HANDBOOK of Installation and Operation of **FIDELITY CONTROL** "Speed Monitor" **CONTROLLER**

Your "Speed Monitor" has been designed and tested by railway modellers, with the view of utmost fidelity of locomotive operation and reliability in mind. In common with most electronic equipment its life is almost indefinite but it depends on the treatment meeted out to it. In other words, do not connect it to a supply with higher than recommended voltage!

Every electric motor can also act as a generator and therefore it can supply a current as well as receive one. This energy a motor supplies is called the 'back EMF (Electro Motive Force)'. The back EMF voltage developed is dependant on the speed of rotation of the motor so by monitoring this voltage a very accurate measure of motor speed is obtained. Sampling of the EMF is done by interrupting the delivery of current at regular but very short intervals. By comparing this sample with a desired level, adjustment to the output of the controller is made electronically to keep motor speed constant. This has value in keeping speed constant uphill and down and through turnouts and round curves where train resistance varies. However its main virtue lies in enabling slow and controlled speed to be attained and maintained. There are limits to this of course and the ability to run really slowly and consistently is also dependent upon the quality of the current collecting system used and the type of motor fitted. As many wheels as possible should be used to collect current.

This controller will not make a silk purse out of a sow's ear but perhaps it can make a satin one. Track cleanliness is of vital importance. The constant speed feature cannot be taken to extremes so there will be some slowing down of heavy trains on steep gradients (this is prototypical) but they will not stall and will not run away down grades. To date, nearly all back EMF measuring controllers (sometimes called Feedback controllers) have used Pulse Width Modulation (PWM) of one form or another to control the average output voltage by supplying variable width pulses at relatively high PEAK value compared with the AVERAGE value. This gives good low speed control. However there are penalties, in the form of motor noise and heating. The heating factor can be observed when train or locomotive lights are in use; lights glow because the filament heats. For any given speed, lights will be brighter with a PWM controller than with a non-PWM one. Moreover, because it can be the case that there is no output from the PWM controller for a comparatively long period there can be problems when train lighting current also comes from the controller; the motor slows down between pulses. The train lighting acts like a resistance brake. The 'coreless' motors with very little inertia definitely do not like PWM controllers. Indeed even without train lighting some coreless motors can slow down between pulses making for rough and noisy running with current peaks which are too high; hence the commutation gear can be damaged.

The Speed Monitor however, has been designed to vary the output voltage LEVEL and the waveform has been developed to produce the best results from traditional IRON CORE model motors as well as from the CORELESS type WITHOUT COMPROMISING any requirements of either type. THERE IS NO NEED TO HAVE SEPARATE CONTROLLERS FOR EITHER TYPE OF MOTOR. Also, because the sample period is very short and of consistent length there are no problems with train lighting. Remember however that when train lighting and motor current are both from the controller total current capability must be kept in mind (as is the case with any controller). You will find that for any given position of the REGULATOR the locomotives will run faster when train lighting is in use than when it is not. In other words, the maximum speed is reached at a lesser rotation of the REGULATOR knob. This is because the EMF from the motor is shared between lighting and controller, which thinks that because of the lesser return, it has to respond by providing a higher supply voltage. When running with multiple locomotives this tends to happen also. In actual practice this characteristic is of no consequence. As a consequence of the control system used the SPEED MONITOR generates no extra noise (it cannot overcome problems of lack of lubrication, slackness or gear noise!! But it will not add to them) and there is no extra generation of heat. It is therefore ideal for CAN motors, small N gauge mechanisms and CORELESS motors (or as sometimes known, instrument motors) as well as being suited to conventional open frame motors.

CONNECTIONS

The RED and BLACK wires must be connected to a transformer delivering 14 to 16 volts AC. They MAY be connected to 12 volts RECTIFIED AC (in other words DC straight out of a rectifier) but because of the built in rectifier the final output voltage will be less than 12. They should NOT be connected to SMOOTH (or FILTERED) DC, as the controller will not work as specified. The transformer must be capable of delivering at least the amount of amps selected with the current limit switch on

the control panel. If for example you wish to run only with Faulhaber motors drawing 250mA maximum, then a 250mA capability transformer would (just) suffice. Best performance is obtained out of a transformer capable of 1 amp or more. EACH SPEED MONITOR MUST HAVE ITS OWN TRANSFORMER (OR TRANSFORMER WINDING) this will also allow "common return" wiring which method simplifies wiring a layout considerably. Your existing Transformer Controller may have suitable terminals. These units usually have an "accessories" terminal or a "lighting" terminal. These are normally a separate winding from the built in controller.
To test for winding separation, take a 12V bulb and wind the Transformer Controller on. The bulb should light across the two "accessories" terminals and the two controller outputs BUT NOT across one "accessory" and one "controller" (4 ways of connecting). If it does the windings are connected and the two cannot be used together.
The other two wires (they may vary in colour) are the controlled output and should be wired to your track directly or via section or cab control switches as for any other controller. It is recommended that the four wires be connected to the layout either via a plug/socket of at least 4 pins or a strip wiring connector with brass inserts, two screws in each, commonly known as a "chocolate block". A 5-pin DIN connection system with plug on the cord is very suitable, but some people may prefer a more robust connector such as the Canon type. Adjust the sense of the connections so that trains run according to the direction switch position on the major part of the layout.

