Evaluation of
TC3 Standby Power Unit
for
Energetix Pnu Power Limited

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Report Summary

This report documents the results from a series of tests carried out by the author on behalf Energetix Pnu Power Limited, Capenhurst Technology Park, Capenhurst, Chester, CH1 6EH, UK.

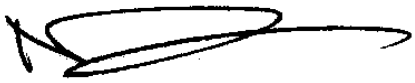
The tests were carried out to evaluate the TC3 Standby Power Unit manufactured by Energetix Pnu Power Limited when subject to typical contactor loads. The loads replicated were a typical:

- spring charging current for the FK 3-1/131, and
- coil operating current for the Frame R contactor coil.

The spring charging current was replicated for a single unit and two parallel connected units. The test voltage was 110Vd.c. The coil operating current load was replicated for one Frame R trip contactor coil.

The TC3 Standby Power Unit was subjected to these tests when connected to a standard 230V, 16A, 50Hz, single-phase mains socket outlet, and a 20 litre, 300 bar cylinder of compressed air.

The results show correct functionality of the power supply with regard to the steady and transient loadings imparted by contactor systems when supplied by both mains electricity and via standby compressed gas. The unit also demonstrates good recovery in terms of dc supply post excessively high loadings.



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1. Test Specification Requirements and Experimental Set-up.

The tests were carried out to evaluate the TC3 Standby Power Unit manufactured by Energetix Pnu Power Limited when subject to typical contactor loads. Two loads were considered, the spring charging current for the FK 3-1/131 breaker operating mechanism, and the operating current for the Frame R trip coil. Details of the contactor current requirements are detailed in the AREVA document "Current curves during operations", as discussed in reference [1]. The main operating curves from reference [1] for the FK 3-1/131 contactor are the typical closing coil current curve, Fig. 1, opening coil current curve, Fig. 2 and the spring charging current curve, Fig. 3.

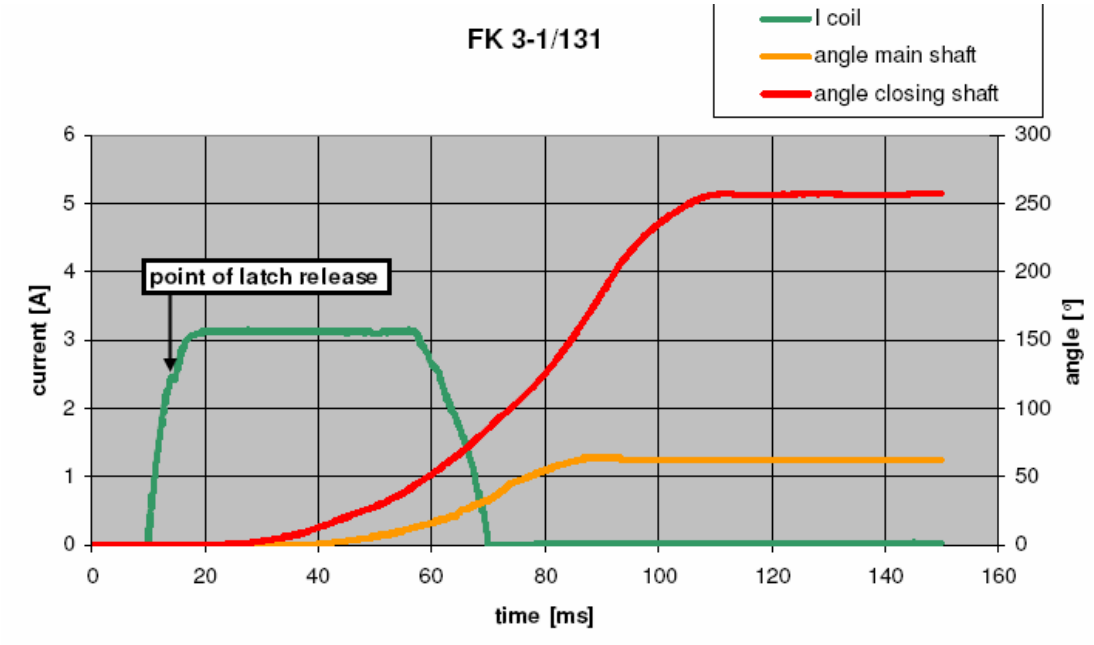


Fig. 1. Typical closing coil current curve for FK 3-1/131.

