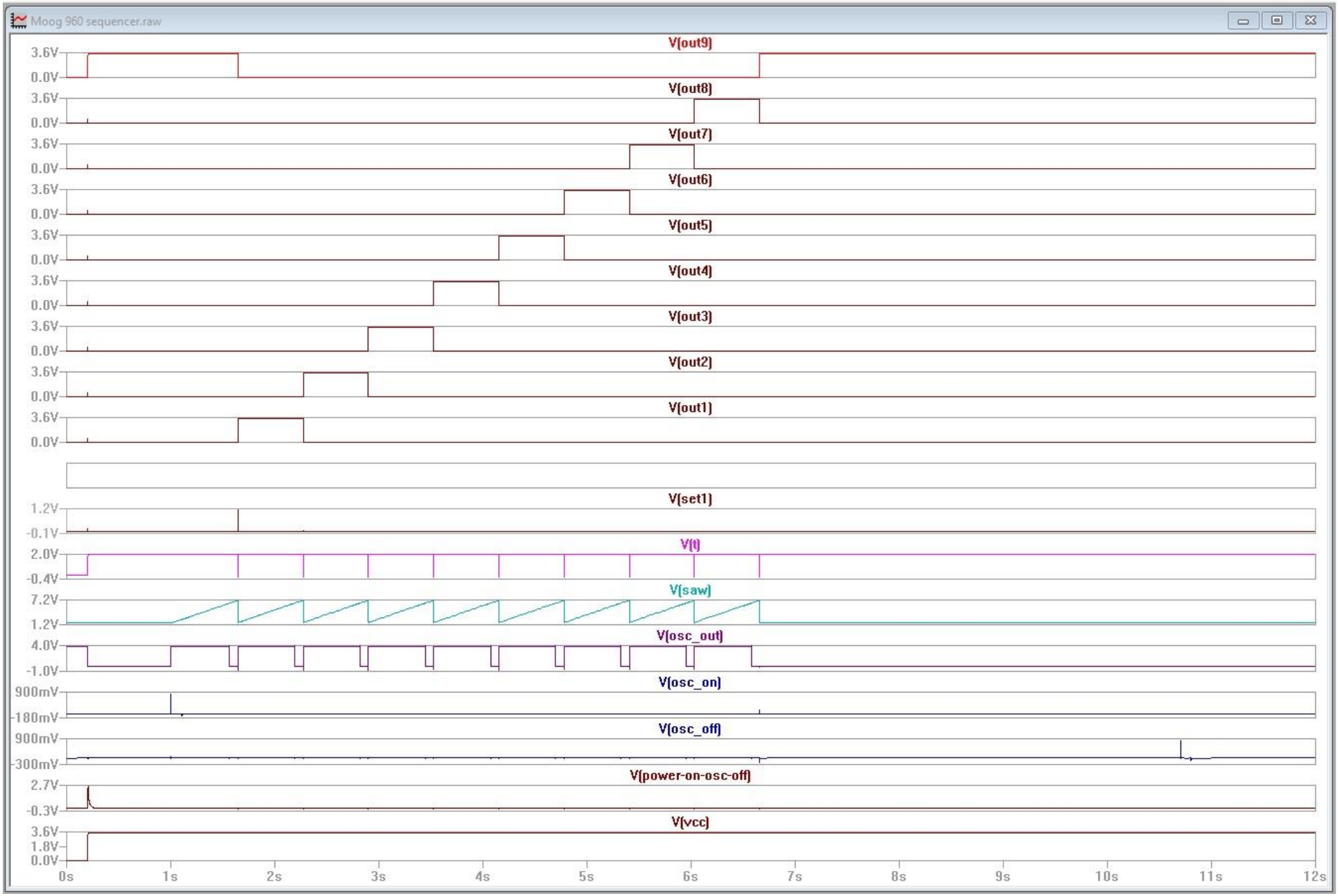
LTSPICE timings 3 - SET1 at start and Stage 1 in SKIP



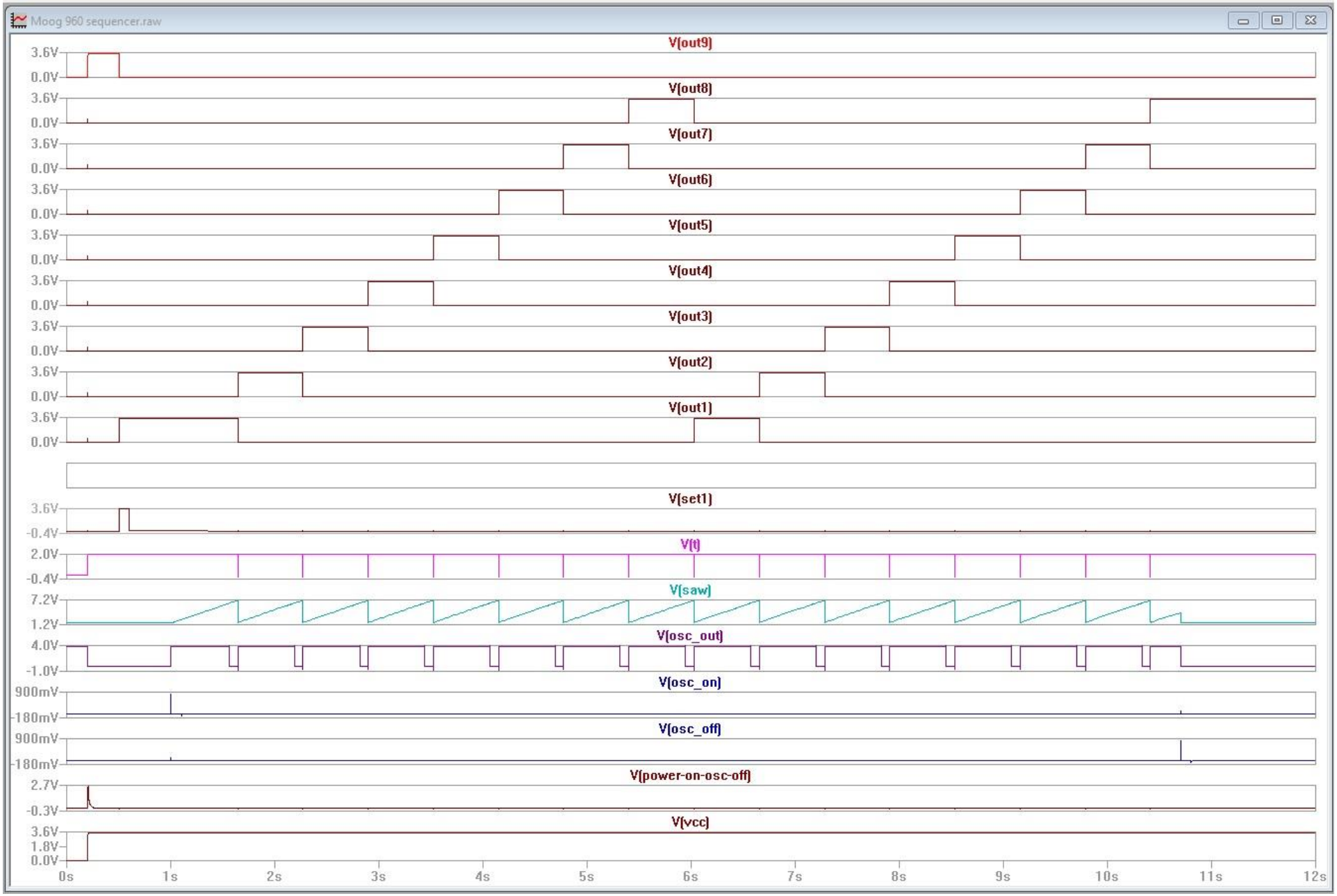
LTSPICE timings 3A - No SET and Start at Stage 1 in SKIP



