Modeling Self Heating using HICUM

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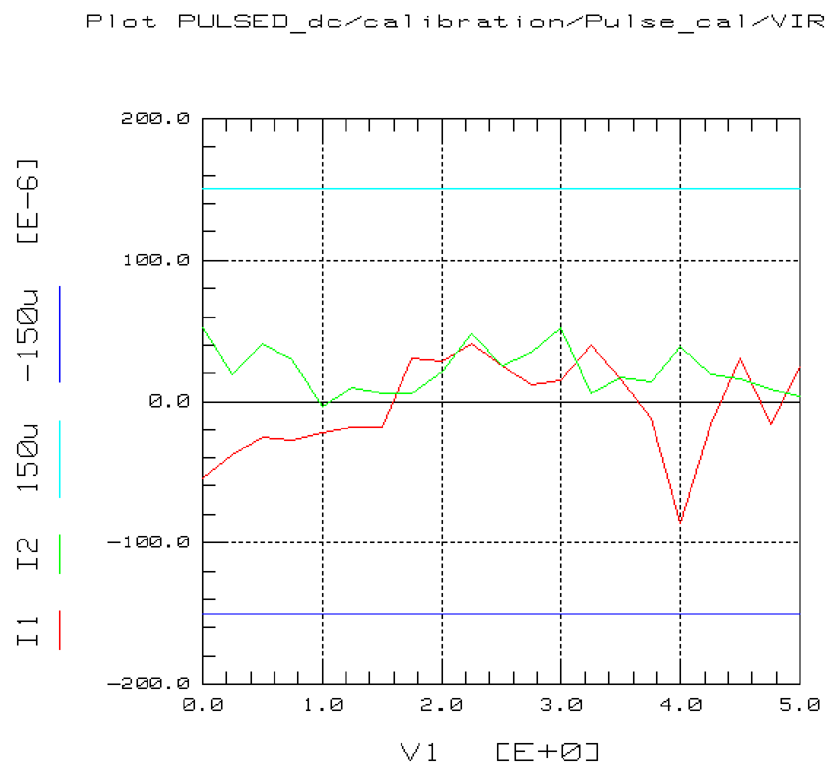
Never stop thinking

Pulsed S-parameter measurement procedure using the HP85124 system

- DC calibration: correction of ohmic losses an delays in the system, data are stored in file pulse.cal
- Measurement of the DC noise level with probes in air: noise level should be smaller than 100 µA
- Non-pulsed forward gummel measurement and non-pulsed forward output measurement, I_B –and V_B – driven, to evaluate the possible operating range of the device
- Measurement of I_C (t) to find out the right pulse period, pulse width and the RF measurement trigger time point
- Pulsed forward output measurement, V_B – driven
- Non-Pulsed S-parameter measurement, V_B – driven
- Check for the maximum possible RF input power
- Pulsed S-parameter measurement, V_B – driven

Measurement of DC noise level

- DC Noise Level of HP85124 system, measured with open probes, is in the order of about +/- 50 uA



