Appendix 8

Training Exercises
to Laboratory Works

BGU 2014

Introduction

Simulation run time is based on the time required to establish the steady state of process under study.

The proposed exercises can start with 10-15 periods (200-300mS)

Maximum step size : 20-30uS for 50Hz..

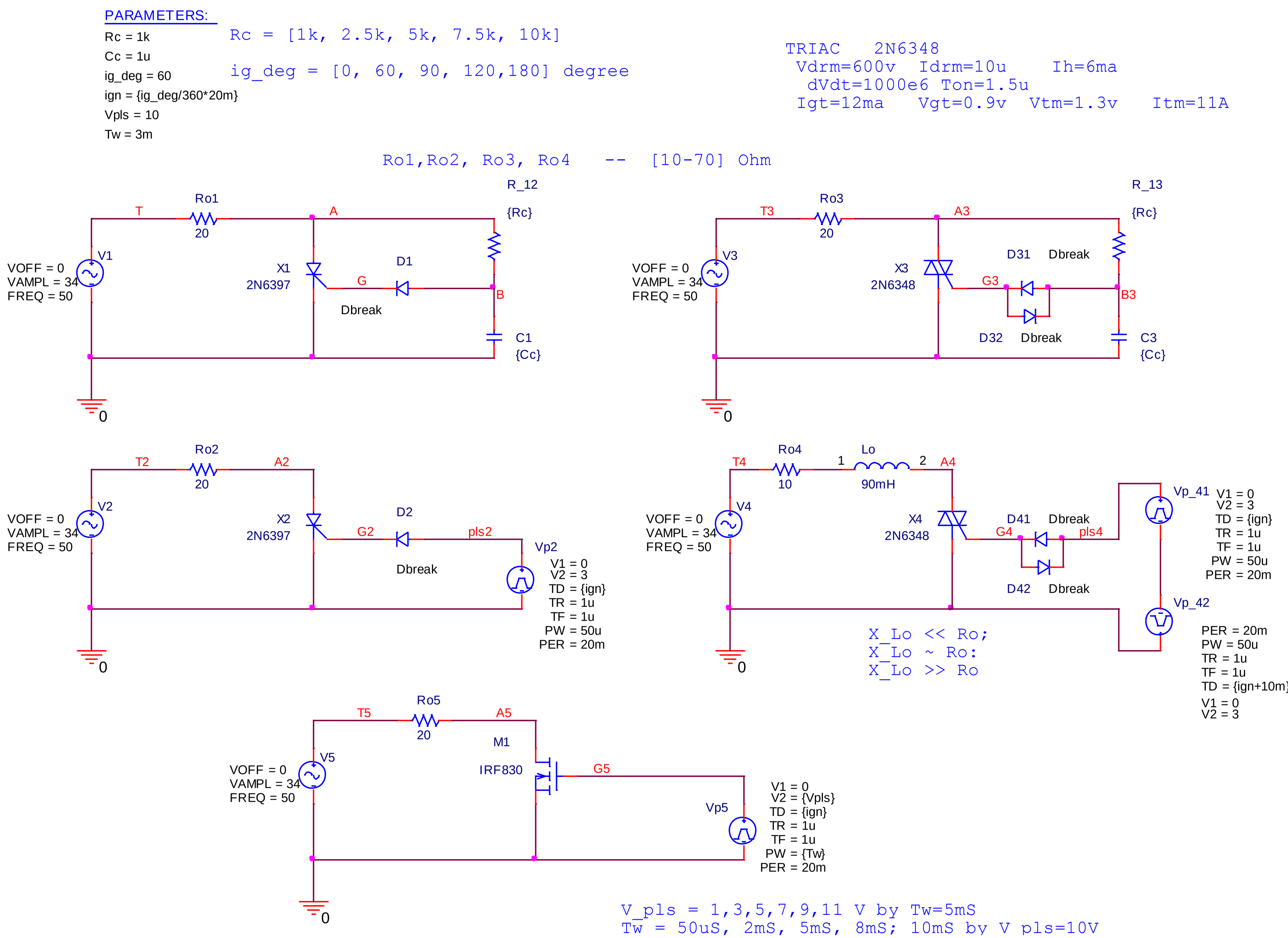
Figures report should be submitted only 2-3 last period.

Figures report should be kept only major grid.

When printed on a black - white printer, the currents and voltages waves in the figures of the report should be named in the appropriate manner.

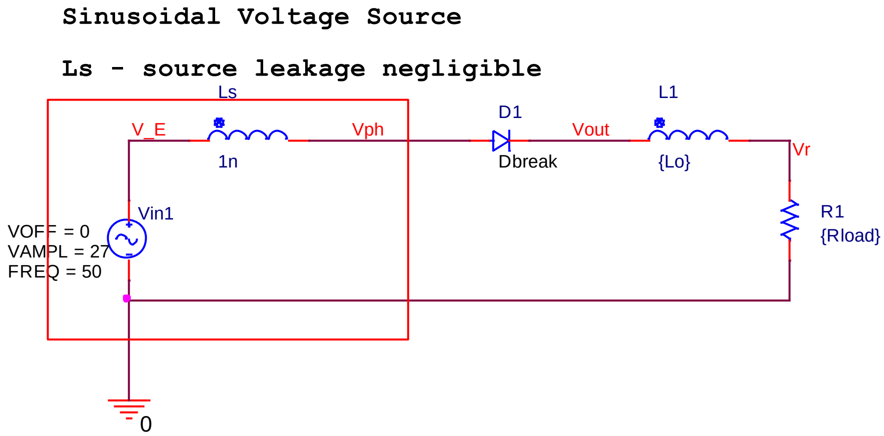
Experiment No.1

1. Construct schemes in SPICE: separately for Thyristors, separately for TRIAC's and separately for MOSFET;
2. Spend simulations (Thyristor and TRIAC circuits)at different values of parameters RC - ignition circuit and compare results (6÷8 variants);
3. Compare gate voltage (V_G, V_{G2} and V_{G3}, V_{G4}) at pulse excitation and excitation from RC - ignition circuit;
4. Spend simulations (TRIAC) at different values of parameters Lo, Ro and compare results;
5. Simulation results presents the report on template form for experiment No.1


PARAMETERS:
Rc = 1k
Cc = 1u
ig_deg = 60
ign = {ig_deg/360*20m}
Vpls = 10
Tw = 3m
Rc = [1k, 2.5k, 5k, 7.5k, 10k]
ig_deg = [0, 60, 90, 120,180] degree
TRIAC 2N6348
Vdrm=600v Idrm=10u Ih=6ma
dVdt=1000e6 Ton=1.5u
Igt=12ma Vgt=0.9v Vtm=1.3v Itm=11A
Ro1,Ro2, Ro3, Ro4 -- [10-70] Ohm
R_12
{Rc}
T
Ro1
20
A
V1
VOFF = 0
VAMPL = 34
FREQ = 50
X1
2N6397
G
D1
Dbreak
B
C1
{Cc}
0
R_13
{Rc}
T3
Ro3
20
A3
V3
VOFF = 0
VAMPL = 34
FREQ = 50
X3
2N6348
G3
D31 Dbreak
D32 Dbreak
B3
C3
{Cc}
0
T2
Ro2
20
A2
V2
VOFF = 0
VAMPL = 34
FREQ = 50
X2
2N6397
G2
D2
Dbreak
pls2
Vp2
V1 = 0
V2 = 3
TD = {ign}
TR = 1u
TF = 1u
PW = 50u
PER = 20m
0
T4
Ro4
10
1
Lo
90mH
2
A4
V4
VOFF = 0
VAMPL = 34
FREQ = 50
X4
2N6348
G4
D41 Dbreak
D42 Dbreak
pls4
Vp_41
V1 = 0
V2 = 3
TD = {ign}
TR = 1u
TF = 1u
PW = 50u
PER = 20m
Vp_42
PER = 20m
PW = 50u
TR = 1u
TF = 1u
TD = {ign+10m}
V1 = 0
V2 = 3
0
X_Lo << Ro;
X_Lo ~ Ro:
X_Lo >> Ro
T5
Ro5
20
A5
M1
IRF830
G5
V5
VOFF = 0
VAMPL = 34
FREQ = 50
Vp5
V1 = 0
V2 = {Vpls}
TD = {ign}
TR = 1u
TF = 1u
PW = {Tw}
PER = 20m
0
V_pls = 1,3,5,7,9,11 V by Tw=5mS
Tw = 50uS, 2mS, 5mS, 8mS; 10mS by V pls=10V

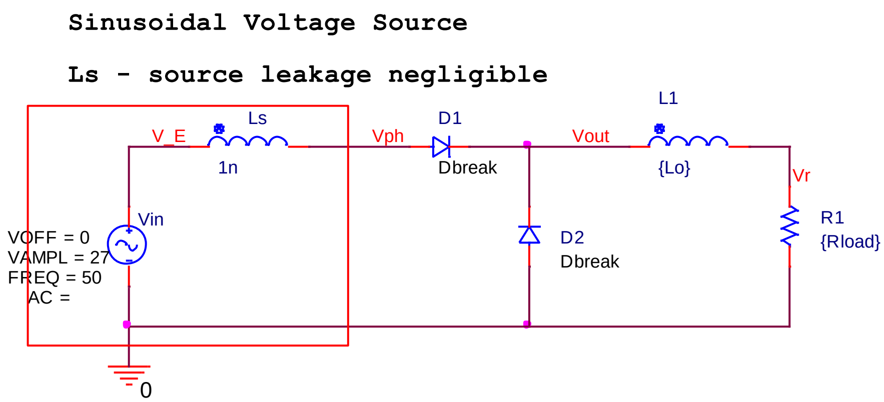
Experiment No. 2

1.