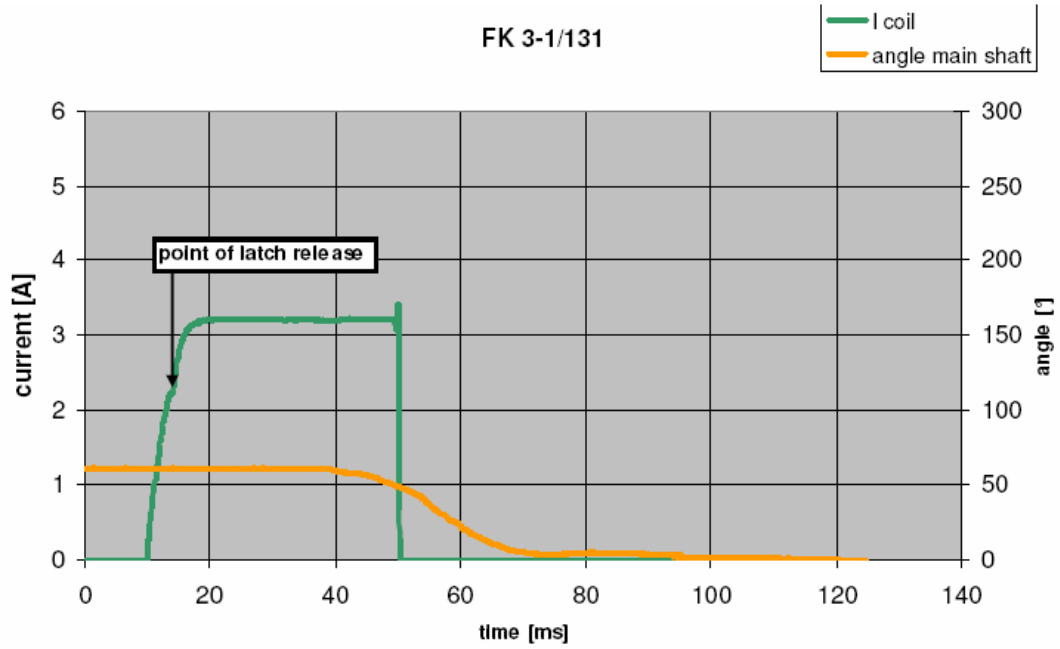


Fig. 2. Typical opening coil current curve for FK 3-1/131.

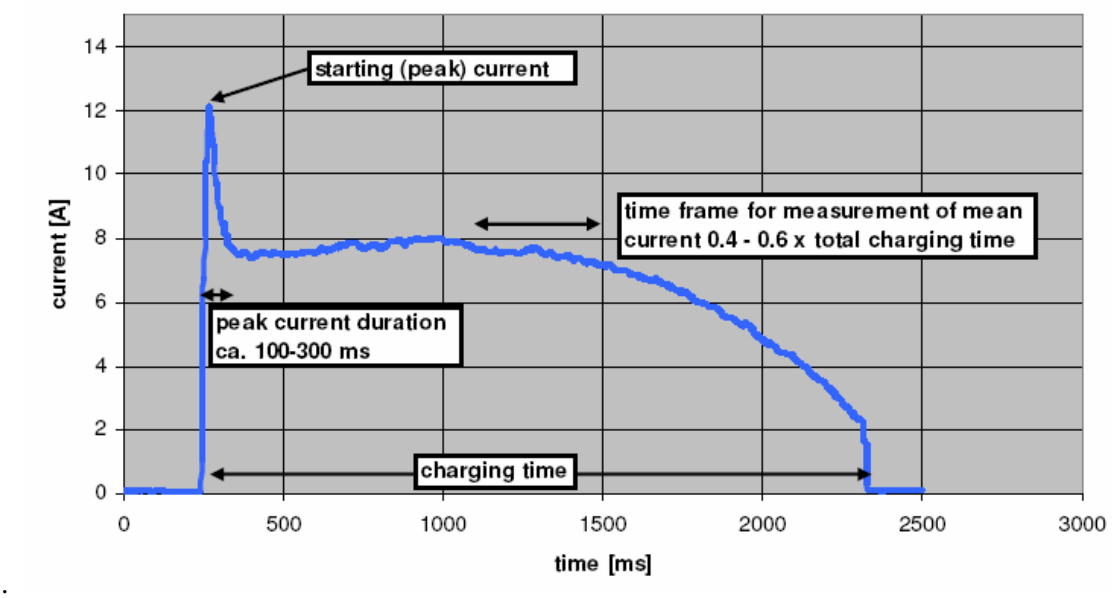


Fig. 3. Typical spring charging current curve for FK 3-1/131.

Test of the closing and opening coil current function was simply performed by direct connection of a contactor to the TC3 Standby Power Unit. However, since the spring charging current is more dynamic a repeatable load test was devised. Here the contactor spring charging current for the FK 3-1/131 is emulated by the switching of three discrete resistors, R_1, R_2 and R_3, the parallel combinations of which results in a piecewise representation of current, as illustrated in Fig. 4. Switching of three discrete resistors, R_1, R_2 and R_3, is facilitated via an IGBT integrated power module controlled via DSpace.

