# Is It Time To Rethink the SPICE Input "Language?"

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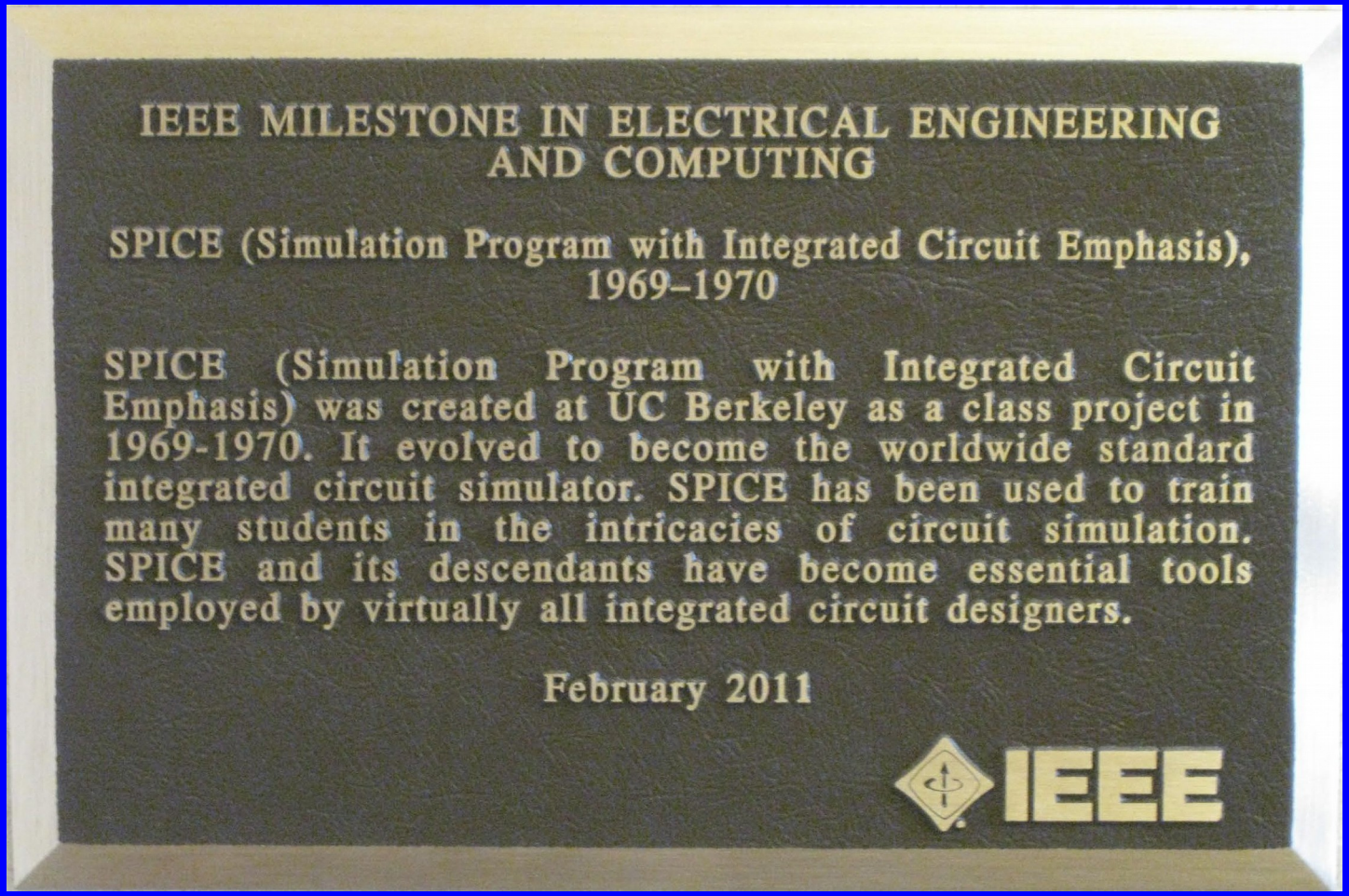
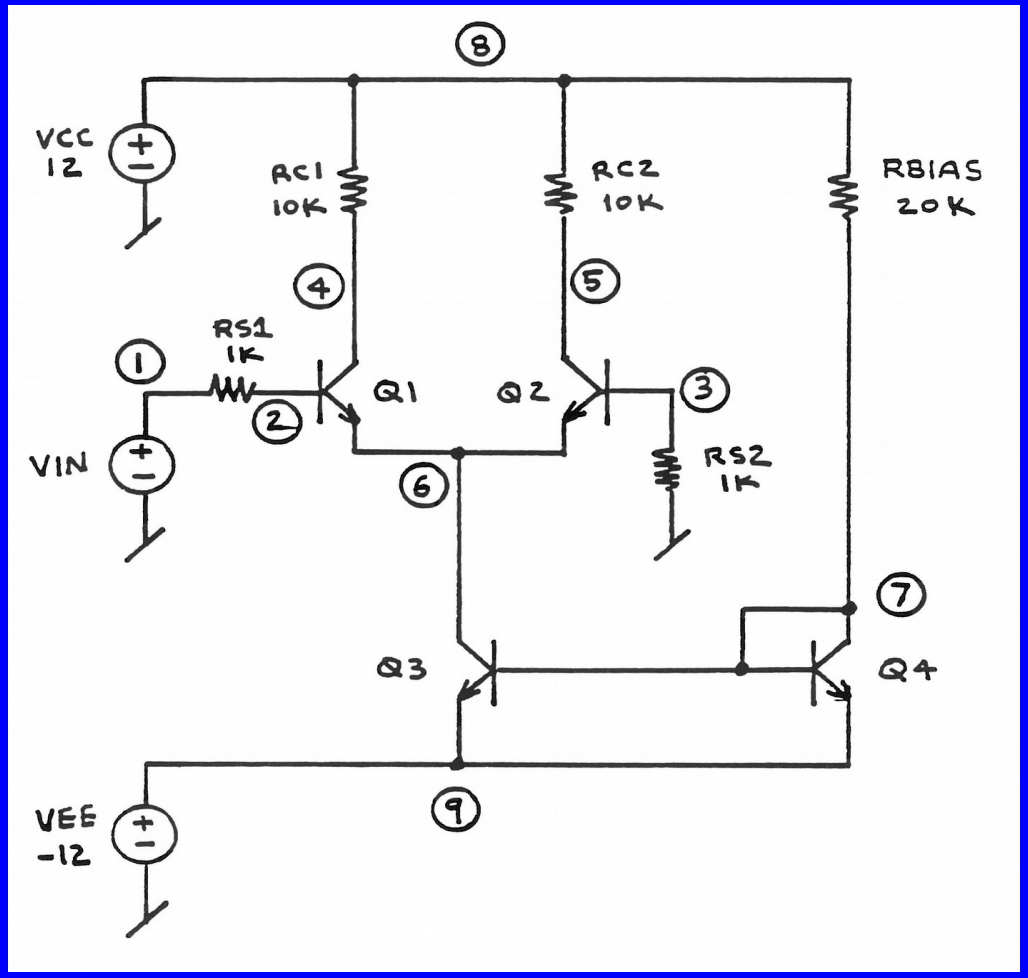
# Simulation Program with Integrated Circuit Emphasis (SPICE)