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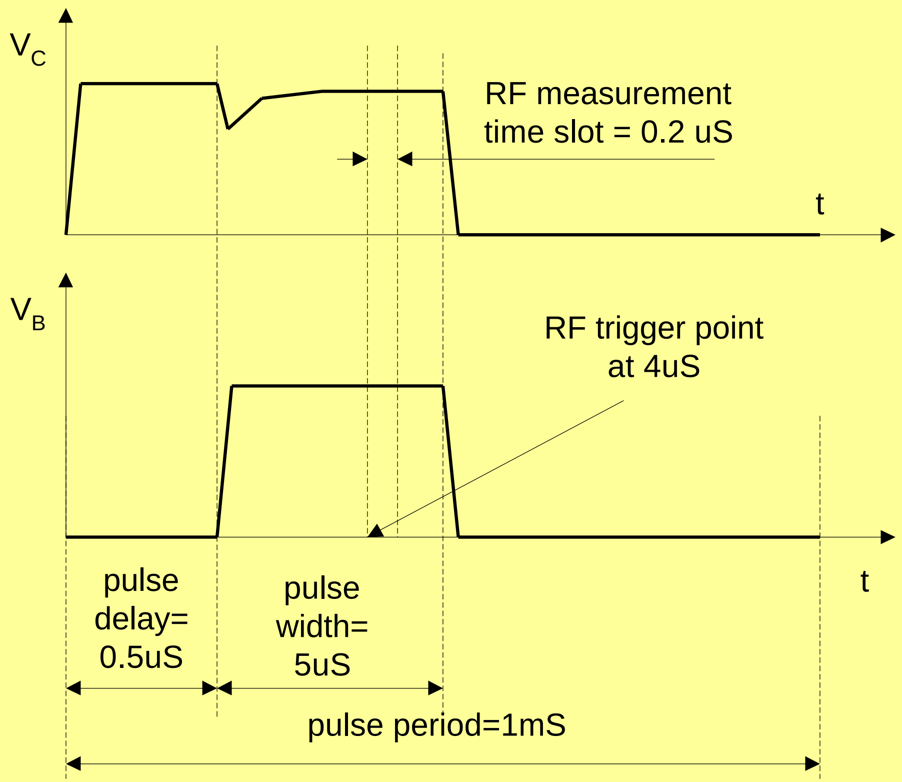
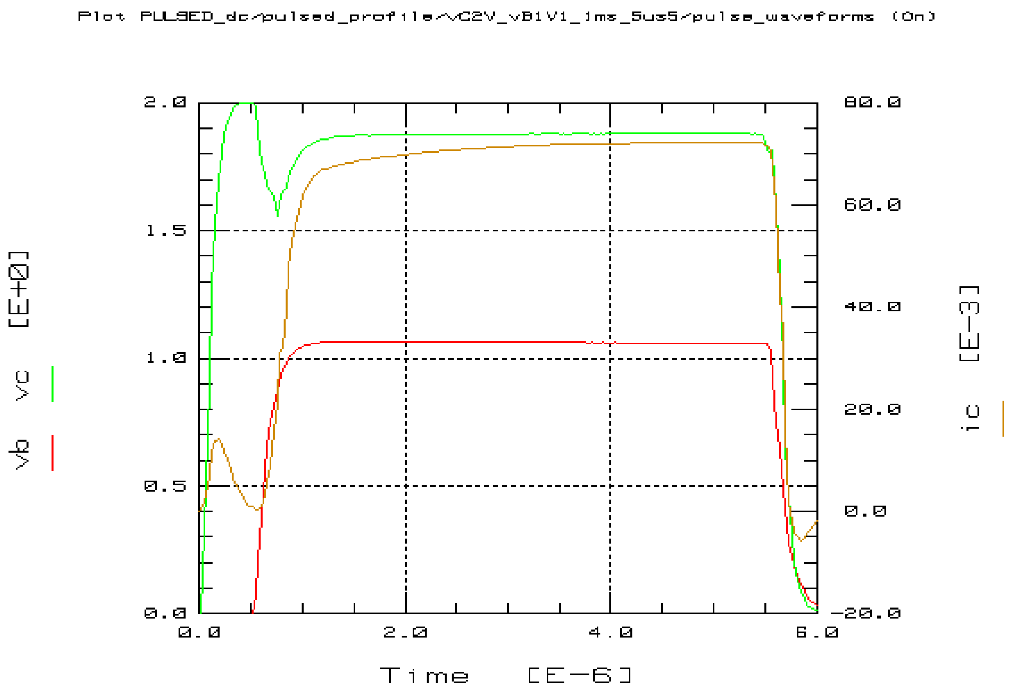
Pulse time diagram, principle

- If VB is witched on, V_C collapses first, and increases than again.
- A small ohmic voltage of about 02.V reduces than VC



Real pulse time diagram



- green: collector voltage VC
- yellow collector current IC
- red: base voltage VB

- Used settings are: Pulse period = 10 mS
- VC: pulse width = 5.5 µS, pulse delay = 0 µS
- VB: pulse width = 5 µS, pulse delay = 0.5 µS
- DUT: b9c, n10b, trench isolated, Ae=2.8 um2, 4 in parallel