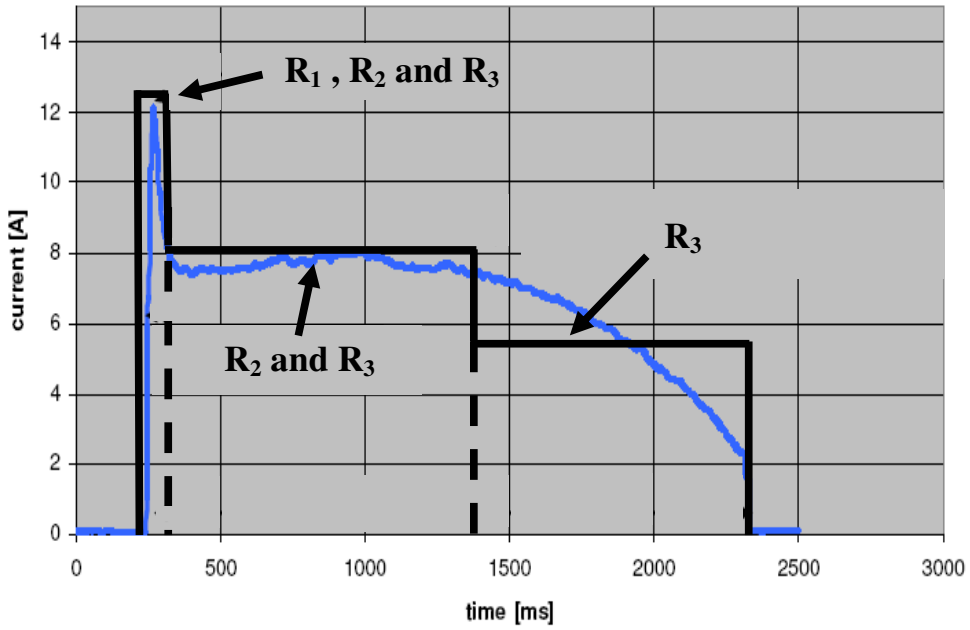


Fig. 4. Emulation of contactor spring charging current curve for the FK 3-1/131.

Fig. 5 illustrates a schematic of one integrated power module, where each of the switches (S1 to S6) represent an IGBT power silicon switching device having a nominal rating of 600V, 25A. A DSpace controller was programmed to output pulses to the top devices of the integrated power module while the bottom devices (S4 to S6) were gated to the off position. Two integrated power modules and sets of load resistors (R_1 to R_3) were used to emulate two contactor spring charging currents for the FK 3-1/131. Fig. 6 illustrates the timing signals output from the DSpace controller and used as input to the integrated power module.

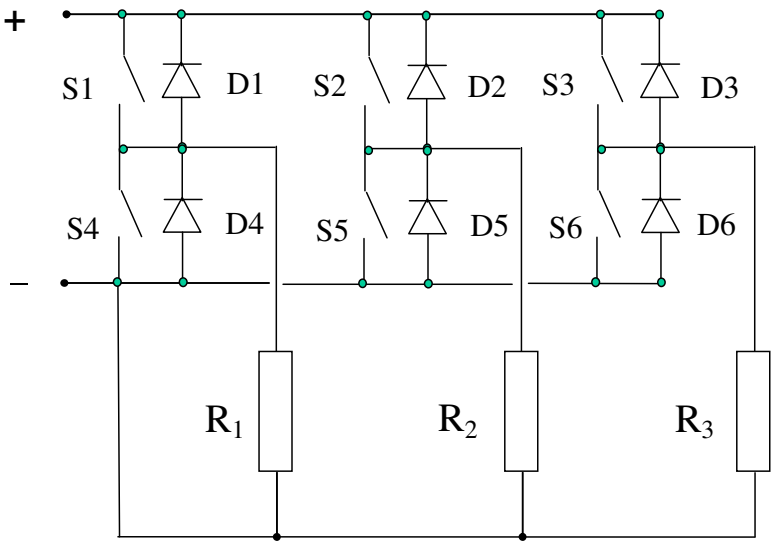


Fig. 5. Integrated power module schematic showing main power electronic devices and the coil load resistance emulators.

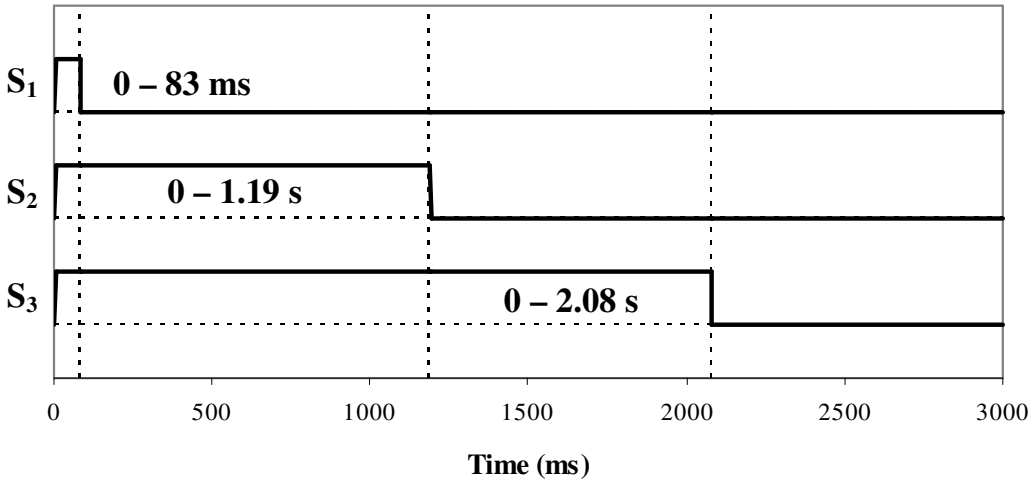


Fig. 6. Timing signals output from the DSpace controller and used as input to the integrated power modules.