# Simulation Program with Integrated Circuit Emphasis (SPICE)

- SPICE is a computer tool that allows an engineer to simulate a circuit (predict how a circuit will work without building and testing the circuit)
- The input is a circuit schematic, or a netlist describing the schematic in textual form
- The output is whatever circuit voltages and currents the engineer wants to know
- SPICE works for dc, ac and transient time-domain analysis

# SPICE Schematic - Circa 1974



# SPICE Netlist - Circa 1974

```
DIFFPAIR CKT - SIMPLE DIFFERENTIAL PAIR
VIN 1 0 SIN(0 0.1 5MEG 5NS) AC 1
VCC 8 0 12
VEE 9 0 -12
Q1 4 2 6 QNL
Q2 5 3 6 QNL
RS1 1 2 1K
RS2 3 0 1K
RC1 4 8 10K
RC2 5 8 10K
Q3 6 7 9 QNL
Q4 7 7 9 QNL
RBIAS 7 8 20K
.MODEL QNL NPN(BF=80 RB=100 CCS=2PF TF=0.3NS TR=6NS CJE=3PF
+  CJC=2PF VA=50)
.END
```

# SPICE Output - Circa 1974

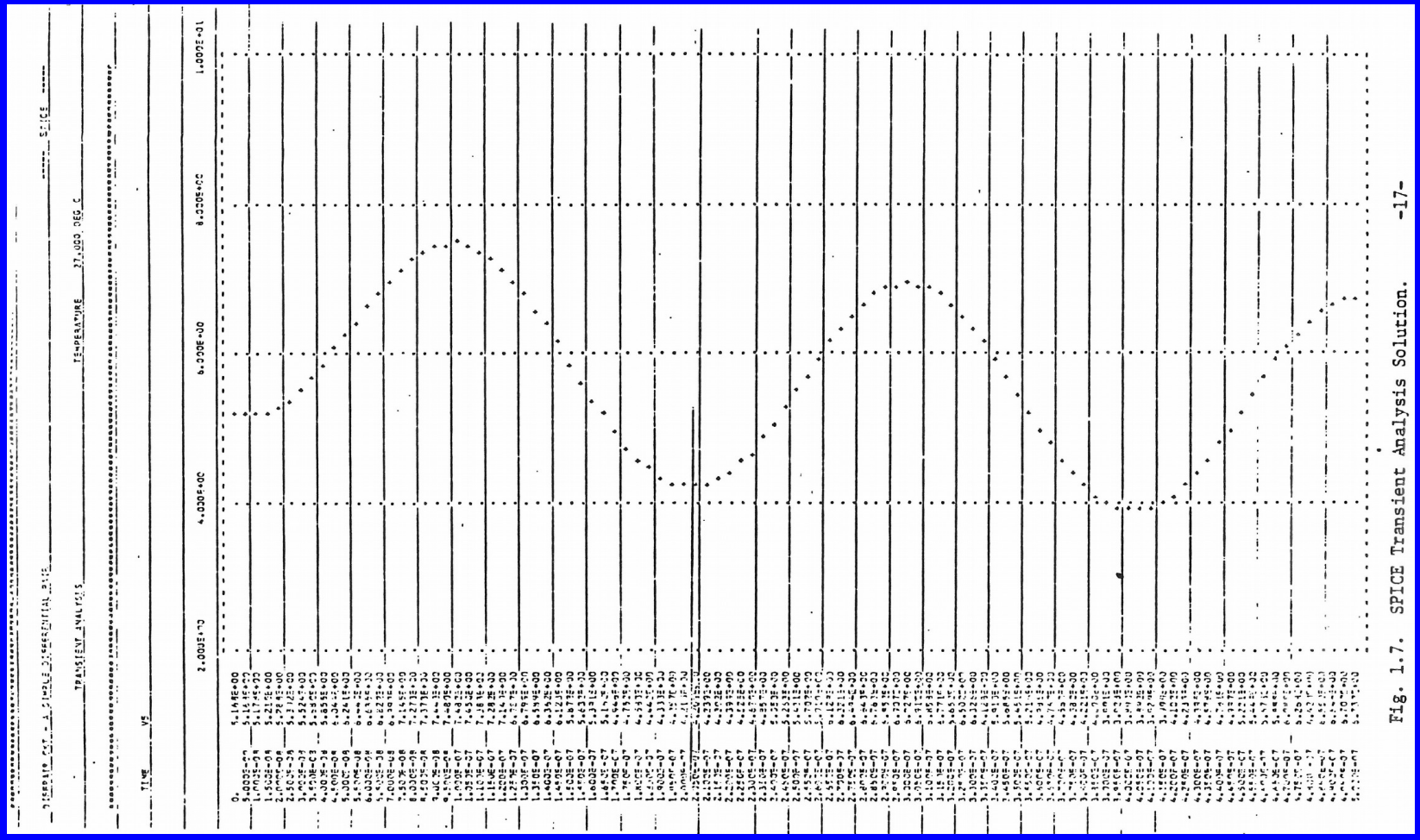
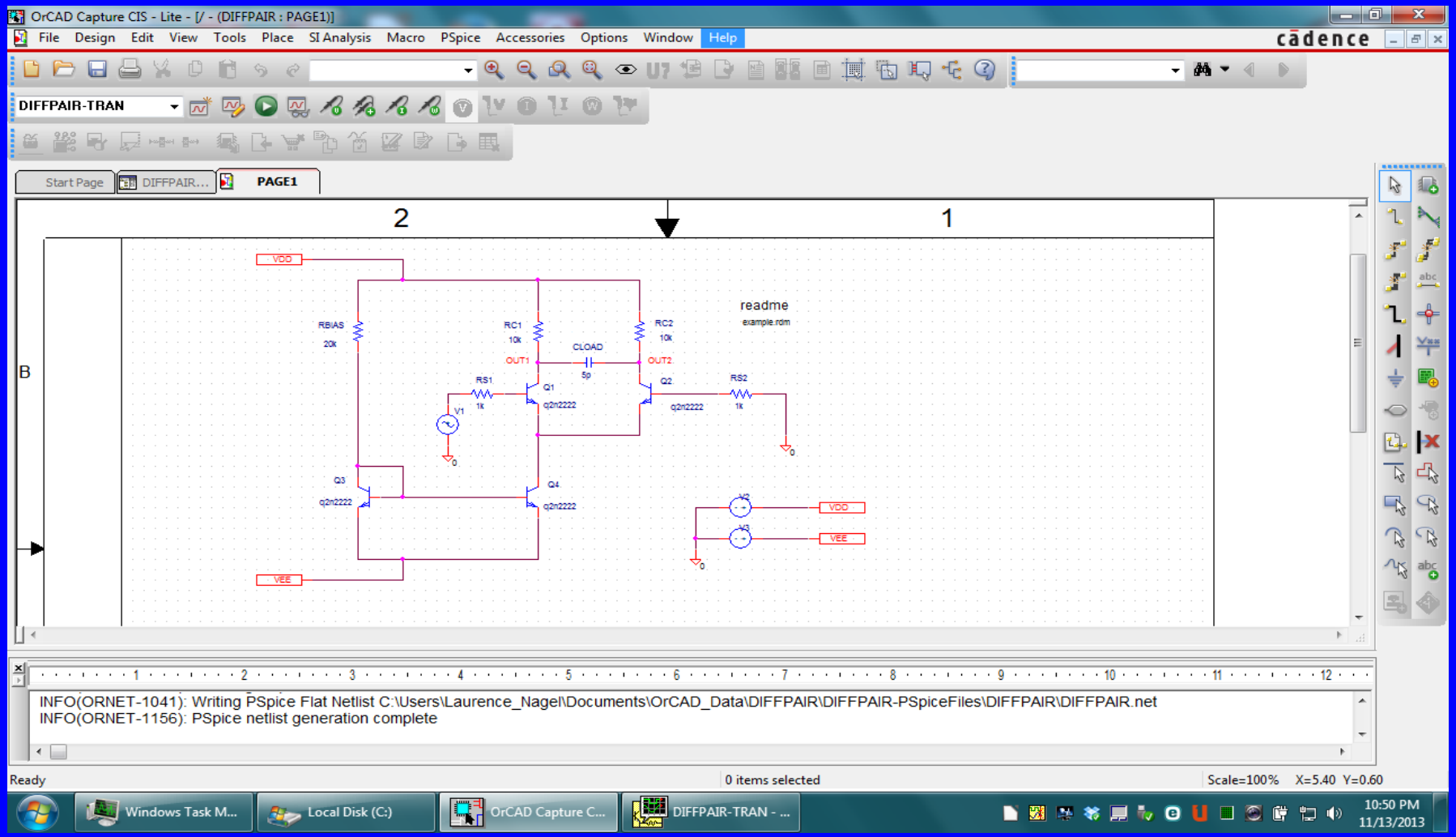
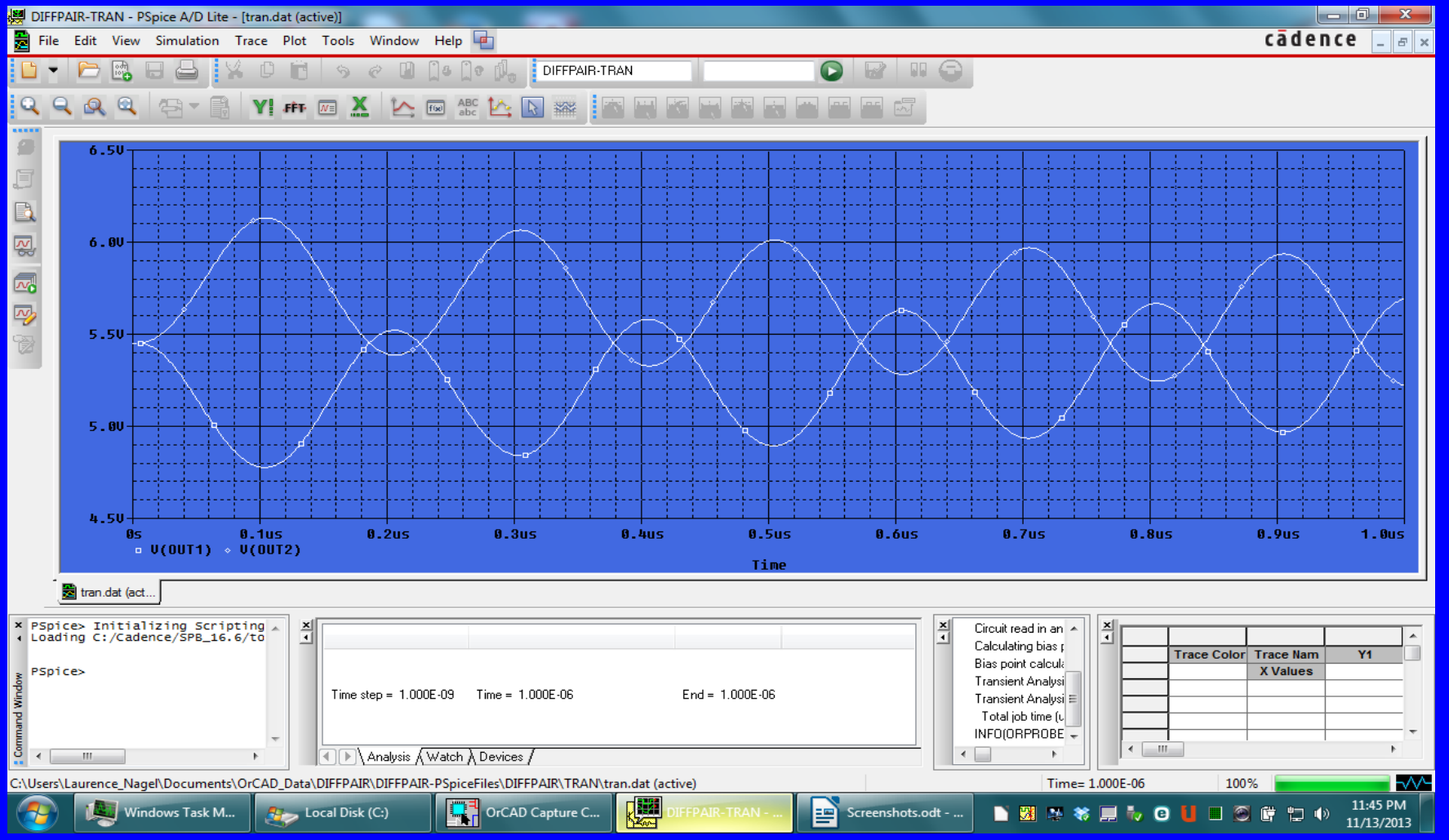


