GaNPowern GaNPowernIC™ Application Note: Three-phase inverter/motor-driver
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.

\[ t_0 = 2U(3^{\frac{-1}{2}})\sin(\alpha) \]
\[ t_a = U[\cos(\alpha) - (3^{\frac{-1}{2}})\sin(\alpha)] \]
where \( U = |u_s| \) (Modulation Index)
\( \alpha = \angle u_s \)

a=> 1   b=>2
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
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
Please note the deadtime requirement (40-50ns) for GaN
Generation of PWM for 3-phase motor

C:\space_vector.exe
==>GaNPowerr 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

Wave form at switching pointing showing duty cycle variation according to space vector modulation control
Input waveforms before and after resistor divider
Phase to neutral voltage output
Phase to phase voltage output

- \( V(N017,N016) \)
- \( V(N016,N015) \)
- \( V(N017,N015) \)
Transistor power loss estimate

C:\3phase_simple>halfbridge_power_ltspe.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
LTSpice circuit model
High-side control circuits
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

==> Please enter to generate data
Switching point waveform showing modulation in duty cycles
Phase to neutral output

![Graph showing phase to neutral output voltage](image-url)
Phase to phase output voltage
Current in primary side of pulse transformer
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)= 0.248628319147570
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!