	Stage resistance (ohms)	Load current (A) (at 110Vdc)
R_1	20	
R_2	41	
R_3	20	
R_1, R_2 and R_3 (in parallel)	8.04	13.7
R_2 and R_3 (in parallel)	13.44	8.2
R_3	20	5.5

Table 1. Resistor details for spring charging current emulator.

Table 1 details the emulator resistances, their total circuit resistance when switched and the respective load currents to which the TC3 Power Supply is subject. Fig. 7 shows the laboratory experimental facility, and Fig. 8 the internals of the control cabinet.

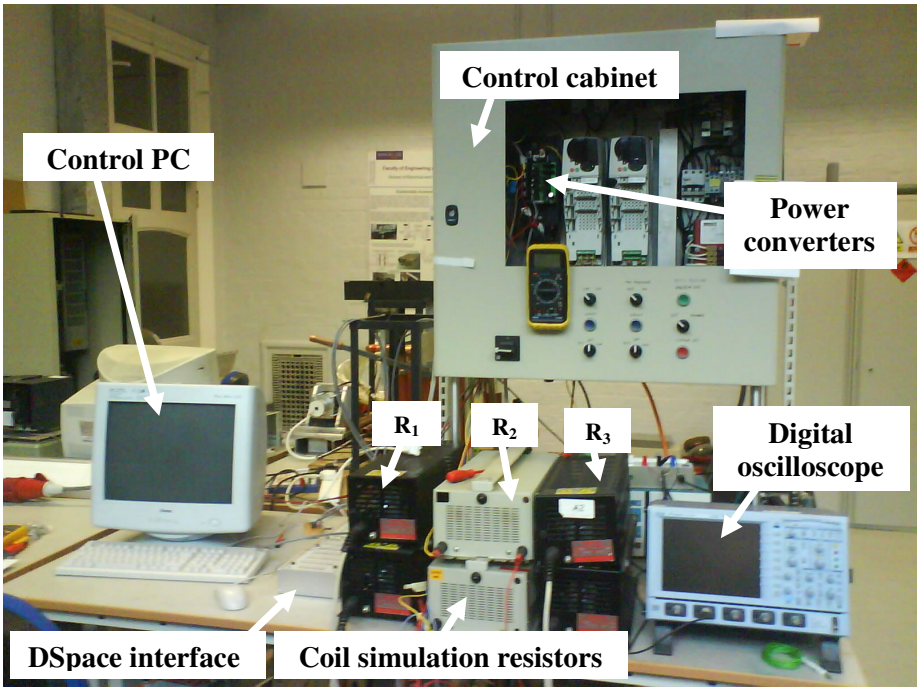


Fig. 7. Laboratory experimental set-up.

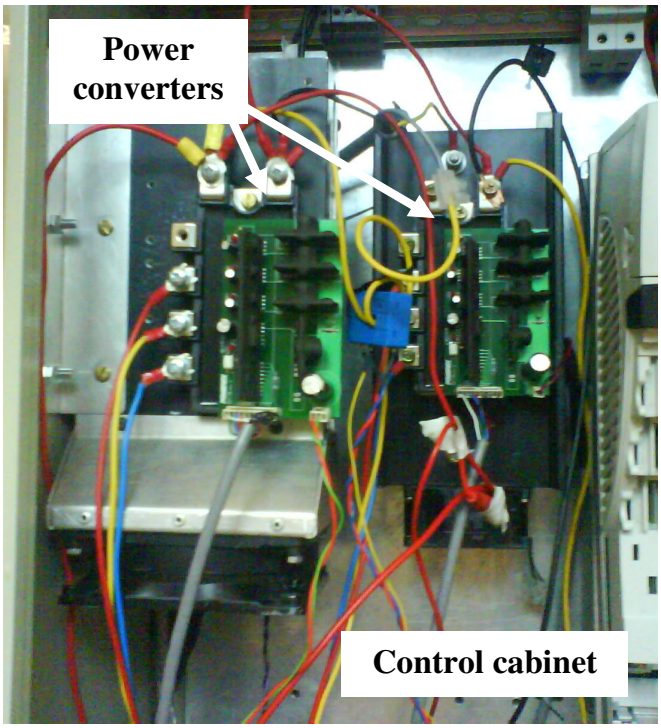


Fig. 8. Laboratory experimental set-up: internals of the control cabinet.

2. Load Tests and Results.

The load tests were carried out to evaluate the TC3 Standby Power Unit manufactured by Energetix Pnu Power Limited when subject to typical contactor loads. The loads replicated were for a typical:

- spring charging current for the FK 3-1/131, and
- Frame R trip coil operating current.

The spring charging current was replicated for a single unit and two parallel connected units. The coil operating current load was replicated for one unit. The nominal power supply output voltage was 110Vd.c.

The TC3 Standby Power Unit was subjected to these tests when connected to a standard 230V, 16A, 50Hz, single-phase mains socket outlet (MAINS), and a 20 litre, 300 bar cylinder of compressed air (GAS).

