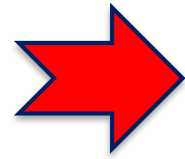


GaNPower GaNPowerIC™ Application Note: Three-phase inverter/motor-driver



GANPOWER INTERNATIONAL
鎳能國際半導體有限公司

3-phase inverter/motor-drive Application Note

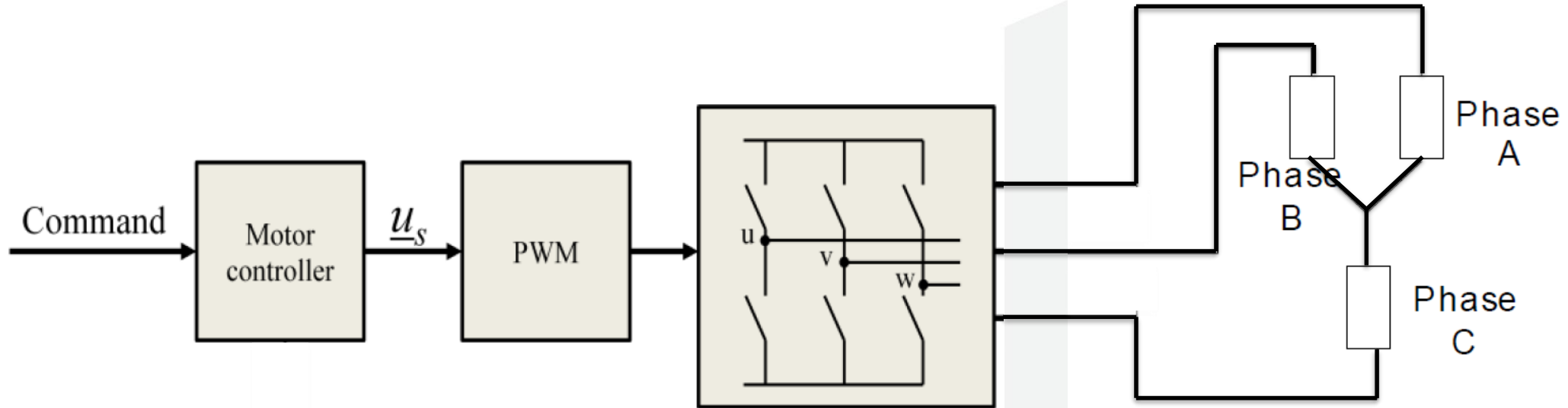


Space vector PWM generation

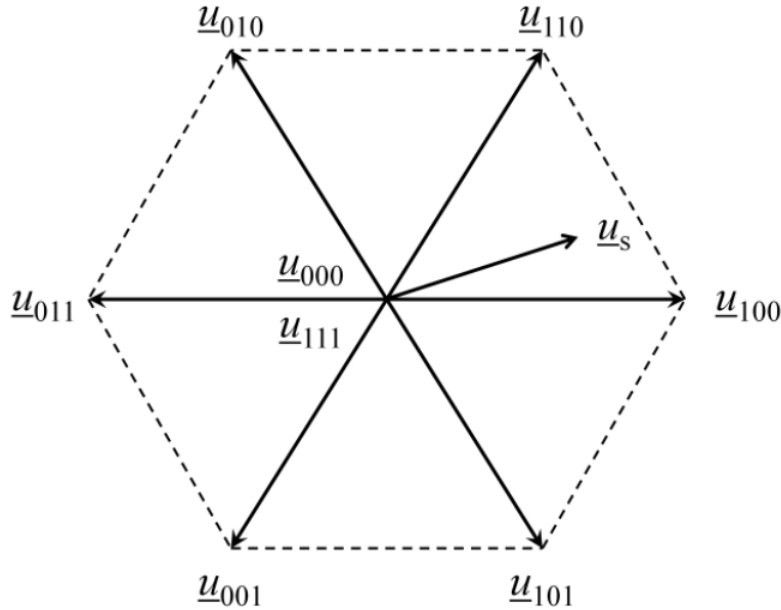
3-phase inverter using existing IPM controller

3-phase inverter using pulse transformer and double pulse trigger

Basic 3-phase motor configuration



Space vector modulation method



Voltage space vectors available using a three phase inverter

Six-step motor plotted on hex is the space vector configuration we work on.

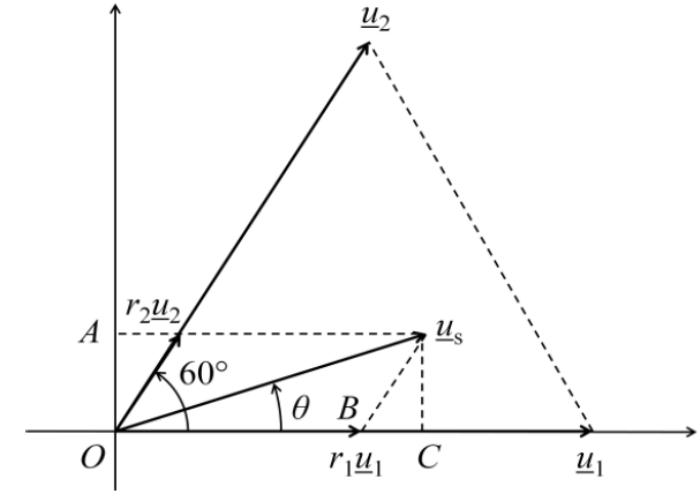
$$t_b = 2U(3^{-1/2})\sin(\alpha)$$

$$t_a = U[\cos(\alpha) - (3^{-1/2})\sin(\alpha)]$$

where $U = |\underline{u}_s|$ (Modulation Index)

$$\alpha = \angle \underline{u}_s$$

a=> 1 b=>2



Approximation of an arbitrary voltage space vector using base vectors

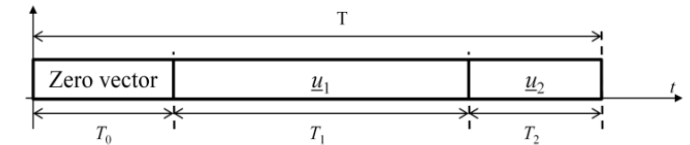
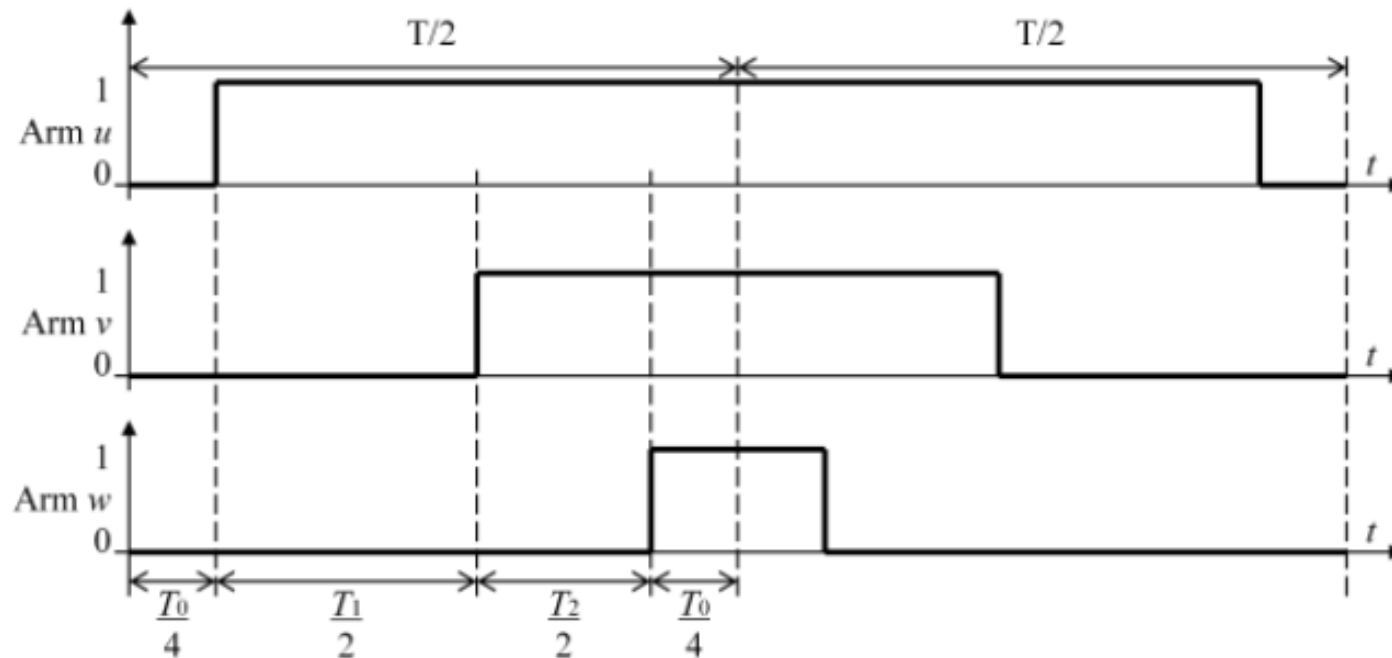


