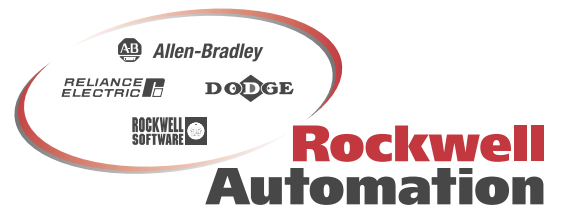




AC Drives

# AC Braking Basics



Bringing Together Leading Brands in Industrial Automation

### **Motoring**

*Transforming electrical energy from the drive into mechanical energy at the drive shaft of the motor.*

### **Regeneration**

*Transforming mechanical energy from the drive shaft of the motor into electrical energy that can be transferred back to the utility grid.*

### **How Dynamic Braking Works – AC Drives**

When an induction motor's rotor is turning slower than the synchronous speed set by the drive's output power; the motor is transforming electrical energy obtained from the drive into mechanical energy available at the drive shaft of the motor. This process is referred to as "motoring". When the rotor is turning faster than the synchronous speed set by the drive's output power; the motor is transforming mechanical energy available at the drive shaft of the motor into electrical energy that can be transferred back into the utility grid. This process is referred to as "regeneration".

On most AC Pulse Width Modulated (PWM) drives, the AC power available from the fixed frequency utility grid is first converted into DC power by means of a diode rectifier bridge or controlled Silicon Controlled Rectifier (SCR) bridge, before being inverted into variable frequency AC power. These diode or SCR bridges are very cost effective, but can handle power in only one direction, and that direction is the motoring direction. If the motor is regenerating, the bridge is unable to conduct the necessary negative DC current, and the DC bus voltage will increase until the drive trips off due to a bus overvoltage trip.

There are bridge configurations, using either SCRs or Transistors that have the ability to transform DC regenerative electrical energy into fixed frequency utility electrical energy but they are expensive. A much more cost-effective solution is to provide a Transistor Chopper on the DC bus of the AC PWM drive that feeds a power resistor that transforms the regenerative electrical energy into heat energy. The heat energy is dissipated into the local environment. This process is generally called "Dynamic Braking", with the Chopper Transistor and related control and components called the "Chopper Module", and the power resistor called the "Dynamic Brake Resistor". The entire assembly of Chopper Module with Dynamic Brake Resistor is sometimes referred to as the "Dynamic Brake Module".

It is the objective of this white paper to help explain the operation of the Chopper Module.

### **How the Chopper Works**

Figure 1 shows a simplified schematic of a Chopper Module with Dynamic Brake Resistor. The Chopper Module is shown connected to the positive and negative DC bus conductors of an AC PWM drive. The two series connected Bus Caps are part of the DC bus filter of the AC drive. The significant power components of the Chopper Module are the protective fusing, the Crowbar SCR, the Chopper Transistor (an IGBT), the Chopper Transistor Voltage Control (hysteretic voltage comparator), and a free wheel diode for the Dynamic Brake Resistor.

The protective fuse is sized to work in conjunction with the Crowbar SCR. Sensing circuitry within the Chopper Transistor Voltage Control determines if abnormal conditions exist within the Chopper Module. One of these abnormal conditions is a shorted Chopper Transistor. If this condition is sensed, the Chopper Transistor Voltage Control will fire the Crowbar SCR, shorting the DC bus and melting the fuse links. This action isolates the Chopper Module from the DC bus until the problem can be resolved.

The Chopper Transistor is an Isolated Gate Bipolar Transistor (IGBT). There are several transistor ratings that are used in the various Chopper Module ratings. The most important rating is the collector current rating of the Chopper Transistor that helps to determine the minimum Ohmic value used for the Dynamic Brake Resistor. The Chopper Transistor is either "ON" or "OFF", connecting the Dynamic Brake Resistor to the DC bus and dissipating power, or isolating the resistor from the DC Bus.

The Chopper Transistor Voltage Control regulates the voltage of the DC bus during regeneration. The average value of DC bus voltage is 375 Volts DC (for 230V AC input), 750 volts DC (for 460V AC input), and 937.5V DC (for 575V AC input). The voltage dividers reduce the DC bus voltage to a low enough value that is usable in signal circuit isolation and control. The DC bus feedback voltage from the voltage dividers is compared to a reference voltage to actuate the Chopper Transistor.