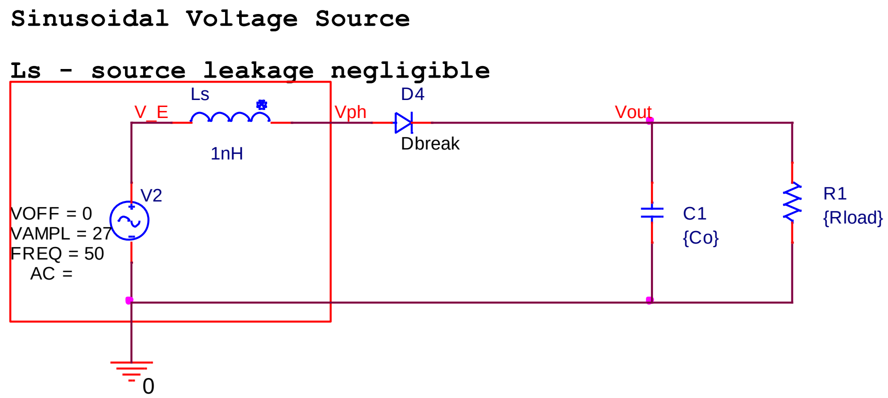
1.Construct schematic;
2. Spend simulations at different values of parameters Lo, Rload :
 a) Lo =5nH, Rload=10 Ω;
 b) Lo=50mH, Rload= 5Ω.
3. Submit current I(R1) and voltage V_E waves in one plot

2.



1.Construct schematic;
2.Spend simulations at different values of parameters Lo, Rload :
 Lo =5nH, Rload=10 Ω;
 Lo=50mH, Rload= 5Ω.
3.Submit current and voltage waves :
 V_E , I(R1);
 I(D1) , I(D2).
4. Compare the simulation results for different variants of parameters and evaluate the influence of parameters.
5. Measure and explain the changes diodes D1,D2 conduction angles (θ)

3.

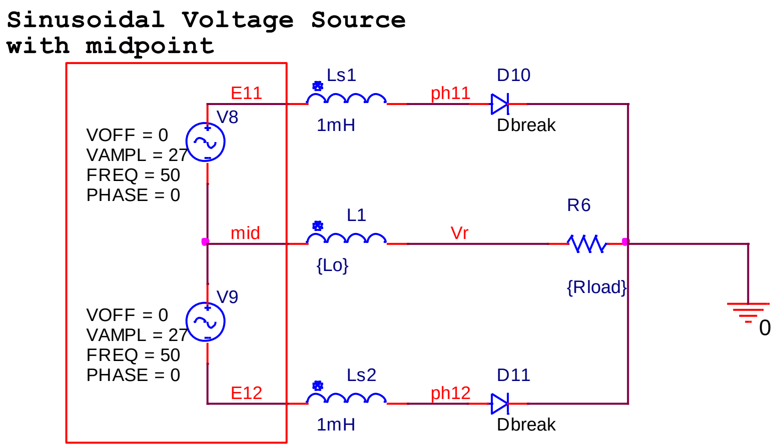


1.Construct schematic;
2.Spend simulations at different values of parameters Lo, Rload , Co:
Co =5nF, Rload=10 Ω;
Co=1000uF, Rload= 10Ω.
3.Submit current and voltage waves :
V_E , I(R1);
V_E , I(D4);
V_E , I(C1);
I(D4) , I(C1).

4. Compare the simulation results for different variants of parameters and evaluate the influence of parameters.

5.Measure and explain the changes diode conduction angle (θ).

4.



1.Construct schematic;
2.Spend simulations at different values of parameters Lo, Rload:
Lo =5nH, Rload=10 Ω;
Lo=10mH, Rload= 10Ω.

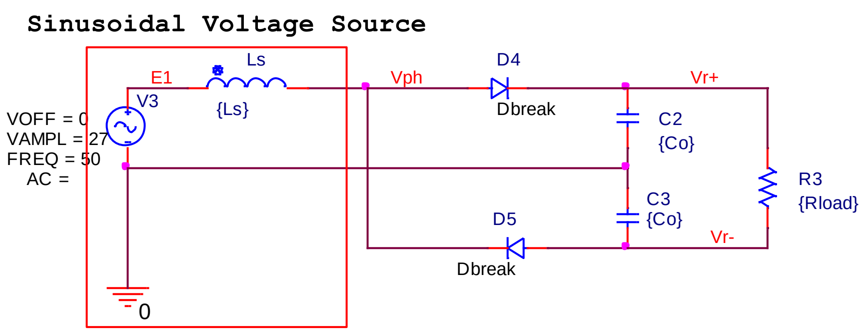
3.Submit current and voltage waves :

V_E11 , V_E12, I(R6);
V_E11 , I(D10);
I(D10), I(D11),

4. Compare the simulation results for different variants of parameters and evaluate the influence of parameters.

5.Measure and explain the changes diode ignition angle (α), conduction angle (θ), commutation angle(γ).

5.



1.Construct schematic;

2.Spend simulations at different values of parameters Ls,Co, Rload:

Ls =100nH, Co=1000uF, Rload=10k **Ω**, 100 **Ω**, 10 **Ω**;
Ls=100uH, Co=1000uF, Rload=10k **Ω**, 100 **Ω**, 10 **Ω**;

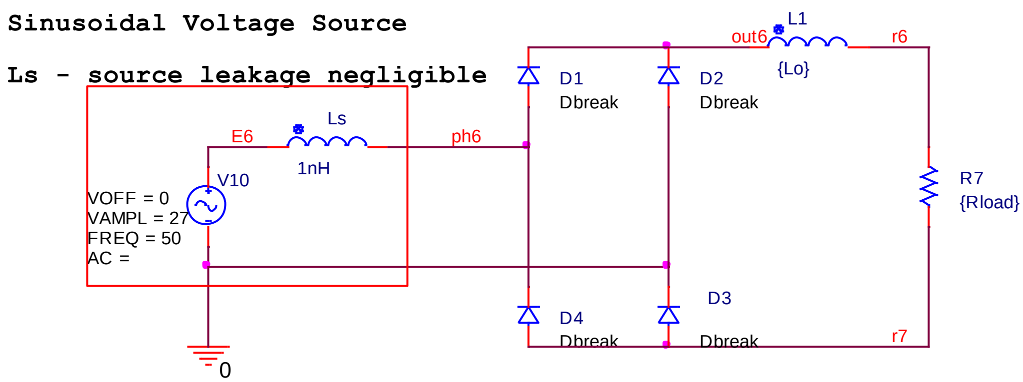
3.Submit current and voltage waves :

V_E1 , (Vr+) - (Vr-),
V_E1 , I(R3),
V_E1 , I(D4),
V_E1 , I(D5),
I(D4), I(C2).

4.Compare the simulation results for different variants of parameters and evaluate the influence of parameters.

5.Measure and explain the changes diode ignition angle (α), conduction angle (θ), commutation angle(γ).

6.

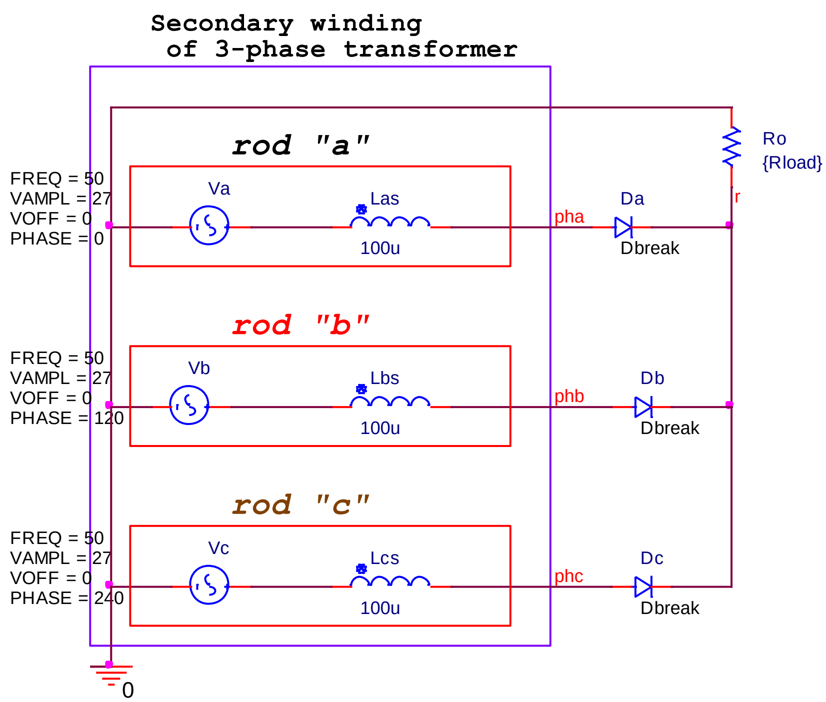


1.Construct schematic;
2.Spend simulations at values of parameters Co, Rload:
Lo =1nH, , Rload=10 Ω;
3.Submit current and voltage waves :
V_E6 , I(R7),
V_E6 , I(D1),
V_E6 , I(Ls).

