Description of the ATS DC Traction Locomotive System

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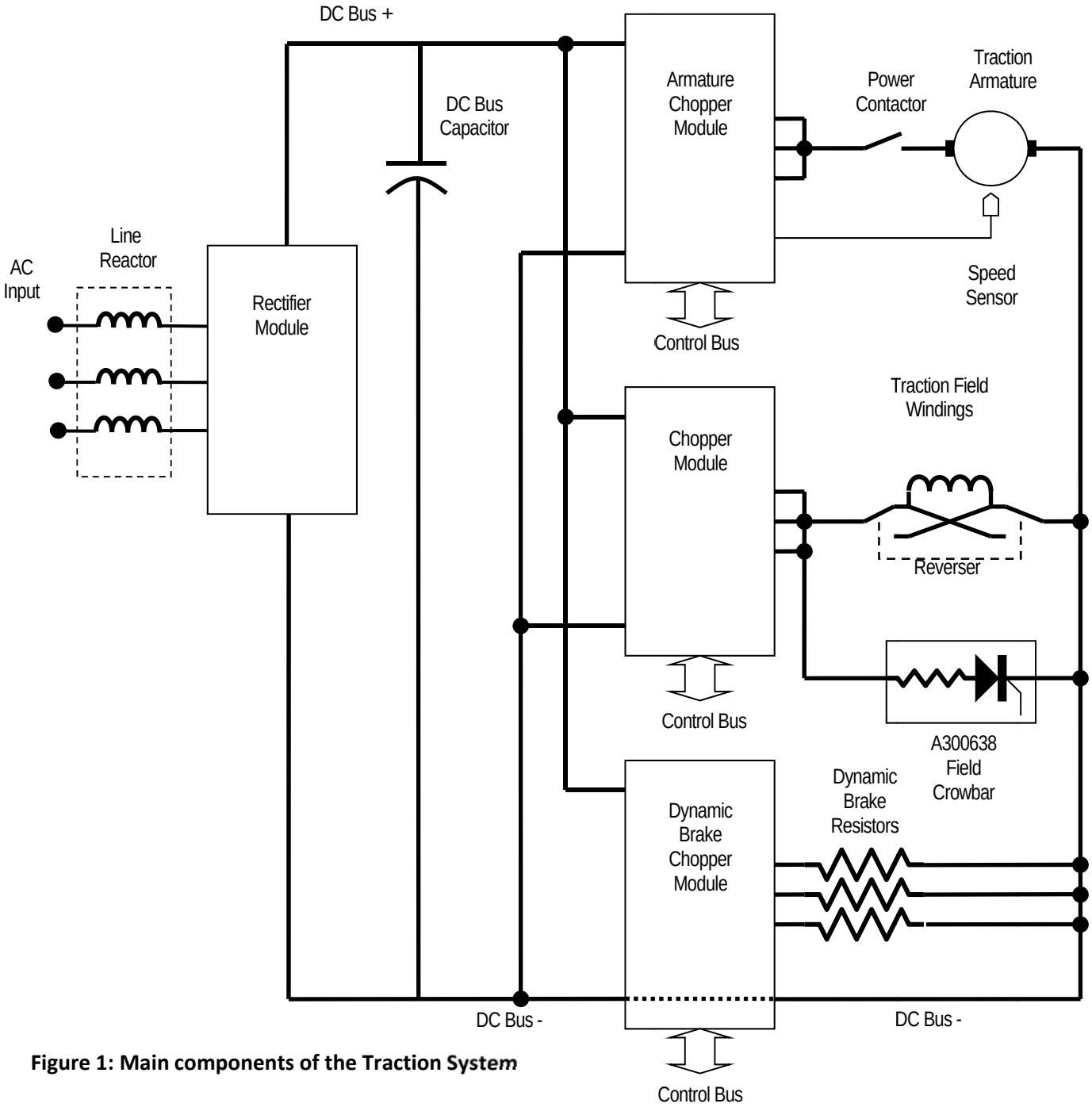

Figure 1: Main components of the Traction System

Description of Modules

The Rectifier Module converts 480V, 60Hz AC power to DC power at a voltage of approximately 650V. The output of the rectifier module is smoothed by six parallel-connected capacitors. Line reactor reduces the harmonic load on the 480V supply. The rectifier module consists of a half-controlled SCR / Diode bridge for the purpose of limiting the charging current drawn by the bus capacitors during power up.

The Chopper Modules are power converters designed to operate over a DC bus voltage range of 500V to 800V. They are used as components of a power conversion system consisting of several modules sharing a common DC bus filter capacitor.

When the Armature Chopper Module is used to control the armature of DC traction motor, it controls the armature current by applying pulses of the DC bus voltage directly to the armature at a frequency of 1kHz. The pulse width, or duty cycle, is varied from zero to a full 1ms period in accordance with the voltage required by the armature. This requirement is determined by a high-speed current regulator which continuously seeks to maintain the output current at a level that matches the value of the traction reference. The mean current drawn from the DC bus is proportional to the duty cycle as well as the armature current. This means that the chopper can supply the armature with a very large amount of current at low speed while consuming a relatively small amount of current from the DC bus. The Armature Chopper Module also receives speed feedback from the axle that it is driving and continuously compares the measured axle speed with a reference input derived from a non-driven axle. For the purpose of controlling wheel-spin or wheel-slide, a speed regulator overrides the traction reference with a lower value if the axle speed deviates outside a small band of acceptable values.

The Armature Chopper Module can also operate very effectively as a brake down to very low speeds. It achieves this by applying a voltage to the armature that is lower than its open-circuit voltage so that both current and power flow are reversed. This change occurs as a seamless transition when the polarity of the traction reference is reversed.

Energy recovered from the traction motors during dynamic braking is returned to the DC bus. All of the energy returned to the bus must be dissipated without resulting in a large increase in voltage. The excess power is absorbed in dynamic brake resistors controlled by the Dynamic Brake Chopper. The Dynamic Brake Chopper normally operates independently by responding only to the increase in DC bus voltage that occurs when power absorbed by the Armature Chopper Modules is returned to the DC bus. A self-load mode is provided for the purpose of applying a test load to the traction power system while the car is stationary.

The Field Chopper Module has identical construction and is used to control the current in the motor field. Typically, a locomotive has either 4 or 6 identical traction motors. The fields require very little voltage, consequently, they may be connected as a series string controlled by a single chopper. By commanding the field current to be equal to the armature currents, the overall traction capability can be made to follow characteristics similar to those of the conventional series-field arrangement. At the nominal DC bus voltage of 750V, traction motors of the EMD D77 and D78 series with typical gearing have a base speed equivalent to approximately 25mph. Above this speed, the field current must be progressively weakened in order to extend the speed range. A spill-over field control system is implemented by using the armature controllers to send a field weakening request when any one of them reaches a duty cycle of 100%.

A separately-excited motor operating at high speed with a weak field can produce a very high armature voltage if the field controller fails in such a way that the DC bus voltage is applied directly to the field circuit. The Field Crowbar is used to prevent a high armature voltage arising in the event of a failure to a high field condition. On detection of such a condition, the SCR in the Field Crowbar diverts the field controller output through a low-value resistor in order to blow the fuse in the Field Chopper Module.