The Free Wheel Diode (FWD) in parallel with the Dynamic Brake Resistor allows any magnetic energy stored in the parasitic inductance of that circuit to be safely dissipated during turn off of the Chopper Transistor.

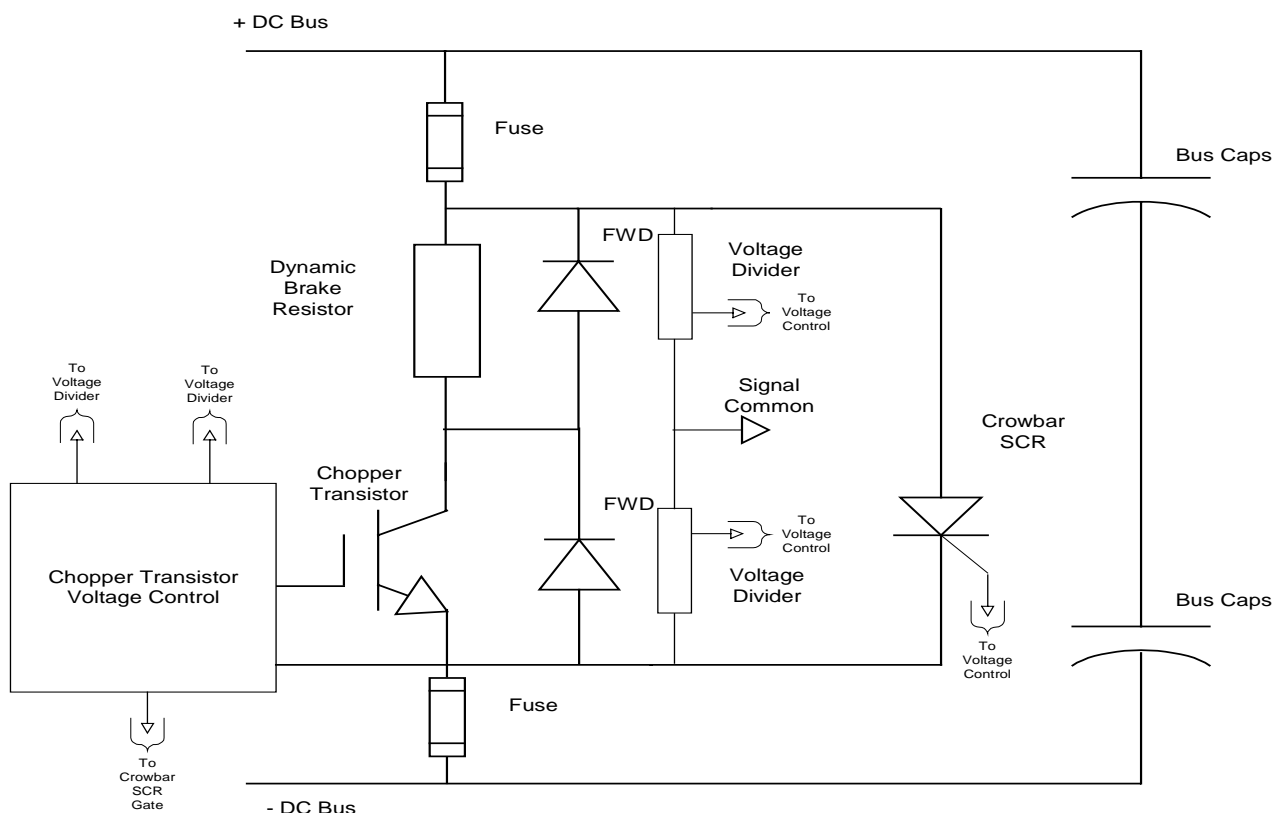


Figure 1 Schematic of Typical Chopper Module and Dynamic Brake Resistor

Chopper Modules are designed to be applied in parallel if the current rating is insufficient for the application. One Chopper Module is the designated "Master" Chopper Module, while any other modules are the designated "Follower" modules.

Two lights have been provided on the front of the enclosure to indicate Chopper Module operation – the "DC Power" light will be lit when the Chopper Module is operating or the "Brake On" light will be flickering when the Chopper Module is "chopping".

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