Figure 4. Combination of vectors using time division

The three time durations are defined as

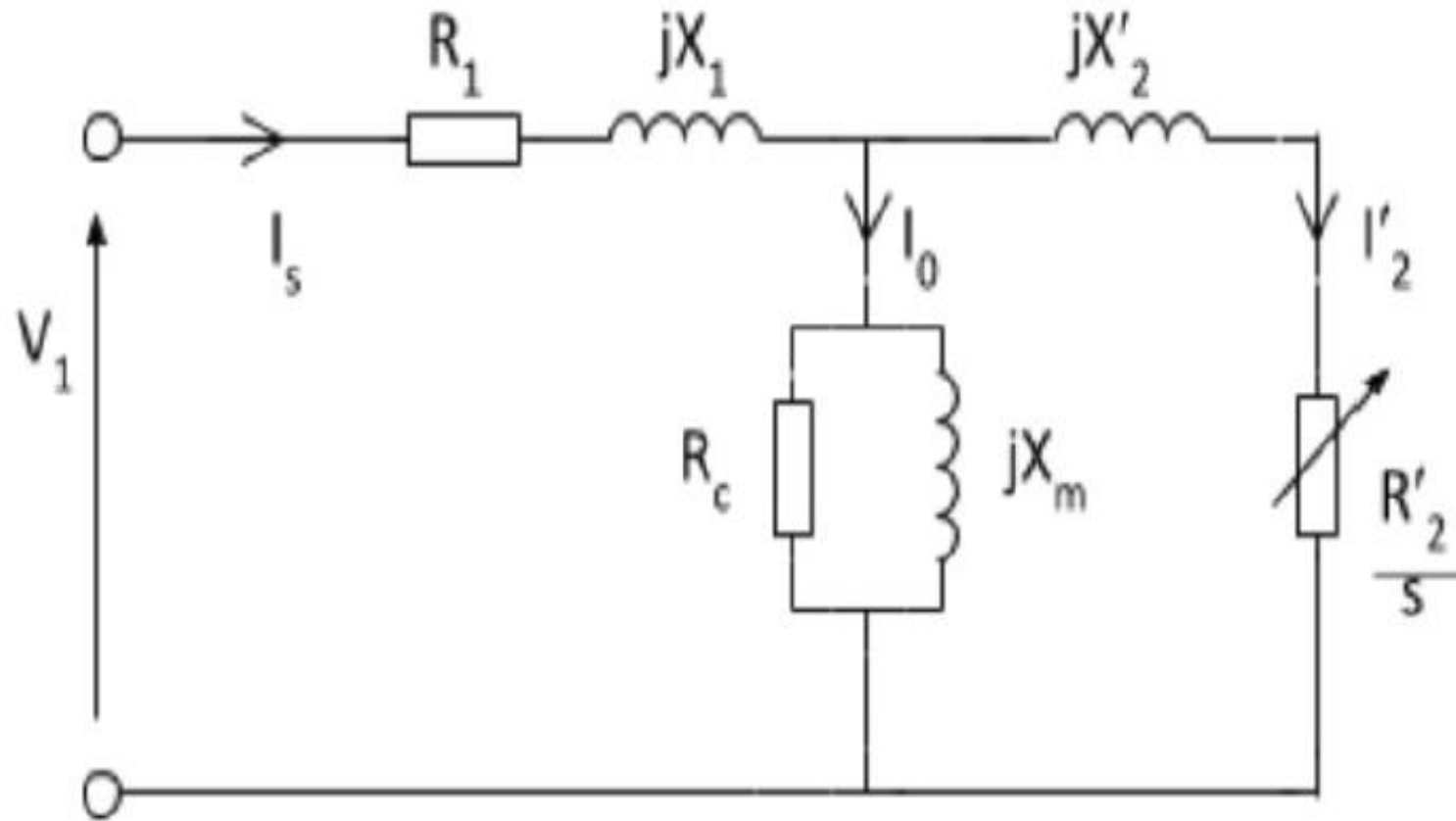
$$\begin{cases} T_0 = (1 - r_1 - r_2)T \\ T_1 = r_1 T \\ T_2 = r_2 T \end{cases}$$

Use of symmetric pulse for better performance With u_{111} inserted in pulse center

