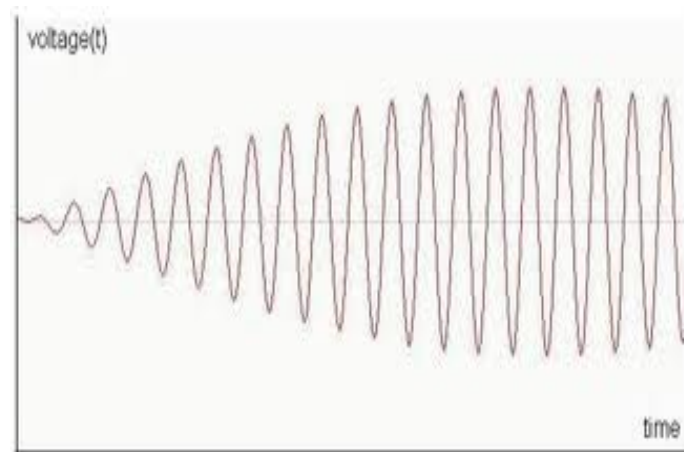




Myths and facts about VFD carrier frequency



Introduction

The speed of motor in VFDs is regulated by converting sinusoidal line AC voltage to DC voltage, then back to a Pulse Width Modulated (PWM) AC voltage of variable frequency. The switching frequency of these pulses ranges from 1 kHz up to 20 kHz and is referred to as the “carrier frequency.”

However there are so many facts and myths related to carrier frequencies. Let's try to understand what carrier frequency is all about.

VFD Operation

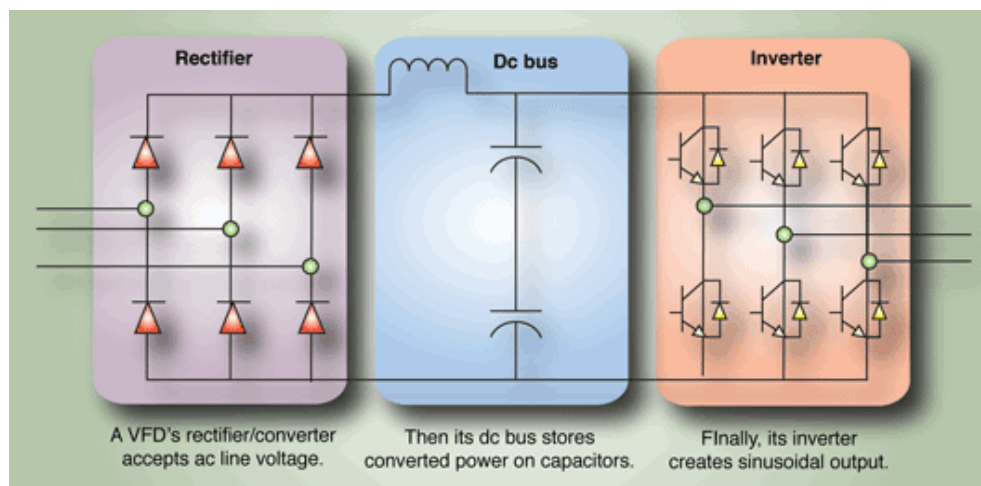


FIG: VFD OPERATION

The above figure shows the basic operation of VFD in which the **Rectifier or Converter** rectifies the incoming ac line voltage to dc line voltage in the converter section which consists of diodes, silicon-controlled rectifiers (SCRs), or insulated gate bipolar transistors (IGBTs) connected in a full-wave bridge configuration.

Then the **DC Bus**, which chiefly comprised of capacitors, stores power rectified by the converter.

