

signal and the carrier signal and cause switching conditions that correspond to the two signals.[11,12].

4.1 Sinusoidal PWM bipolar switching:

The magnitude of a triangle carrier signal is compared to a sinusoidal reference.

If : $V_{reference}(V_{sine}) > V_{carrier}(v_{tri})$ PWM = high.

If $V_{reference}(V_{sine}) < V_{carrier}(v_{tri})$ PWM = low

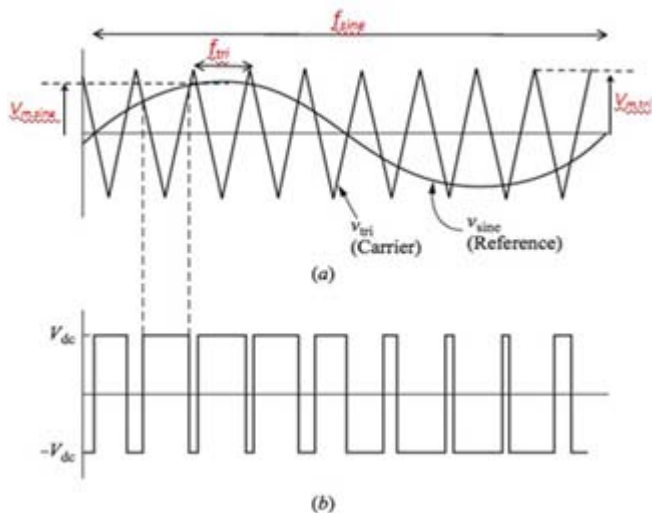


Figure 7: Triangular wave and output voltage

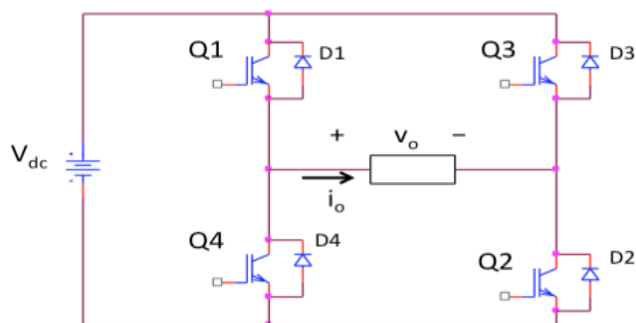


Figure 8: Bipolar full-bridge inverter

$(v_{sine} > v_{tri})$: Q1 and Q2 ON; $v_o = V_{dc}$
 $(v_{sine} < v_{tri})$: Q3 and Q4 ON; $v_o = -V_{dc}$ [13], [14]

4.2 Sinusoidal PWM Unipolar Switching

In unipolar switching: Two sinusoids compared to a triangle reference. Switching frequency is doubled with better frequency response and better output voltage. Unipolar is more complex switch control.

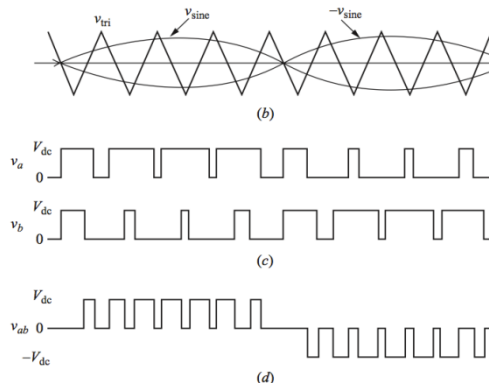


Figure 9: two sinusoidal with triangular wave and the doubled output voltage

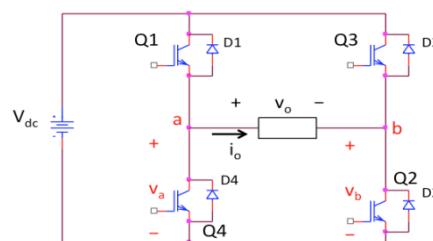


Figure 10: uniBipolar full-bridge inverter

$(v_{sine} > v_{tri})$: Q1 ON, Q4 OFF; $v_a = V_{dc}$

$(-v_{sine} > v_{tri})$: Q3 ON, Q2 OFF; $v_b = V_{dc}$

$(-v_{sine} < v_{tri})$: Q3 ON, Q2 OFF; $v_b = V_{dc}$

$(v_{sine} < v_{tri})$: Q1 OFF, Q4 ON; $v_a = 0$

Equation (3) Frequency Modulation ratio, m_f
 For Bipolar PWM, $m_f = \text{odd integer}$

For Unipolar PWM, $m_f = \frac{f_{triangle}}{f_{carrier}}$, $m_f = \text{even integer}$. [14].

5. Conclusion

In this article, PWM technique general features are being discussed, common PWM inverters are being summarized, Matlab codes are being used for signal generation.

References

[1] Wikipedia the free encyclopedia .definition of Modulation http://en.wikipedia.org/wiki/Pulse-width_modulation
 [2] FuelSaver-MPG Inc. What is PWM? <http://www.fuelsaver-mpg.com/what-is-a-pwm>
 [3] National instruments: test ,measurement and embedded systems.What is a Pulse Width Modulation (PWM) Signal and What is it Used For? <http://digital.ni.com/public.nsf/allkb/294E67623752656686256DB800508989>
 [4] By Val Tocitu, Jason Kulpe, Alex Mariuzza .ME 4447/6405 October 29th, 2009. Pulse Width Modulation

- http://ume.gatech.edu/mechatronics_course/PWM_F09.ppt
- [5] By Gregory Bonisteel Bryan Oneal Jieun Yoo ME 4447/6405 November 3rd,2011 Pulse Width Modulation http://ume.gatech.edu/mechatronics_course/IntroMech/PWM_F11.pptx
- [6] PWM Signal Generators –Net V3.02 27Jul04.<http://homepages.which.net/~paul.hills/Circuits/PwmGenerators/PwmGenerators.html>
- [7] Matlab codes for PWM generation <http://www.cheers4all.com/2012/06/pulse-width-modulation-matlab-code/>
- [8] 4c: single phase VSI with sine _Triangular PWM <http://iitd.vlab.co.in/?sub=67&brch=185&sim=469&cnt=1>
- [9] G. Sree Lakshmi, S. Kamakshaiah & G. Tulasi Ram Das. Closed Loop Control of Three-Level Diode Clamped Inverter Fed IPMSM with Different Modulation Techniques. https://globaljournals.org/GJRE_Volume13/2-Closed-Loop-Control-of-Three-Level-Diode.pdf
- [10] Project Report on Matlab Pulse Width Modulation, *Department of EEE, GEC. Thrissur*
- [11] jian sun chapter 2 Pulse Width Modulation. http://www.springer.com/cda/content/document/cda_downloaddocument/9781447128847-c2.pdf?SGWID=0-0-45-1326538-p174291486
- [12] The Inverter, updated 04/22/03. <http://eccs.onu.edu/~seniordesign/2003webpages/dcac/inverter.htm>
- [13] Thomas Carley ,Luke Ketcham and Brendan Zimmer. Bradley University Department Of Electrical Engineering 5/1/12 Photovoltaic Power Converter
- [14] INVERTERS(DC-AC Converters) http://encon.fke.utm.my/courses/SEE4433-JB/inverters_1.pptx