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**Application report**

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# Duplicating Real Life Load Profiles in the Laboratory

## Introduction

Automated Battery Test Systems function by simulating battery usage using electronic loads operating under computer control. To do this a multiple step test plan is programmed into the system that closely duplicates the load on the battery during normal operation.There are some applications where this method of manually programming a multi-step test has limitations. This is primarily in applications where the load profile is extremely complex and variable. Attempts to write test plans for such tests are often tedious, complex, lengthy, are prone to errors, and may not in the end accurately duplicate the real life load profile. These applications can be found, for example, in testing batteries and electric motors for Power Tools, Electric Vehicles, Medical Devices, Personal Hygiene Items, and others.

**BaSytec offers a solution to this problem by allowing any ascii test data file to be used to accurately duplicate a real life load profile in a laboratory test.**

This application note describes the use of this feature by simulating the screwing process of a cordless electric screwdriver. The following figure shows a typical current profile for screwing a wood screw. The data was measured with a 12V cordless electric screwdriver. At the beginning a high but short current peak is caused by the starting of the motor. The current then falls to about 1/10 of the start up peak current. Then the current rises again as the friction of the screw increases by depth of the screw. At the end the final tightening process increases the current to a high value.

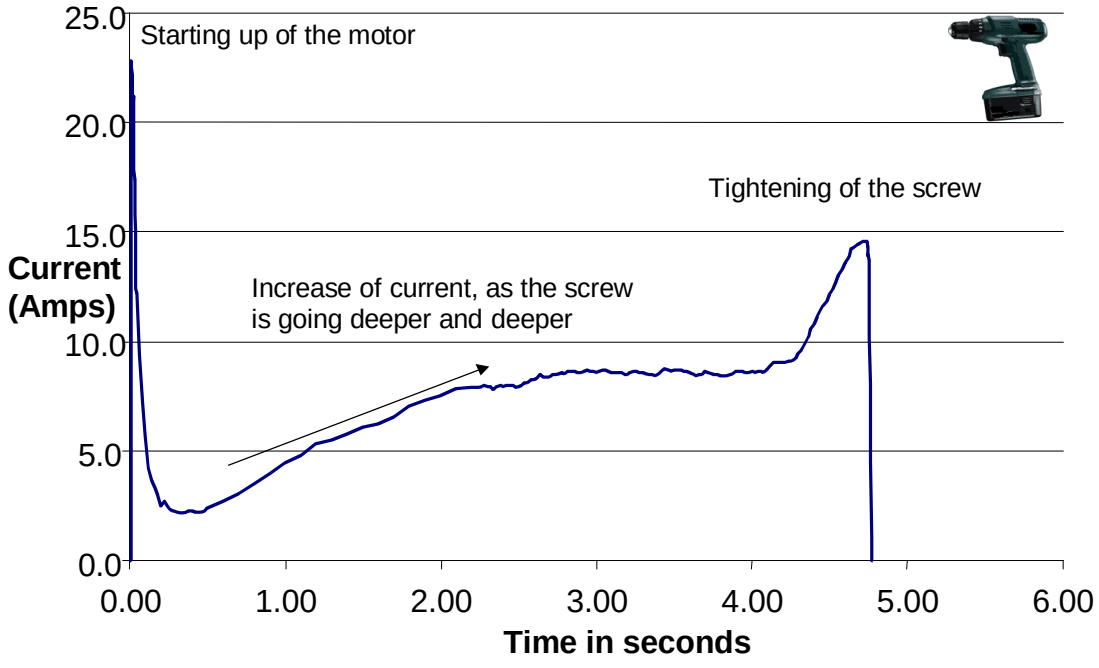


**Figure 1: Current profile for the screwing process**

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# Generating load profiles

Any load profile that is available as an ascii file can be used as part of a test plan in a BaSyTec Battery Test System. This means for example that:

- In the field, you can connect a device to a data logger, operate the device under normal working conditions, collect the voltage and current data, convert this data into an ascii file and place the file into the BaSyTec system Test Plan, to easily and accurately duplicate the real life load profile in a laboratory test.

- If you can perform the initial test in the laboratory, you have the option to record the real life load profile directly into the BaSyTec test system. The measurement of the load profile can be done by the current sensor of the external charger option or by any analogue input if a separate current voltage converter is used. Once the profile is recorded, it is simple to generate an ascii file from the data.