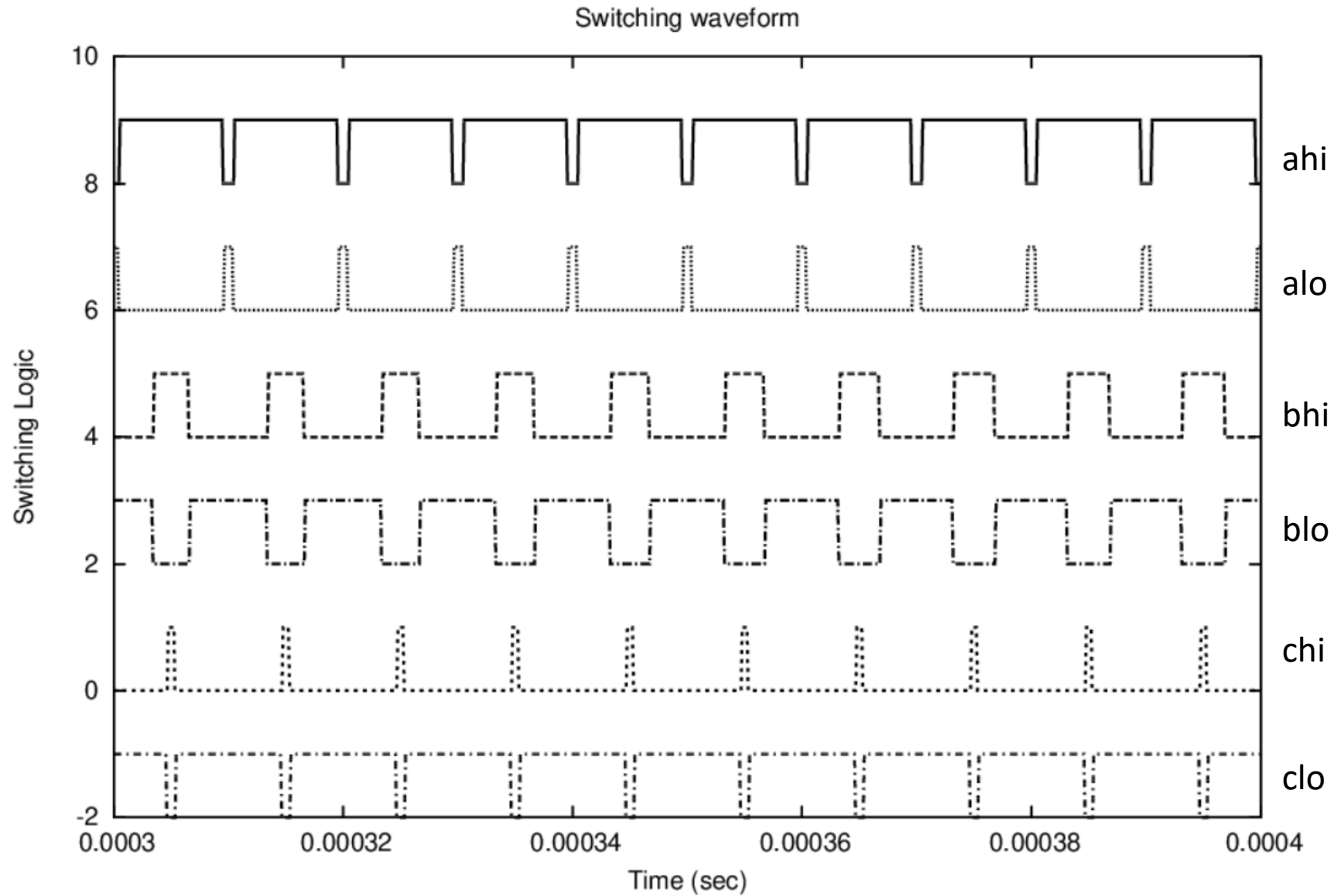


PWM switching sequence using both u_{000} and u_{111} as zero vectors

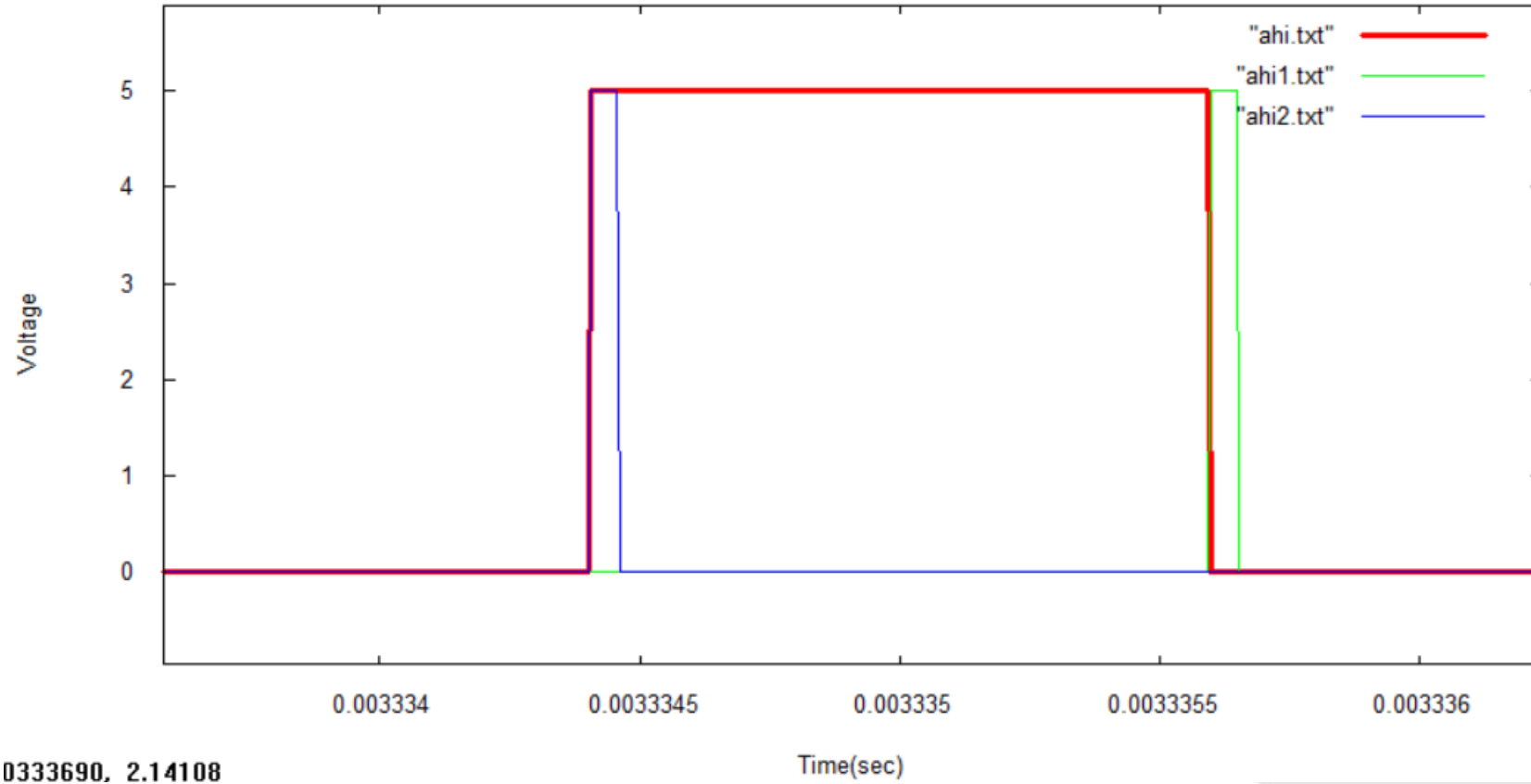
Induction motor equivalent circuit (single phase)



Normalized waveform for all six transistors



Use of narrow pulse (50ns-300ns) to trigger turn-on and turn-off of the main switch, so that micro pulse transformer can be used for level shifting

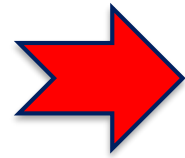


0333690, 2.14108

Time(sec)