Fig. 1.7. SPICE Transient Analysis Solution. -17-

# PSPICE Schematic - Circa 2014



# PSPICE Output - Circa 2014



# What Is Missing In A Spice Circuit Description?

- Physical (Mask) Design Intent
  - Proximity of transistors, nodes that are sensitive to capacitance, lines that need to be shielded
- Electrical Design Intent
  - What function(s) the circuit is intended to perform
  - Why this particular topology was chosen to perform this particular function(s)

# Physical Design Intent

Captures the intent of the designer about the mask layout

- Proximity of devices to achieve matching
- Which devices require common centroid layout
- Which devices must be located far away from each other to prevent thermal feedback
- Which nodes are sensitive to capacitance
- Which signals must be shielded to prevent noise or crosstalk

# Physical Design Intent

- Typically appears as “annotated schematics” which are notes scrawled electronically on a schematic
- The is no “standard” way of specifying physical design intent in a machine-readable form
- Perhaps what is needed is a textual language for describing physical design intent

# Layout Extraction and LVS Tools

- Layout extraction provides a SPICE netlist with all parasitic capacitances, resistances, and inductances
- LVS compares the layout netlist to the original netlist to correct layout
- Simulating the post-layout netlist will determine if the circuit as fabricated will function as intended

# Layout Extraction and LVS Tools

- Extraction and LVS tools cannot ascertain if the layout fulfills the physical design intent
- Extraction and LVS tools cannot tell you why the post-layout and pre-layout simulations differ
- What is needed is a tool that compares mask layout and physical design intent

# Physical Design Intent Checker

Error: LWN requires that Q13 and Q36 be within 2 um of each other but are spaced 10 um apart

Error: LWN specifies that node SENSE have less than 30 aF of capacitance but the capacitance load is 125 aF