Coming back to our example of figure 1, the data was measured with a current probe and a digital oscilloscope (both from Tektronix). The generated data was imported in Excel. The data was filtered to reduce the noise and finally exported in blanc separated ascii file (*.prn). Take care of the sign rules within the file: A positive current and power represents charging, negative signs represent discharging. This is worse wise to the data given in figure 1.

# Basytec Battery Test Systems have a special function to simulate real life load profiles.

The basytec test plan editor offers the **table** command. This command can playback a load profile that is read from an ascii file. The ascii file needs as minimum two columns (blanc separated), one for the time and one for the current, the voltage or the power. It is also possible to use a file with 3 or 4 columns. It is then possible to limit by all selected values. The table command has a wizard to make it easier to use. The next figure shows the wizard. Within the wizard the used columns must be defined. Additionally it is possible to enter a factor for each column. All data from these columns are then multiplied by this factor.

The time column is always required. So it it necessary to define the column number of the time. If the time is not in seconds it is necessary to use the factor. To convert hours to seconds the factor must be 3600. It is also necessary to select the time format:

**Duration of step**: The time column describes the duration of each line
**Start of step**: The time column describes the start time of each line
**End of step**: The time column describes the end time of each line

The control parameters (I, U, P) must be selected (minimum one) and the corresponding columns must be defined. If necessary also the factor. If more then one parameter is used, the same rules as in the charge step and discharge step are used[1].

[1] See the manual at commands charge and discharge for further information

If the repeat switch is selected, the table is cyclic repeated. In many cases it is more comfortable to repeat the profile by using start-cycle and end-cycle statements. The reason for this is that the cycle-counter is then available for data analyzing.

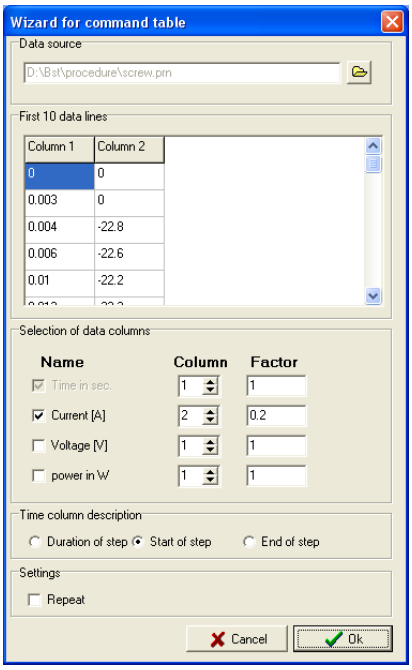
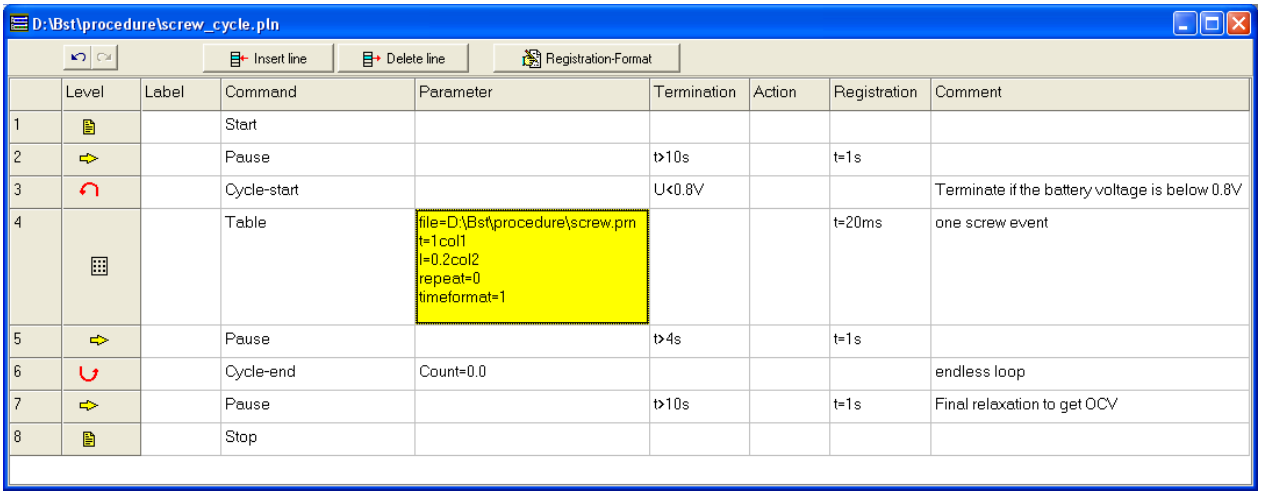