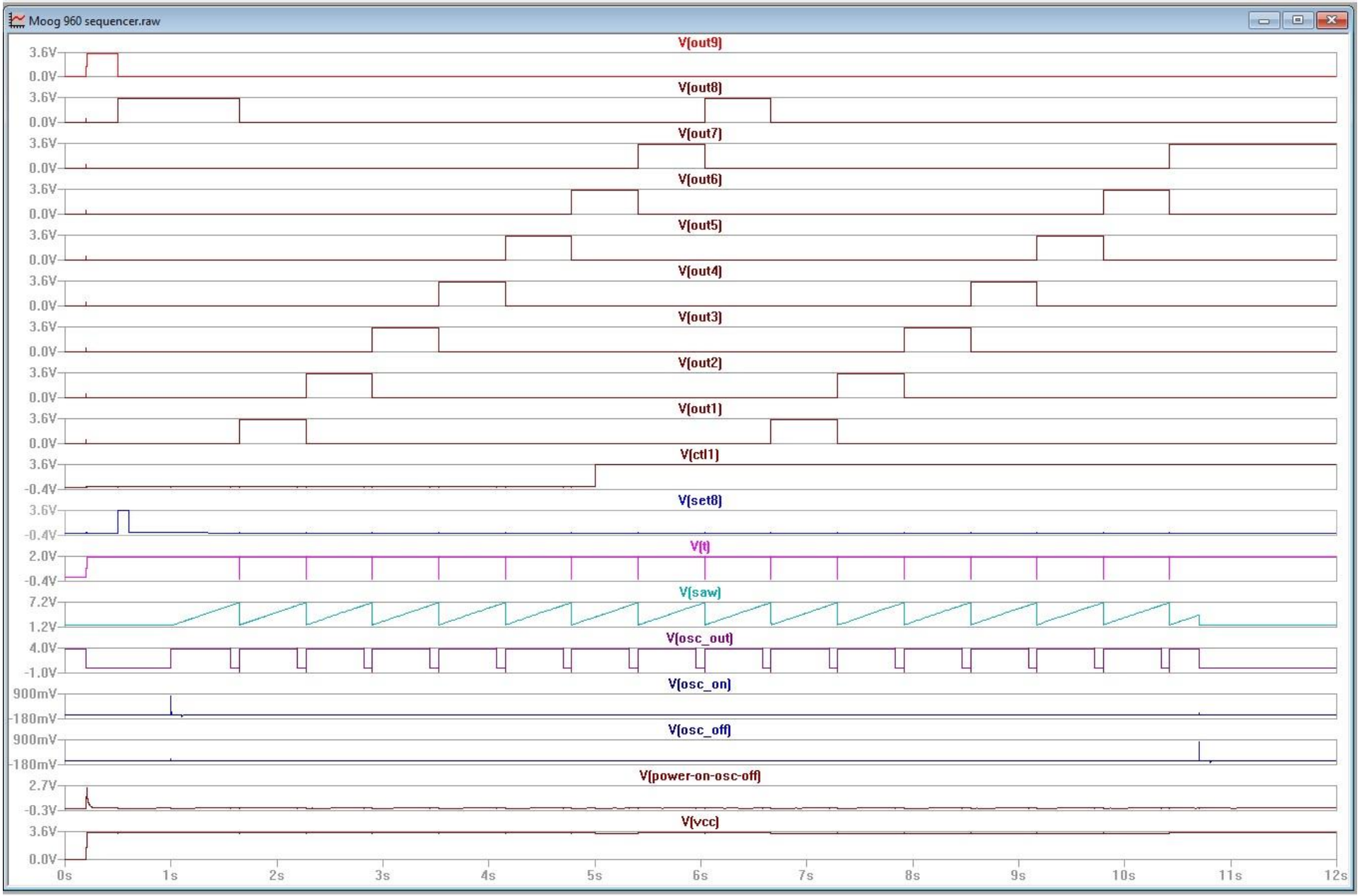
LTSPICE timings 4 - normal timings but stage 9 is in STOP



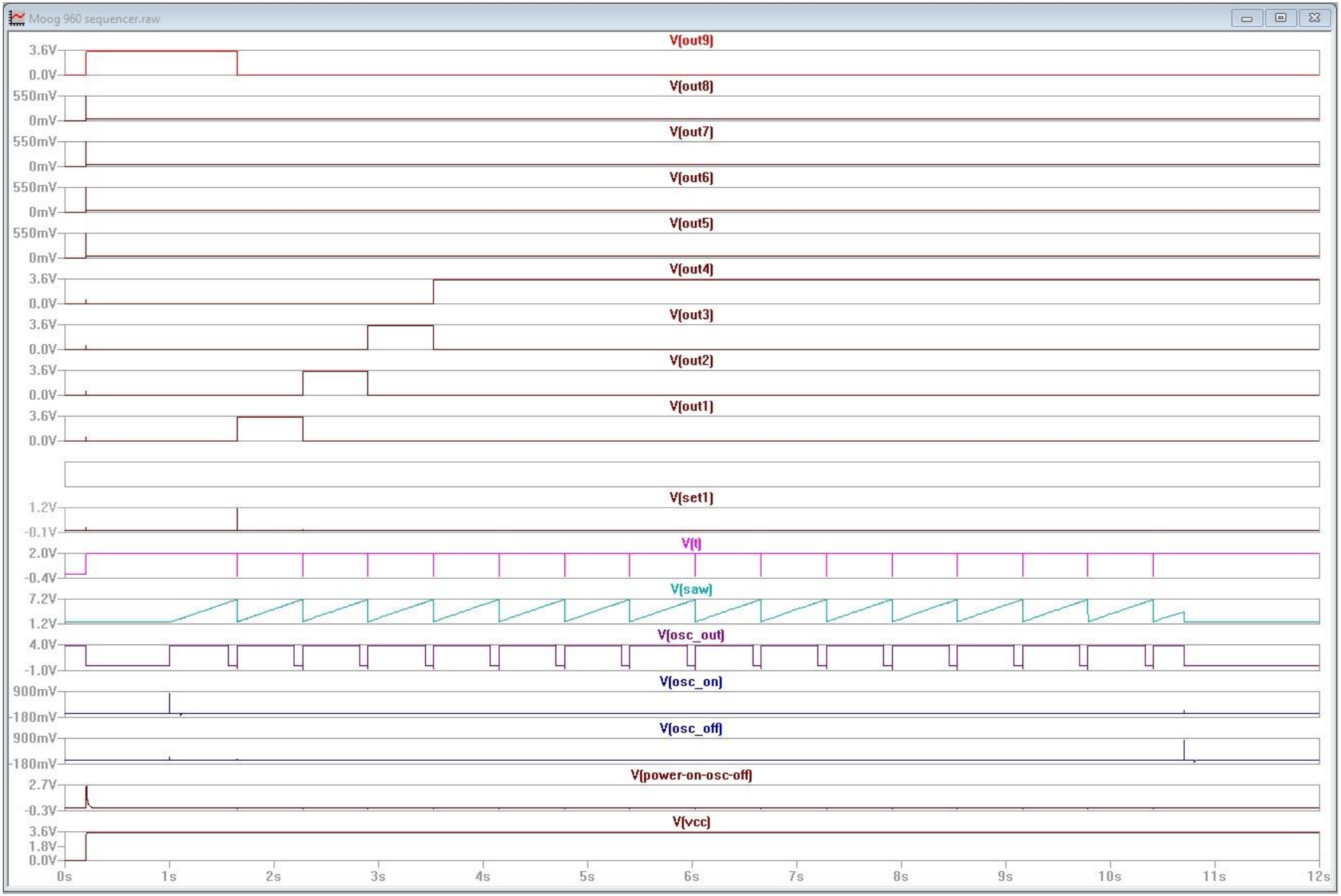
LTSPICE timings 5 - normal timings but SET1 before clock started



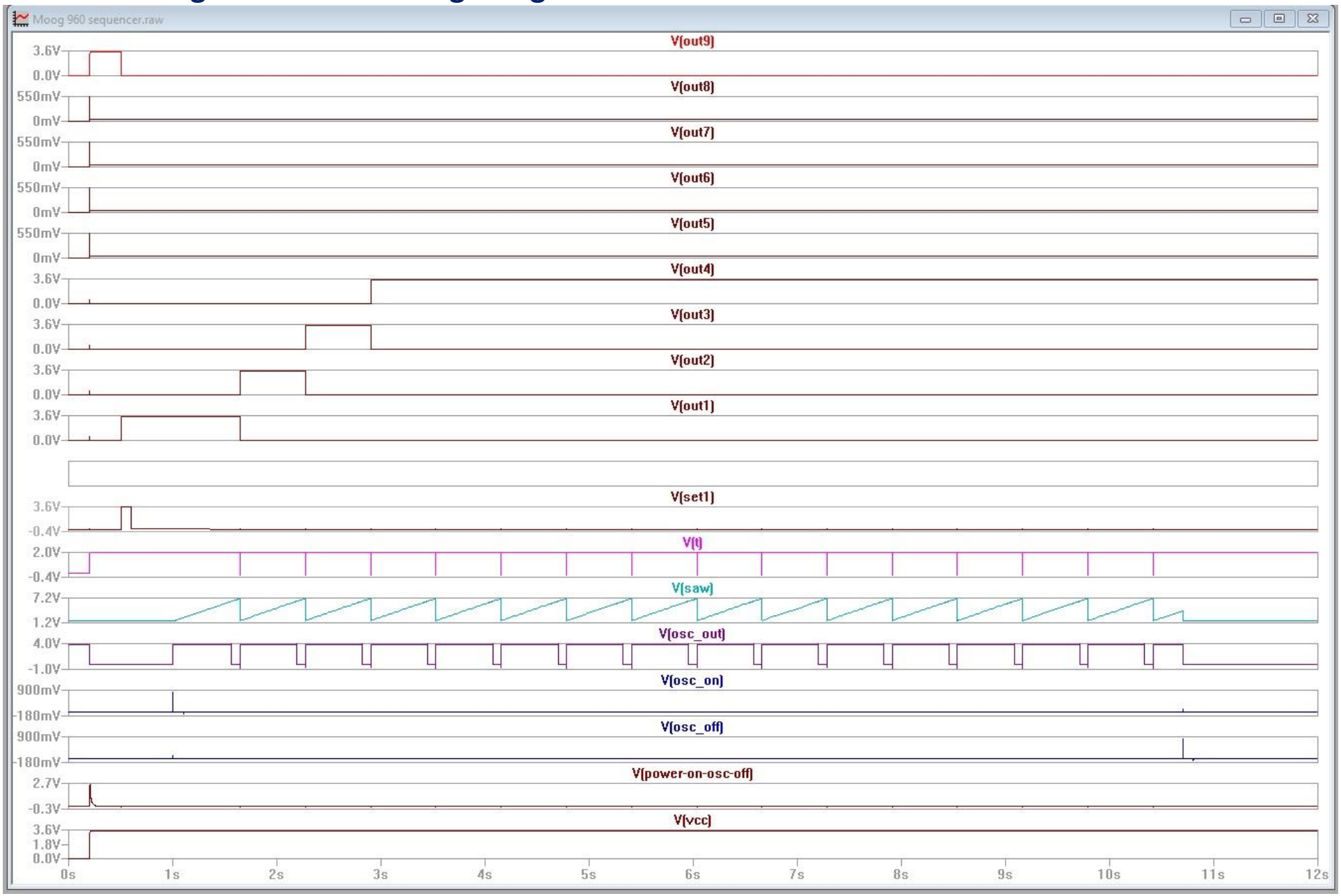
LTSPICE timings 6 - normal timings but SET8 before clock started



