Harmonic Components of a Phase-Shift Modulation

The objective of this material is to demonstrate the peak harmonic components of a single-phase inverter with phase shift modulation.

A single-phase inverter is presented in Figure 1.

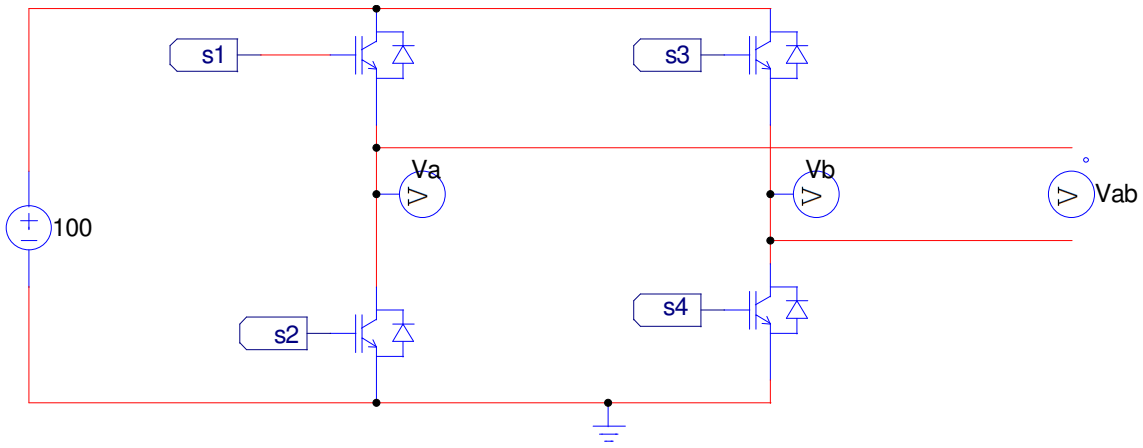

Figure 1: Single-phase inverter.

The phase shift modulation is presented in Fig. 2. Notice that the alfa angle is the angle that the signals are coincident.