Results showing the power supply dc output voltage and current when subjected to the following test loads are given in Appendix 1:

- load emulation of 2 x spring charging circuits with MAINS supply (Test: 11-07-09; 15:19:10), Fig. 9,
- load emulation of 1 x spring charging circuit with MAINS supply (Test: 11-07-09; 15: 23:48), Fig. 10,
- load emulation of 1 x spring charging circuit with GAS supply (Test: 11-07-09; 15:31:04), Fig. 11,
- with initial load emulation of 2 x spring charging circuits and then 1 x spring charging circuit with GAS supply (Test: 11-07-09; 15:52:42), Fig. 12,
- loaded by Frame R trip contactor coil with MAINS supply (Test: 11-07-09; 16:38:58), Fig. 13, and
- loaded with load emulation of 2 x spring charging circuits and Frame R trip contactor coil supplied via GAS (to 15 seconds) and then via the MAINS (Test: 11-07-09; 16:50:22), Fig. 14.

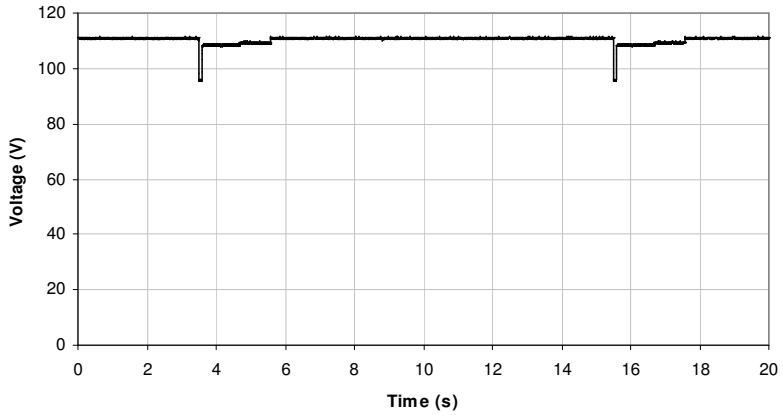
3. Conclusions.

The results show correct functionality of TC3 Standby Power Unit manufactured by Energetix Pnu Power Limited with regard to the steady and transient loadings imparted by contactor systems when supplied by both mains electricity and via standby compressed gas. The unit also demonstrates good recovery in terms of dc supply post excessively high loadings.

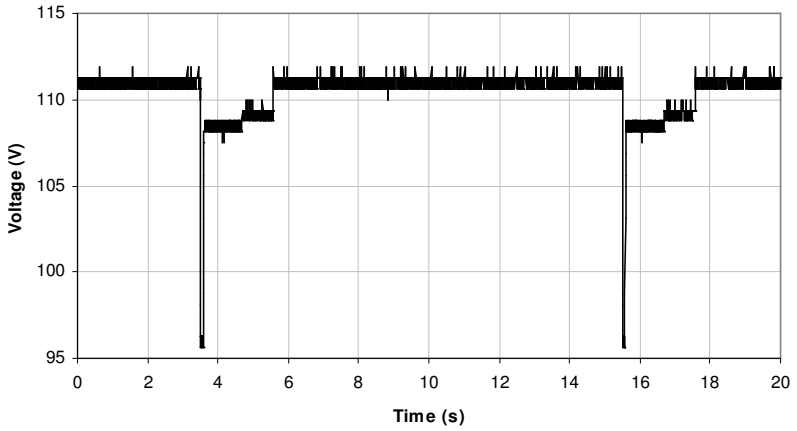
4. References.

[1] Current curves during operations; © AREVA/Mischa Castiglioni, TMVA-SHE, 04-06-2009.

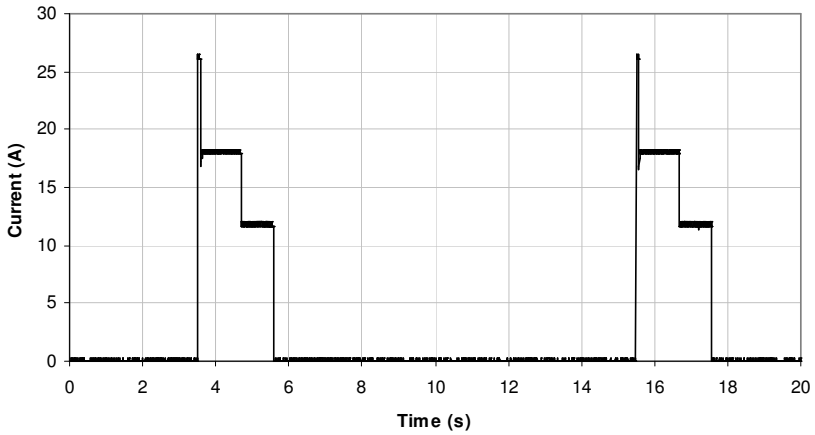
5. Appendix 1. Measured Waveforms.