THE CONTROL PANEL

At the top are three indicators, YELLOW for indicating that the AC supply is on, GREEN to show when there is an output voltage and RED to show when an overload or short circuit has occurred. The YELLOW indicator is a necessary part of the circuit, not an addition merely to show the supply. Under certain circumstances it may flicker momentarily.

When the controller is not connected to the track or when there is no locomotive on the track the GREEN indicator will glow faintly. The RED indicator will flash on initial turn on. The TOP switch has three positions to select the maximum output supply current. The correct selection of maximum current will protect motors against burn out, in particular the CORELESS types that have very delicate commutators and brushes. The supplier of the motor should indicate the maximum current but in case of doubt select the lowest setting that allows normal operation without the current limit operating. Faulhaber and Escap 1219 types have a 100 milliAmp (mA) limit, the 1624, 250mA. All motors will operate satisfactorily on the 1 Amp setting and indeed, even if you run coreless types, but use train lights from the controller, this setting will have to be used to power the lights!

The SECOND SWITCH is a toggle switch and is for FORWARD/REVERSE. It does not have a centre off position. This means that you cannot inadvertently switch it to off and end up wondering why your loco does not move!   With the REGULATOR off or the BRAKE fully on there is NO output so a centre off switch is superfluous.

The THIRD SWITCH also has three positions and these select the MODE of operation. The DIRECT setting is hopefully self-explanatory, in that it allows for direct control of trains via the REGULATOR. Turn this clockwise and trains will speed up in direct response; turn it anticlockwise and trains will slow down. A very small amount of delay has been built in to prevent jerkiness. SIMULATE 1 and 2 are used to select two rates of acceleration and the brake is brought into use. There is no difference in braking between the two modes. The acceleration rate set by SIMULATE 2 is always slower than that set by SIMULATE 1. The rates can be set by pre-sets accessible through small holes in the bottom of the case. Turn the controller over and note in the bottom right hand corner two small holes. The one on the left sets the acceleration rate for SIM 1. The one on the right sets SIM 2, ONCE YOU HAVE SET SIM 1. See later for adjustments. Switching from SIM to DIRECT is possible once speed has stabilised; DIRECT to SIM at any time.

The REGULATOR. In Direct mode it functions as explained above. In SIM 1 and SIM 2 it sets the maximum speed after acceleration. The rate of turning the Regulator or the position it is moved to has no bearing on the RATE of acceleration, unless you have set a rapid rate and manage to turn the Regulator very slowly. Once a train has achieved its desired speed, the Regulator can be moved to 0 in preparation for braking the train, which will continue, slowing down very gradually (unless you have a very large layout or are running many times round you will not notice the slow down). It is not necessary to move the Regulator to 0; if you want your train to continue running without slowing down AT ALL just leave it. However, for correct braking you must move it to 0 before applying the Brake. The circuit contains elements that give a constant acceleration rate. The time taken to go from 0 volts to 5 volts is the same as from 4 volts to 9 volts. This gives smooth, slow starts.

The BRAKE. This only functions in SIM 1 or SIM 2. When running and accelerating trains this needs to be fully off at 0. A small step can be felt when moving to 0. For the brake to be fully off it needs to be "on" the step. When you want to stop a train, turn the regulator to 0 and turn the BRAKE round to any position other than 0 and leave it there. The train will slow down at a CONSTANT RATE dependant only on the position of the knob. The controller contains a circuit that, for example, allows the voltage to drop from 11 volts to 8 volts in the same time that it takes to drop from 6 volts to 3 volts. This is the same as the REGULATOR does in the acceleration circuit. This allows you to predict much more accurately where to stop in comparison with some published circuits which are decidedly unprototypical in that for any given setting most of the braking occurs at the top end with braking fading out at the Bottom end. If you want the train to come to a stop you can leave the Brake in position and the train will come to a firm and definite stop. If you merely wish to slow it down, turn the brake to off once you are down to the desired speed. Best practice for coming into a station for example is to select a reasonably firm brake rate, and then, once you have the train "under control" to turn it back to a lesser position allowing the train to stop gently. Prototype practice is to stop with minimum pressure in the brake cylinders, to avoid a harsh snatch on stopping. Because of the "inertia" built into the system both Regulator and Brake can be turned quickly to new positions without jerking the train.

In cases of emergency turn the Brake to 10. There is no Panic button as the number 10 position is almost instantaneous. No damage will occur if the Brake is applied with the Regulator On. But proper operation will only occur with the Regulator Off.