4. Compare the simulation results for different variants of parameters and evaluate the influence of parameters.

5.Measure and explain the changes diode D1 ignition angle (α), conduction angle (θ), commutation angle(γ).

7.

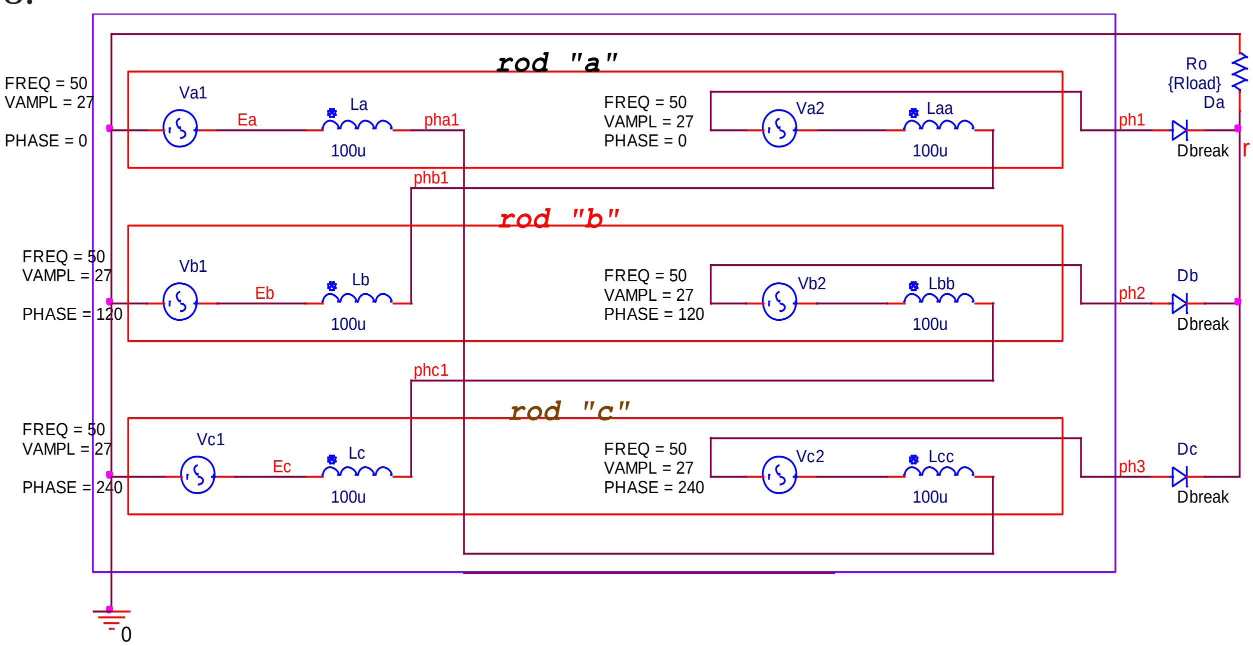


**Each phase contains a single coil, which sits on one of the rod of the 3-phase transformer*

1.Construct schematic;
2.Spend simulations at Rload=10 Ω.
3.Submit current and voltage waves :
V_Ea , V_(Ea, Eb);
V_Ea , V_pha;
V_Ea , V_Eb , V_Ec ;
V_Ea ,I(Ro);
I(Da), I(Db), I(Dc),
V_Ea , I(Da),
Rod current I(Las) and *average* I(Las).

4.Measure diode's Da ignition angle (α), conduction angle (θ), commutation angle(γ).

8.

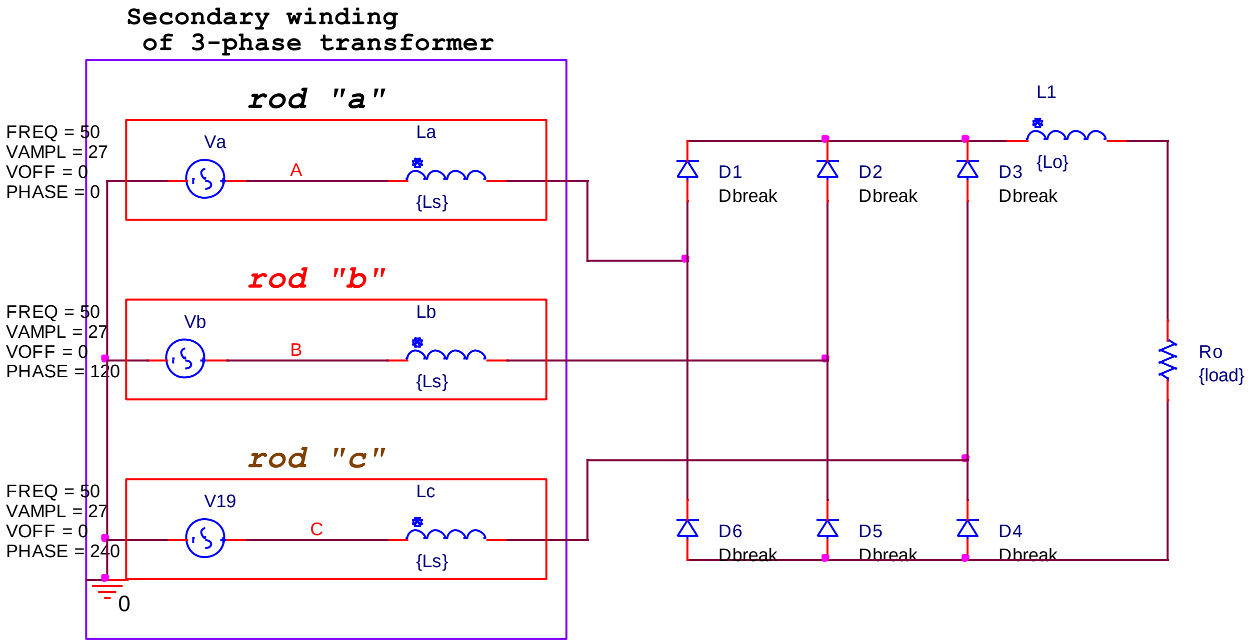


***Every phase contains two identical coils sitting at one rod of the 3-ph transformer*

1.Construct schematic;
2.Spend simulations at Rload=10 Ω.
3.Submit current and voltage waves :
V_Ea , V_(ph1, ph2); /single coil EMF and transformer line voltage/
V_Ea , V_pha1; /single coil EMF and voltage/
V_pha1 , (V_ph3) –V(pha1) ; / coil voltage at rod "a" and coil voltage at rod "c" - components of phase3 /
V_Ea ,I(La);
I(La), I(Laa)
Rod current I(La) + I(Laa) and *average* I(La) + I(Laa) ;

4.Compare and explain the results of exp.7 and exp.8.

9.



1.Construct schematic;
2.Spend simulations at different values of parameters Ls, Rload:
  Ls =10nH, Rload=10 Ω;
  Ls=100uH, Rload=10 Ω;
3.Submit current and voltage waves :
  V_A , V(A,B);
  V_A , I(La);
  V_A , I(Ro);
  V_A , I(D1);

Measure and explain the changes diode D1 ignition angle (α), conduction angle (θ), commutation angle(γ).

