DIRECT CONTROL

Although not strictly a “multiple” unit system, this was the earliest system that allowed electric trains to be driven from either end using locomotives or motor cars. The motors were simply connected to either one controller or the other by a traction current bus running the length of the train. Direct control was originally used on the following lines:

Liverpool Overhead Railway
City and South London Railway
Waterloo and City Railway
Lancashire and Yorkshire – Liverpool and Southport

The use of the system continued on the Waterloo and City and Liverpool to Southport routes until 1940. Lancashire and Yorkshire Railway trailer carriages were wired so that they could work either with direct control motor cars or with the multiple unit stock later introduced for the Aintree and Ormskirk services.

MULTIPLE UNIT CONTROL

Manual ‘Notching’ controllers

Although the intention of multiple unit control had been to provide a simple controller offering automatic acceleration, early attempts to do this often proved unreliable in railway service and some railway companies opted to use manual rather than automatic control. Most significant amongst these was the District Railway which used a manual control system on all stock built before 1927. Most older stock was later rebuilt with automatic acceleration but the 1920 ‘F’ stock retained manual notching until withdrawn in the early 1960s.

The two main manual control systems for d.c. units were:

(1) British Thomson-Houston ‘Sprague’ electro-magnetic control, which was used on the District Railway and on some early tube stock.

(2) Dick-Kerr ‘Zweigbergk’ electro-magnetic control used on the Lancashire and Yorkshire Liverpool to Aintree and Ormskirk units and LYR/LOR units.

The early a.c. units used by the Midland Railway and London Brighton and South Coast Railway used manual tap changer controllers.

Automatic Acceleration – electro-mechanical systems

Various systems of automatic acceleration have been used on electric multiple units during the twentieth century. The most widely used systems were:

(1) British Westinghouse / Metropolitan Vickers electro-pneumatic control used by the Metropolitan Railway.

(2) Metropolitan Vickers electro-magnetic control used by the Southern Railway and on tube stock built between 1915 and 1930. (Two different systems were used by the Southern, the earlier system

used on suburban stock used a 600 v control cable, the later system used from 1935 on the express stock used a 150 v control circuit making the two types incompatible.)

(3) Pneumatic camshaft control. This was used for the 1938 tube stock and all London Transport stock built between 1949 and 1978. The LNER used this system for the Liverpool Street to Southend and Manchester, Glossop and Hadfield units. It became standard for all British Rail d.c. units built between 1957 until 1990.

(4) Automatic tap changer control. British Rail a.c. electric units of classes 302-305 and 307-312 used a tap changer system.

Early systems generally gave two running notches "FULL SERIES" and "FULL PARALLEL". Common controllers being:

OFF - Shunt or Inch - SERIES - Transition - PARALLEL

or

OFF - Shunt or Inch - SERIES - PARALLEL

Southern Railway drivers were instructed that the "Shunt" notch "*should not normally be used for more than three minutes at a time*" as it could result in overheating of the resistances.

Later controllers on British Railways dc units had three running positions:

OFF - Shunt - SERIES - PARALLEL - WEAK FIELD

This was then standardised as a set of controller positions for both a.c. and d.c. units:

0 - 1 - 2 - 3 - 4

The same notches being used subsequently with more modern units. Generally 1 is minimal power or lowest tap (equivalent to an older dc unit running in series with all resistances in circuit); 2 provides about half power and half speed; 3 either provides full power at lower speeds or about ¾ full power and 4 provides full power up to maximum speed.

London Transport did not add a fourth position for weak field but rather had a separate switch that added field weakening to the 'Full Parallel' notch. As this is not possible in OpenRails then an additional notch has been added to London Transport controllers to represent this.

More information about the weak field flag and coasting flag can be found on the District Dave website.

OpenRails model of electro-mechanical automatic acceleration

It is not possible to fully model the automatic acceleration that is used on electric multiple units. In the real systems used for d.c. traction, acceleration was automatic, but deceleration was not. To reduce power the driver had to return the controller to 'OFF' before moving it to a lower setting. Apart from that a fairly reasonable model can be made by using ORTSMaxTractiveForceCurves.

Dealing with Low Adhesion – Two different systems

In the case of icy or greasy rails the driver may want to accelerate at a rate less than that normally set by the current controlled relays that control ‘notching up’. On the main line railways moving the controller back to ‘Shunt’ had the effect of holding whatever notch was reached at that time and preventing further acceleration until the controller was moved forward again. This is not possible in OpenRails. When driving in snow or conditions of low adhesion the following method is recommended:

Remain in Notch 1 (Shunt) until speed is above 5 mph.
Then Remain in Notch 2 (Series) until speed is above 20 to 30 mph depending on the unit.

Driving in this way will generally prevent wheelslip.

London Transport took a different approach to this problem. In the drivers cab there is a ‘Rate Switch’ which can be set to either ‘Rate 1’ or ‘Rate 2’. This causes the acceleration relays to switch and either a higher or lower current giving higher or lower rates of acceleration. The rate switch can not be modelled in OpenRails. The work around used in this case is to set the series notch to the lower rate of acceleration and the parallel notch to the normal rate. When driving London Underground stock then:

For normal acceleration use the ‘Full Parallel’ notch.

For low adhesion conditions use ‘Full Series’ until speed is above about 15 to 20 mph.

Automatic Acceleration – The Metadyne Machine

The Metadyne machine used on the London Transport O and P stock built in the late 1930s might be considered as somewhere between a direct current transformer and a motor generator set. It was able to provide direct current at variable voltage to the traction motors without the need for a system of contactors and resistors. By the 1950s the machines were becoming unreliable and were replaced by pneumatic camshaft control. (O and P stock being converted to CO and CP stock.)

More information on the Metadyne Machine can be found on Wikipedia.

Automatic Acceleration – Solid State Technology

Thyristors or Insulated Gate Bipolar Transistors (IGBT) have been used to replace electro-mechanical control systems on electric mulitple units built since the mid 1970s. To begin with solid state technology was only used on a.c. units as it was not considered robust enough to deal with the electrical variations found in third rail areas. Units built for d.c. traction and dual voltage units continued to be built with pneumatic cam control until the 1990s.

To begin with IGBT control was used to control direct current motors. From the early 1990s 3-phase a.c. motors have been used rather than d.c. motors. The power supply for these is provided by a variable voltage variable frequency (VVVF) system.