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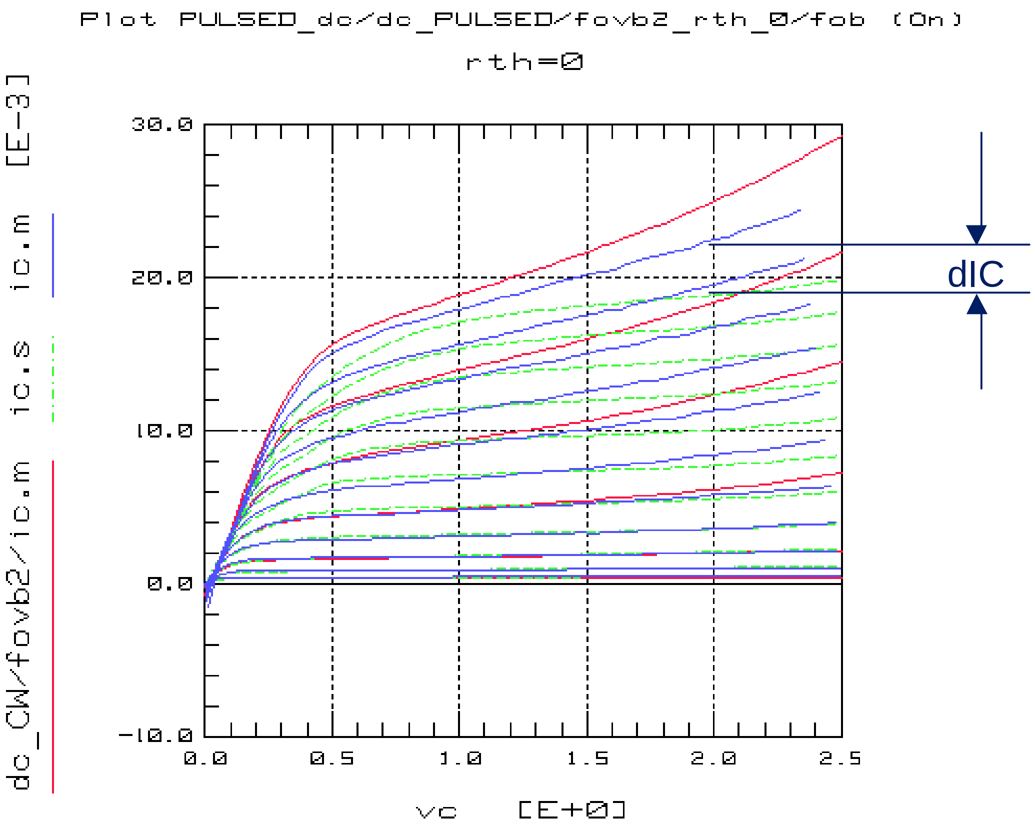
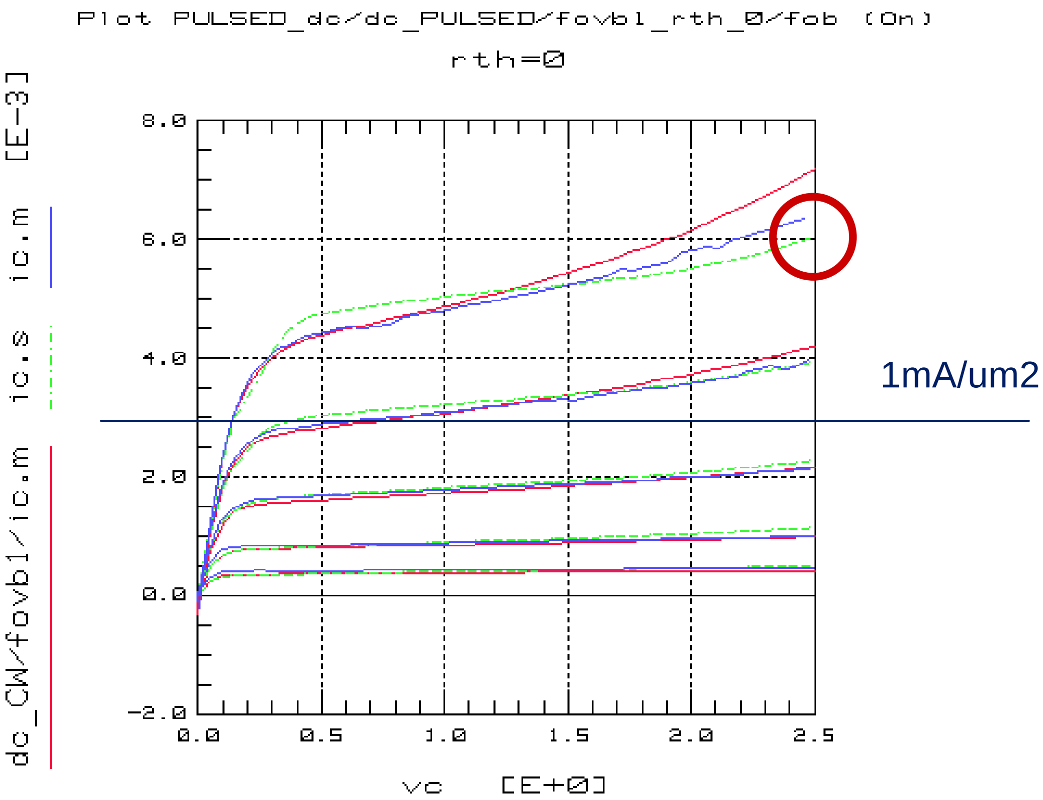
Pulsed, non-pulsed and simulated output characteristics in comparison (1)