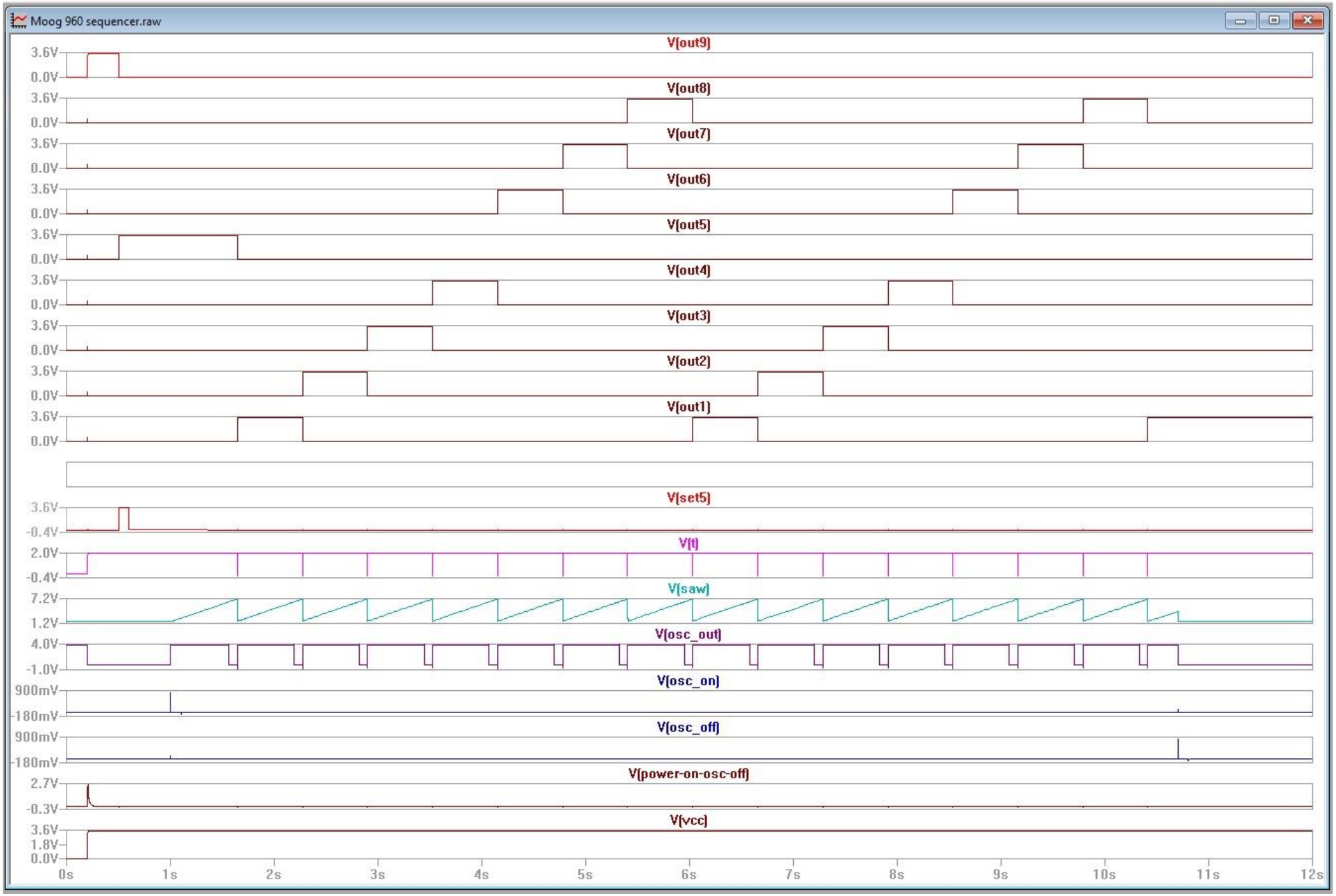
LTSPICE timings 7 - normal timings Stage 4 in STOP but no SET before clock started



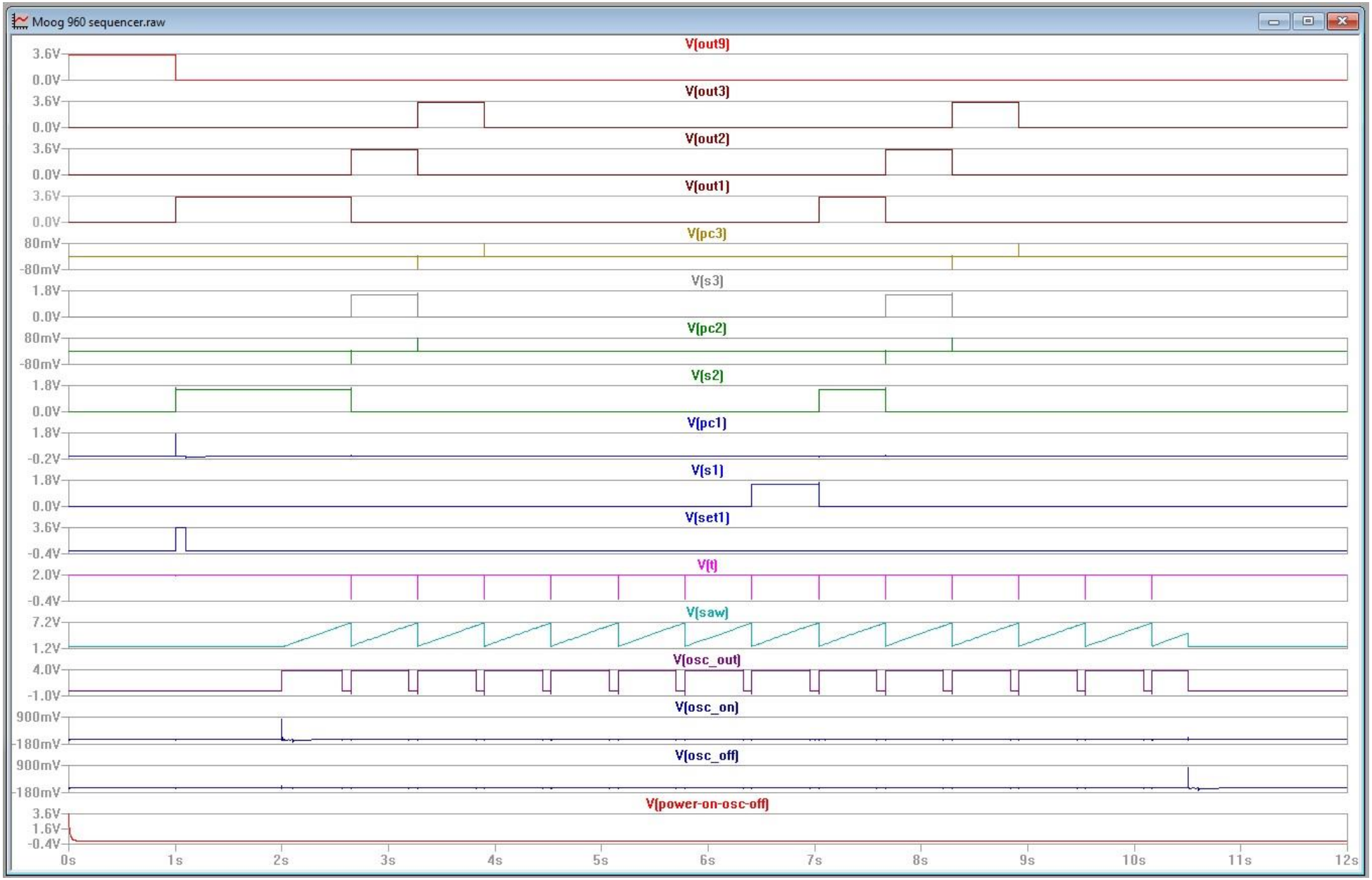
LTSPICE timings 8 - normal timings Stage 4 in STOP but SET1 before clock started



