Data and Calculations relating to the 'Ringwood Energy Recycler' Experiment

1) Measure times to discharge Battery voltage from 4.2V to 3.45V

(The following times are averaged from several tests; representative graphs are shown in Fig. 3 - Fig. 6)
NIMH + 268R:
 42.5h
NIMH + LED cluster + 78R:
 45h
NO FB ('No Feedback') cct:
 30.5h
WITH FB ('With Feedback') cct:
 60.5h

2) Derive Vav from resistor/led cluster discharge results

For Vav = 3.86V;

(discharge current using 268R)
Idis:
 3.86V / 268R = 14.4mA

(discharge current using 78R, LED cluster @ 2.8V forward voltage)
Iled:
 (3.86V - 2.8V) / 78R = 13.59mA

(confirm Iled by comparing discharge times)
Iled:
 14.4mA * 42.5h / 45h = 13.6mA

3) Derive Currents

NIMH + R
Idis:
 3.86V / 268R = 14.4mA

(The following current paths are identified in Fig. 1)

NO FB
Iin:
 14.4mA * 42.5h / 30.5h = 20.1mA

WITH FB
Ivirtual:
 14.4mA x 42.5h / 60.5h = 10.1mA
Ifb:
 20.1mA - 10.1mA = 10mA

4) Calculate Energy and Work totals & Efficiencies

(a factor of 3.6 is used to convert mWh to Joules)

NIMH + R
Etot: (total energy drawn from battery by 268R resistor)
3.86V x 14.4mA x 42.5h x 3.6 = 8504J

NO FB
Etot: (total energy drawn from battery by circuit)
3.86V x 20.3mA x 30.5h x 3.6 = 8603J

Eled: (work done by LEDs)
2.8V x 10.1mA x 30.5h x 3.6 = 3105J
Enimh: (work done recharging spare NiMH)
3.86V x 10mA x 30.5h x 3.6 = 4238J

7343J (quantifiable-work done)

quantifiable-work efficiency (NO FB)
n1 = 7343J / 8603J = 0.85
(quantifiable-work done / total energy input to cct)

(the mid-duration LED output was measured as approx. 147 foot-candles at 6")

WITH FB
Etot: (total energy drawn from battery by circuit)
3.86V x 20.1mA x 60.5h x 3.6 = 16898J

Eled: (work done by LED cluster)
2.8V x 10.1mA x 60.5h x 3.6 = 6159J
Enimh: (work done recharging supply NiMH)
3.86V x 10mA x 60.5h x 3.6 = 8407J

14566J (quantifiable-work done)

quantifiable-work efficiency (WITH FB)
n2 = 14566J / 16898J = 0.86
(quantifiable-work done / total energy input to cct)

(the mid-duration LED output was measured as approx. 146 foot-candles at 6")

quantifiable-work efficiency (WITH FB)
n3 = 14566J / 8504J = 1.7
(total work done / total original energy supplied)

total system efficiency (WITH FB)
n4 = 16898J / 8504J = 1.99
(total energy converted / total original energy supplied)

5) Cross-check extended work values

The 'No-Feedback' cct converts 3105J in the LED cluster,
and it stores 4238J in the spare NiMH,
so the extra work done in the 'With-Feedback' cct must be due to the equivalent of this 4238J stored back in the battery

If we subtract the original supply value, 8504J, from the total input supply to the 'With-Feedback' cct, 16898J, we see that the equivalent of that 4238J energy stored (ie. as recharged previously into the spare NiMH) has now enabled:

8394J of extra energy

to be supplied to the 'With-Feedback' cct, which results in (14566J - 7343J) = 7223J of extra quantifiable-work done

As a check, since the cct, on its own, is 86% work-efficient, that 7223J of extra work done would be equivalent to
(7233J / 0.86) = 8399J of extra energy input

(See below for graphical data)