I(La), I(Lb);
Rod "a" current I(La) and *average* I(La);
Show the sequence of phase operation during one period

4. Compare the simulation results for different variants of parameters and evaluate the influence of parameters.

Experiment No.3

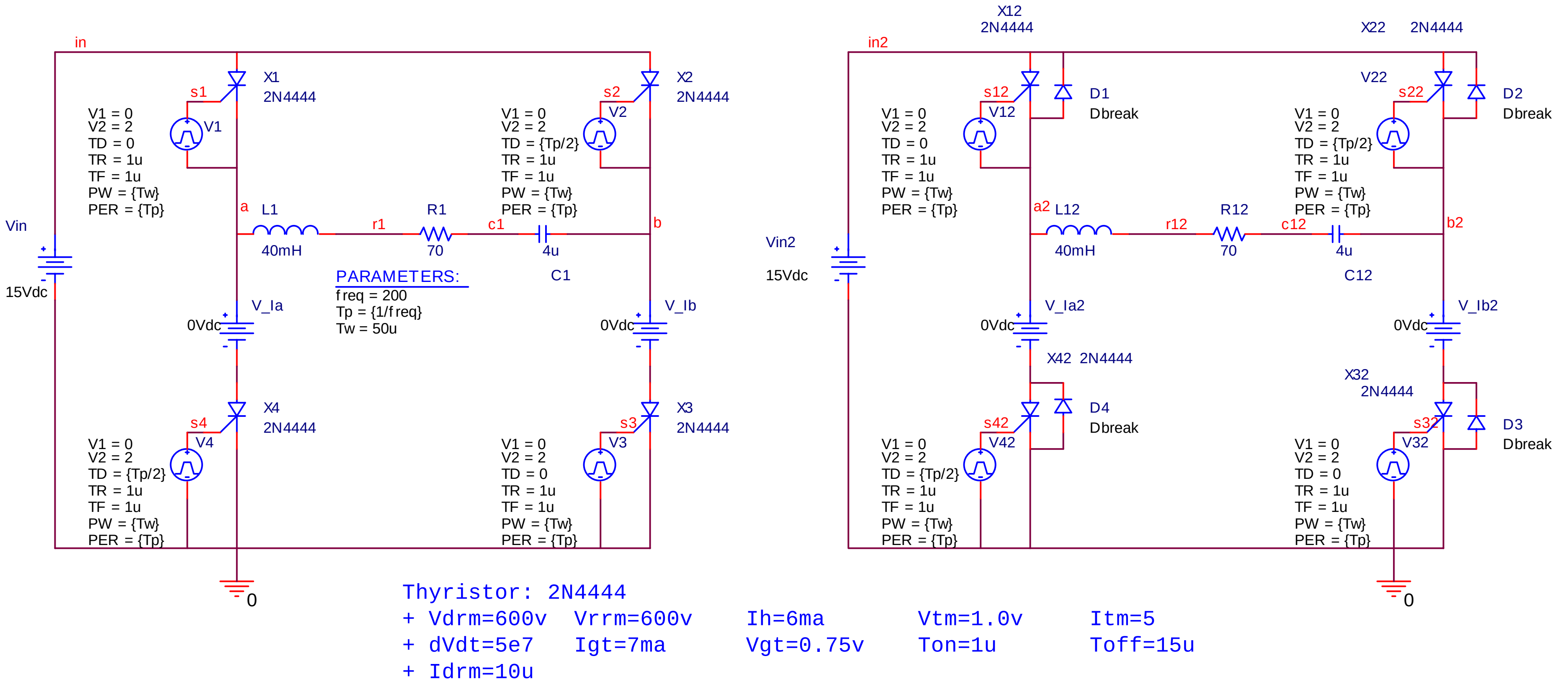


Fig. 3.A1.3. Schematic of bridge Voltage Inverter (without/with clamping diodes)

Vin; R1; C1; L1; Vin2; R12; C12; L12; freq = var;

$I_{thyristor}$;$V_{thyristor}$; V_{ab}; I_{R1}; V_{ab2}; I_{R12} = ??

Summary

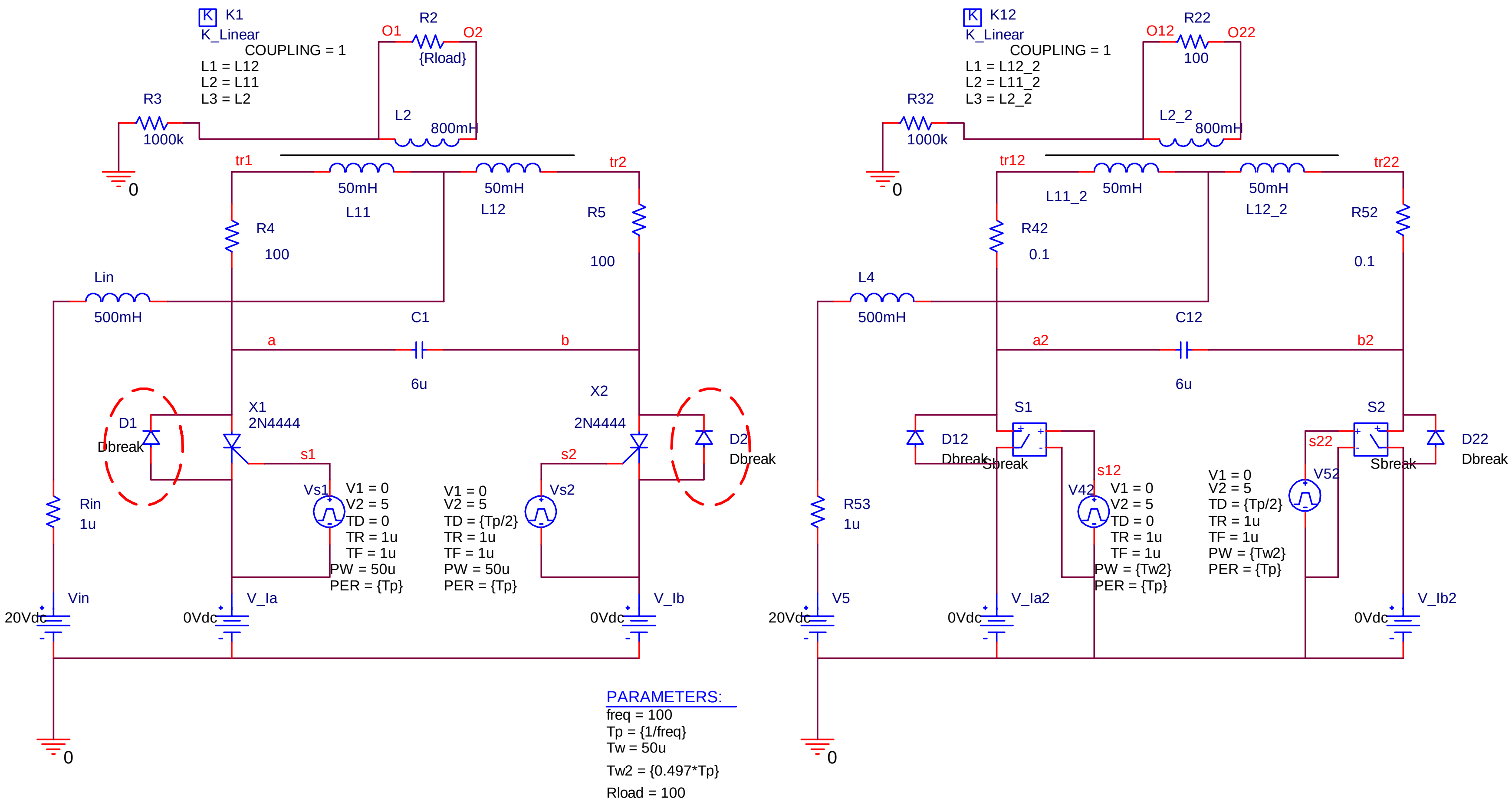


Fig. 3.A1.4. Schematic of Current Inverter (without/with clamping diodes)

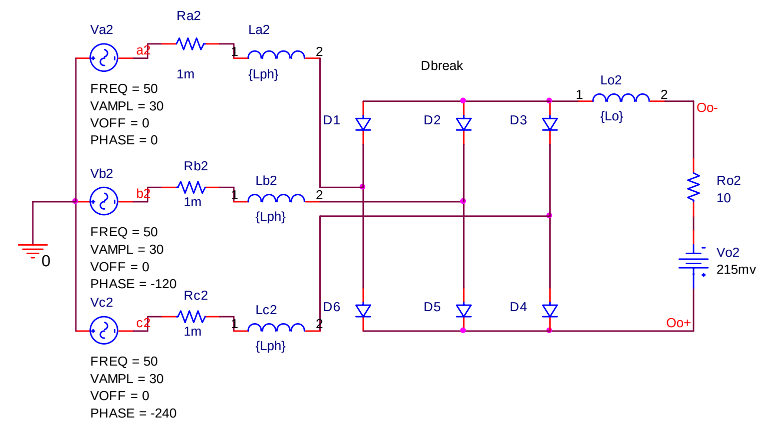
Vin; Rload; C1; Vin2; C12; freq = var;

$I_{thyristor}$ (I(V_la));$V_{thyristor}$; $V_{o1,o2}$; I_{R1}; V_{ab2}; $V_{o12,o22}$ = ??