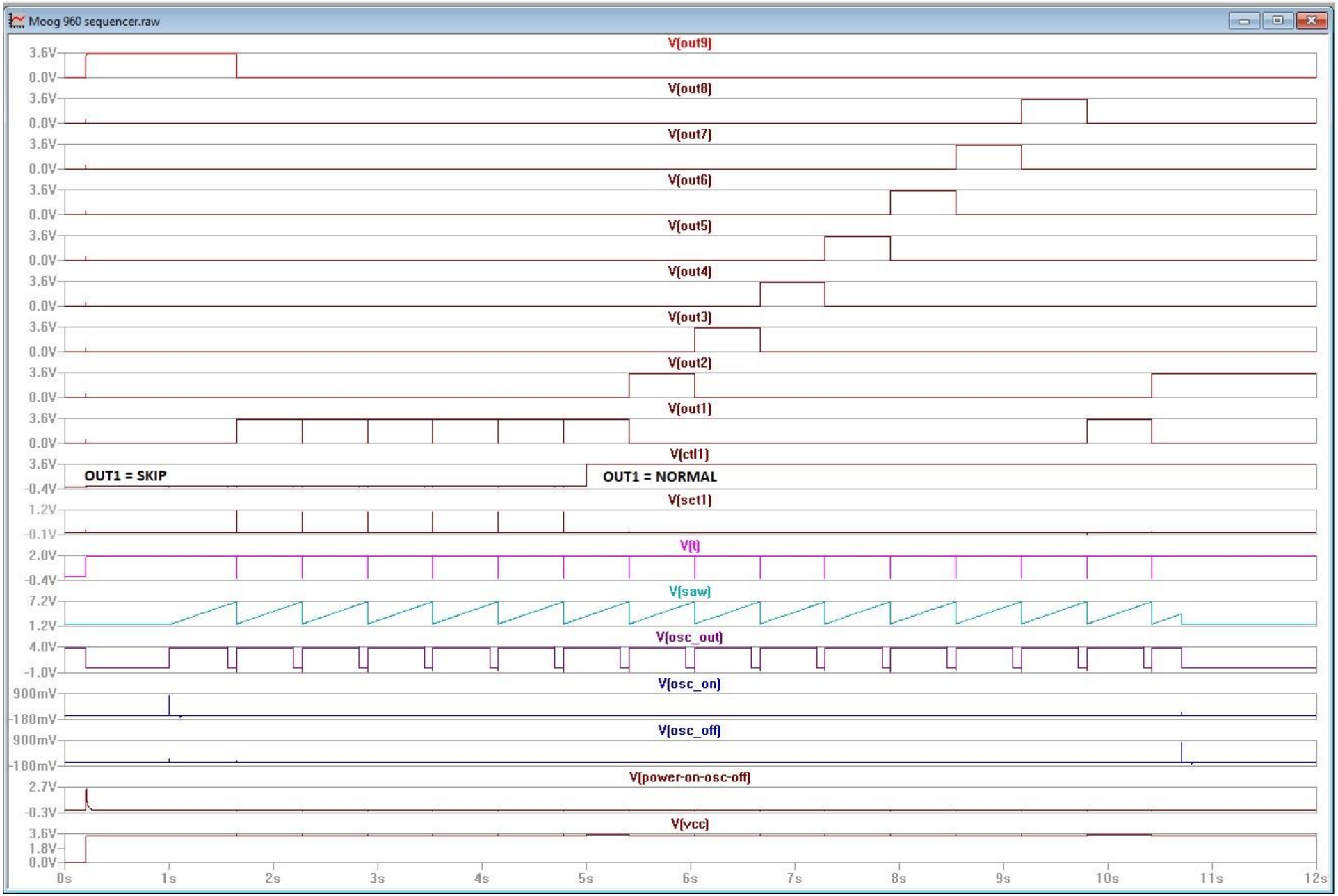
LTSPICE timings 9 - normal timings SET5 before clock started & stage 5 is in SKIP



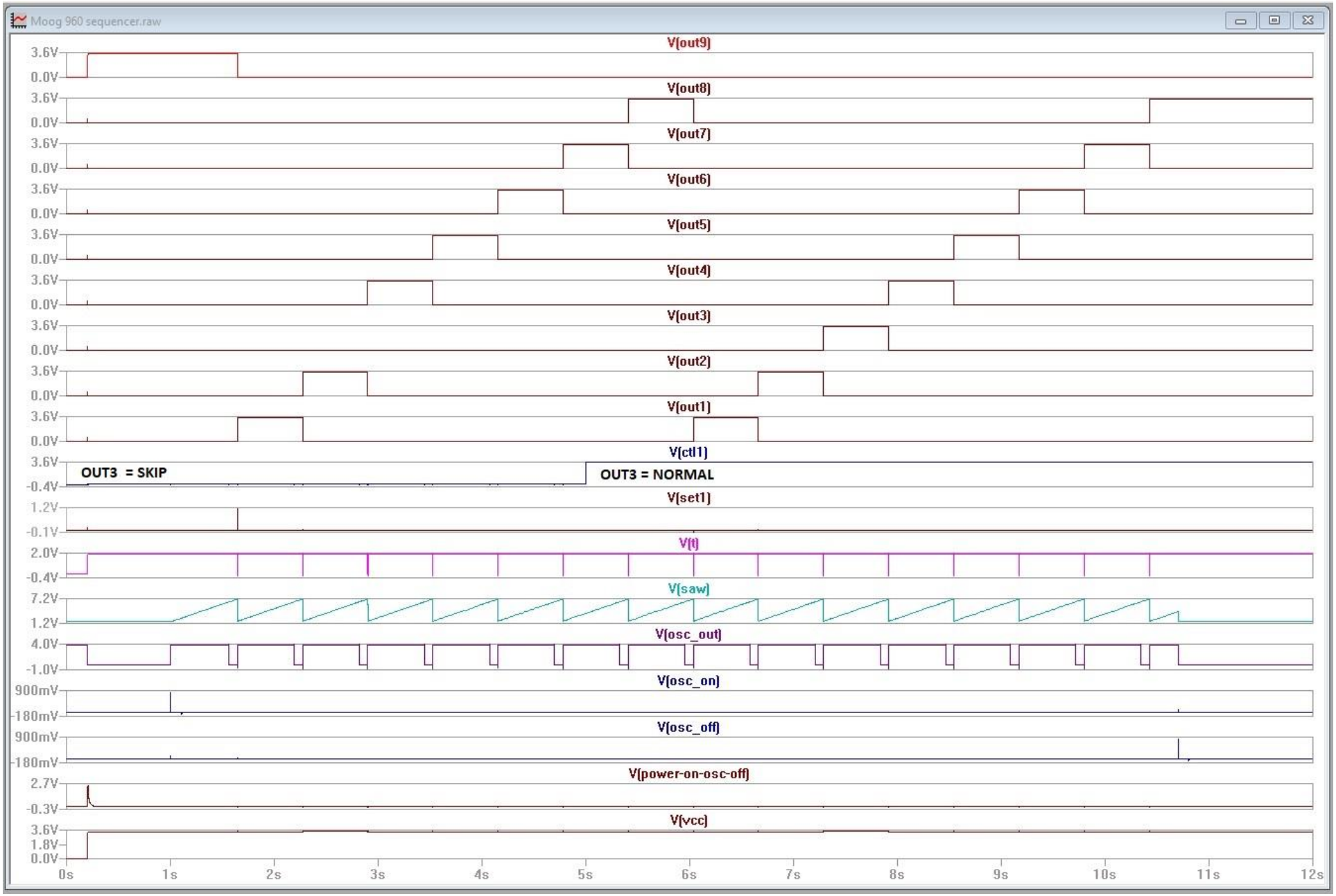
LTSPICE timings 10 - normal timings SET1 before clock started PS-PC-S-T flip-flop



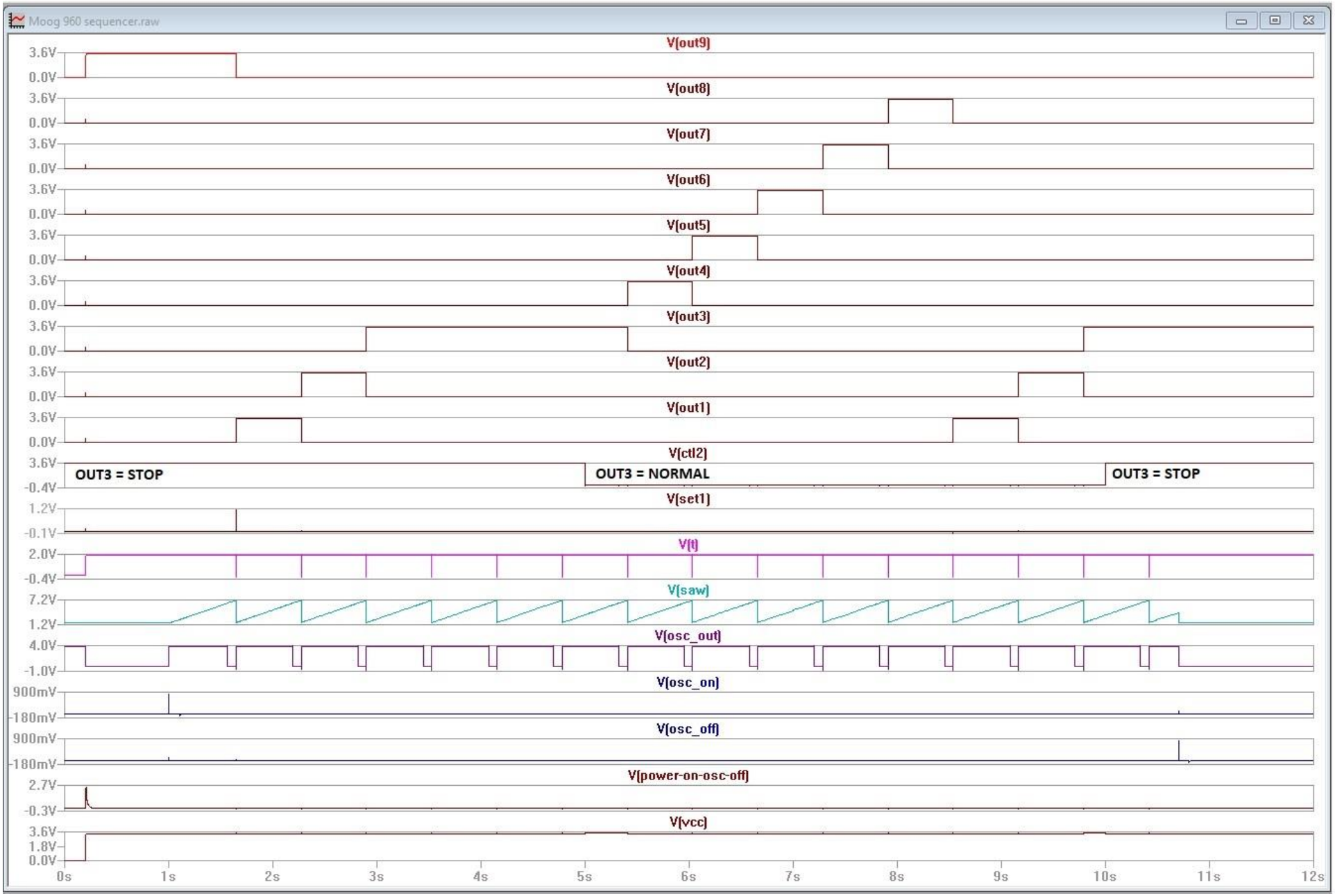
LTSPICE timings 11 - start at stage 1 in SKIP then in NORMAL on next sequence