SRobson
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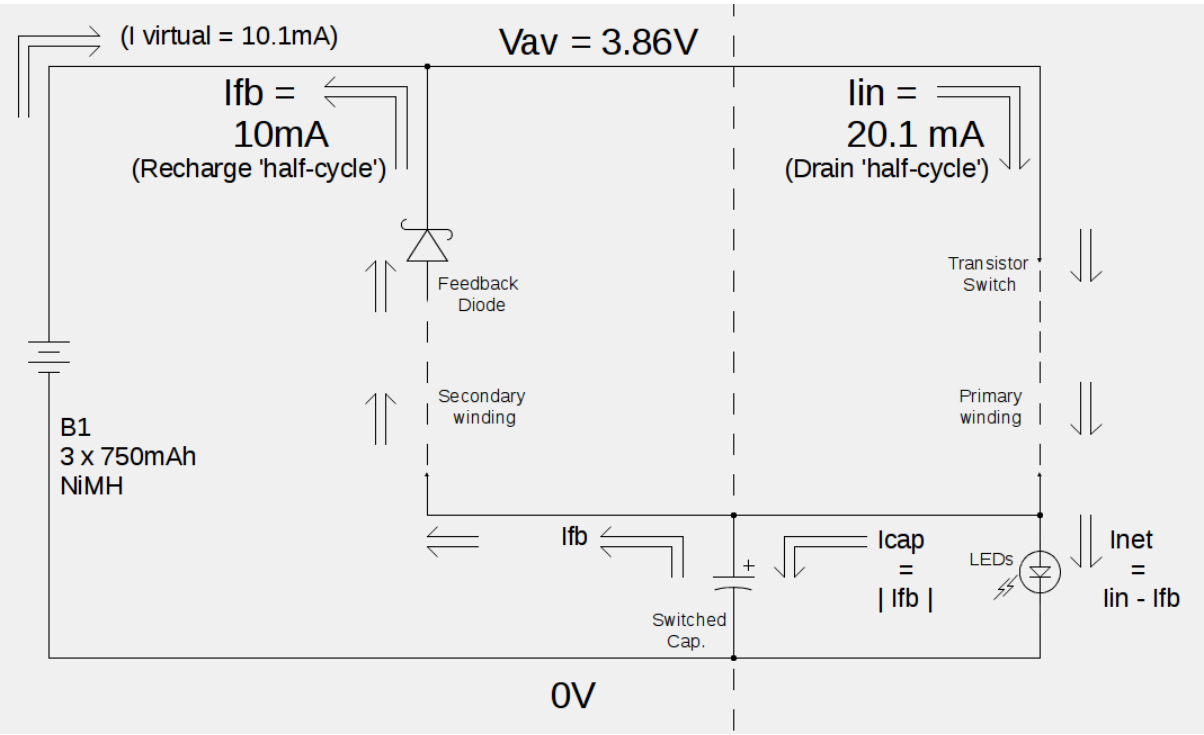