Summary

Experiment No.4

Controlled rectifier simulation model

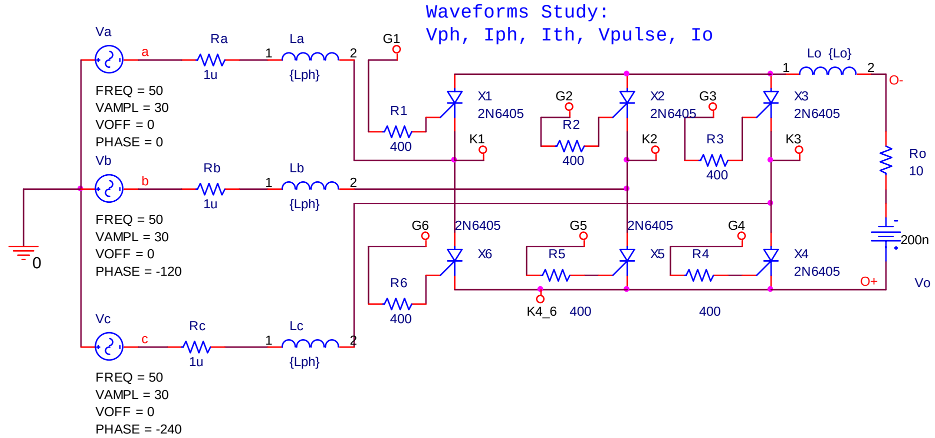


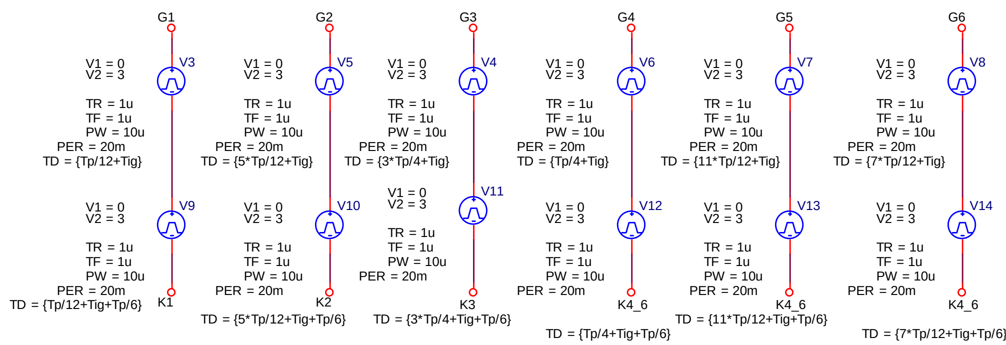
PARAMETERS:
Tp = 20m
Tig = {Kig*Tp/3}
Kig = 0
Lph = 0
Lo = 0

a) Kig=0, 0.1, 0.3; Lph=0; Lo=0
b) Kig=0; Lph=0.1mH, 0.2mH; Lo=0
c) Kig=0; Lph=0; Lo =0, 5mH, 15mH
d) Kig=0.3; Lph=0.75mH; Lo=0
e) Kig=0.3; Lph=0; Lo=30m

2N6405:
V_DRM,_RRM =800V;
I_T(rms) =32A;
I_G =5mA

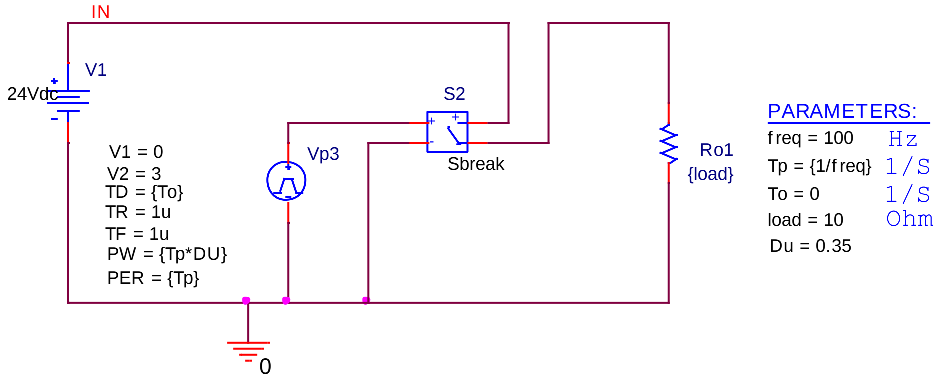
Waveforms Study:
Vph, Iph, Ith, Vpulse, Io





Experiment No.5

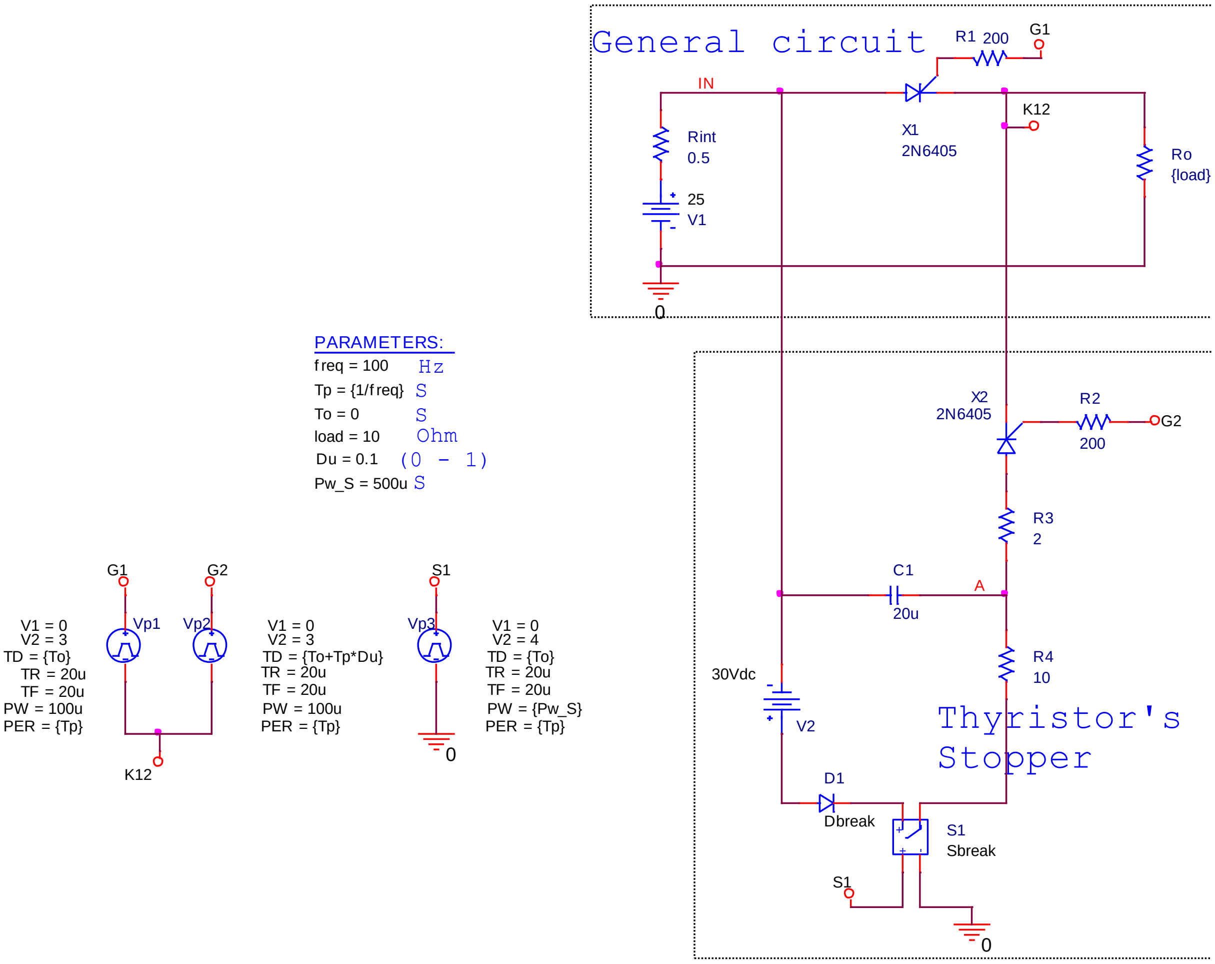
1. Introduction in chopper techniques.



- construct presented schematic in SPICE;
- carry out simulations (transient) for different values (6-8) of parameter Du (0 -1);

-draw the diagram of dependence of average value of loud current from parameter Du