3-phase inverter/motor-drive Application Note

Space vector PWM generation

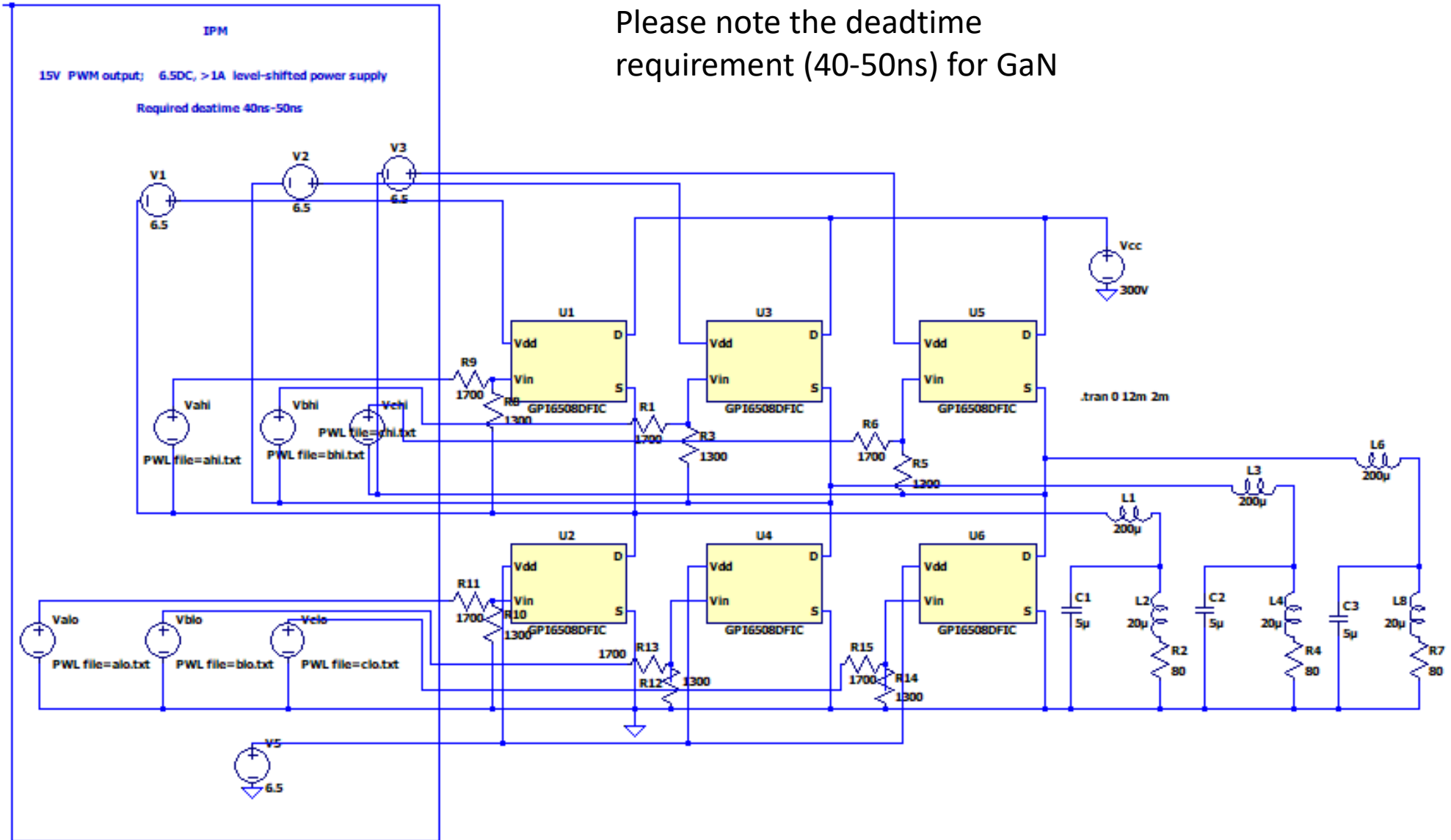


3-phase inverter using existing IPM controller

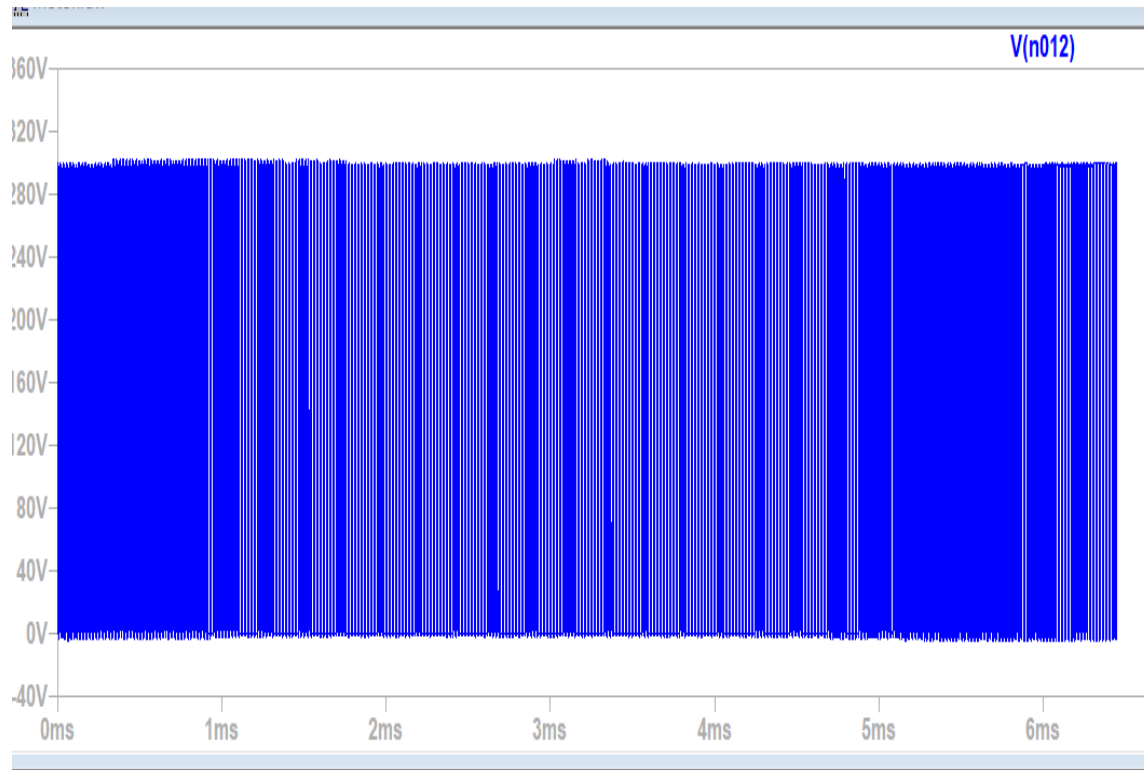
3-phase inverter using pulse transformer and double pulse trigger

Schematic

Please note the deadtime requirement (40-50ns) for GaN



Generation of PWM for 3-phase motor



Wave form at switching pointing showing duty cycle variation according to space vector modulation control

C:\space_vector.exe

==>GaNPower space vector modulation program<==

For tech support: iganpower.com

This program uses input_3phase.txt as input

Explanation is contained within the input file.

The output is PWM waveform for 3-phase switches

For phase a, b, c, low and high side switches:

Output files: alo.txt, ahi.txt

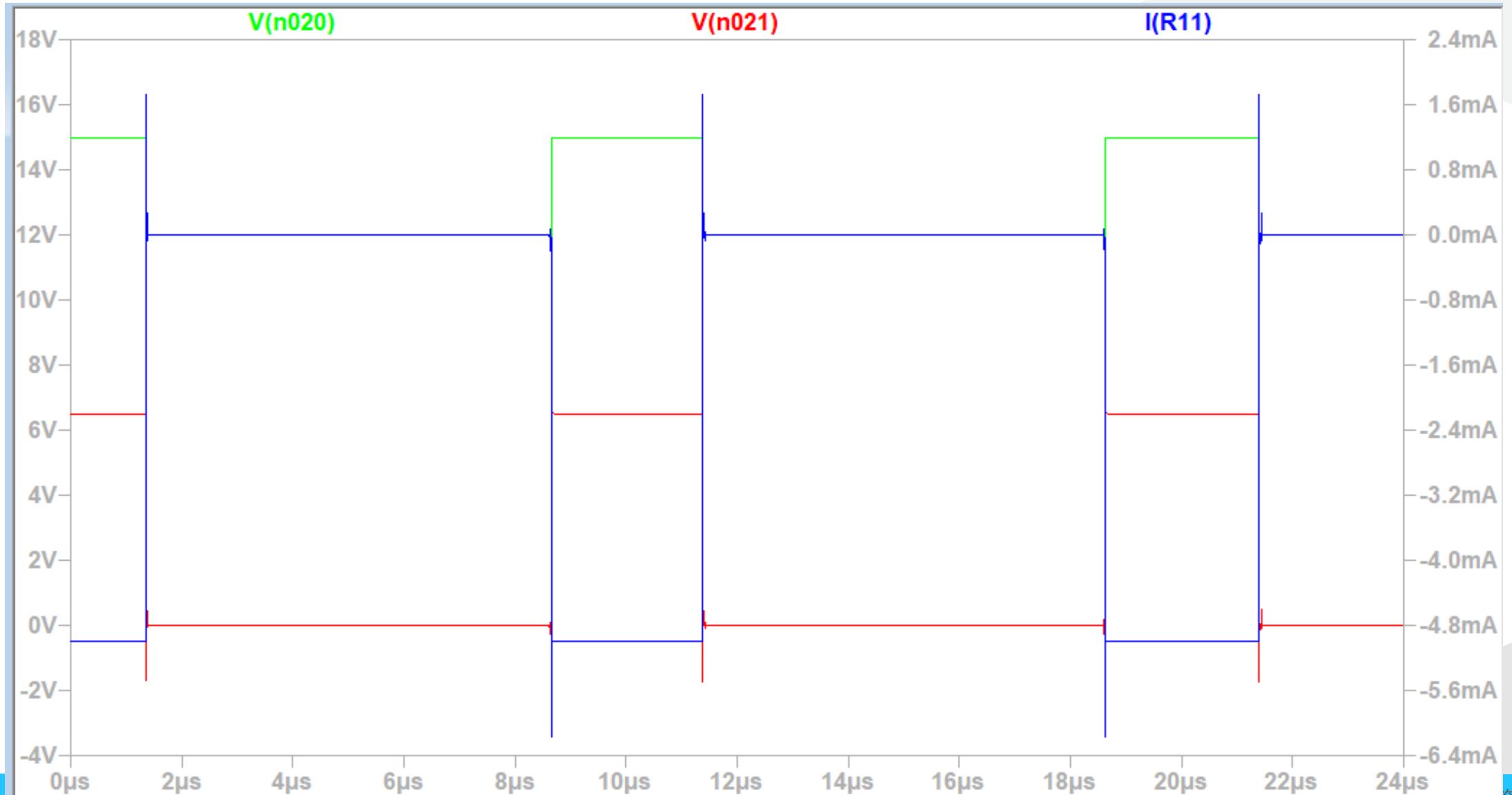
Output files: blo.txt, bhi.txt

Output files: clo.txt, chi.txt

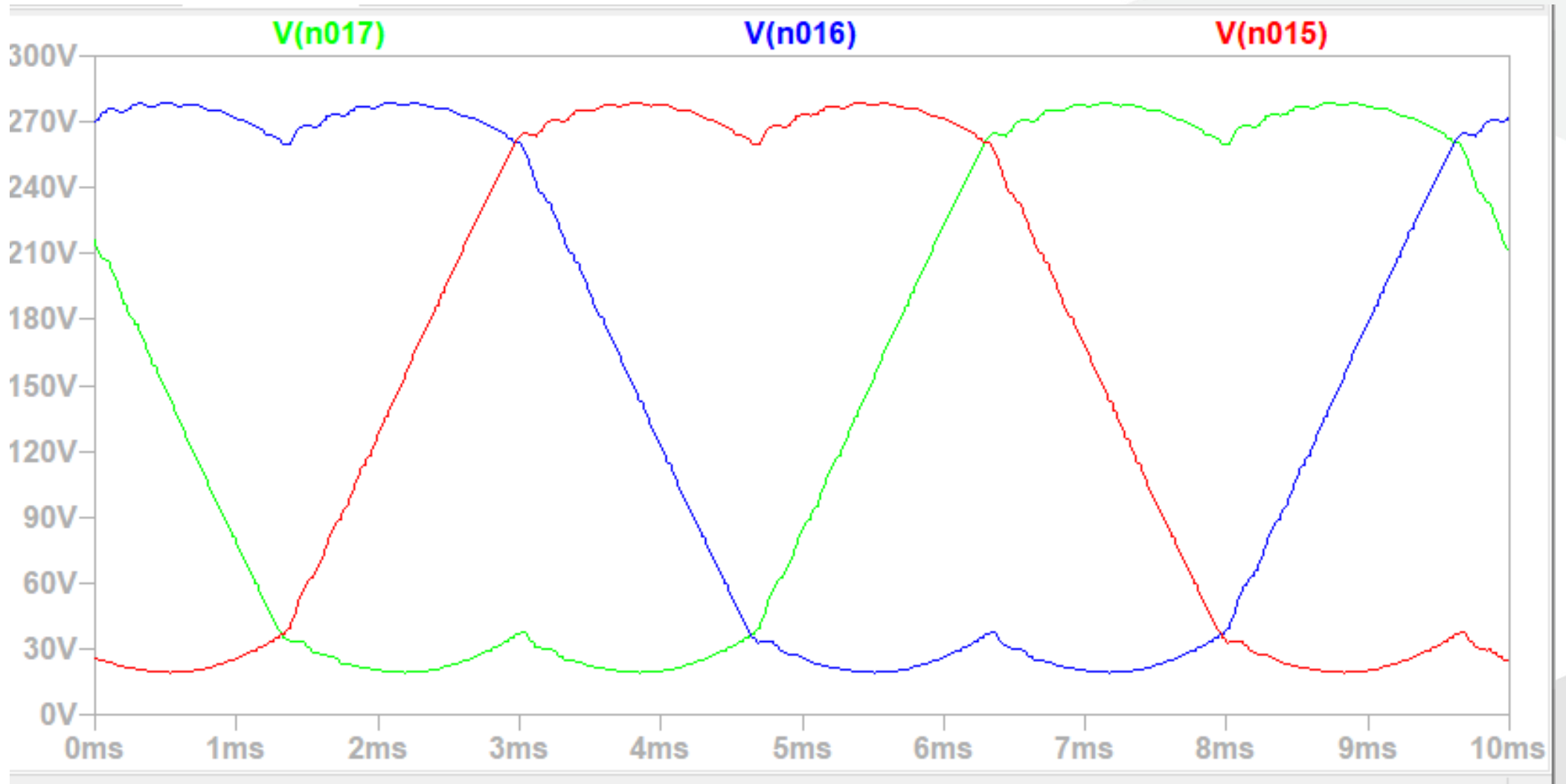
In the case of edge-triggered double narrow pulse, labels 1 or 2 will be appended to the above filenames.

==> Please enter to generate data

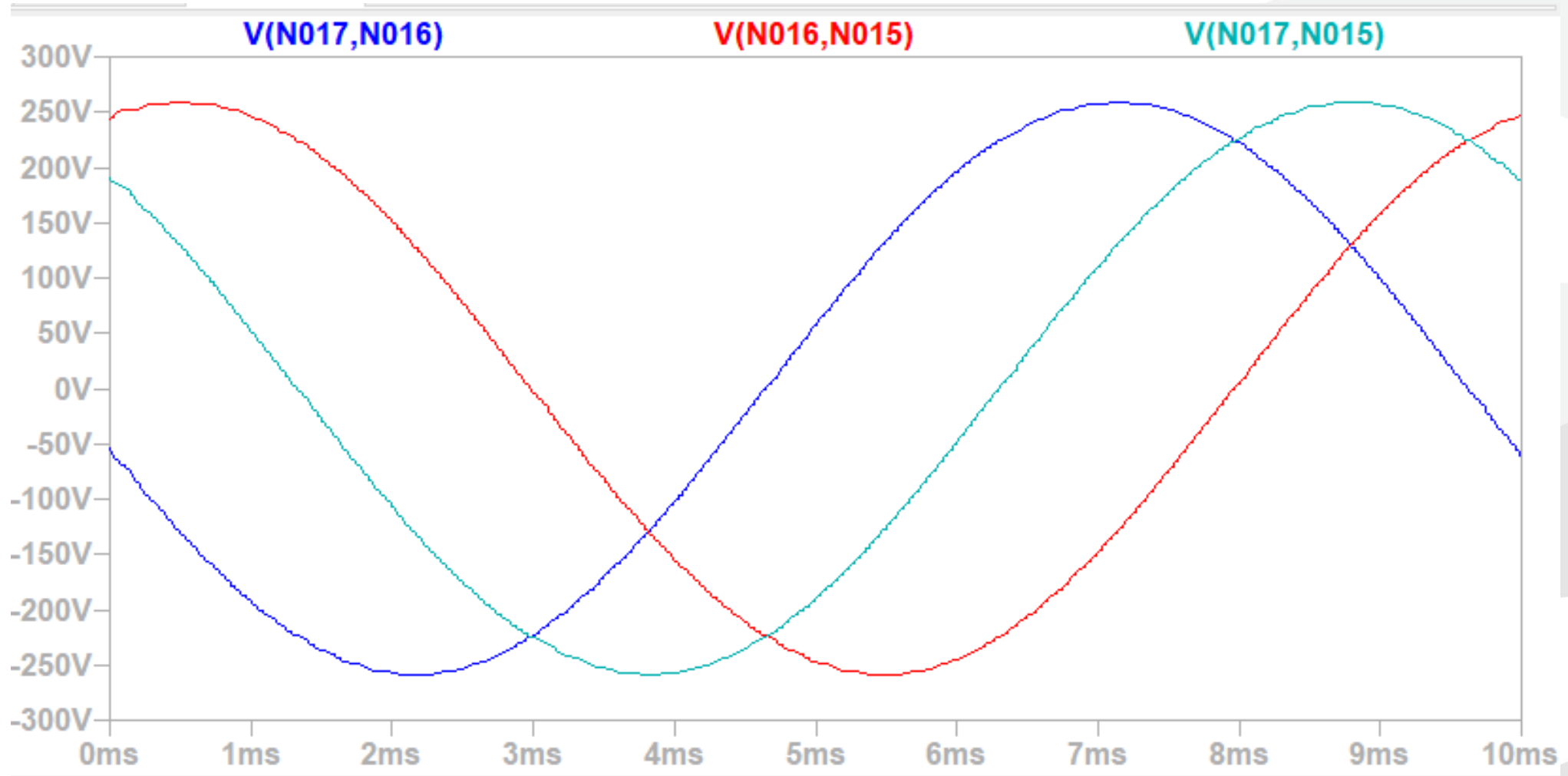
Input waveforms before and after resistor divider



Phase to neutral voltage output



Phase to phase voltage output



Transistor power loss estimate

```
C:\3phase_simple>halfbridge_power_ltspice.exe
Welcome to GaNPower Half Bridge
Power Loss Calculator
Input control is input.txt
Please hit return to run the calculator or
enter i for information on the calculator

-->> Average Vd*Id power loss:
Power loss for low side (W)= 0.261508221055837
Power loss for hi side (W)= 1.22697196017061
Average load power (W)= 745.170281266409
Percent power loss= 0.199750341451727
-->>
Please enter again to close the program
```



Summary

- GaNPowerIC™ single channel integrated IC is easy to use with existing IPM controller unit.
- Resistor voltage divider is effective.
- GaNPower IC has very low power loss when used with a smaller switching deadtime (40ns).