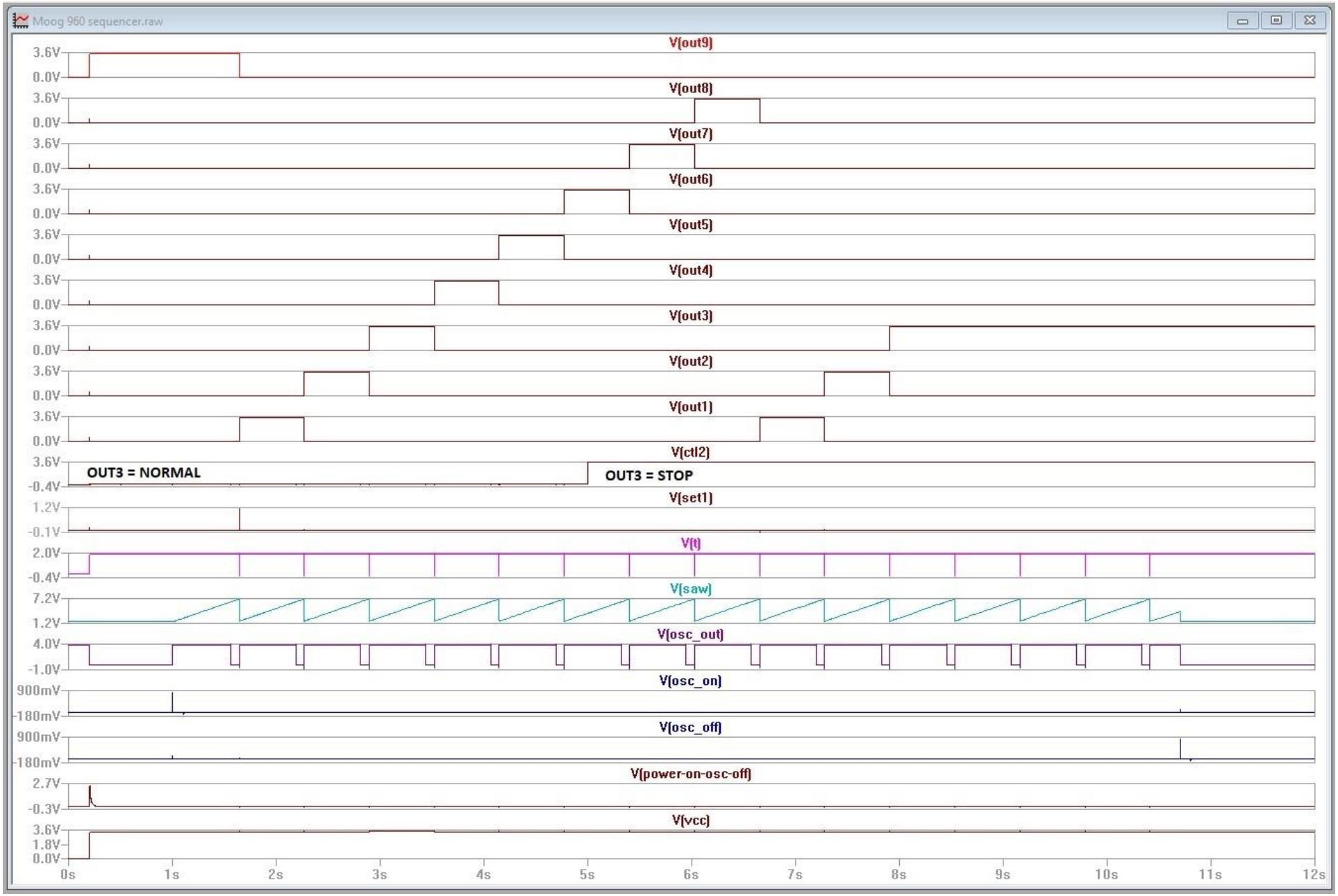
LTSPICE timings 12 - normal timings but Stage 3 in SKIP then in NORMAL on next sequence



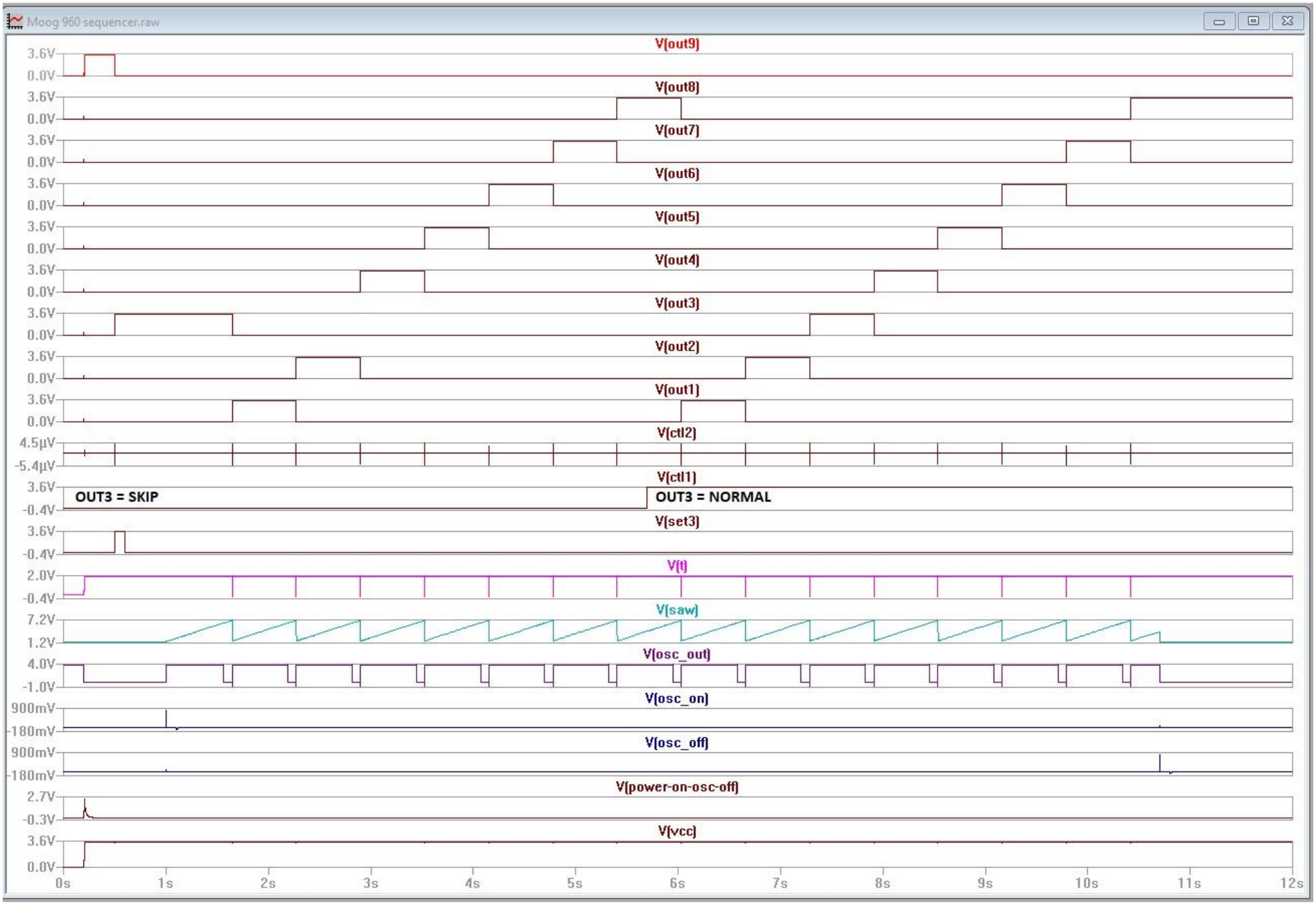
LTSPICE timings 13 - normal timings but Stage 3 in STOP then NORMAL then STOP