- red: CW, with self – heating
- blue: pulsed, no self – heating
- green: simulated, HICUM2.1, Spectre 4.4.6 (230203), RTH=0

- VB=0.85 to 1.1V, step= 0.05V, n=1, Ae=2.8 um2
- Problem: the simulation with RTH=0 does not agree with the non-pulsed measurement

Pulsed, non-pulsed and simulated output characteristics in comparison (2)



- red: CW, with self – heating
- blue: pulsed, no self – heating
- green: simulated, RTH=0

- VB=0.85 to 0.95V, step= 0.025V, n=1, Ae=2.8 um2
- Same picture at lower currents: the increase of simulated IC does not match the non-pulsed measurement

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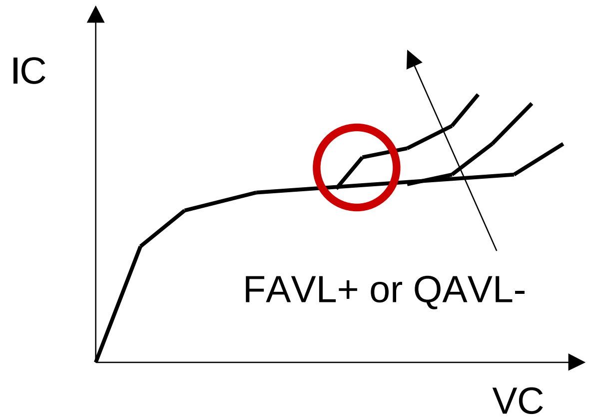
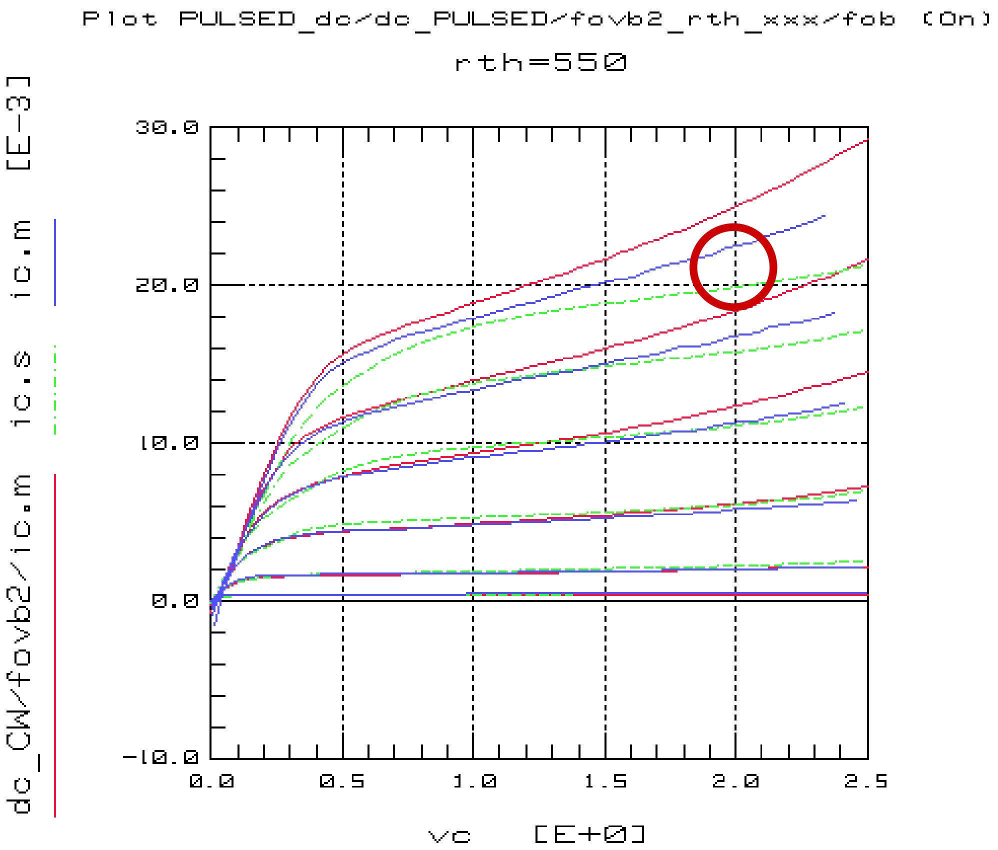
Pulsed, non-pulsed and simulated output characteristics in comparison (3)