(a) Power supply dc voltage output

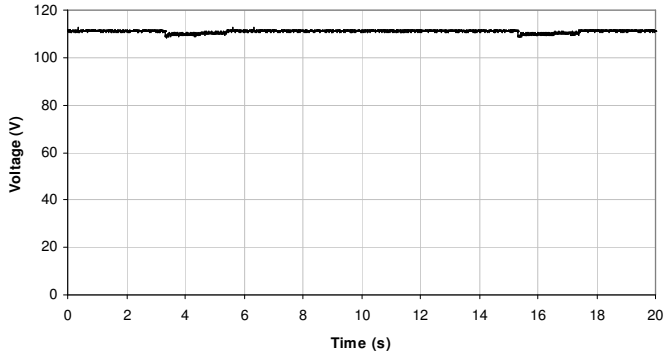


(b) Power supply dc voltage output detail

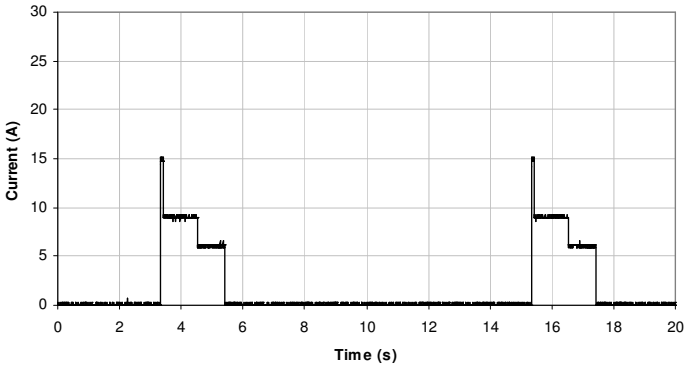


(c) Power supply output current

Fig. 9. TC3 Power supply with load emulation of 2 x spring charging circuits with MAINS supply.
(Test: 11-07-09; 15:19:10)

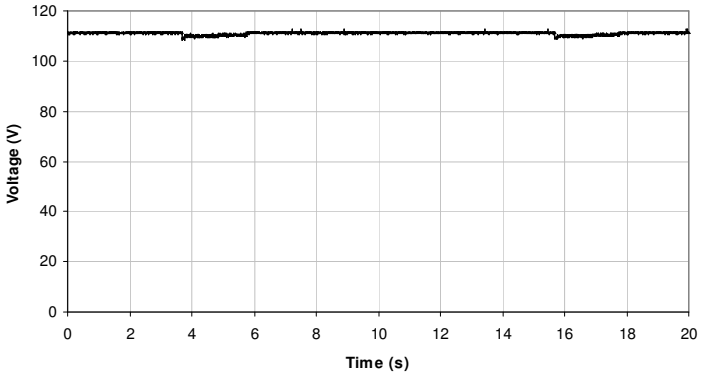


(a) Power supply dc voltage output

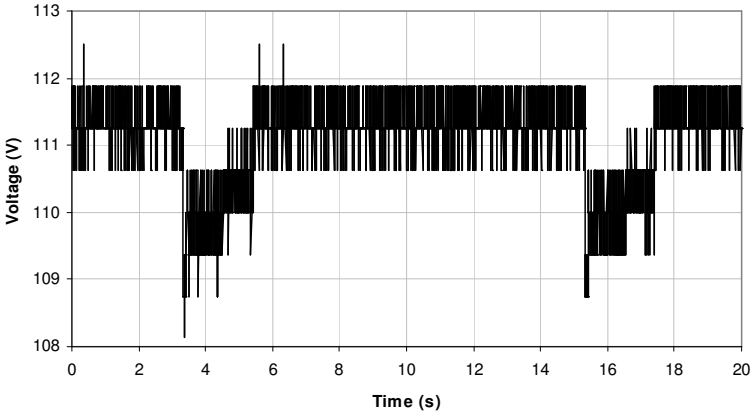


(b) Power supply output current

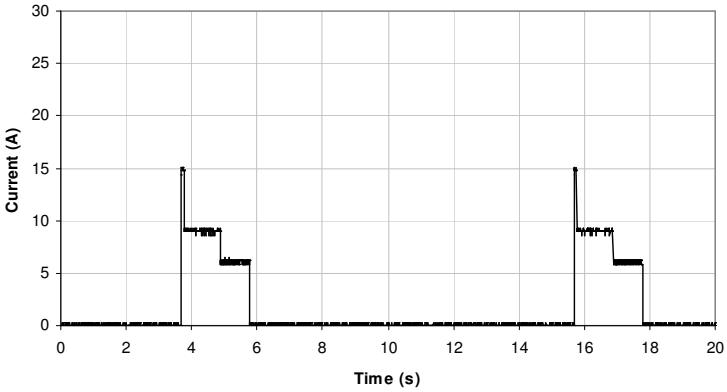
Fig. 10. TC3 Power supply with load emulation of 1 x spring charging circuits with MAINS supply.
(Test: 11-07-09; 15: 23:48)



