MSS Lab **Part A: Lumped Element Simulation (Saber)** **Exercise 1: Basic electrical simulation**		Prof. Dr.-Ing. G.Schmitz **Flugzeug- Elektrik und Elektronik**
Last Name	First Name	Matr.-Nr.
Date	Confirmation (Testat)	

1 Introduction

For the design of electronic circuits a simulation is a valuable tool to shorten the development process. No expensive hardware experiments are necessary. Sometimes, especially in the design of highly integrated circuits it is nearly impossible to do the development process without simulation.

2 Execution of the exercises

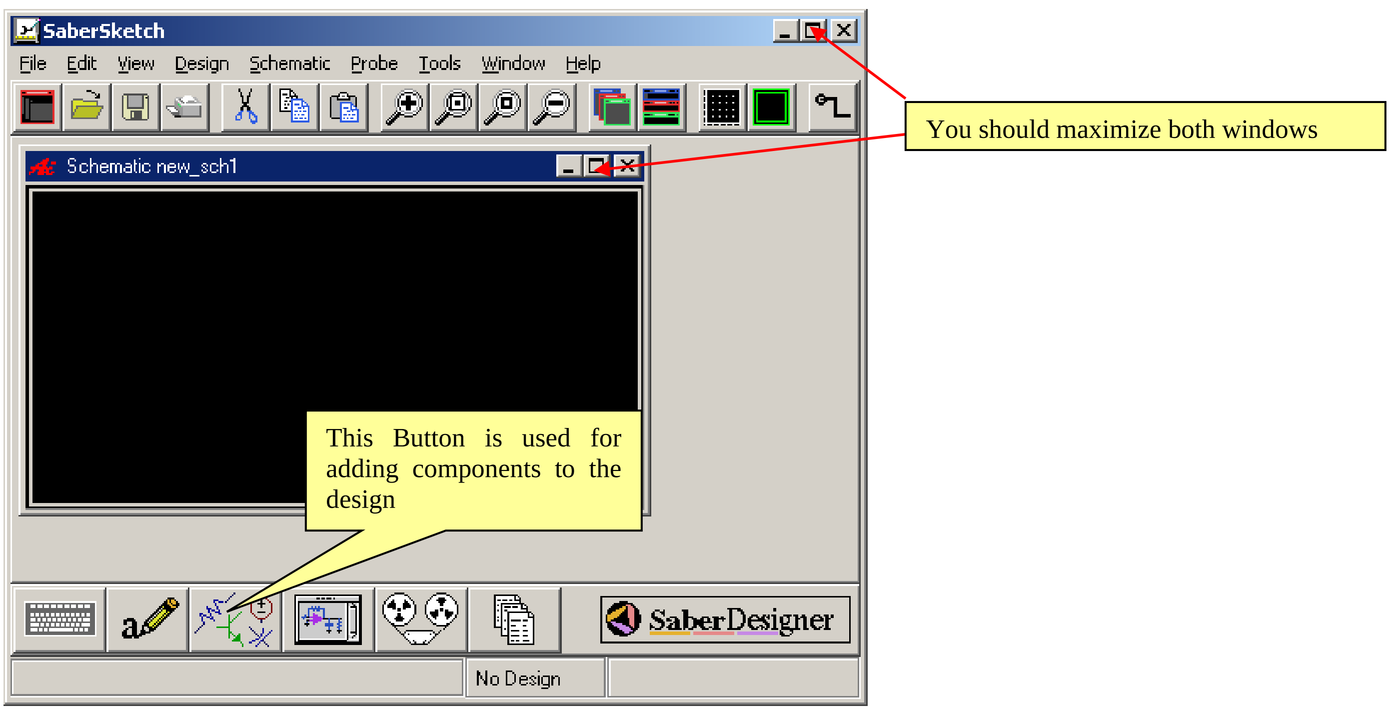
In the exercise you will design a simple circuit and analyze the function using the "Transient Analysis Function". First you should use the components and parameters provided in this paper. Then do your own variations and observe the results. Print out the final results, the oscillograms and the respective circuitries.

