SFM1 Battery Test - Report

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Aim:

To test and determine the longevity of field deployment of the SFM1 Sap Flow Meter using a small 12 V DC, 7 Ah Lead Acid rechargeable battery, as the sole source of external power supply to maintain the SFM1 internal 4 V, 1 Amp Lithium Polymer battery.

Note: When the SFM1 is connected to an external supply the instrument is powered directly from this power source bypassing the internal battery, except for the heat pulse. The measurement Heat Pulse is always supplied directly from the internal battery this is to ensure continuity of supply from a regulated stable power source for the very high, instantaneous current required by the heat pulse. The internal 4 V lithium battery of the SFM1 is trickle charged at a very low rate by the external power supply to maintain its full charge (Figure 1).

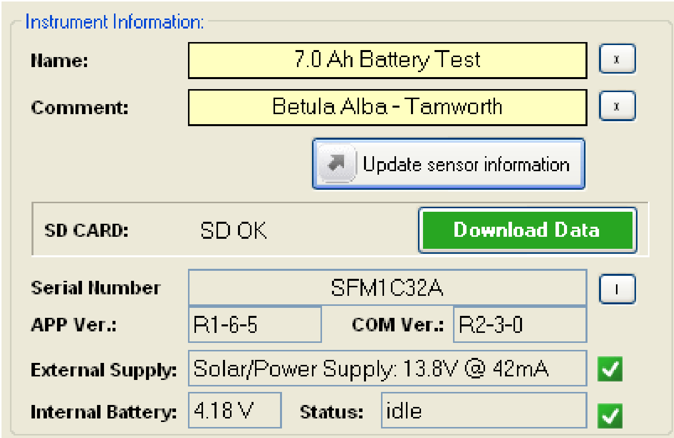

Figure 1. Power Parameters Monitored via SFM1

As the internal battery has the capacity to sustain the SFM1 for up to 23 hours (Figure 4. note the period between 4:10PM 1/11/12 to 3:15PM 2/11/12 where external charging ceases) there is the ability to either remove a discharged external battery and swap it with a fully charged battery, or remove the discharged battery leaving the instrument to operate independently from the internal battery whilst the external battery is recharged and replaced.

Methods:

The SFM1 measurement mode was set to a temporal logging interval of 10 minutes, with a Pulse Energy setting of 20 Joules for each heat pulse. The data reporting option was set to Needle Temperature Mode with a sampling frequency of three (3) samples per second and 900 measurements after the heat pulse for each measurement. This results in a total measurement time of 5 minutes and 32 seconds for each measurement of sap flow. The actual Logging Options used in the trial are displayed directly (Figure 2) from the SFM1 configuration window.

Note: In every 10 minute period the SFM1 instrument is only idle for 4 minutes and 28 seconds. This was chosen deliberately to increase the power burden on the 7 Ah battery whilst using the minimum recommended configuration for the SFM1, being a 10 minute sampling interval at 20 Joule heat pulses.

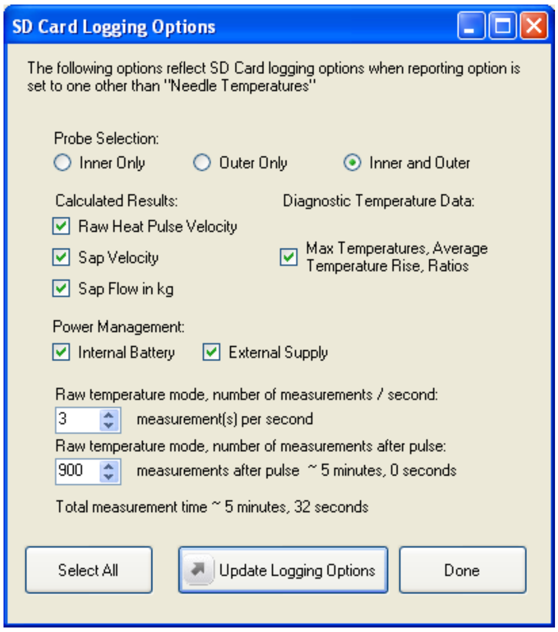

Figure 2. Actual Logging Options Settings used in Trial

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To ensure a thorough test a new 7.0 Ah Lead Acid rechargeable battery was purchased and placed on charge for the recommended 12 hour period prior to use. This was done to ensure the battery was at full capacity prior to commencing the test. The battery was removed from charge and independently measured with a voltmeter to verify the starting voltage.