Fig 1 - Switched Current flows

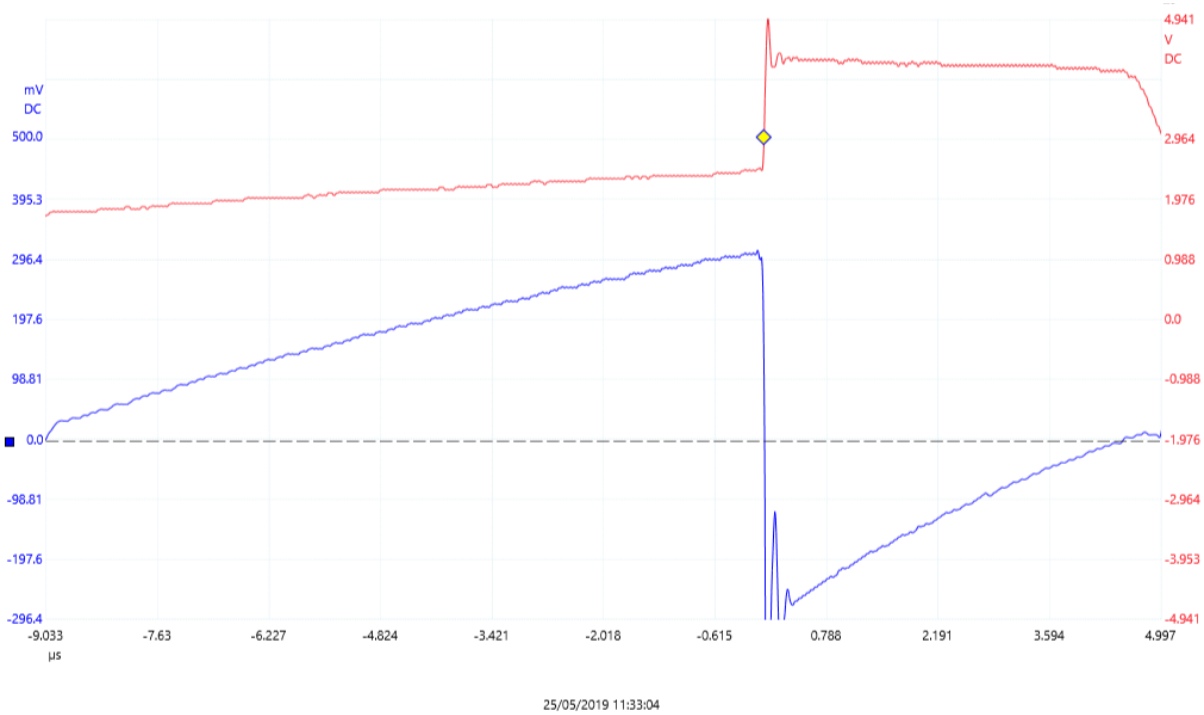

Fig 2 - Feedback pulse (Red),
Bi-polar current pulses (Blue)
(from/to supply battery for 'With Feedback' cct)

Two bi-polar current pulses occur within each cycle (approx. 14us total duration); the positive-going 'sawtooth' pulse is the supply current (Iin), and the negative-going 'sawtooth' pulse is the feedback current to the battery (Ifb). (The bi-polar pulse trace was obtained just for illustrative purposes, using a current-sensing resistor in the supply path)

(In the four battery-discharge profile graphs below, the blue traces show the battery terminal voltages; the red traces show the forward voltage of the LED cluster)

