

Using Pulse Width Modulation (PWM) Supply with Flux®

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Pulse width modulation is a technique frequently used by variable-frequency drives to adjust motor speed. In this article, we will see how to establish a PWM with Flux using a macro. The example used is the Toyota Prius II motor: a brushless IPM motor initially powered by three-phase currents (figure 1). We consider the case at constant speed.

Implementation

This macro makes it possible to establish a two-level PWM, the most common, most popular version. It is the comparison of a sine wave (modulating signal) and a triangular wave (carrier wave), with a two-level output. The three different signals are shown in figure 2. The modulating signal is green, the triangular carrier wave in blue and the resulting PWM signal is purple. When the macro is implemented, the dialog box shown in figure 3 appears.

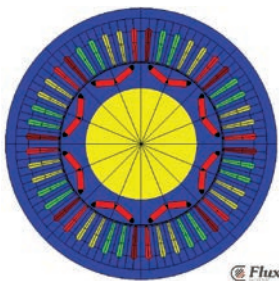


Figure 1: Geometry of the IPM Prius motor.



“Even if there is a drawback (number of computation steps) this is very interesting because it allows putting our motor on the real working condition.”

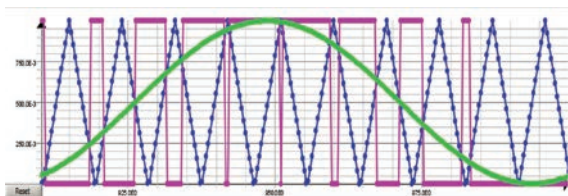


Figure 2: The three different signals.

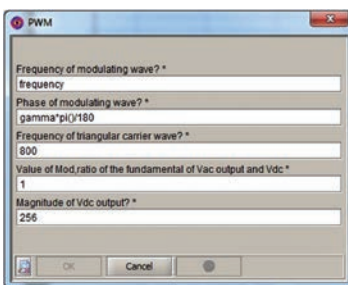


Figure 3: Dialog box of the macro.

Five text areas have to be filled for each voltage source to define the pulse width modulated signal under Flux:

- Frequency of the modulated wave, in our case it is 80Hz: supply frequency of the motor.
- Phase of modulating wave: in our case it is a balanced three phase circuit.
- Frequency of triangular carrier wave: it must be significantly superior to the frequency of the modulating wave.
- Value of Mod: ratio between Vac output and Vdc input.
- Magnitude of modulated signal: in our case it is the magnitude of the fundamental value of the voltage across current sources.

Because of the triangular carrier wave, the number of time steps is high, significantly extending calculation time, which is the main

drawback of this type of computation. The main advantage is better current waveforms, giving better iron loss accuracy.

Results

In figure 4, the currents obtained, nearly a sinusoid thanks to smoothing inductance which filters high frequency components of the signal. This produces the three-phase current required to supply the Prius engine.

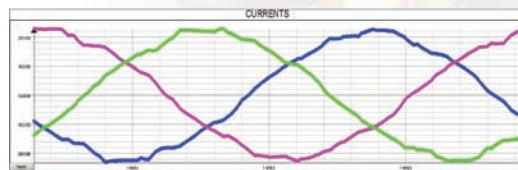


Figure 4: Currents at the output of the PWM.

After that we can compare torque and iron loss values with and without pulse width modulation to measure its impact:

- Torque (figure 5) has a slightly lower mean value with PWM. This is because only the fundamental of the current generates the torque and its amplitude is less.
- There are more iron losses because the current comprises of harmonics which have bigger amplitudes with PWM.

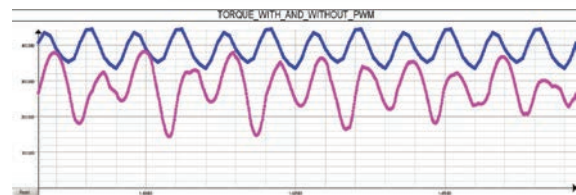


Figure 5: Torque with (purple signal) and without (blue signal) PWM.

Comparison	With PWM	Without PWM
Torque (mean value)	405 Nm	411 Nm
Iron losses (mean value between LS and Bertotti model)	158.8 W	135.96 W

Figure 6: Comparison of torque and iron losses with and without PWM.

Conclusion

In this article, we have seen how to establish a PWM signal using a Flux macro. In spite of its drawback (number of computation steps), it is very helpful because the motor can be placed in real working conditions: plugged into an inverter. More details will be available with Flux 12.1 in the folder of the PWM macro with a PowerPoint document.