2. chopper with external commutation source



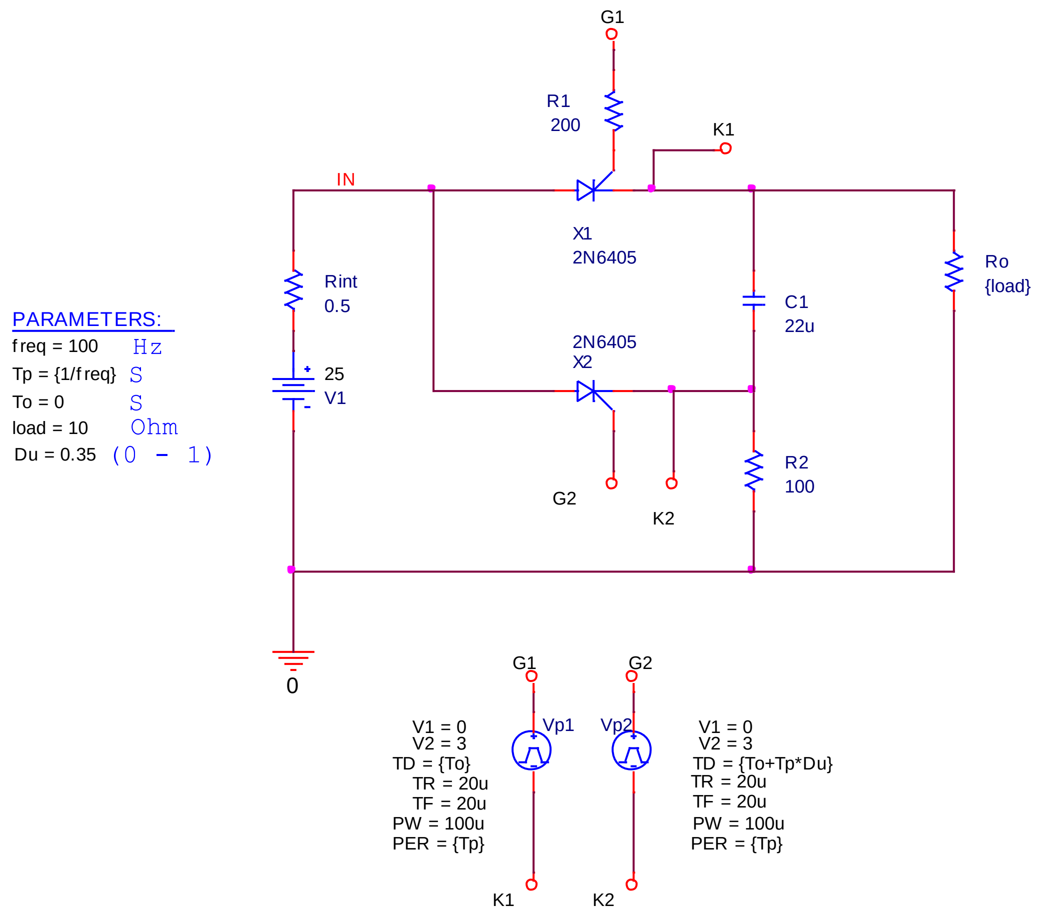

```
.subckt 2N6405
+ Vdrm=800v   Vrrm=800v    Ih=6ma      Vtm=1.7v     Itm=32
+ dVdt=50e6   Igt=5ma      Vgt=.7v     Ton=1u       Toff=15u
+ Idrm=10u
```

- construct schematic in SPICE;
- carry out simulations (transient) for different values of frequencies (20 -800Hz) → find the range of frequencies of working ability of the scheme at the specified parameters;
-draw the current waveform in loud, thyristors, capacitor for one value of frequency;
- explain currents forms.

Device's principle of action:

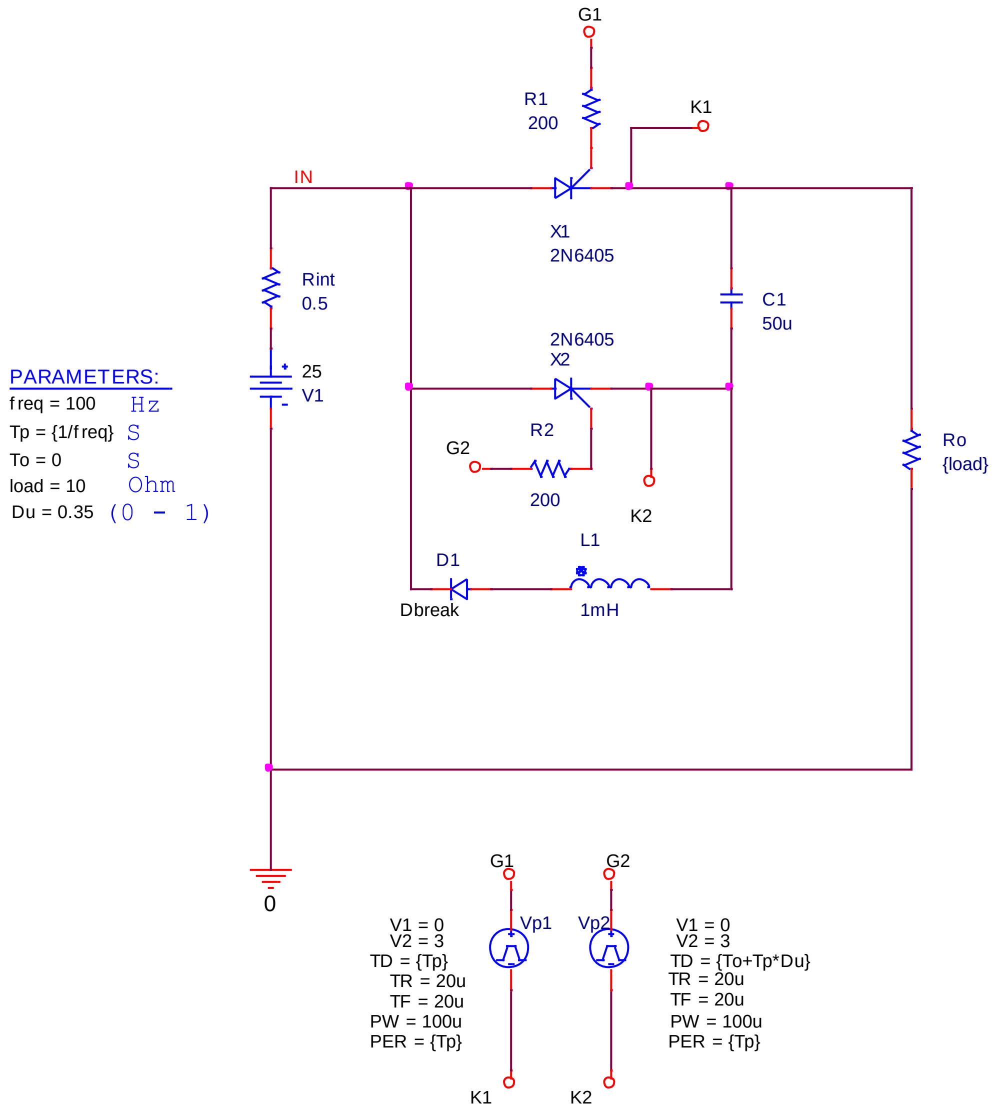
The pulse on a gate G1 opens the first thyristor X1. The current in load Ro starts to flow.   In the same time the switch S1 opens and a source V2 charges the capacitor C1.   At the necessary moment the pulse on a gate G2 opens the thyristor X2 and the positive pole A of a capacitor C1 is put to the cathode of the thyristor X1 and the negative pole is put to the its anode. The current through thyristor X1 stops and the Thiristor X1 is closed. The Thyristor X2 will be closed when capacitor C1 will be discharged.

3. RC-chopper



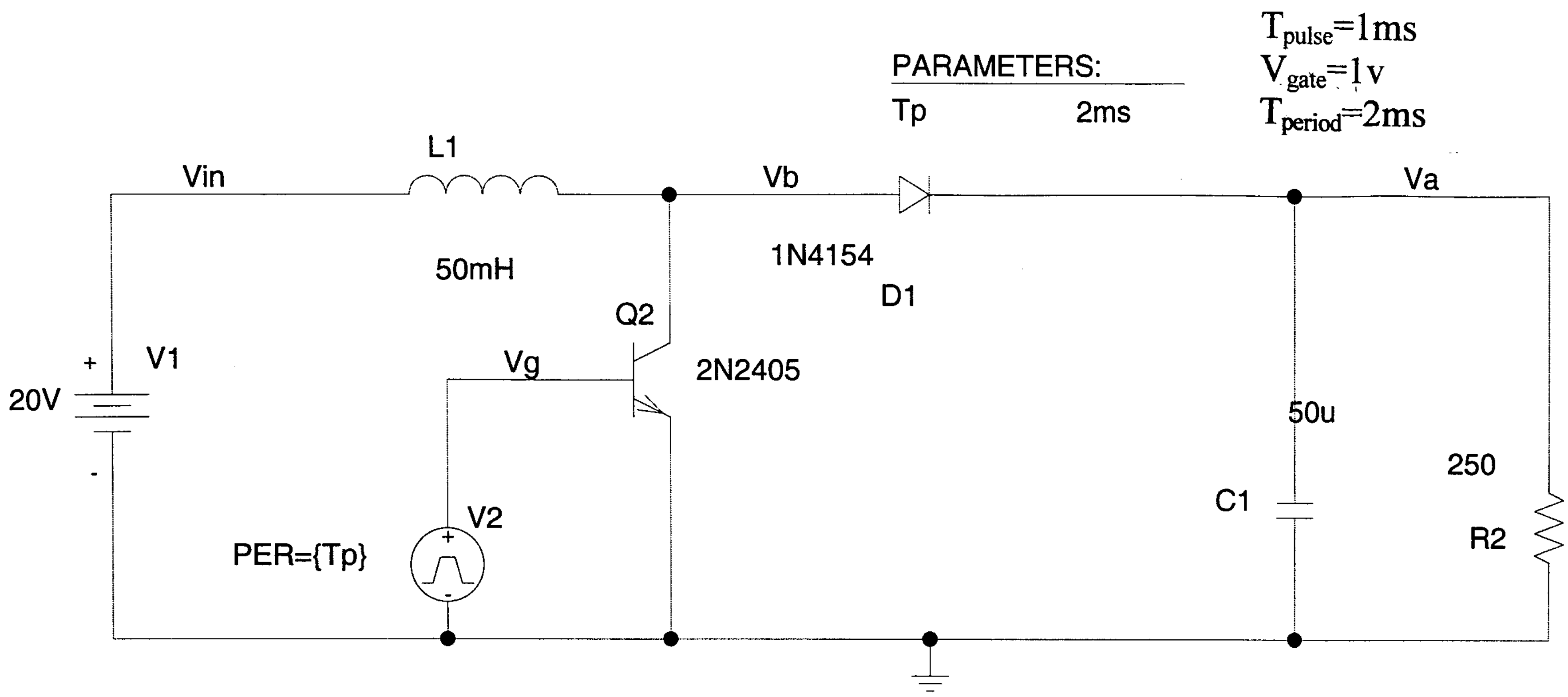
- construct schematic in SPICE;
- execute simulations (transient) for different values of frequencies (20 -800Hz) → find the range of frequencies of working ability of the scheme at the specified parameters;
-draw the current waveform in loud, thyristors, capacitor for one value of frequency;
- explain currents forms.

