**Introduction & Outline**

Hello everyone. I’m Ahmetcan Akuz. This is my third semester in Mester of Science. My supervisor is Emine Bostancı and my thesis is about Fault Tolerant Operation for 3-Level NPC inverters. Before explaining the aim of the study, I want to talk about applications of electrical machines and how we can drive them. Then, I’ll explain one of the specific drivers that we focus: 3-level inverters. I’ll also mention the possible fault states and how they can operate under these fault situations.

**Electrical Machine Drives**

In industry and daily life AC machines have lots of application areas. Such as in today’s one of the most famous trends, electrical vehicles. Or for renewable energy systems like wind turbines. These machines need a source to work. However, for different demands of these machines, magnitude and frequency of the AC source must be controlled.

For most applications, the source is DC. For example, Energy is stored in the batteries as DC for the motor of the car. And this DC source must be converted to AC and controlled. The best way to control these parameters is to use power electronic circuits. These converters are called as DC/AC converters or most common name is inverters.

You can see the structure of the EV. Inverter is an interface between battery and the motor and for the efficient and proper drive inverter has a very critical role.

**Inverters**

Let’s focus on the inverters. As I mentioned, inverters convert DC source to AC source. They obtain AC output voltages by opening and closing the switches at different times. This causes positive and negative voltages at the output. So, we can obtain a square wave voltage. This can be converted to sinusoidal signal by using some filters. Or the motor itself is enough to filter the output signal. You can see the single-phase inverter and three phase inverter examples. Since the AC motor has a 3- phase, we need to use a 3-phase inverter to drive.

For 3-phase inverters, for the applications like EV, 2-level or 3-level inverters are commonly used. You can see the comparison of two types of methods. In the 2-level inverters, we have 6 switches to obtain Vdc/ and -Vdc/2 voltage levels. These switches opening and closing wrt some reference signals to occur alternating output. Finally the voltage stress over 3-level inverter’s switch is half of two-level one. This is because there is NP and the each switch will see only half of input voltage.

In my thesis, I’ll focus on the 3-level NPC inverters because of the efficiency and the ability of managing the fault cases.

**Aim of the Study**

In this research, I’ll mainly focus on the 3-level NPC Inverters and the fault states of this inverter. Also, how to operate under this fault conditions.

**Inverter Control Techniques**

Before the drive methods of 3-level inverters, I want to talk about drive methods with 2-level inverter examples to become more clear.

**Sinusoidal PWM**

Firstly, I’ll talk about the sinusodial PWM method. In the sinusoidal PWM there is a carrier signal which is a triangular waveform and 3 reference signals with 120 degree phase shift. The carrier signal is compared with the referenc signal and according to this comparison switches are opened and closed at each leg. The amplitude of the signals can controlled by the amplitude of reference signals. This called as modulation index. The peak amplitude for output voltage is Vdc/2 for this method.

**SVPWM**

On the other hand, there is another method called as Space Vector PWM. In this method, we want to convert reference voltages from rotational 3 signal to stationary 2 signal to decrease number control parameters. To make this we use two tranformation methods called clarke and park transformation. After these transformations, we can obtain a stationary vector with d and q axes. You can see the vector diagram here.

**3-Level Inverters and Drive Methods**

Let’s briefly talk about 3-level NPC inverters. Unlike 2-level inverters, there are 4 switches and 2 diode s to obtain 3 stages instead of two. These are Vdc/2, 0 and -Vdc/2. Output voltage of the inverter can be look like this. In this research we’ll focus on the SVPWM control methods of 3-level inverters.

Like 2-level inverters, we want to obtain a vector to drive the motor. However, since we have 3 stages in 3-level inverters, we can obtain 27 different vectors. There are wtill a hexagonal space vector diagram as in 2-level but the vectors magnitudes are different. So we can control the magnitude and phase with both null vectors and small vectors. To define the desired vectors, we must divide this diagram to 6 and adjust timing of the vector according to this information.

To minimize losses, we need to adjust timing and sequence of the vectors like in the 2-level control. In the normal operations, everything can be OK but due to nature of the components or because of the disturbances, there will be a fault in switches. The behavior of the inverter also important for our operations.

**Possible Fault States**

For the switches, we can face two important fault scenarios: open circuit and short circuit. Short circuit is far more dangerous and not controllable after the fault happens. Best option to stop the motor as fast as possible under this condition. The phase current distortion is hig and overcurrent condition happens. On the other hand, there is a change to operate with open circuit fault. However, the middle switch give larger damage to operation strategy. We’ll see in the next slides.

Let’s look at the all fault situations

**Fault Tolerant Operation**

Hepsini tek tek anlat.

Conclusion