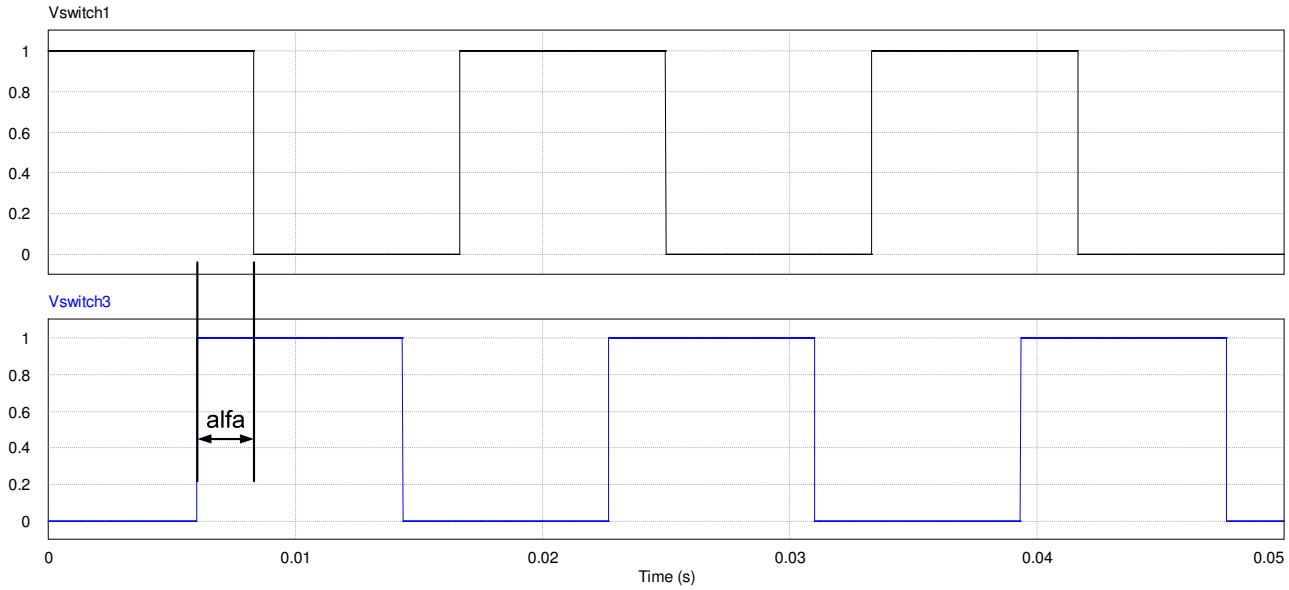

Figure 2: Phase Shift Modulation.

According to the book “Pulse Width Modulation for Power Converter – Principle and Practice” by Holmes, the peak harmonic line-to-line amplitude of each harmonic n is given by (1).

$$V_{ab(n)} = \frac{Vdc}{2}\frac{8}{n\pi}\cos\left(\frac{n\alpha}{2}\right) \quad (1)$$

where Vdc is the total DC link voltage.

The Fig. 3 presents the chart for some harmonics.