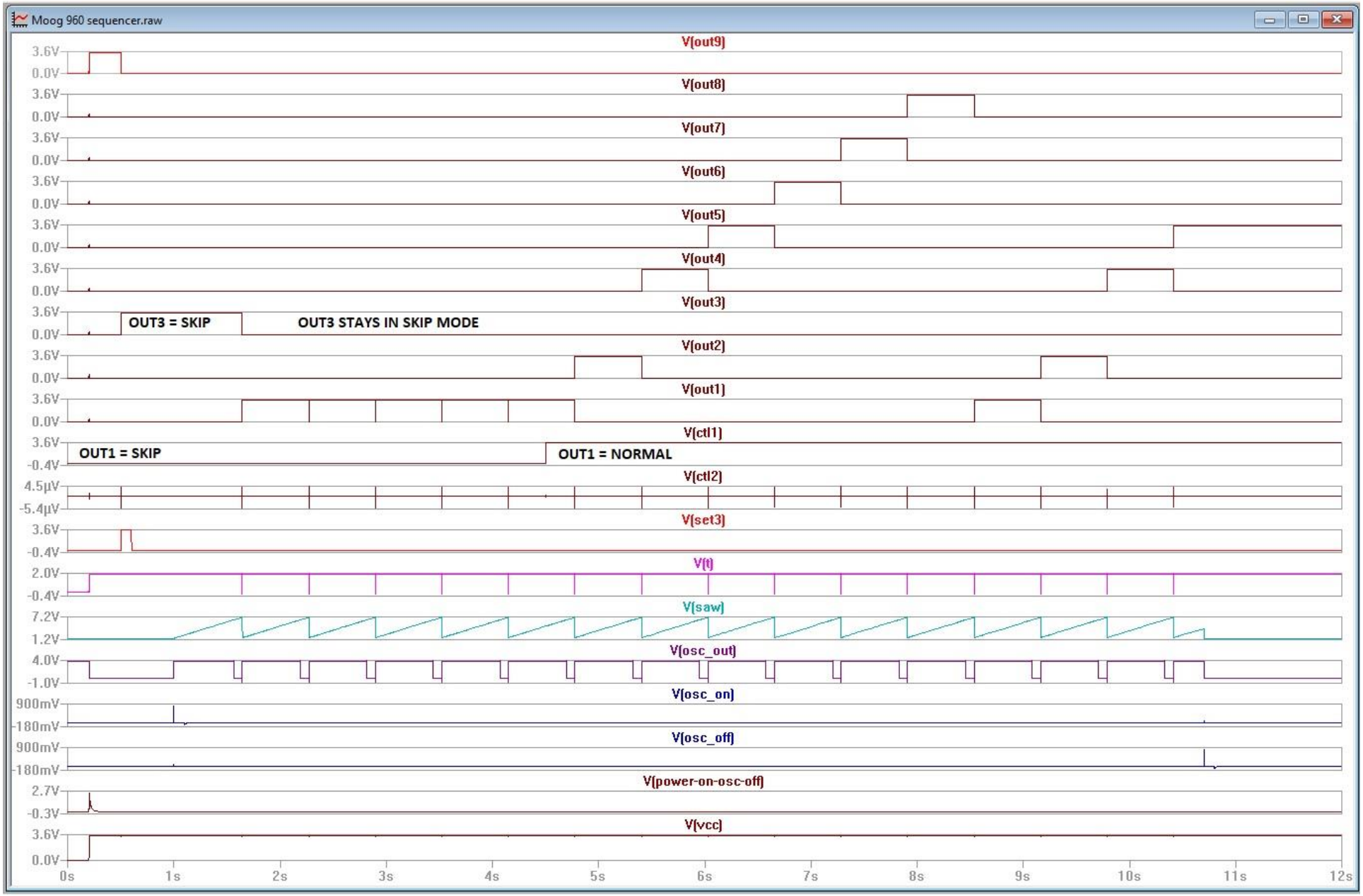
LTSPICE timings 14 - normal timings but Stage 3 in NORMAL then STOP on next sequence



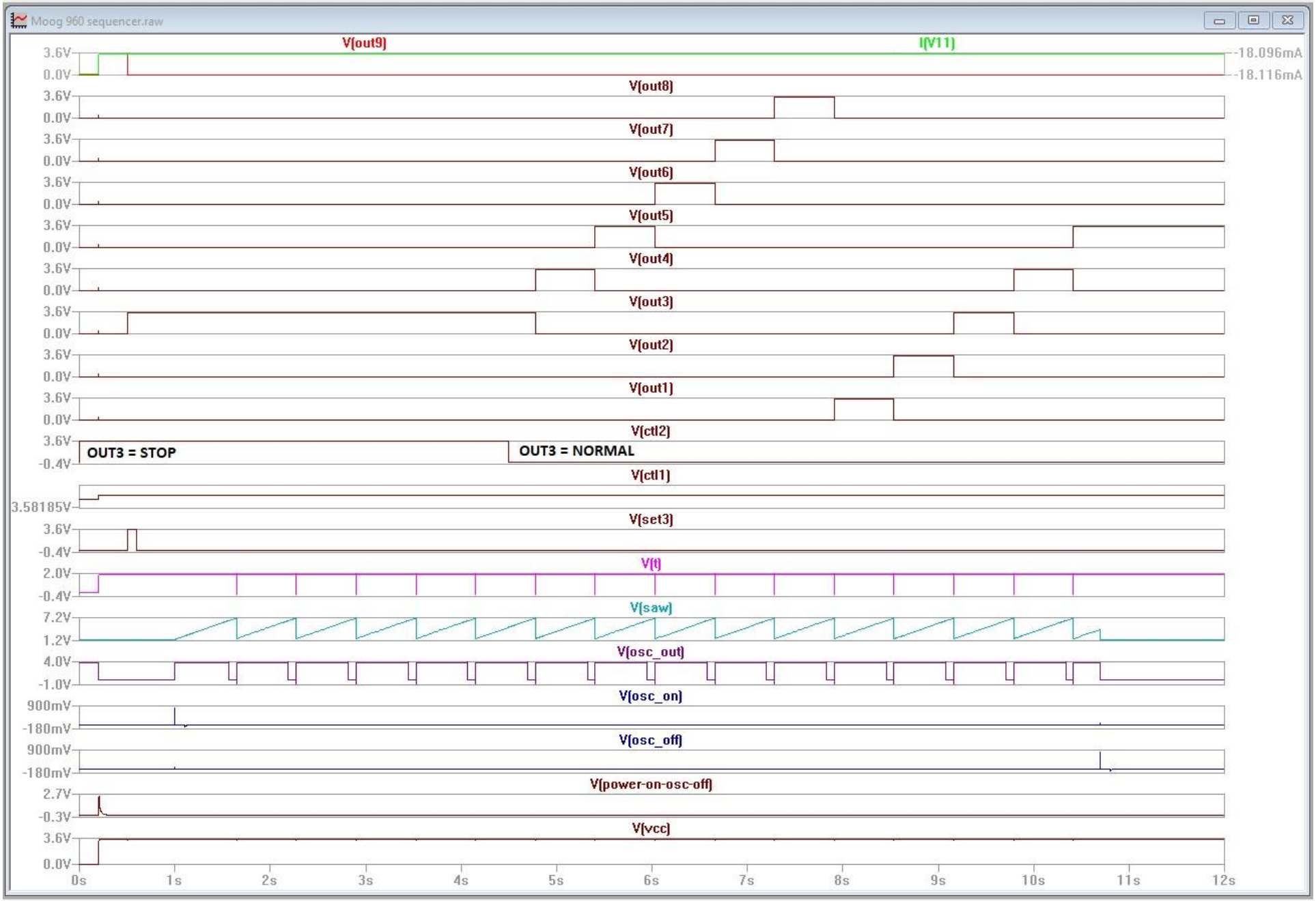
LTSPICE timings 15 - SET3 at start and Stage 3 in SKIP then NORMAL on next sequence