2.1 Simulation of your first circuit

In the introduction lecture you have seen the RC- circuit, which you now should investigate by yourself. Remember to use the Saber Node '0', Otherwise you will get an error message like "Floating Ground Error": *Singular Jacobian Matrix, possible reason: Node/subsystem with no connection to the reference (floating).*

To draw the circuit first invoke the Saber Sketch Program. Start → Programme → Avant! → SaberDesigner….. → SaberSketch

After several seconds you should see a screen like the following:



Now you should place the required components to the blackboard.

First of all we should add the Saber Node '0' i.e. the Ground Node. Next we want to place a resistor and a capacitor to the design. Al last the pulsed voltage source is added.

The components can be found using the paths:

→ MAST Parts Library→Electrical→Passive Elements→Resistors→Resistor (-)

→MAST Parts Library→Electrical→Passive Elements→Capacitors→Capacitor (|)

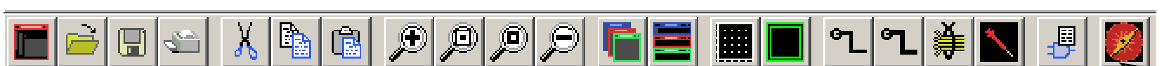
→MAST Parts Library→Electrical→Electrical Sources→Voltage Sources→Voltage Source, Pulse.

After doing this we draw the connections. The parameters are entered by double-clicking to the components.

For your first experiment you should use the following:

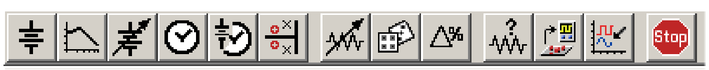
Component	**Parameter**	**Value**	**Unit**	**Meaning**
resistor	Rnom	1k	Ω	Resistance
Capacitor	C	1u	F	Capacity
Voltage source	Initial	0	V	Initial Voltage
Voltage source	Pulse	10	V	Pulse Voltage
Voltage source	width	0.5m	s	Pulse width

Now we prepare the simulation. In the menu bar you will find  as the rightmost symbol:



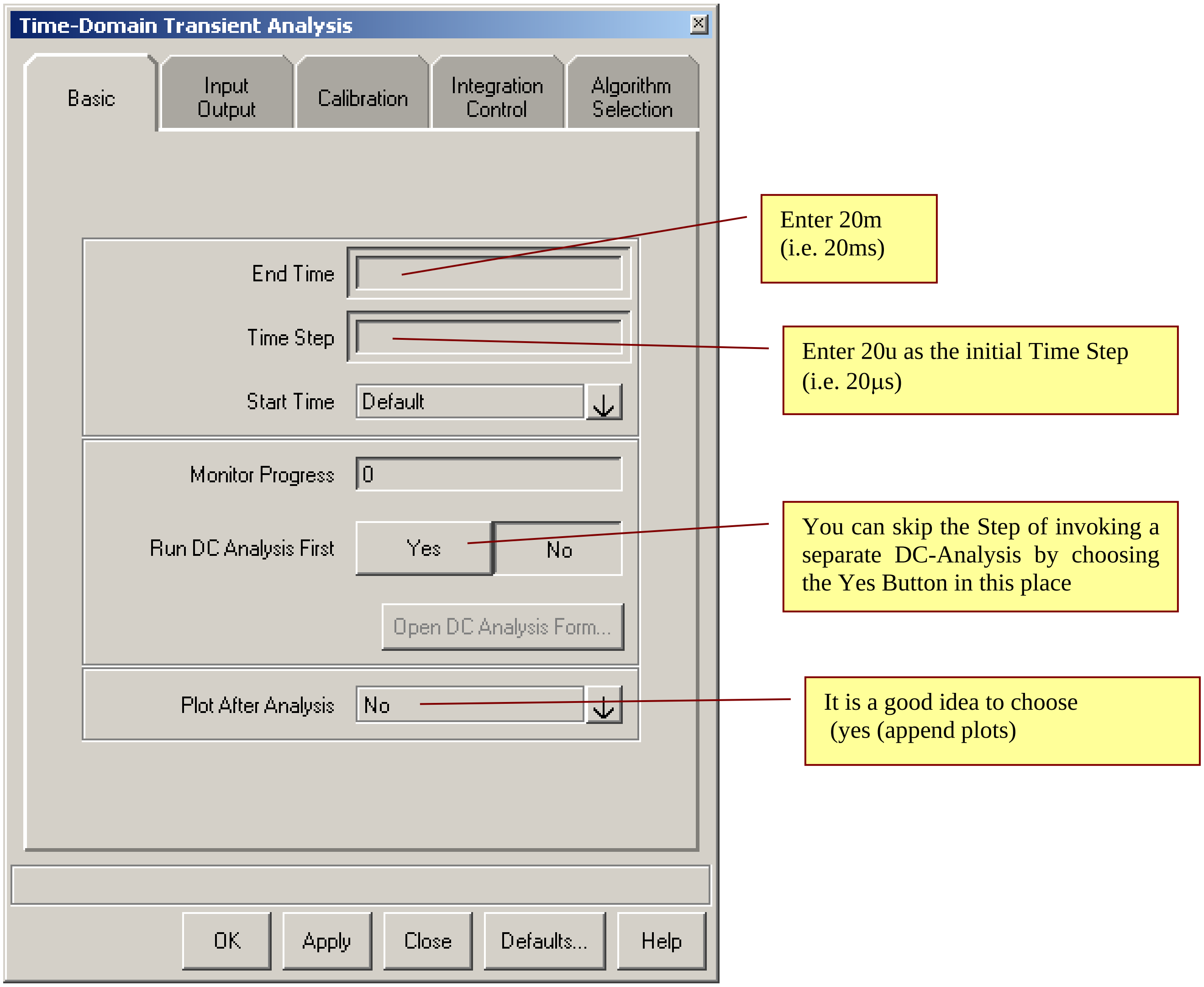
Please click on that button and an additional menu bar will appear:

It is important to remember that a click to this symbol will display the action menu



We will discuss the symbols later. Now we will use the leftmost button to start a "DC-Analysis". That means we will do a Direct Current analysis to find the initial operating point of the circuit. That will give initial values for all of the variables (current, voltage) for each component. We need this for the Transient Analysis as the initial data.

After this we can do the Transient Analysis, which we can start with the clock button. A window will open now, where we can do certain settings for the simulation.



After doing the settings you can click the OK- Button and the Simulation will start. If the design is new or modified, you will be asked if the design should be saved before netlisting. Answer with ‘yes’.

In the upper right corner you can watch the progress: 

A click to the “>cmd”- Button will show you more in detail, what is happening. You even can enter commands manually in the command mode (if you know the commands;-)

Now if everything is ok, the SABER-Scope should start, where you are able to display the results. The basics in the handling of Saberscope will be shown in the Lab.

Now, looking at the results you will find a difference to the example which was given during the introduction lecture. Find out why there is only one “event” and not a continuous signal.

Modify your design until you get a “continuing signal”.

Save the sketches and the final results.

2.2 Modification of your first circuit

For the next simulations you should modify some of the components. You should do the following experiments and **document them by printing the design and the result(s):**

2.2.1 Double the value of the resistor and the capacitor

2.2.2 Modify the duty cycle of the voltage source (20%, 80%). The frequency should be held constant. What is your observation concerning the mean value of the output?

2.2.3 Now replace the voltage source by a sine with 10V amplitude and 1kHz frequency

2.2.4 Change again the value of the frequency. Is the amplitude of the voltage drop at the capacitor frequency dependent?

2.2.5 Now replace the Voltage source to a Piece Wise Linear Voltage Source (pwl)

You can enter now pairs of time and voltage. First try with a single pulse; try to get the same result as in the very first simulation. Then try a triangle and a trapezoid.

2.2.6 Now modify your circuit by placing a diode in series to the resistor. You could use now the pulse and/or the sine source. Also it would be interesting to use the pwl-source with different levels of voltage with some drops to zero or negative voltages

2.2.7 Add a resistor in parallel to the capacitor. And do some experiments to get a peak- detector circuit.

3 Appendix

3.1 Entering Parameters

Entering parameters in Saber you should obey some rules:

Separate the decimal fraction (Nachkommestellen) with a period not with a comma. E.g. 5.332 not 5,332. A faulty entry leads later on to an error which is not easy to interpret correctly!

