373 to 307 A Very Brief AC Traction Introduction.

By **Mark Bott.**

This is a bit of a strange title, but the theme of the article is about understanding how rolling stock in general, and electric multiple units in particular work. As a general rule people are put off working on electric traction for fear of high voltages. The simple fact is that almost as soon as the high voltage enters the vehicle it is transformed into something more useful. The 25KV is mainly used to overcome transmission difficulties, and to keep the amount of current drawn from the supply network to a manageable amount. For example a Eurostar train travelling at 300KmH [186mph] draws less than 18 amps. The same train sitting in the station with the power cars only supplying the train auxiliary load draws less than 3 amps.

The current is collected from the overhead line via the pantograph, through the main circuit breaker into the main transformer primary winding. The residual current is returned to the feeder station through the running rails via the current return braids, which allow the current to go to the wheels without going through the axlebox bearings. This is a very simple description of the differences between electric traction, and something like a class 56 diesel. A very senior rolling stock engineer on the Western Region was overheard explaining that a class 47 works in exactly the same way as a class 86, except the diesel engine goes where the transformer lives on an 86. Well this may not be strictly true, but it is not all wrong either.

On first generation EMU types the transformer has a number of secondary windings; the main one is to supply traction voltage via the control system, and rectifier to the traction motors. Auxiliary windings supply current for systems such as heating, rectifier fans, transformer oil pumps, and battery charging. Voltage for the train lighting, and unit control systems is normally 110V DC supplied by the train batteries.

The traction voltage on most first generation and some earlier second generation AC EMU types is controlled by altering the amount of resistance in the circuit. If full supply voltage were to be applied to a traction motor which was stationary, as there is no current flowing in the motor field windings all you would get is a dead short across the motor. To prevent this a lower voltage is applied, as the motor starts to turn a back electromotive force is generated in the field windings. This provides an internal electrical resistance within the motor. As the motor, and therefore the train increases speed. The resistances in to the supply voltage can be reduced in sequence. In diesel electric locomotives, the traction supply voltage is altered by changing the engine speed, and thus the output, of the traction generator, or alternator. On the earlier electric types the transformer secondary voltage is altered, by means of the tap changer. Once full supply voltage is applied to the traction motor, it will not be able to further increase speed. However there is an electrical slight of hand trick, that can be employed by weakening the back electromotive force in the motor field windings. Therefore hopefully it can be seen that the theory of controlling an EMU is more or less the same as controlling a class 47, or such like. It is only the way it is done is slightly different.

If washing machines work quite well with AC motors why did trains have rectifiers, and DC traction motors? Well the simple answer is it is quite difficult to control the speed of AC motors. Widespread application of AC motors in traction applications did not come about until the late 1980's. With the advent of high power GTO thyristors. In fact AC units that have three phase AC traction packages still have the transformer, and rectifier arrangement.

The DC voltage goes through a chopper to provide pulsed DC, which the motors see as AC. Speed controlled by a variable voltage variable frequency arrangement. But this is outside the scope of this article.
The low voltage control systems on most traction are tailored for the specific type. However as I mentioned in my last literary ramblings on most first generation AC EMU stock there is a high degree of standardization. This is to allow for multiple working within types, and to reduce the need for traction specific training for maintenance people. This will also allow for a degree of interchange of components. An example of this in the diesel traction world is an HST power control relay, is the same as those fitted to class 56, and 47 locomotives. On Brush traction drawings wire 27 is always the common negative, CN on EMU drawings. Wire 52 is a common positive, which would be either BP, or CP on EMU stock. In most traction applications the most common voltage is likely to be 110V DC. Normally the higher voltages are behind protective covers to reduce the likely hood of the unwary blowing them self up. On older units there is a simple padlock system to physically lock the pantograph isolating, and earth switch. On newer stock there may be a key sequence which has to be followed to allow access to the high voltage equipment. Even HST power cars have an interlock on the traction equipment cubicle door, which will either stop the engine, or prevent it from starting.
Other electrical systems which may be fitted to preserved EMU vehicles include wheel slide protection. The Girling type is fitted to the 312, the 316/457 vehicle has the BR type. Both of these can still be seen in daily use on HST trailers, Mk3 hauled coaches, and in the case of the BR type on all second generation EMU types running out of Kings Cross, and Liverpool Street, and the 319 fleet on the Thames Link route.
As for the strange title. A few weeks ago I was on a class 373 air, and brakes course, and when I finished I went straight to Pump House to look at an earth fault on the 307. Truly a technological journey in reverse. However the principle is exactly the same.
The intention of this article is simply to try, and unravel some of the mystery of what happens between the electric string in the sky, and the wheels. If there is interest maybe I could focus on other train systems in future issues.

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