Thanks for your
attention!

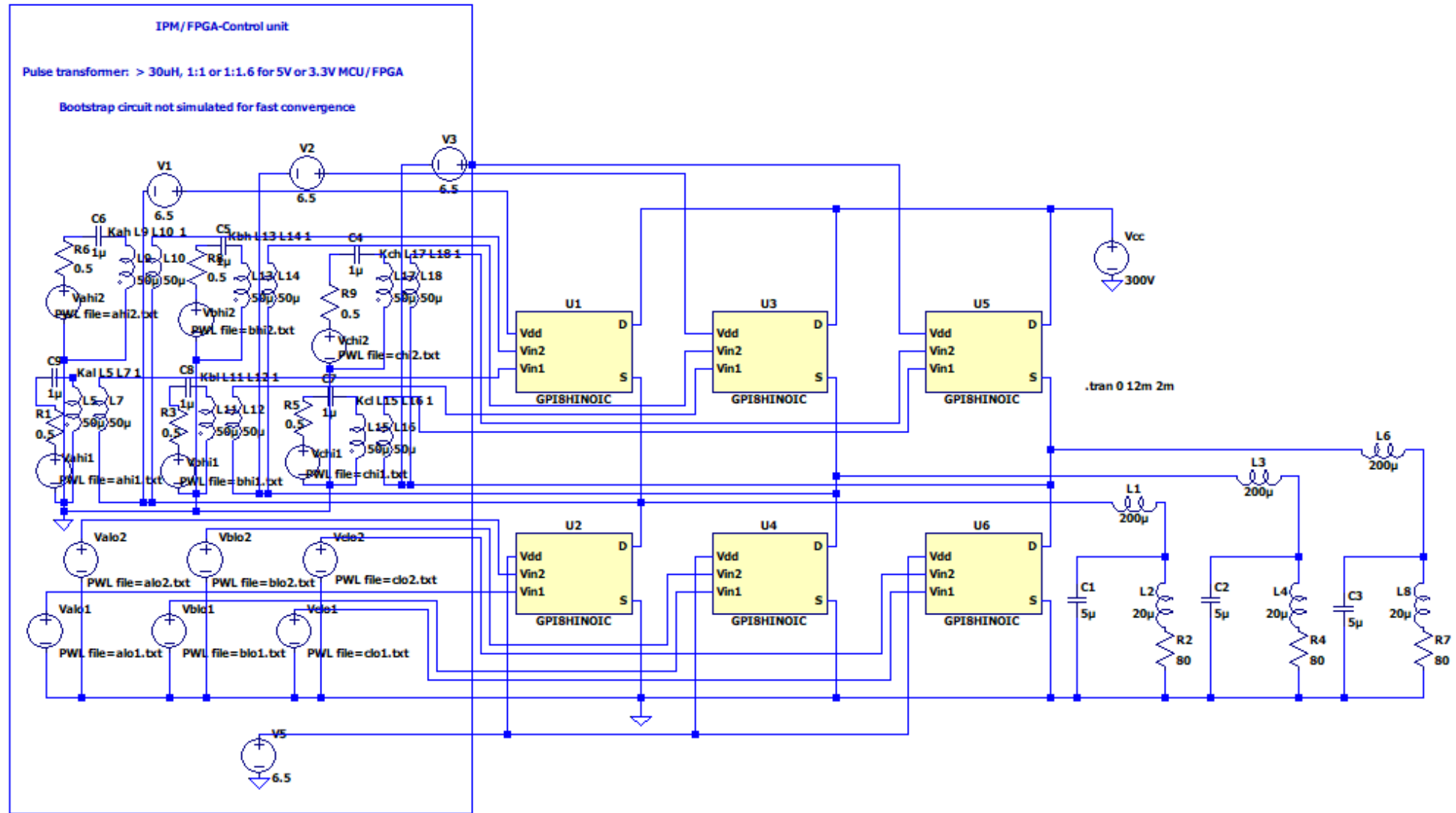
3-phase inverter/motor-drive Application Note

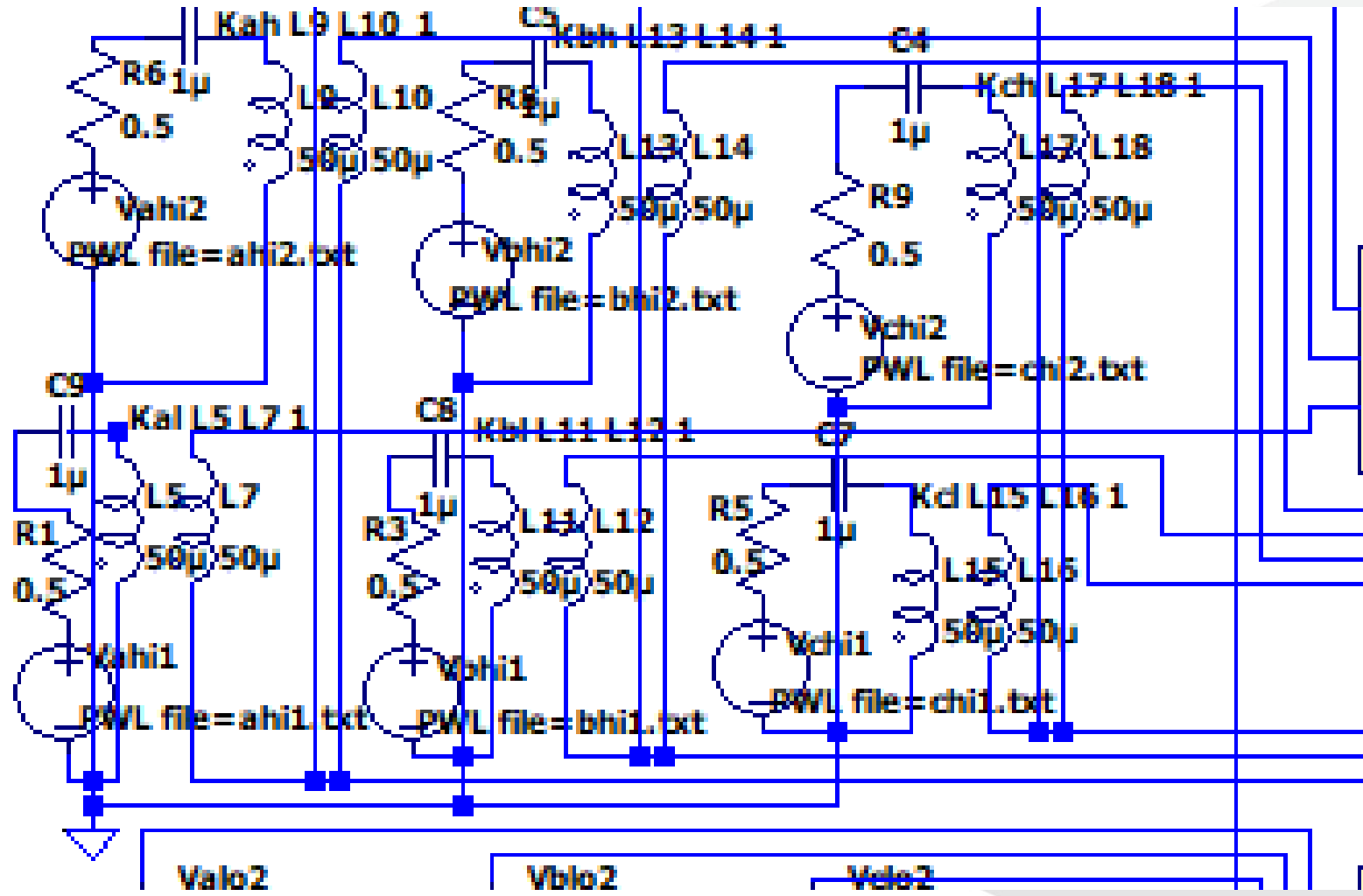
Space vector PWM generation

3-phase inverter using existing IPM controller



3-phase inverter using pulse transformer and double pulse trigger





==>GaNPower space vector modulation program<==

For tech support: iganpower.com

This program uses input_3phase.txt as input

Explanation is contained within the input file.