The **inverter** section is comprised of IGBTs that create sinusoidal output

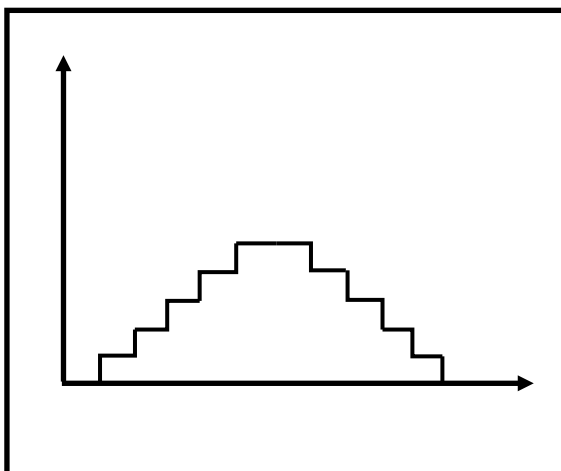
current using pulsed dc bus voltage, or pulse width modulation (PWM).

IGBTs in VFDs allow higher carrier frequencies. One of the main reasons for the widespread use of these devices is their extremely fast switching time. This switching time results in very low device transition losses and, therefore, results in highly efficient circuits. In addition, a fast switching time allows drive carrier frequencies to be increased above the audible range. (Slower switching topologies operating at a range of 1 to 2 kHz often induced irritating mechanical noise in a motor). However a higher carrier frequency is good up to a point as it creates unexpected problems, such as motor bearing damage, high levels of conducted EMI, breakdown of winding insulation and motor leakage currents.

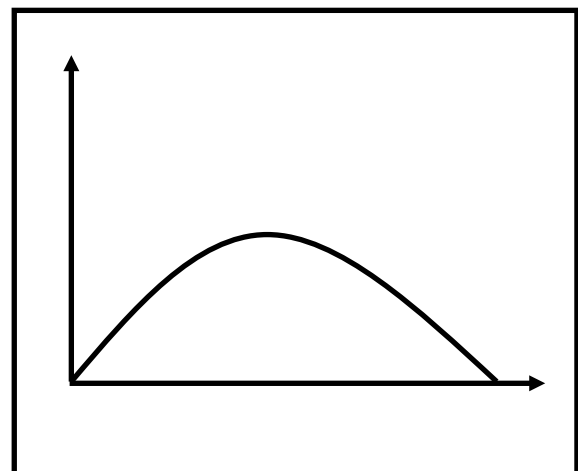
The carrier, or switching frequency used for IGBT-based VFD, generally ranges between 3 to 15 kHz. Switching time is the time required for the IGBT inverter to transition from the “off” (high impedance) state to the “on” (low impedance) state and vice-versa.

However fast switching has several advantages such as:

1. AC drive tries to simulate line power by using PWM. The higher the carrier frequency, the closer the drive comes to line power.
2. Motor connected to AC drives produces audible noise at a tone that is close to carrier frequency. People hear tones in the 1-3 kHz range better than they hear higher tones. Higher tones from a higher carrier frequency don't appear loud.



Lower carrier frequency makes a crude waveform



Higher carrier frequency makes a better waveform



- Carrier frequency in fact causes the audible noise which is generated by frequency distortion.
- These pulses may cause a resonance in the motor stator or cooling fins.
- Higher carrier frequency will reduce audible noise but at the same time increase losses in the variable frequency drive also it is more destructive on motor insulation and bearings. PWM frequency can vary from 2 kHz to 12 kHz. *(In extreme cases some drives may allow you to go above 20 kHz rendering the noise inaudible to the human ear but it can have disastrous effect on the drive and motor.)*
- At lower carrier frequencies VFD losses are lower but due to more harmonics, motors heat up more and also generate more noise which can be annoying sometimes.

Conclusion

Most experts recommend that the carrier frequency be adjusted as low as possible without creating unacceptable audible noise levels, and to avoid frequencies above 6 kHz altogether. In order to generate a variable frequency, most PWM controlled drives have a switching frequency of 2 to 6 kHz.

In case if the carrier frequency noise is still too loud LC filters can be placed between the VFD and the Motor. This will lead to a substantial reduction in noise.