Error: LWN specifies that node INSENSE is to be shielded but it is not

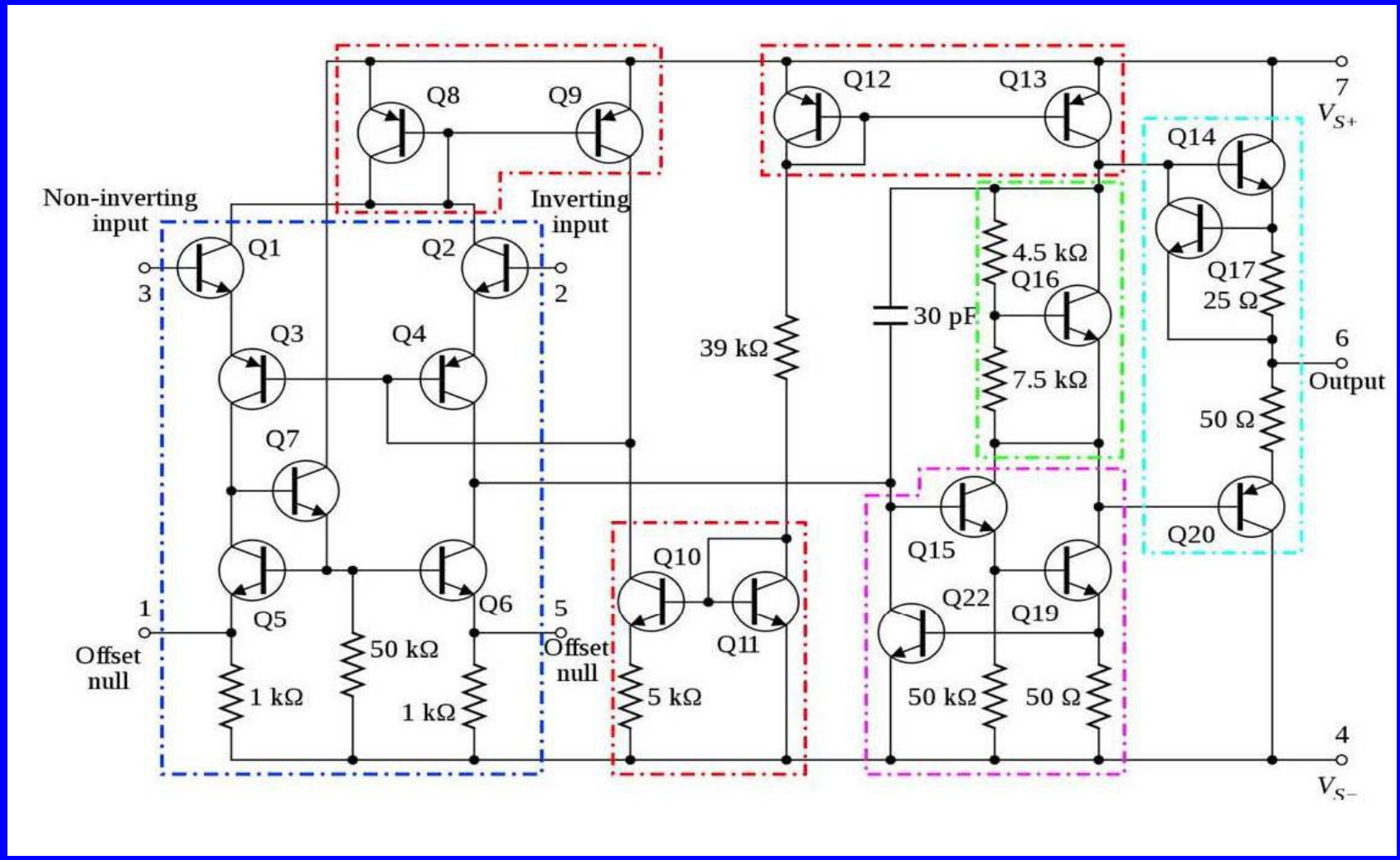
# Electrical Design Intent

- A circuit schematic contains few clues of what function(s) the circuit performs
- There usually is no explanation why this particular topology is selected to perform this function (these functions)
- Sometimes this information may be in notebooks or documentation, but rarely in machine readable form

# Electrical Design Intent

- A complete set of SPICE simulations with all the test conditions (test benches) yields some idea of the circuit operation
- An experienced design engineer can ascertain circuit operation from a schematic
- The is no “standard” way of specifying electrical design intent in a machine-readable form
- Perhaps what is needed is a textual language for describing electrical design intent

# The uA 741 Operational Amplifier



# Some uA 741 Specifications

- Voltage gain
- Current gain
- Bandwidth
- Slew rate
- Maximum output swing
- Maximum load current
- Power supply range
- Power Supply Rejection Ratio
- Noise Figure
- Distortion Figures
- Power dissipation
- Stability
- Input impedance
- Output impedance

# A Real Design Intent Quagmire

How do you capture (in machine readable form) why David Fullagar chose this particular topology to implement the function(s) of the uA 741?

My answer: I have no idea!

# Electrical Design Intent

- Clearly defines what outputs are important and what range of values they can have
- Circuit performance is specified at a higher level than the SPICE netlist
- The statistical variables for a variational analysis are clearly defined
- If design optimization is employed, the objective function is readily determined

# Electrical Design Intent

- It will still be necessary to look at voltages and currents if the circuit performance does not meet the design intent
- It will still be necessary for the circuit designer to understand how the circuit works
- Design intent capture simply automates some of the more tedious parts of performing SPICE simulations

# Electrical Design Intent

- Would aid cell library characterization
  - Would allow a tool to categorize a cell library and allow a designer to search the library electronically for a block that performs the needed function
  - Would reduce the number of blocks that are (re)designed from scratch
  - After all, how many different band-gap regulator circuits do we really need?

# Electrical Design Intent

- The circuit description becomes self testing
  - SPICE would be able to test the circuit against all specifications to determine if the design passes or fails
  - If the technology changes, an entire library of blocks could be tested without human intervention