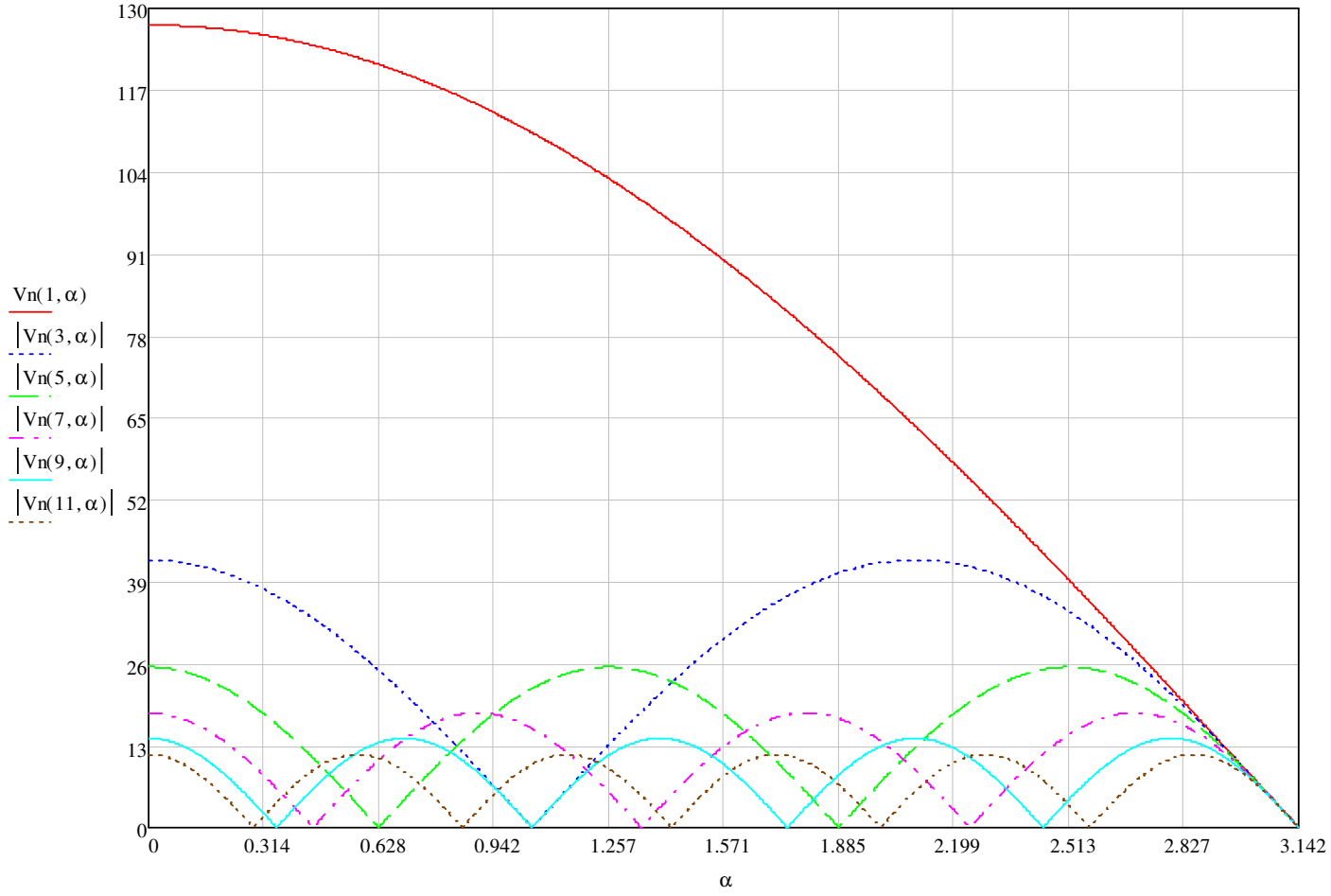

Figure 3: Chart for some harmonics.

As an example, we will consider alfa = 50 degrees (= 0.872 rad). The following equations present the peak amplitude for this angle obtained from the chart.

$$Vn\left(1, 50 \cdot \frac{\pi}{180}\right) = 115.395$$

$$\left|Vn\left(3, 50 \cdot \frac{\pi}{180}\right)\right| = 10.985$$

$$\left|Vn\left(5, 50 \cdot \frac{\pi}{180}\right)\right| = 14.606$$

$$\left|Vn\left(7, 50 \cdot \frac{\pi}{180}\right)\right| = 18.12$$

$$\left|Vn\left(9, 50 \cdot \frac{\pi}{180}\right)\right| = 10.004$$

$$\left|Vn\left(11, 50 \cdot \frac{\pi}{180}\right)\right| = 1.009$$

A simulation was made to prove the equation (1).

The Fig.4 presents the line-to-line voltage Vab, the phase voltage Va and the phase voltage Vb.