The starting voltage immediately measured after removal from charge was 13.67 V. This voltage steadily decreased until it stabilised at approx 13 V as measured with the voltmeter prior to connection to the SFM1.

This value of approx 13 V was confirmed by the SFM1 immediately upon connection to the instruments internal power circuit.

The voltage of the external 7 Ah battery was measured continuously using the internal voltmeter function of the SFM1 Sap Flow Meter. The data was analysed using the SFT Sap Flow Tool software. The results of the test are displayed below.

Figure 3. Century PS Series Model 1270 Sealed Lead Acid Battery (12V 7 Ah) used in Trial

Results:

The Blue line (as referenced in the legend displayed on the 1st Y-Axis on the left hand side of the graph Fig.4) is the continuously measured external battery voltage of the 12 V 7 Ah Lead Acid rechargeable battery. Note prior to commencing the external battery test the SFM1 was connected to a 12 V DC mains powered plug pack supplying a relatively constant 13.8 V supply.

The external mains power supply was disconnected at (10:50AM 24/10/12) shown by a sudden drop in voltage to zero. The external Lead Acid battery is connected and the first measurement taken at 11:20AM 24/11/12). Note the lower supply voltage delivered by the 12 V 7 AH battery (approx 13 V) compared to the mains powered 12 V DC Plug pack supplying 13.8V.

The external battery voltage displays a general negative trend as power is supplied to the SFM1. A slight diurnal temperature effect (ambient temperature not specifically monitored although a 25°C diurnal temperature range is common at the site the test was conducted) indicated by minimum battery voltage measured at approx 5:30AM each morning and a maximum voltage measured at approx 11:30AM – 12:00PM each day. This correlates (anecdotally) with the maximum and minimum temperatures measured. This fluctuation is most probably due to the ambient heating of the battery resulting in a higher voltage yield or output from the battery as the internal cells are heated.

Over the first 5 ½ days (between 11:20AM 24/11/12 to 4:00PM 29/11/12) the voltage dropped by 1 Volt, from 13 V (fully Charged) to 12 V. The subsequent two days (between 4:00PM 29/11/12 to 4:00PM 31/11/12) the battery dropped by a subsequent 0.5 V to 11.5 V. The battery then drops a subsequent 0.5V in only 16 hours. At this point the battery begins a terminal decrease to zero Volts over an 11 hour period (between 9:00AM 1/11/12 to 8:00PM 1/11/12) which coincides with a rapid decline in the SFM1 internal battery as it can no longer recharge from the external supply.