Parameters are entered without their units.

Parameter werden ohne ihre Einheiten angegeben. The parameters are based on the mks system (as long as no other system is chosen, which is not recommended). Prefixes like “milli” and “kilo” can be used (with one exception: Mega) as usual. A resistance of 1kΩ can be entered as 1k; a time of 1 microsecond as 1u. Please note: **u not µ**.

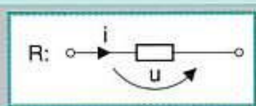
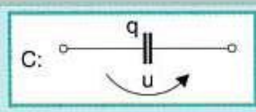
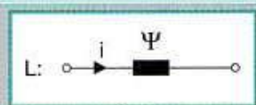
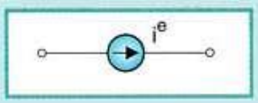
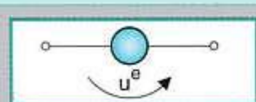
3.2 Table of Prefixes

Decimal Power	Usual Prefix	Saber-Prefix
10^{12}	Tera	T
10^{9}	Giga	G
10^{6}	Mega	**Meg** (**Caution not M**)
10^{3}	kilo	k
10^{-3}	milli	m
10^{-6}	micro	**u**
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

3.3 Table of Across- and Through- Quantities

Gebiet (topic)	**Flußgröße (Through)**	**Differenzgröße (Across)**
Elektrotechnik (electronics)	Strom (current)	Spannung (voltage)
transl. Mechanik (transl. mechanic)	Kraft (force)	Weg, Geschwindigkeit (position, velocity)
rot. Mechanik (rotational mech.)	Drehmoment (torque)	Winkel, Winkelgeschwindigkeit (angle, angular velocity)
Thermik (thermal systems)	Entropiestrom (power)	Temperatur (temperature)
Hydraulik (hydraulic systems)	Volumenfluß (flow rate)	Druck (pressure)
Magnetik (magnetic systems)	Fluß (flux)	Durchflutung (magnetomotive force)

Further Equivalents:

	Symbol		Allgemeines NW	Mechanisch-translatorisches NW	Mechanisch-rotatorisches NW	Elektrisches NW	Strömungs-NW	Thermisches NW
Signale	i		Flußgröße	Kraft	Drehmoment	Strom	Volumenfluß	Wärmestrom
	u		Differenzgröße	Geschwindigkeit	Winkelgeschwindigkeit	Spannung	Druck	Temperatur
	q		integrierte Flußgröße	Impuls	Drehimpuls	Ladung	Volumen	Wärmemenge
	Ψ		integrierte Differenzgröße	Weg	Drehwinkel	magnetischer Fluß	Strömungsbewegungs-Größe	–
Netzwerk-Elemente	R:		Verbraucher $R = u/i$ $(G = 1/R)$	Reibungsmitgang	Drehreibungsmitgang	Ohmscher Widerstand	Strömungswiderstand	Wärmewiderstand
	C:		F-Speicher $C = q/u$ $(E_q = q^2/2C)$	Masse, kinetische Energie	Trägheitsmoment, kinetische Energie	Kapazität, elektrische Energie	Strömungskapazität (potent. Energie)	Wärmekapazität, Wärme
	L:		D-Speicher $L = \Psi/i$	Federnachgiebigkeit, potentielle Energie	Drehfedernachgiebigkeit, potentielle Energie	Induktivität, magnetische Energie	Strömungsträgheit (kinet. Energie)	–
			F-Quelle, i^e = vorgegebene Zeitfunktion	Kraftquelle	Drehimpulsquelle	Stromquelle	Volumenflußquelle	Wärmestromquelle
			D-Quelle, u^e = vorgegebene Zeitfunktion	Geschwindigkeitsquelle	Winkelgeschwindigkeitsquelle	Spannungsquelle	Druckquelle	Temperaturquelle