The output is PWM waveform for 3-phase switches

For phase a, b, c, low and high side switches:

Output files: alo.txt, ahi.txt

Output files: blo.txt, bhi.txt

Output files: clo.txt, chi.txt

In the case of edge-triggered double narrow pulse,
labels 1 or 2 will be appended to the above filenames.

==> Please enter to generate data

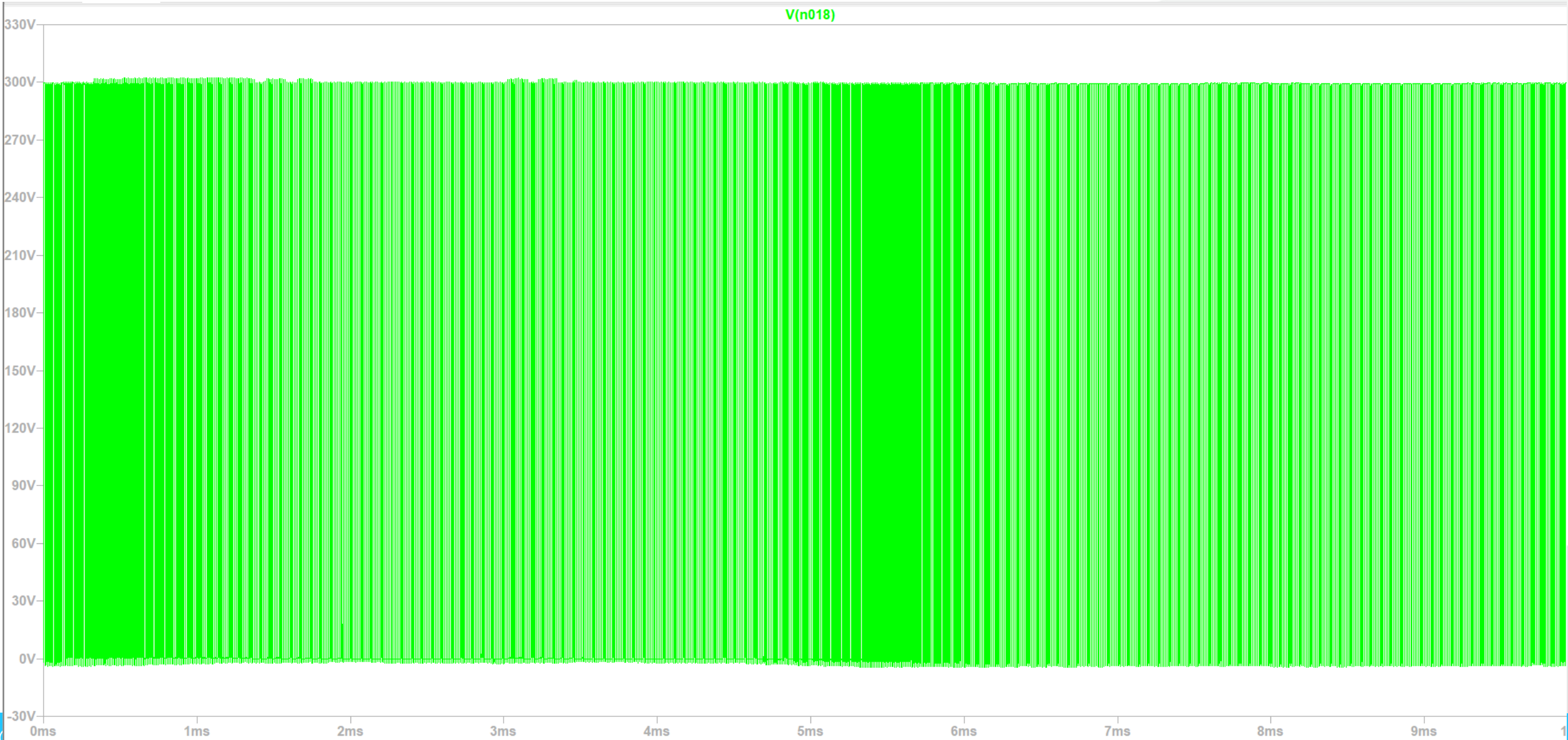
Program provided to generate the PWM waveforms Or the corresponding narrow double pulse

```

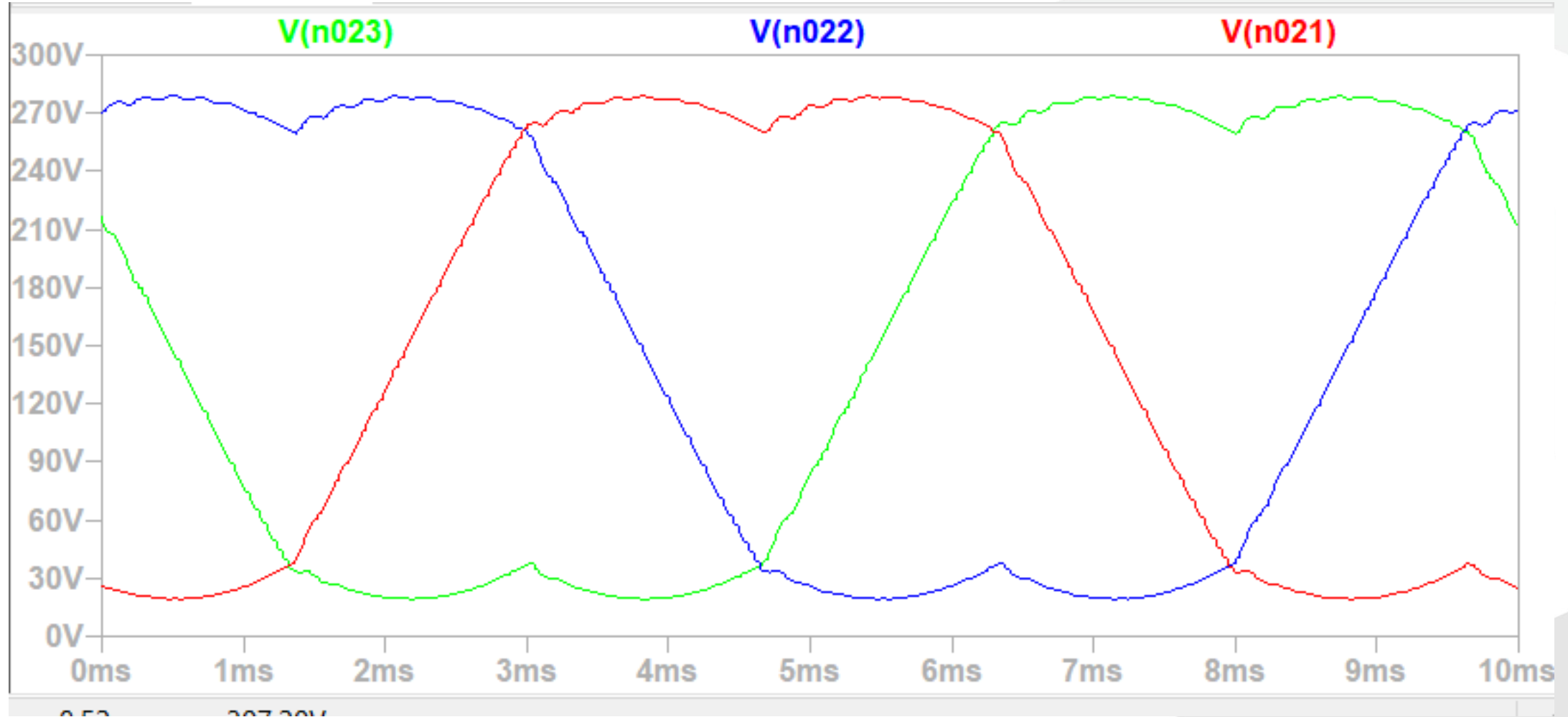
5.      #vmax
40.e-9  #deadtime or leadtime
5.e-9   #rise/fall time
0.75    #modulation index (intensity of modulation/power
max=0.866)
100.    #ACline frequency
100000. #switching freq
1       #number of ACline cycle
50.e-9  #if positive, it is the on-time of edge triggered
narrow pulse