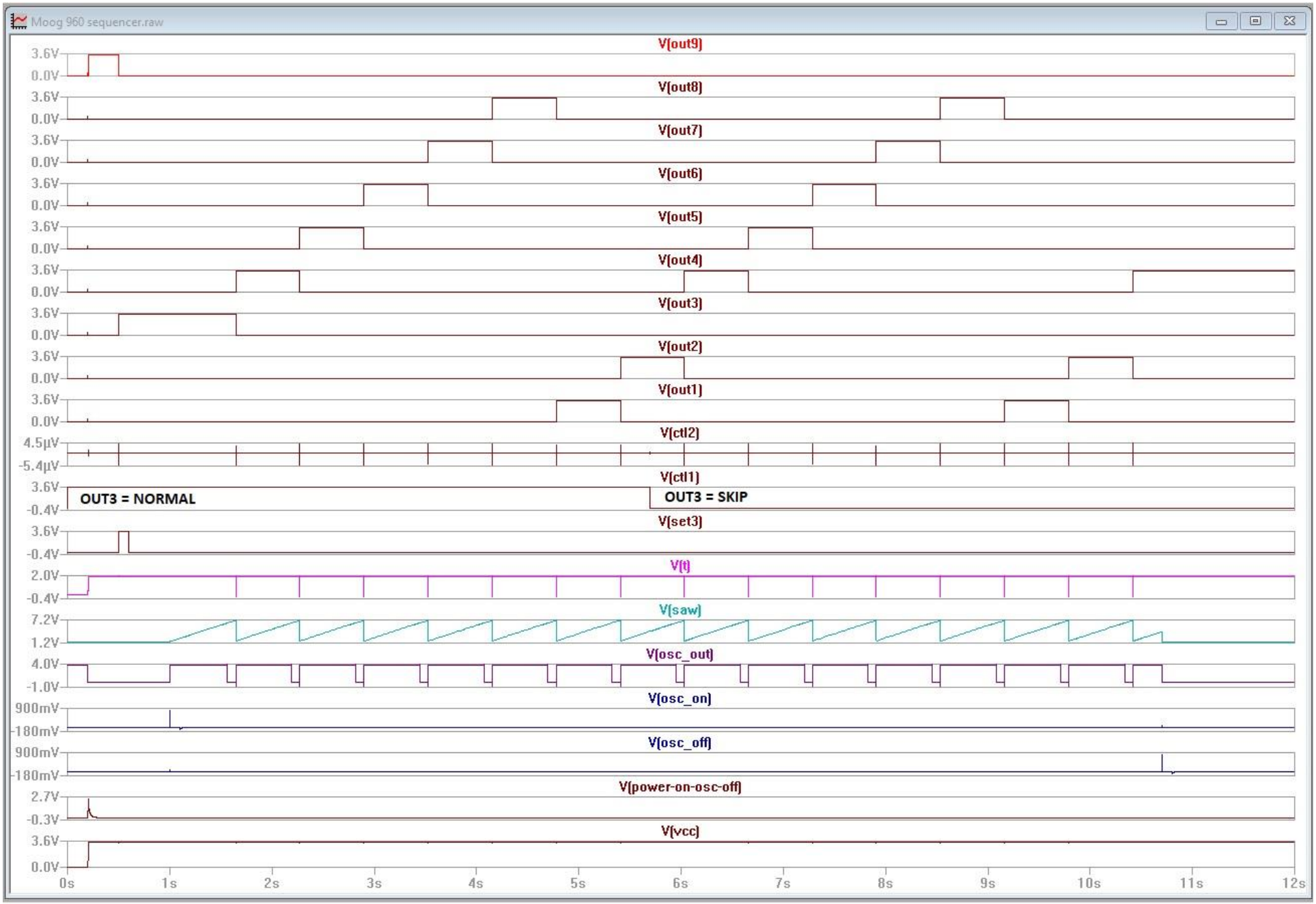
LTSPICE timings 16 - SET3 at start and Stages 1+3 in SKIP then Stage 1 NORMAL on next sequence



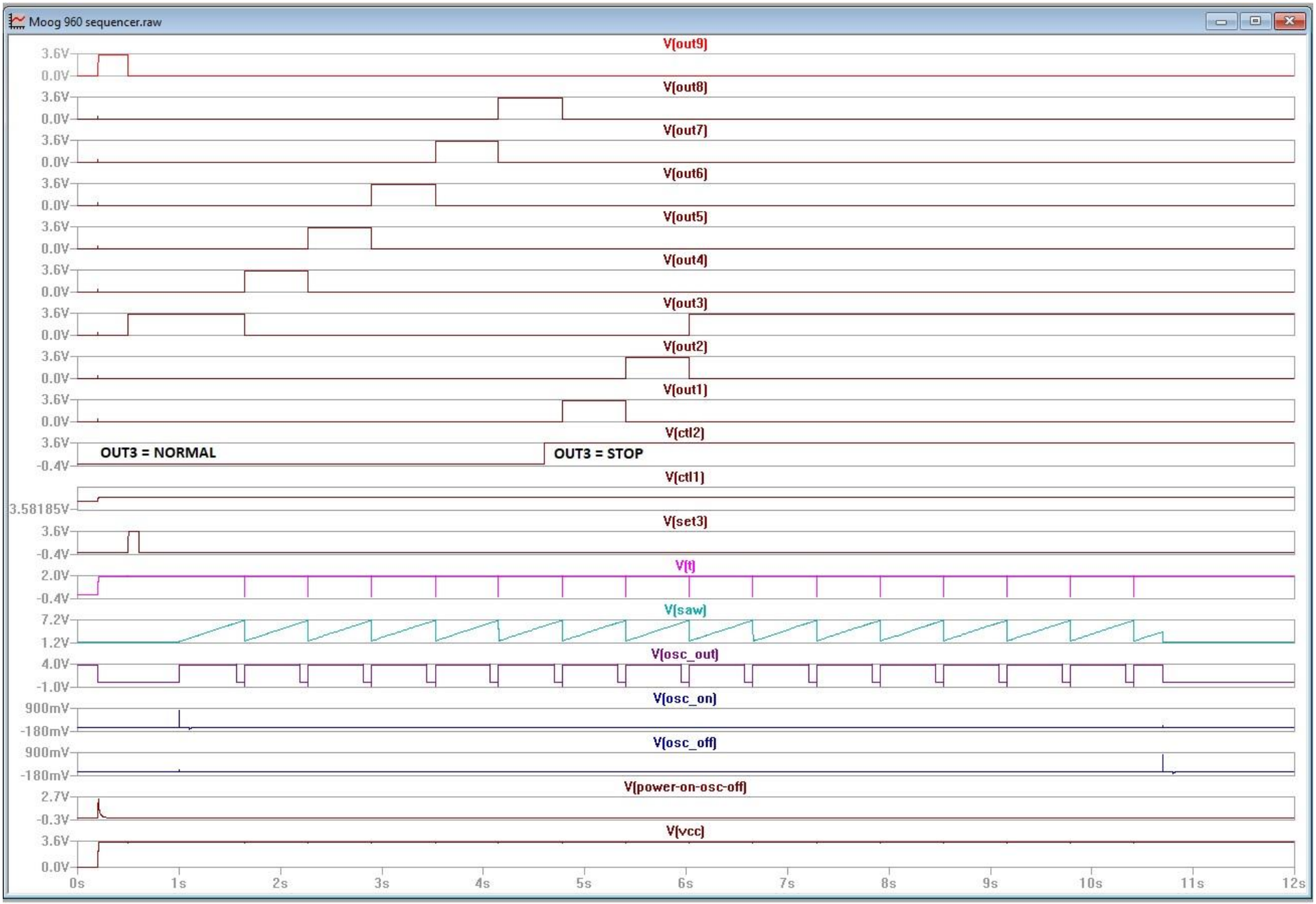
LTSPICE timings 17 - SET3 at start and Stage 3 in STOP then NORMAL on next sequence



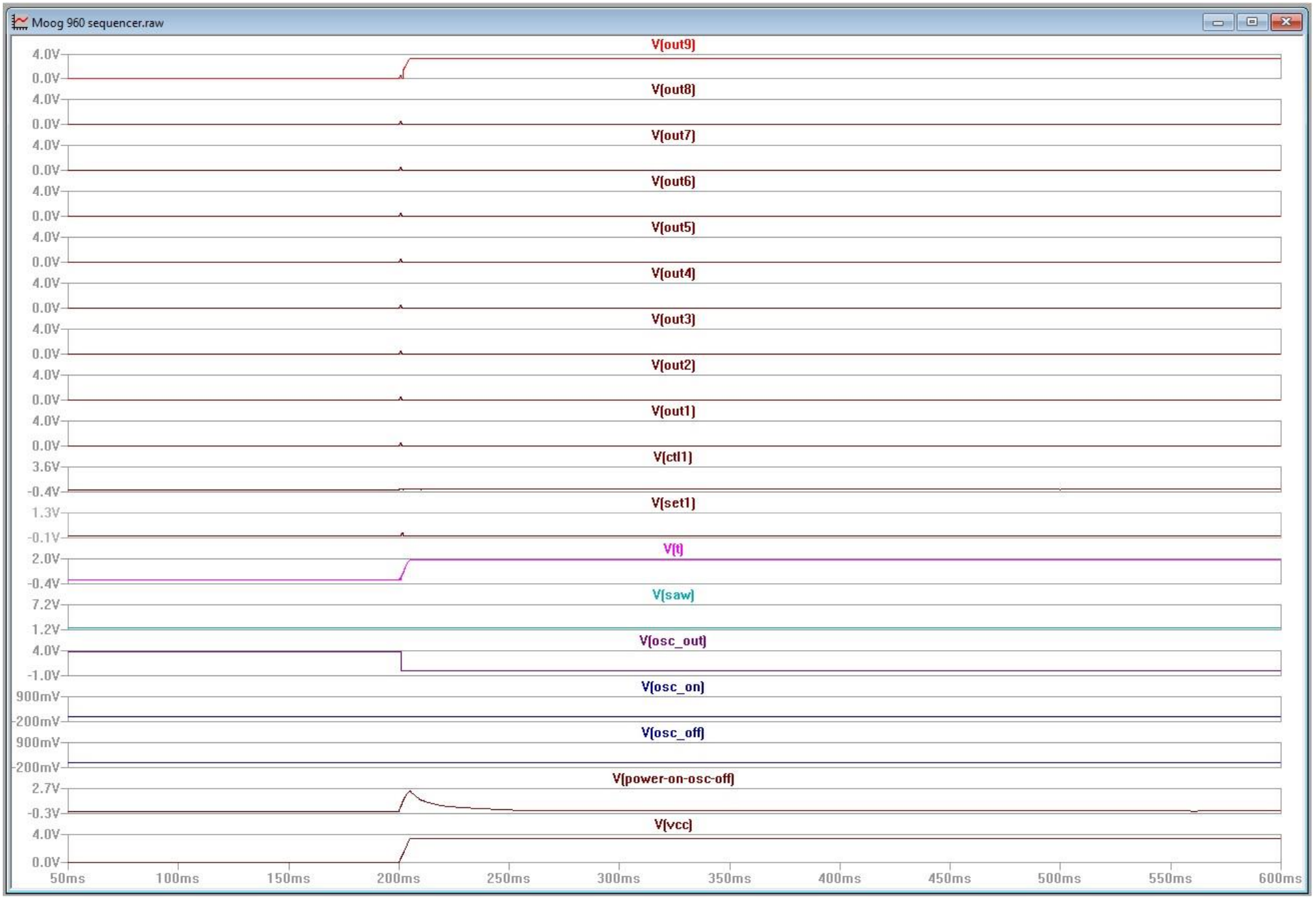
LTSPICE timings 18 - SET3 at start and Stage 3 in NORMAL then SKIP on next sequence