(a) Power supply dc voltage output

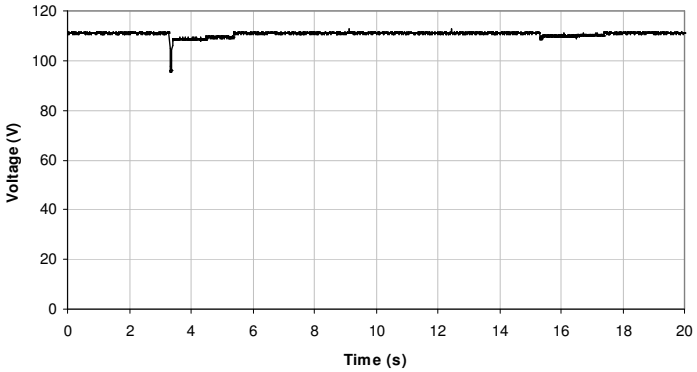


(b) Power supply dc voltage output detail

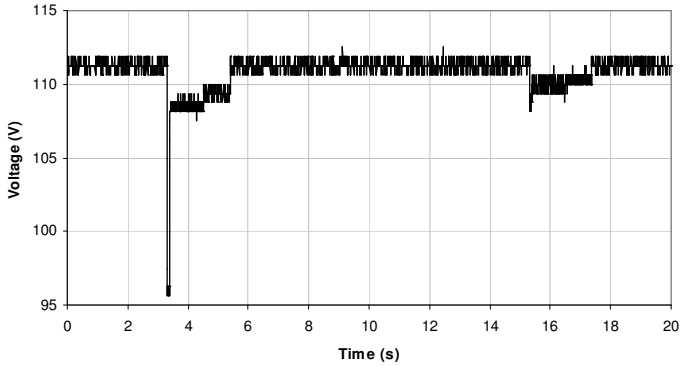


(c) Power supply output current

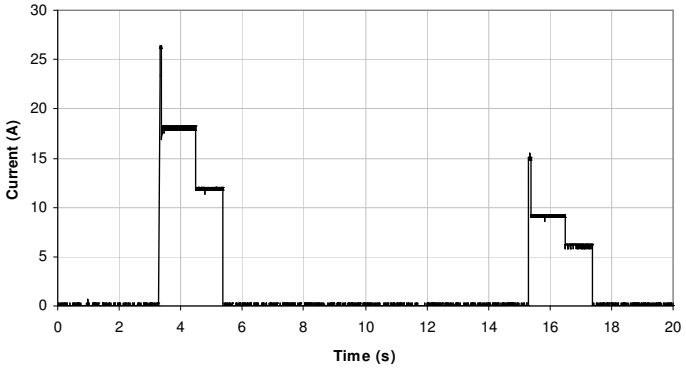
Fig. 11. TC3 Power supply with load emulation of 1 x spring charging circuits with GAS supply.
(Test: 11-07-09; 15:31:04)