4. LC - chopper



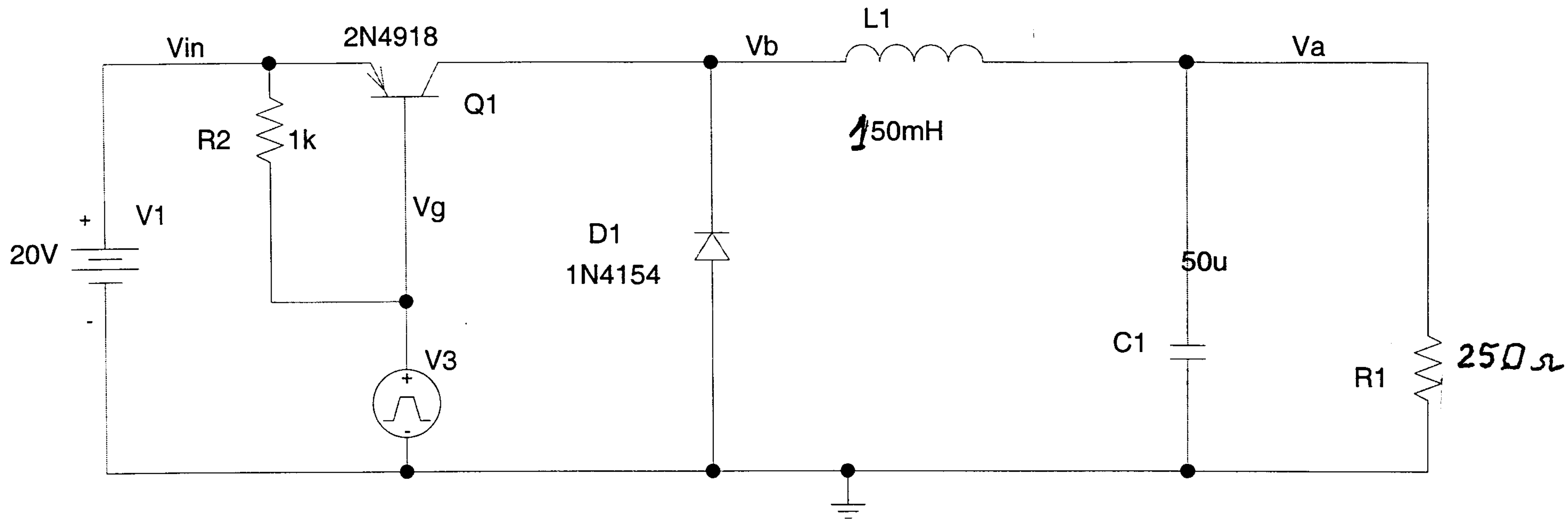
- construct schematic in SPICE;
- carry out simulations (transient) for different values of frequencies (20 -800Hz) → find the range of frequencies of working ability of the scheme at the specified parameters;
- draw the current waveform in loud, thyristors, capacitor for one value of frequency;
- explain currents forms.

Experiment No.6



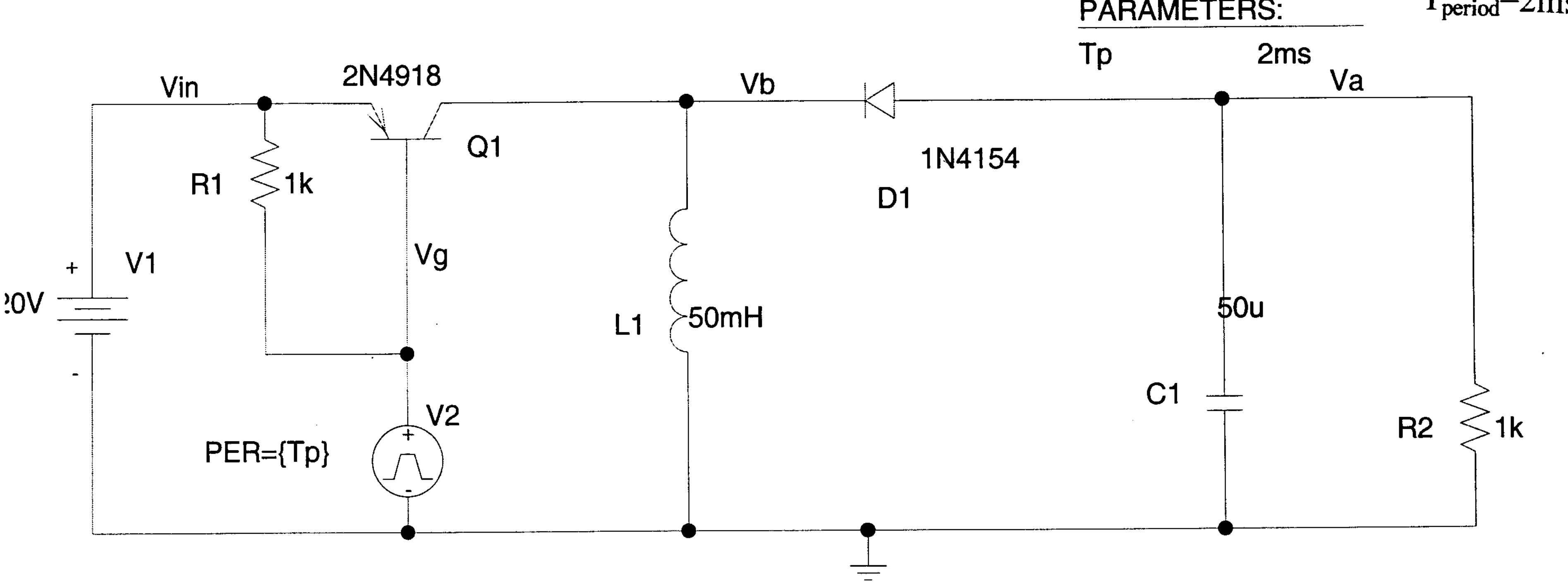
Boost converter - 6 סכימה לסמולצייה לניסוי מס'

$T_{pulse}=1ms$
$T_{period}=2ms$



Buck converter 6 - סכימה לסמולצייה לניסוי מס'

T_{pulse}=1ms
T_{period}=2ms



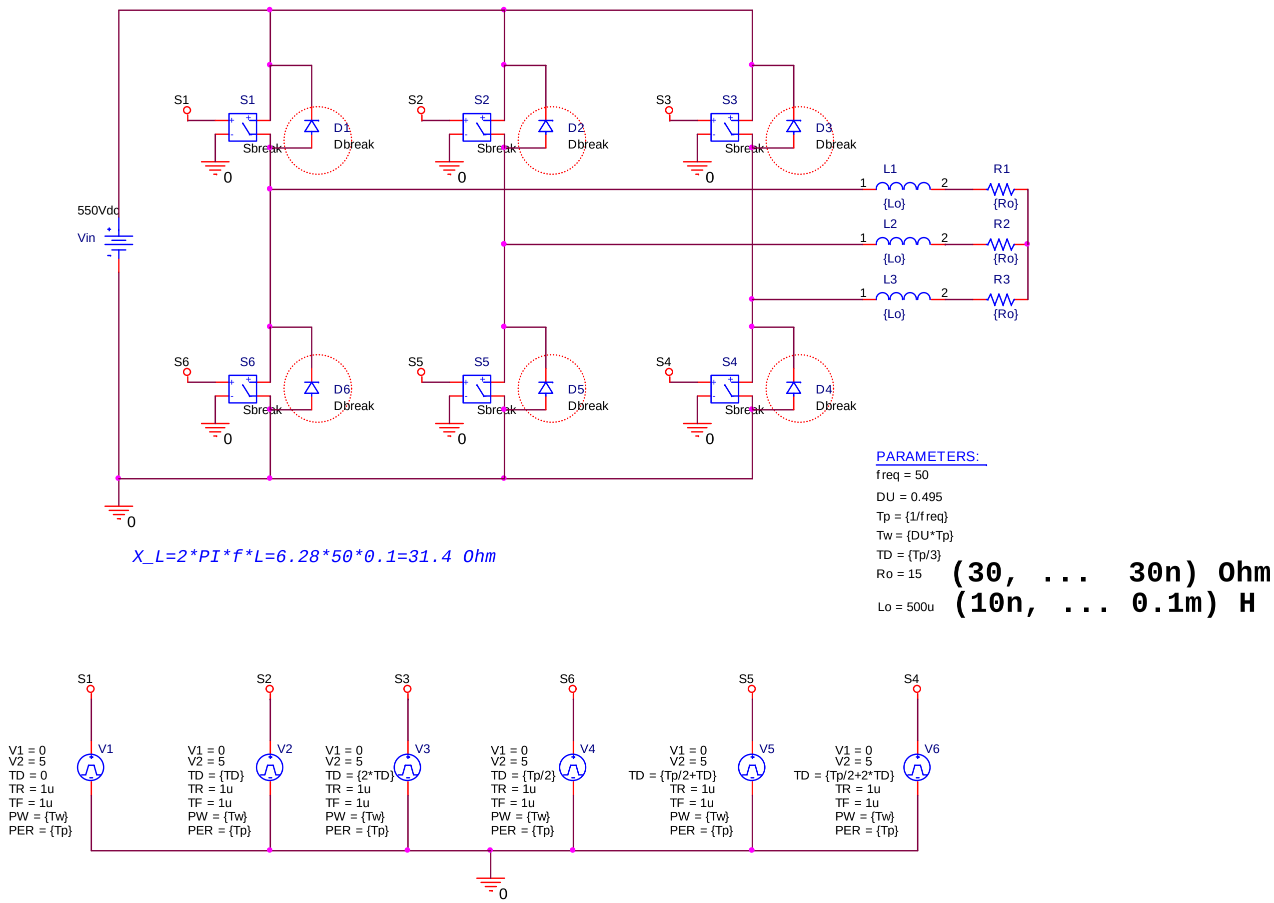
Buck- Boost converter 6 - סכימה לסמולצייה לניסוי מס'