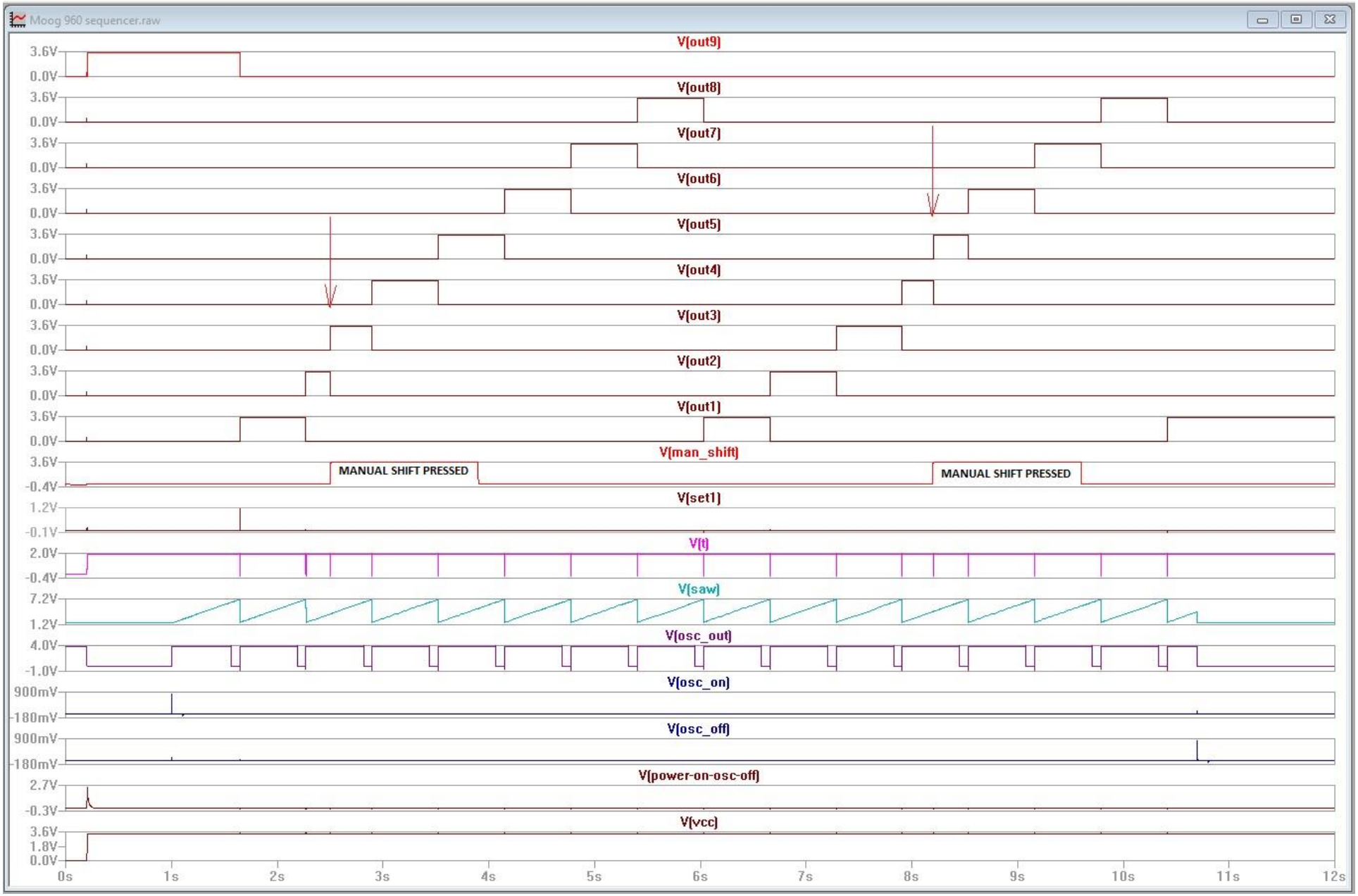
LTSPICE timings 19 - SET3 at start and Stage 3 in NORMAL then STOP on next sequence



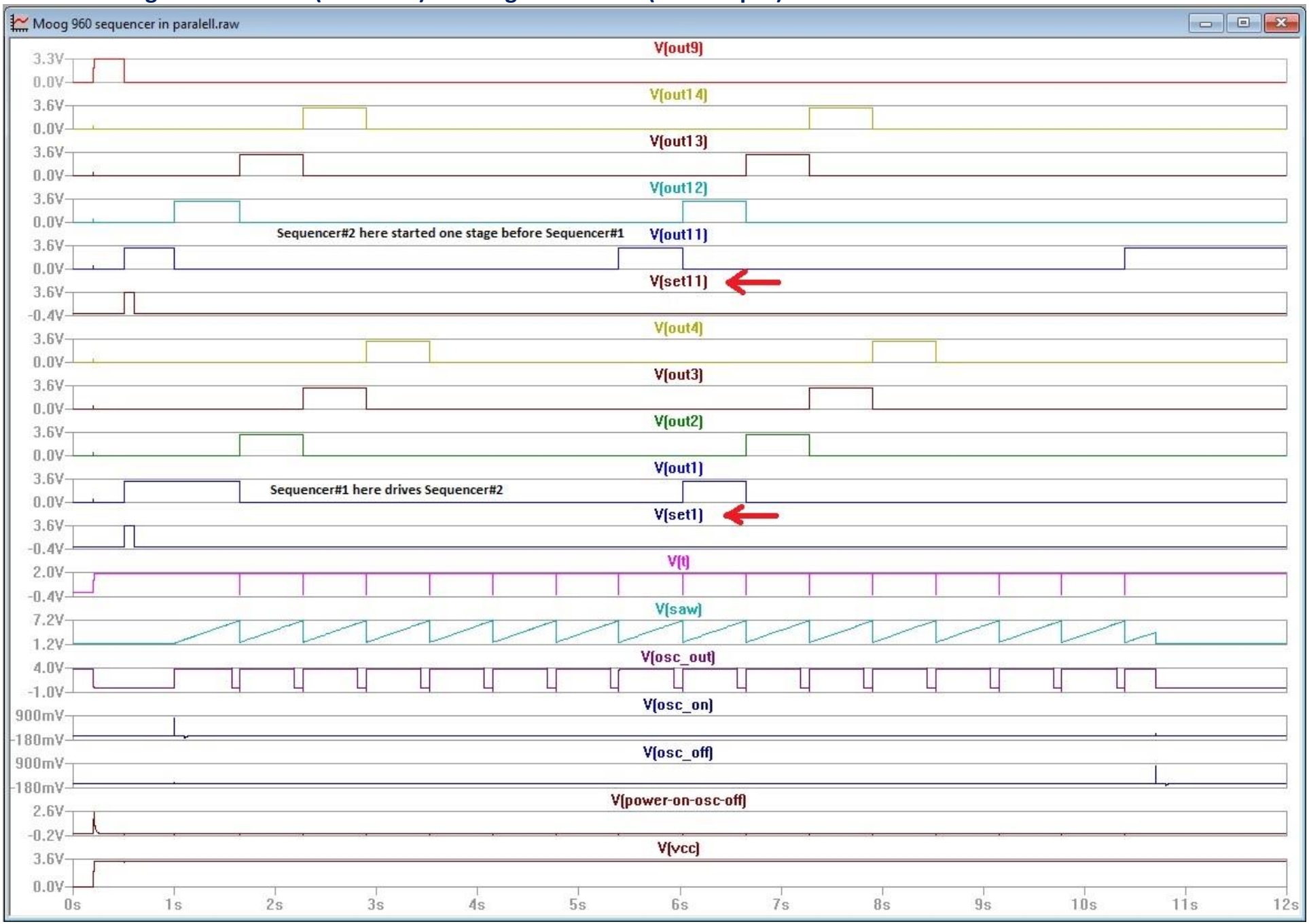
LTSPICE timings 20 - Start timings of POWER-UP pulse and PS pulse



LTSPICE timings 22 - Manual Shift button pressed twice



LTSPICE timings 23 - First 960 (OSC-OUT) clocking second 960 (SHIFT input) both first to SET1 before clock started



LTSPICE timings 24 - First 960 (OSC-OUT) clocking second 960 (SHIFT input) first SET1 and second SET8 before clock started