(a) Power supply dc voltage output

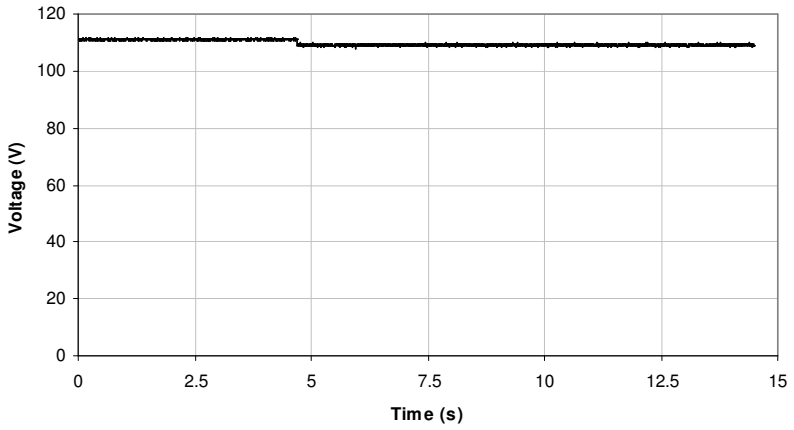


(b) Power supply dc voltage output detail

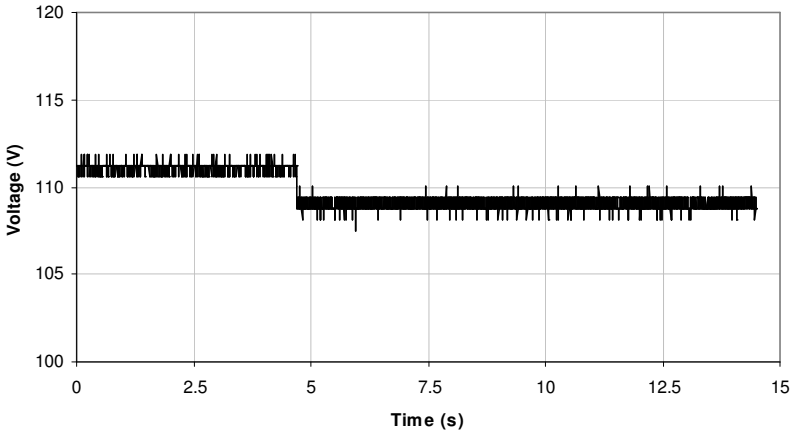


(c) Power supply output current

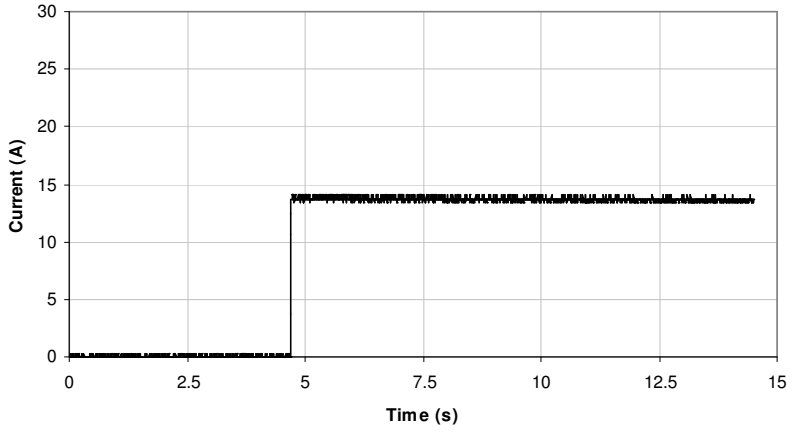
Fig. 12. TC3 Power supply with initial load emulation of 2 x spring charging circuits and then 1 x spring charging circuit with GAS supply.
(Test: 11-07-09; 15:52:42)



(a) Power supply dc voltage output

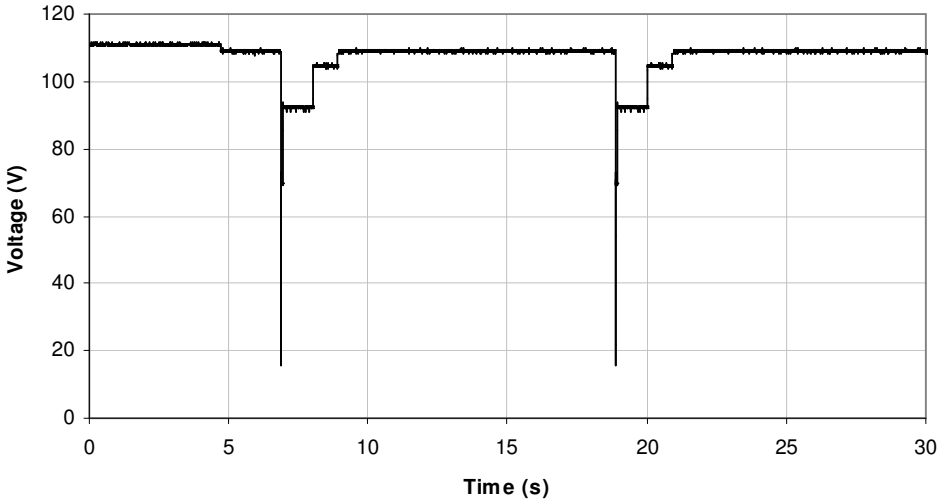


(b) Power supply dc voltage output detail

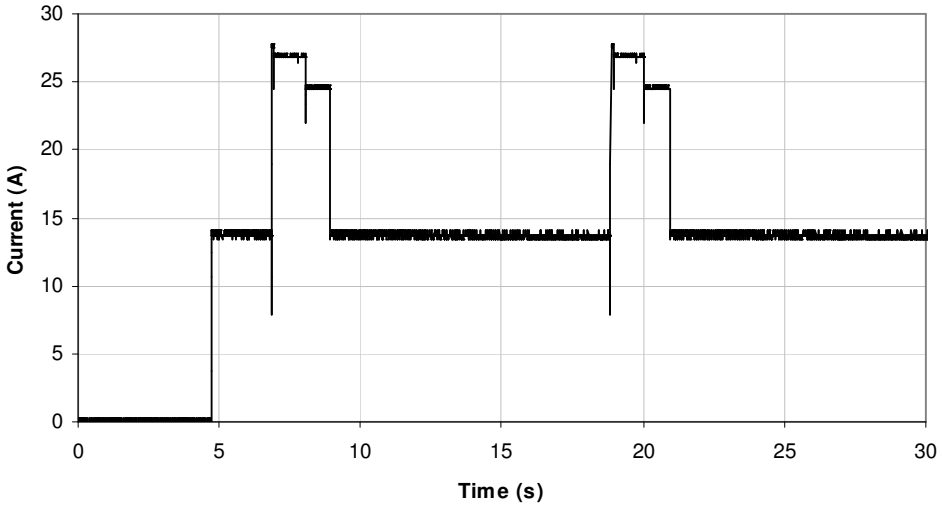


(c) Power supply output current

Fig. 13. TC3 Power supply loaded by Frame R trip contactor coil with MAINS supply. (Test: 11-07-09; 16:38:58)



(a) Power supply dc voltage output



(b) Power supply output current

Fig. 14. TC3 Power supply with load emulation of 2 x spring charging circuits and Frame R trip contactor coil supplied via GAS (to 15 seconds) and then via the MAINS. (Test: 11-07-09; 16:50:22)