Experiment No. 7

Exercise 1

6-step inverter

Running time ~ >15-20 periodes

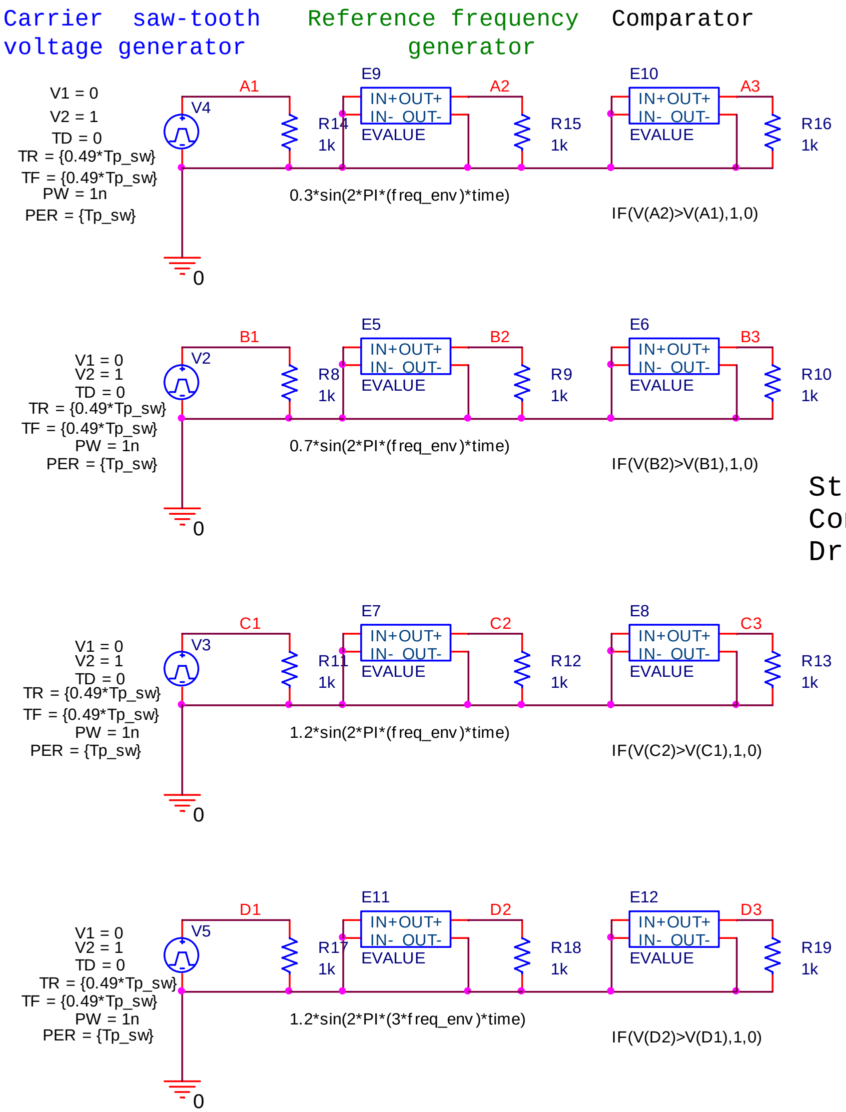


Result voltages and currents of switch and load in the scheme without diodes:
(Z~30 Ohm)
1. for active load :
2. for active-inductive load;
3. for mainly inductive load.
The same in the scheme with diodes

PWM forming

Exercise 2

PWM are created at comparison of a signal of carrier frequency with a signal of reference frequency



PARAMETERS:
freq_env = 25
freq_switch = 1000
Tp_sw = {1/freq_switch}
PI = 3.141592654

freq_env - output frequency (reference);
freq_switch - internal switching frequency (carrier frecuency)

Study process of pulses formation on the specified schemes;
Compare spectra of output signals;
Draw spectra curves

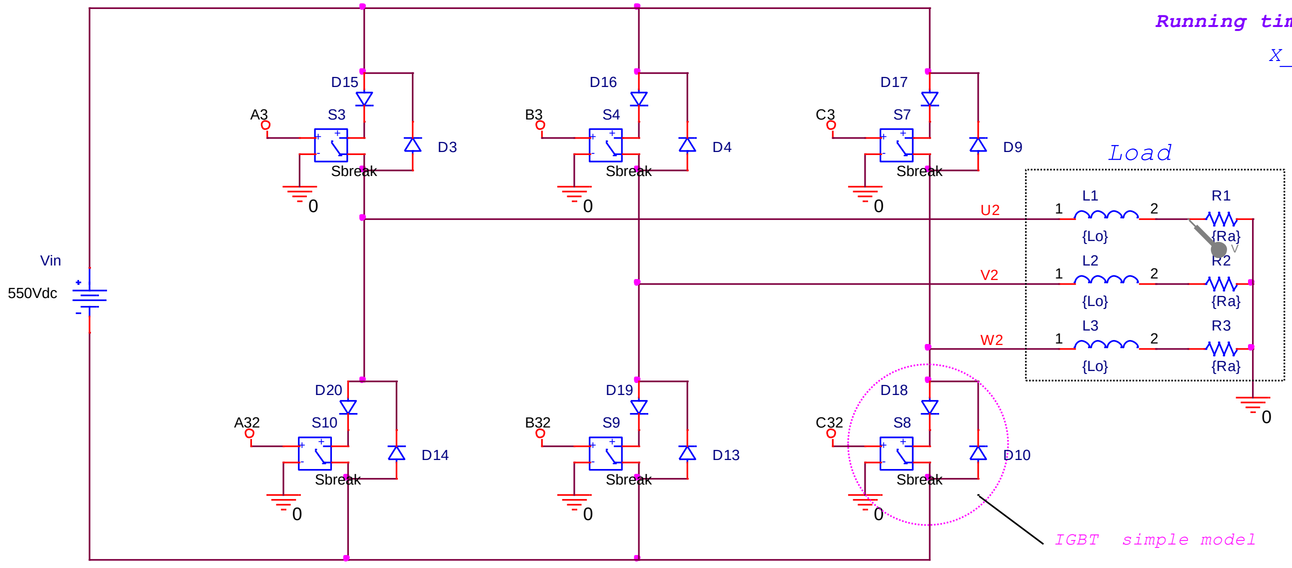
For calculation of spectra use SPICE option :
Simulation Setting\Output File Options
Center frequency - freq_env;
Number of harmonics - 45;
Output variables - V(A3) , V(B3), --- V(D3)

PWM 3-phase inveter

Exercise 3

Running time ~ >15-20 periodes of envelope curve

*X_L=2*PI*f*L=6.28*50*0.01H=3.14 Ohm*



PARAMETERS:
freq = 50 *envelope frequency*
Tp = {1/freq}
TD = {Tp/3}

freq_car = 1000 *carrier frequency*
DU_car = 0.495
Tw_car = {DU_car*Tp_car}
Tp_car = {1/freq_car}

Lo = 10nH (*10mH*)
Ra = 30.14 (*30.14n*)
V_du = 0.8

(Pi=3.141592654)

Result voltages and currents of switch and load
1. for active load (Z~30 Ohm);
2. for active-inductive load (Z~30 Ohm)

Pulse Generator