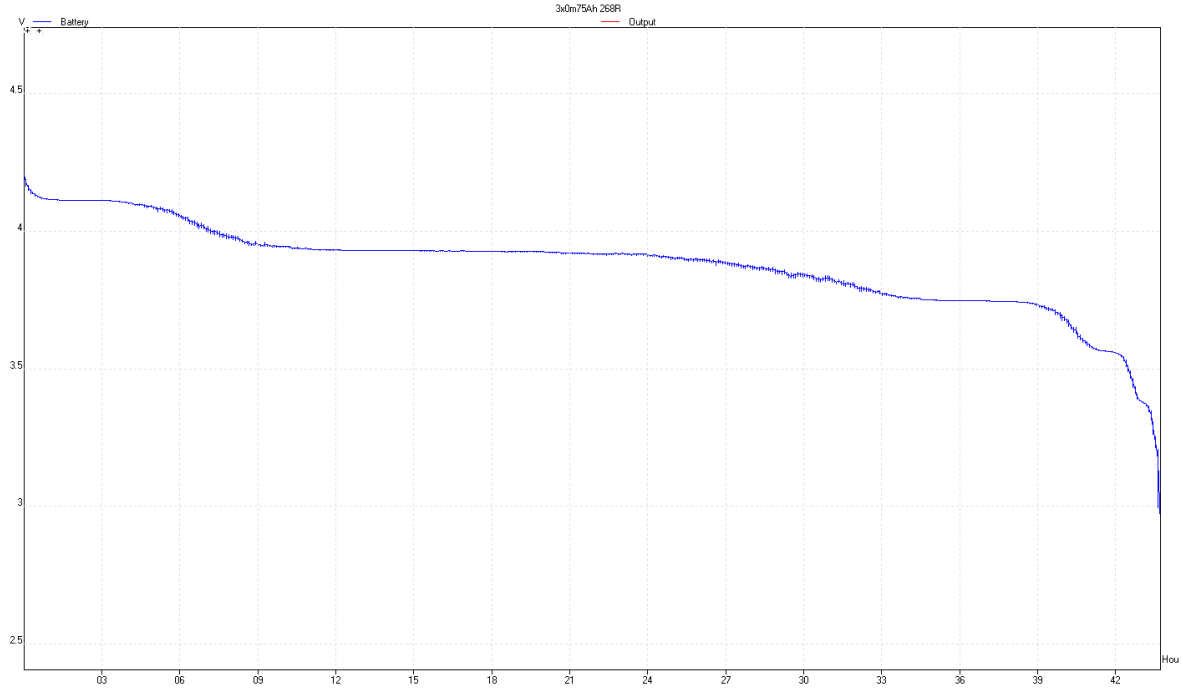

Fig 3 - Battery Discharge profile, 268R

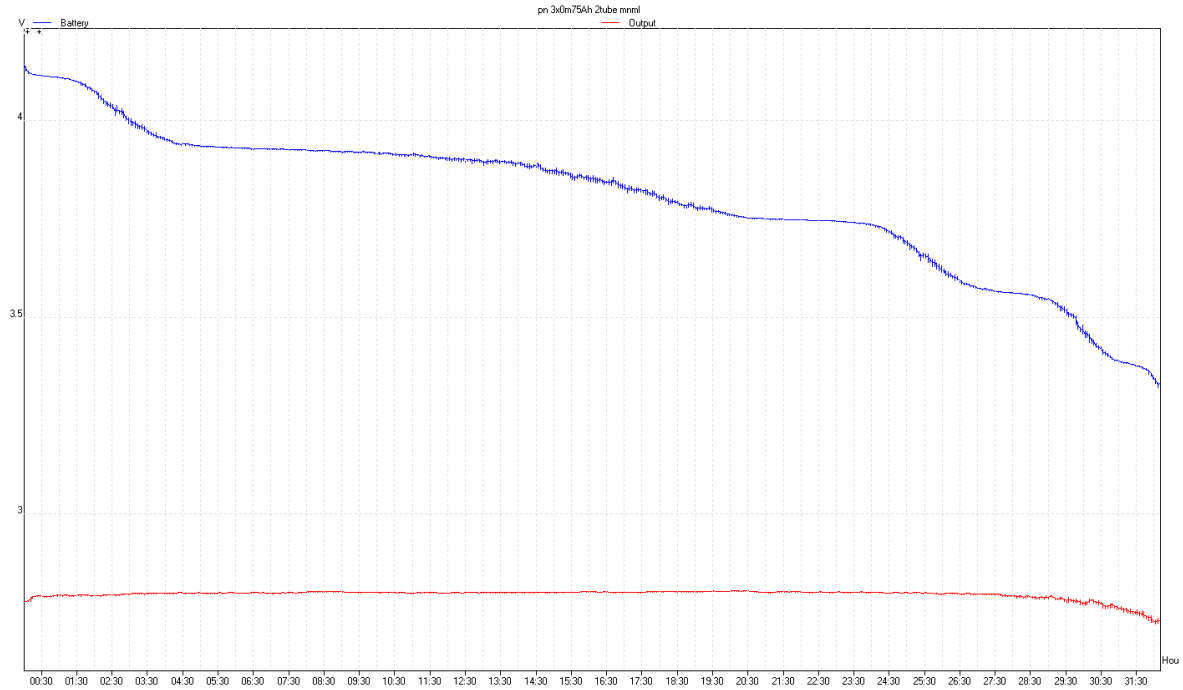

Fig 4 - Battery Discharge profile, 'no-feedback' circuit

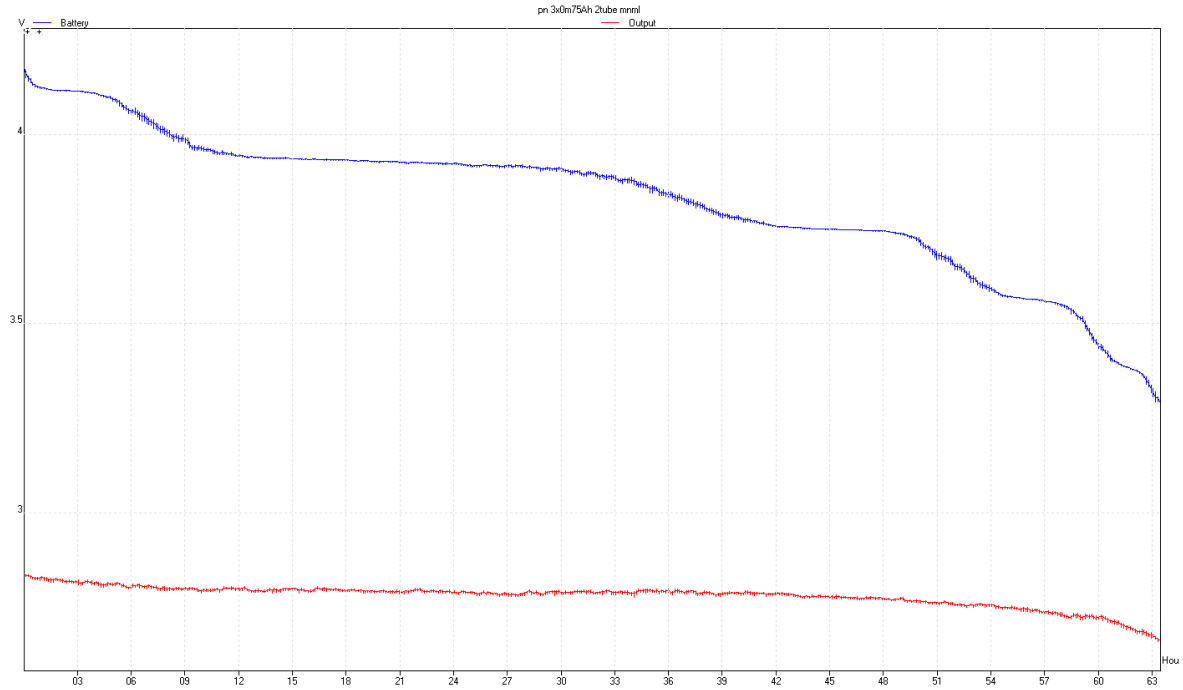

Fig 5 - Battery Discharge profile, 'with-feedback' circuit

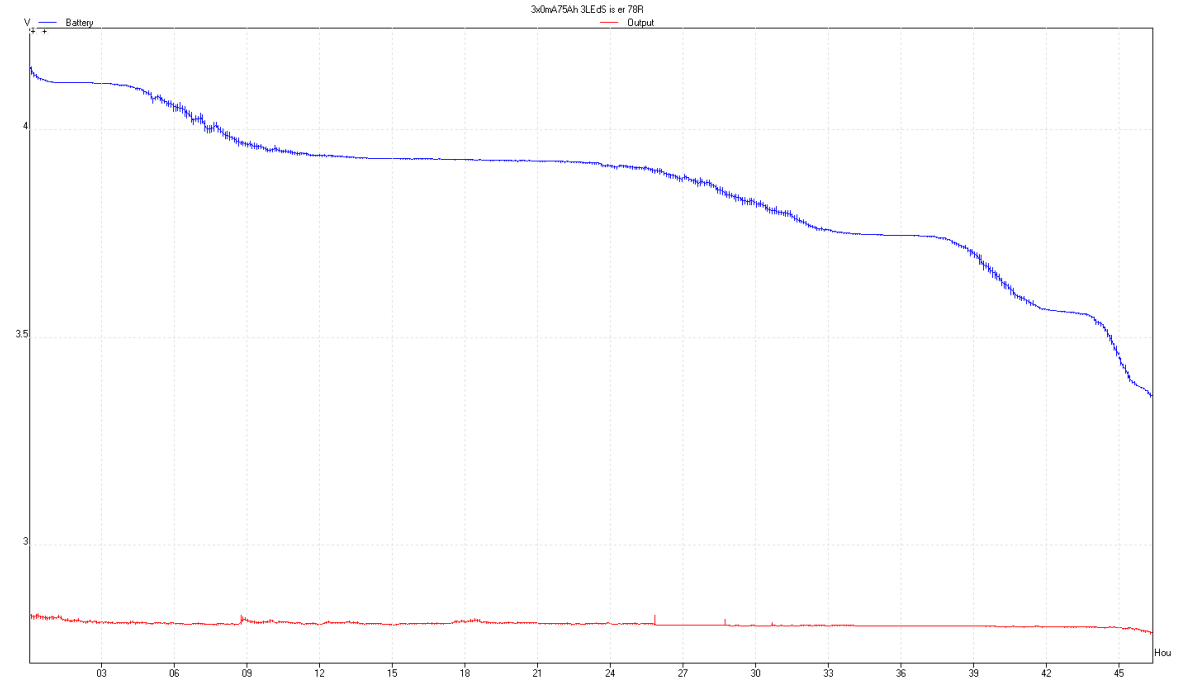

Fig 6 - Battery Discharge profile, LED cluster, 78R (in series)

As a comparison, an additional battery-discharge profile was logged using a load comprising a 78R (measured) resistor in series with the same LED cluster as used in the test circuits

The series resistance was chosen to produce an average current-draw similar to that of the series 268R resistance load, which gives a value between those of the 'With-Feedback' and 'No-Feedback' configurations of the test circuit

In the battery-discharge profile shown in Fig. 6 the mid-duration LED output was measured as approx. 140 foot-candles at 6"