```

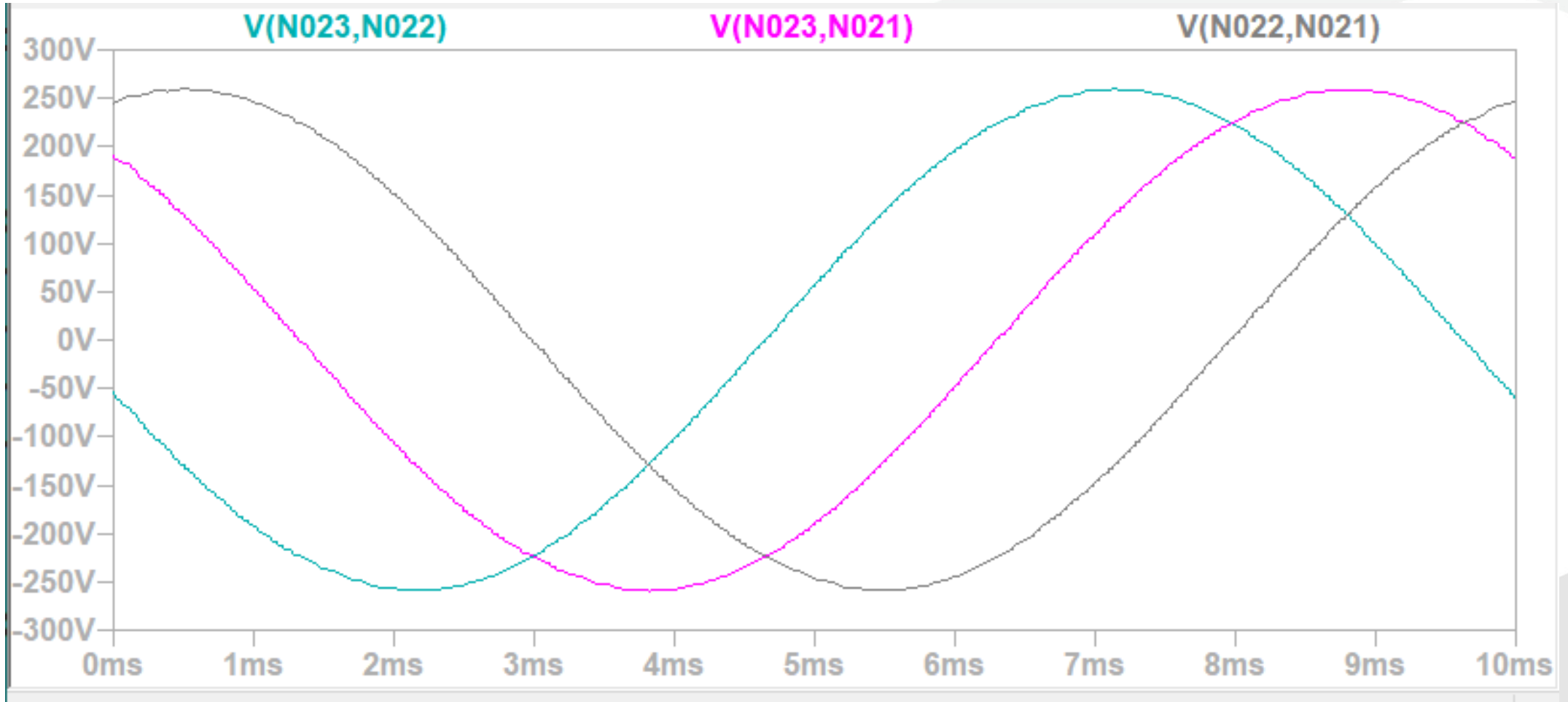
Switching point waveform showing modulation in duty cycles



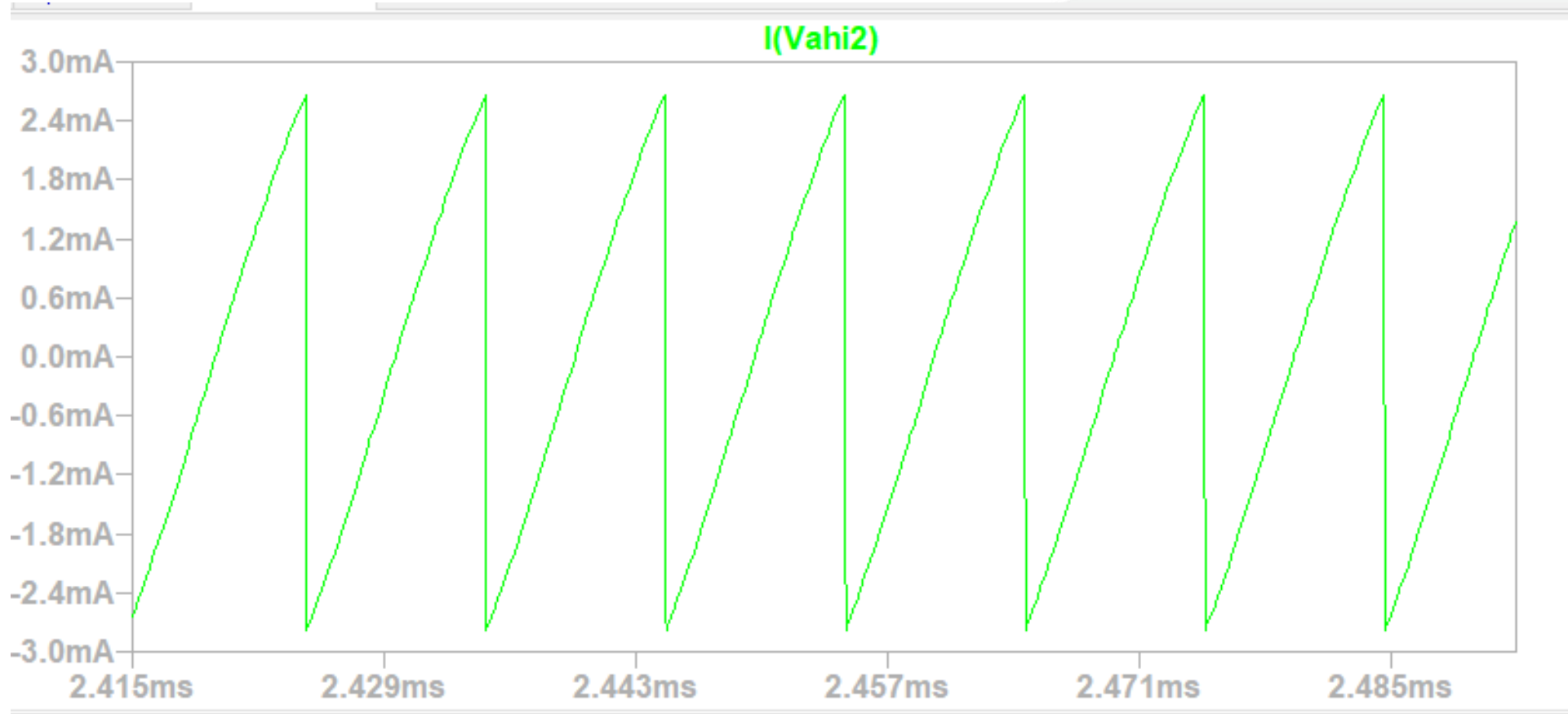
Phase to neutral output



Phase to phase output voltage



Current in primary side of pulse transformer



Power loss estimate using program Halfbridge_power_LTSpice.exe

Welcome to GaNPower Half Bridge
Power Loss Calculator
Input control is input.txt
Please hit return to run the calculator or
enter i for information on the calculator

-->> Average $V_d \cdot I_d$ power loss:
Power loss for low side (W)= 0.248628319147570
Power loss for hi side (W)= 1.22974952148440
Average load power (W)= 747.025024964907
Percent power loss= 0.197902050296296
-->>
Please enter again to close the program

Summary

- GaNPower IC can be programmed using small transformer for coupling and level shifting for the high side and low side.
- Since the same narrow pulses are used for all switching frequencies, there is no need to change the transformer when changing the switching frequency as commonly done in IPM controller.
- GaNPower IC has very low power loss when used with a smaller switching deadtime (40-50ns).

**Thanks for your
attention!**