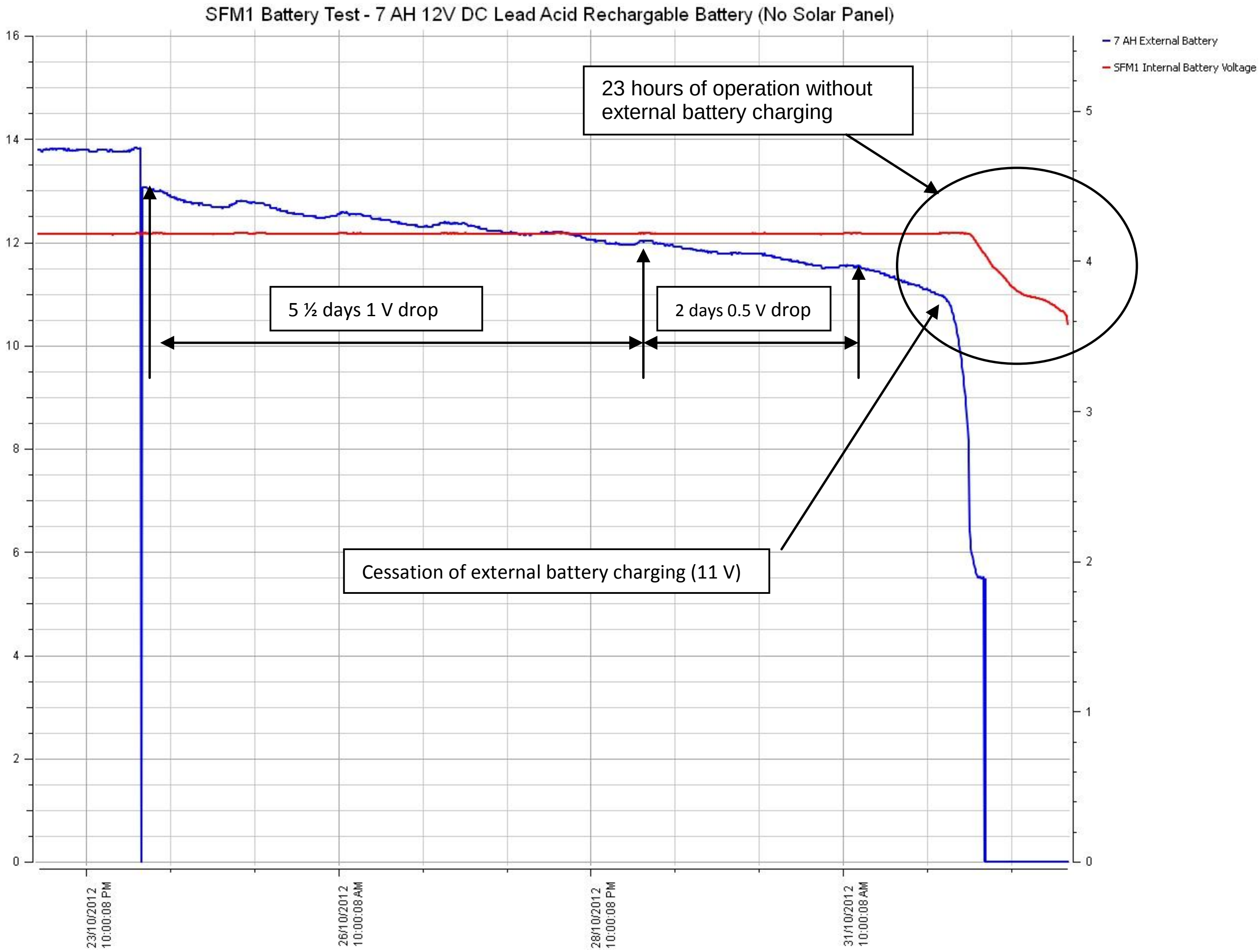

Figure 4. SFM1 Internal battery voltage overlaid against external 7 Ah battery voltage

The red line (as referenced in the legend and displayed on the 2nd Y-Axis on the right hand side of the graph Fig.4) is the continuously measured battery voltage of the 4 V internal Lithium battery of the SFM1. Note it maintains a constant voltage from before the commencement of the battery test when connected to mains power, throughout the external power supply disruption when the external battery was connected (11:20AM 24/11/12) right through in excess of 8 days (4:00PM 1/11/12). At this point the SFM1 internal battery begins to drop as it can no longer source sufficient power for operation or trickle charging of the internal battery. All functions are now being performed from the internal battery which is no longer able to be charged by the external 7 Ah battery.

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Conclusions:

Based on the results of this test it would appear the SFM1 can be used for independent operation in the field for up to a period of 9 days 4 hours and 10 minutes using a single (fully charged) 12 V DC 7 Ah Lead Acid Rechargeable battery. At which point the instruments internal battery reaches the minimum voltage threshold and measurements are suspended.

As this test takes the external battery to failure (fully discharged) it is advised to reduce the expected longevity for field deployment to 7 days to allow a safety margin to prevent the external battery from being fully discharged and possible interruption of measurements through automated suspension of datalogging. Further testing will be conducted to evaluate the effect of constant deep discharge on the performance of the Lead Acid batteries as it is noted they are not specifically designed for such heavy workloads. Deep Cycle Marine batteries are however, designed to withstand such heavy workloads and occasional, to regular deep discharge without immediate impact on the serviceable life of the battery. Where possible ICT recommends using large capacity 100 Ah rated (or greater) Deep Cycle Marine grade batteries for charging the SFM1 Sap Flow Meter in field applications, either with solar charging and especially when solar charging is not available.