- Which model parameters are available to affect the increase of the output characteristic ?
- HJCI: the weigting factor for the inner BC charge, however, very high values are necessary (HJCI=10), but not reasonable, additional, HJCI is intended to fit in the LOW current range
- FAVL, QAVL: the avalanche parameters, however, high values of FAVL creates bumps etc., additional, convergence problems appear



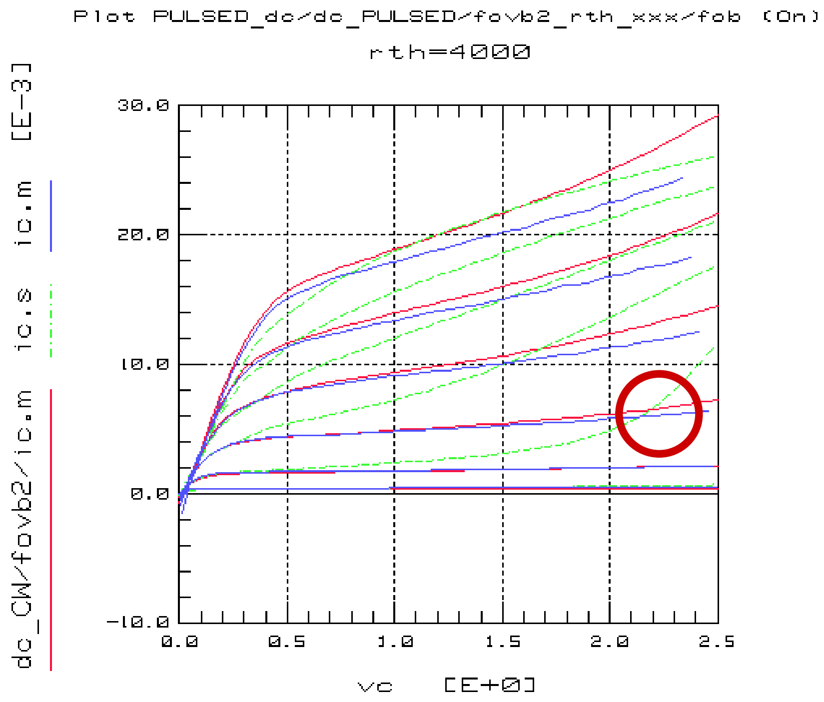
Pulsed, non-pulsed and simulated output characteristics in comparison (4)



- red: CW, with self – heating
- blue: pulsed, no self – heating
- green: simulated, RTH=550, VGB=1.169, ALB=0.555m, ALTO=0.75m, KT0=4.8u, ZETARCX=0.372, ZETARBX=0.753

- VB=0.85 to 0.95V, step= 0.025V, n=1, Ae=2.8 um2
- Simulation using RTH=550 K / W gives only a rough approximation for low currents, but not for high

Pulsed, non-pulsed and simulated output characteristics in comparison (5)



- red: CW, with self – heating
- blue: pulsed, no self – heating
- green: simulated, RTH=4000, other see above

- VB=0.85 to 0.95V, step= 0.025V, n=1, Ae=2.8 um2
- RTH=4000 K / W, a typical value for trench isolated structures, gives a rough approximation for high currents, but overestimates the self heating at low currents.

Pulsed, non-pulsed and simulated output characteristics in comparison (6)

- Possible reason for the problem:
- The collector current at high VB is affected both by self heating and the avalanche effect
- The avalanche model used in HICUM is sufficient for low current densities, but not for high
- If we try to model both effects with a high RTH value, an overestimated self heating at low current is the result
- Conclusion for this example: modeling the self heating using HICUM is restricted to current densisities up to 1 mA/um2

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