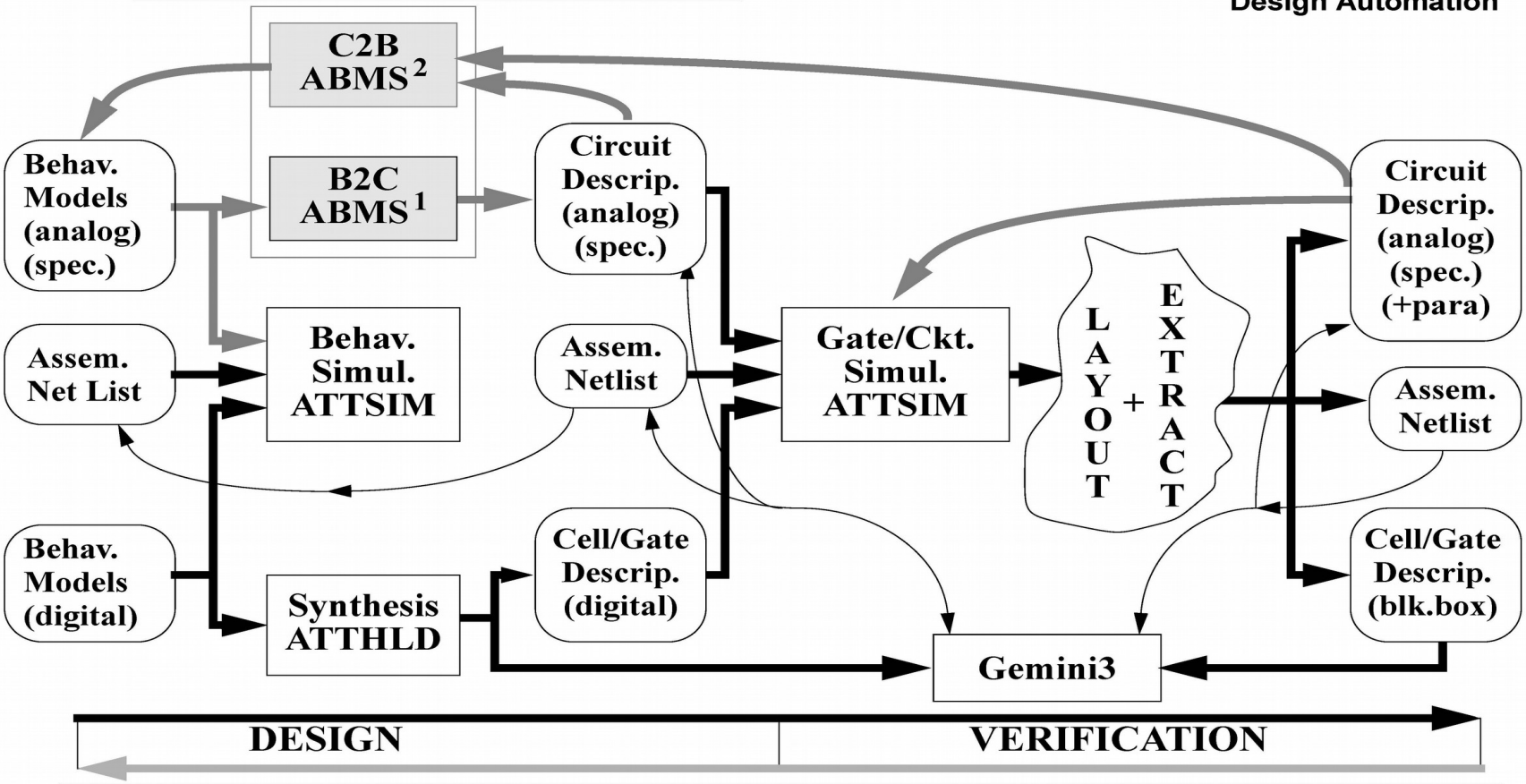
# Electrical Design Intent

- Would provide behavioral model generation
  - Tools can be developed (have been developed?) that can created a behavioral model for the circuit block that can be used in a system-level simulation
  - This behavioral model creation would occur without human intervention, providing the software were capable of representing all of the design intent contained in the circuit description

# *Mixed Signal Product Perspective*

AT&T

Design Automation



# Conclusions

The traditional method of describing a circuit has two major limitations:

- It does not capture the physical design intent
- It fails to capture the electrical design intent that explains what function(s) the circuit is supposed to perform and why the particular topology was chosen

What is needed is a more comprehensive circuit description

# Thank You!!!