ADJUSTING ACCELERATION

Use a screwdriver with 2mm wide blade. Having wired up the controller, check that the transformer is on and that the yellow indicator is on. Select an appropriate current limit and select SIMULATE 1. Ensure the brake is off (0), a loco is on the track then wind the REGULATOR open. The loco should move smoothly off (if the track is clean) and accelerate away. The time taken before it starts to move will be dependent on the construction of the motor. Real trains in fact take some time to move after the driver has opened the throttle and most real locomotives have some time delay circuitry built in to build up power slowly in order to prevent wheel slip. Note the rate of acceleration. If it is too fast, it can be reduced by turning the left trimpot (looking at the rear of the controller) clockwise. Remember that the SIMULATE 2 setting will produce a rate the same as or LESS than SIM 1. SIM 1 could be used to represent faster accelerating passenger trains and SIM 2 slower accelerating goods trains. Once SIM 1 is set switch to SIM 2 and check the rate again. Adjust in the same way, using the right hand trimpot. It is possible to adjust both trimpots fully anticlockwise. In this case there will be no delayed acceleration in either position and the REGULATOR will control it as in DIRECT. However the COAST feature will still operate and the BRAKE must be used for stopping. The SIM 1 trimpot set for no delay and delay on SIM 2 is also a viable selection.

START VOLTAGE AND FINAL VOLTAGE

Another hole, on the left hand side rear is used to access the adjustment for the start voltage so that a locomotive will move sooner after movement of the regulator. The motor will hum even with the Regulator on "0". Turn clockwise for an increase in starting volts. The top right hand hole is for setting the maximum voltage relative to Regulator knob position. It does not alter the final maximum output but only where it occurs. A low back EMF motor will cause the max volts to occur at a lower setting, say 7,whereas a coreless one such as a Portescap will reach it only at 10. To INCREASE the Rotation necessary to reach max volts turn clockwise. At max clockwise Portescaps may not reach maximum volts but how many of us ever run at maximum voltage? You may need to reset the starting voltage again as these two interact slightly.

CURRENT LIMIT

When the set current is reached the RED LED will begin to light up. Current will not increase even if the overload tends to a short circuit. After a few seconds, depending on the severity of the overload, the current output will fall to a lesser value (see Specifications). On removal of the overload, the REGULATOR will need to be moved to 0 to reset the system. When in SIMULATOR mode the BRAKE needs to be applied fully. The system will also reset if ALL LOAD is removed (i.e. if a loco is removed from the track. If for example a short circuit occurs while a loco is on the track (say a screwdriver across the rails) the system will not reset when the screwdriver is removed; the regulator must first be moved to 0 (or brake applied as above). This prevents damage to mechanisms by immediate reapplication of full power. On the other hand if there is no loco on the track and the only load is the screwdriver, the system will reset as soon as the load is removed. When a short circuit occurs, the GREEN LED will extinguish.

HEAT

In order for the constant input voltage to be varied from 0 to 12 at the output, the difference is dissipated via the output transistor. This generates heat. Part of the heat sink is the front panel of the controller that, during use, will heat up. There is nothing alarming about this; transistors are designed to be able to run internally at 125 degrees C! The panel will not get to this temperature (naturally). But after running for an hour or so drawing maximum current of 1 amp it should be quite warm. The "duty cycle" of most layouts will mean that little heating will be evident. Maximum heat dissipation occurs on short circuit with 1 amp setting and regulator just open.

ERGONOMICS

The controller panel layout has been carefully chosen so that it can be operated both by left-handers and right-handers. In both cases the thumb seems to be the natural digit to use for the reversing switch. Also, it seems to be the obvious one, in the case of single-handed operation (while the other hand is operating turnouts etc.) to operate the Regulator and Brake. This is particularly so in the case of Simulator operation when delicate turning is not required. To avoid strain on the connections at the controller and at the layout and to provide a cable with the largest practical conductors 3 metres of straight cable is supplied. Least strain occurs when the cable is allowed to fall onto the floor. However feel free to cut it to a shorter length! Requirements for storage of the handset out of use will vary but a Velcro or similar patch on the back is suggested. The panel label has been laminated so that it should stand wear and tear.

SPECIFICATION

Input: 14 to 16 volts AC
Output: 0 to 12 volts DC (nominal, depends to some extent on type of motor)

Current Limits: 100mA max (folds back to less than 20mA)
250mA max (" " " " " 20mA)
1.0 A max (" " " " " 150mA)
Acceleration:
SIMULATE 1: Minimum: direct response to Regulator
Maximum: 0 to Max. Volts, 24 seconds.
SIMULATE 2: Minimum: corresponds to SIMULATE 1.
Maximum: 0 to Max. Volts, 36 seconds.

Braking: Minimum Rate: Max. Volts to 0, 36 seconds.
Maximum Rate: Instantaneous.

Size: 69mm wide x 131 length x 58 high (including controls)

Cable: 3 metres 4 core.

Features: Twin knob control (Regulator, Brake),
Toggle Direction switch (on-on),
3 Modes (Direct, Simulate 1, Simulate 2),
Pre-settable acceleration,
3 Current settings (100mA, 250mA, 1.0 A),
3 Indicators (input, output, overload),
3 Language choices for panel (English, German, Dutch)

Fidelity Control (John Brouwer) 31a Naseby Street, Christchurch 8014, NZ. E: brouwer@es.co.nz
Tel: (03) 3556-534 Feedback controllers for coreless and standard motors.