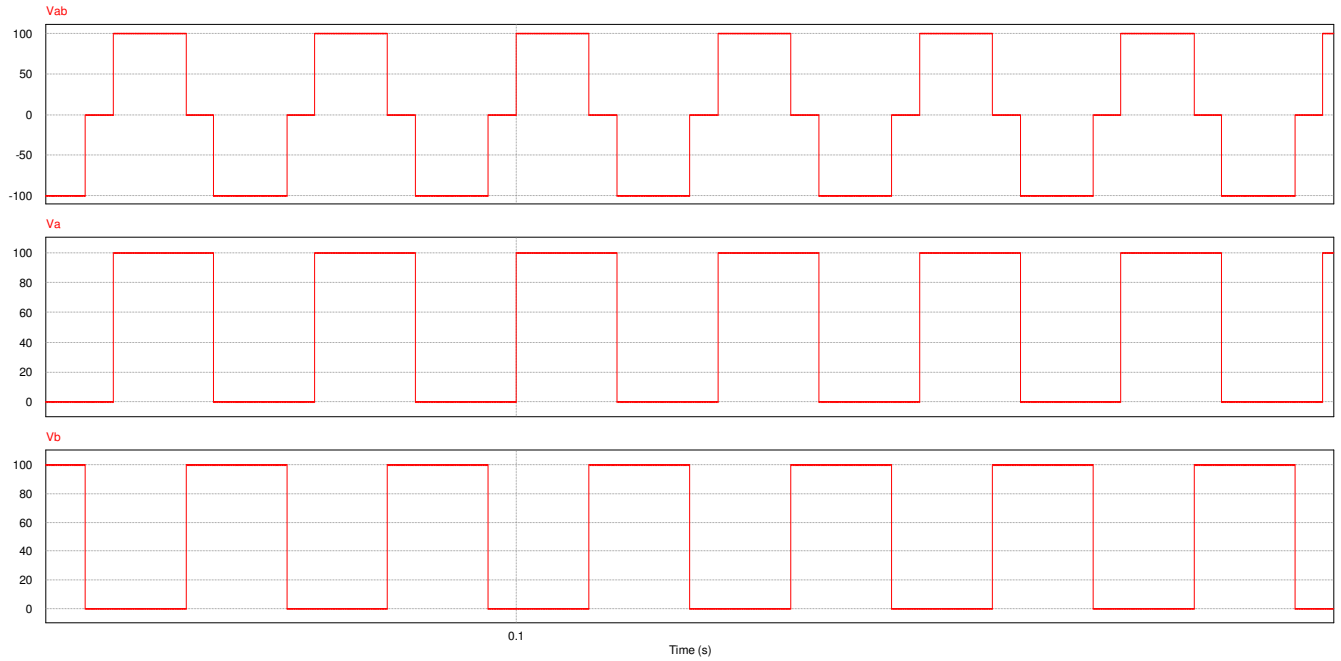

Figure 4: Line-to-line voltage Vab, the phase voltage Va and the phase voltage Vb

The fig. 5 presents the line-to-line voltage spectra. It is possible to see that the peak harmonic amplitude is very close to those obtained from the chart.

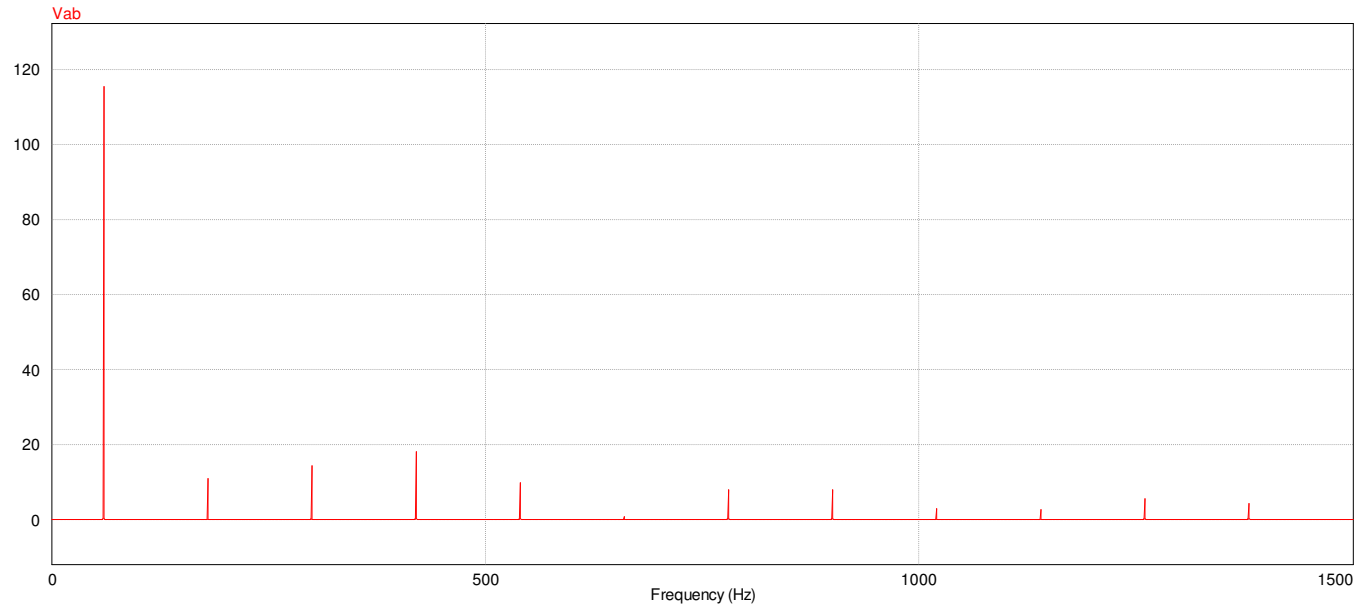

Figure 5: Line-to-line voltage spectra.

The simulation file of this report is available on https://sites.google.com/site/busarellosmartgrid/home