**Figure 2: The wizard for the table command**

## Making a test sequence

The following figure shows a simple test plan that repeats the load profile for a single cell discharge test. The discharge test is finished if the cell voltage falls below 0.8V.




| | Level | Label | Command | Parameter | Termination | Action | Registration | Comment |
|---|---|---|---|---|---|---|---|---|
| 1 | | | Start | | | | | |
| 2 | | | Pause | | t>10s | | t=1s | |
| 3 | | | Cycle-start | | U<0.8V | | | Terminate if the battery voltage is below 0.8V |
| 4 | | | Table | file=D:\Bst\procedure\screw.prn<br>t=1col1<br>I=0.2col2<br>repeat=0<br>timeformat=1 | | | t=20ms | one screw event |
| 5 | | | Pause | | t>4s | | t=1s | |
| 6 | | | Cycle-end | Count=0.0 | | | | endless loop |
| 7 | | | Pause | | t>10s | | t=1s | Final relaxation to get OCV |
| 8 | | | Stop | | | | | |

**Figure 3: Test plan for a repeated load profile**

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# Comparing real and simulated data

The following figure shows the current of the original measured data file and the current that was measured by simulating the profile. This demonstrates the high accuracy of this method, something that would be difficult or even impossible using a manually generated load profile. The test system generates current steps stair-wise and makes no linear interpolation.

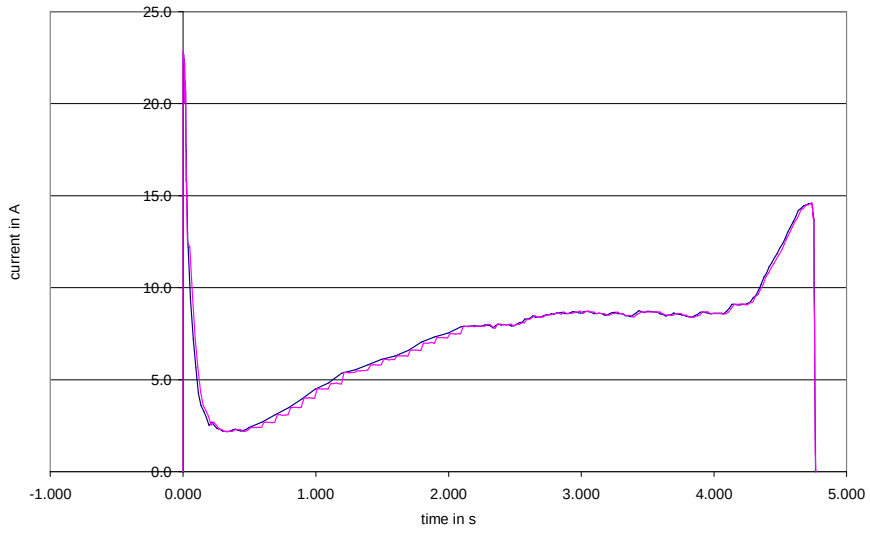


**Figure 4: Comparison of real data (blue) and simulated data (magenta).**

# Analyzing of the test results

Figure 5 shows the voltage for a complete discharge of a battery as it was carried out with the test plan shown in Figure 3. The screwing process was repeated for 137 times until the battery voltage falls below 0.8V. The zoomed figure shows the voltage for one cycle.

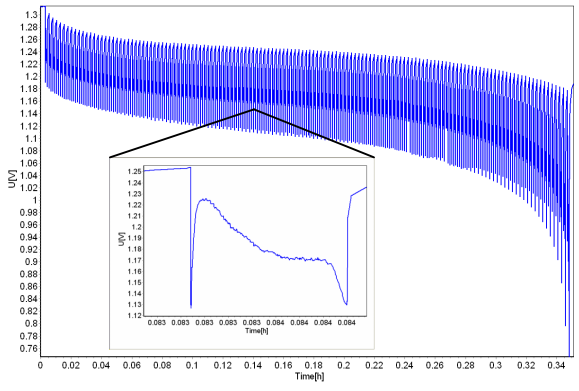


**Figure 5: Voltage during a simulated screwing test.**

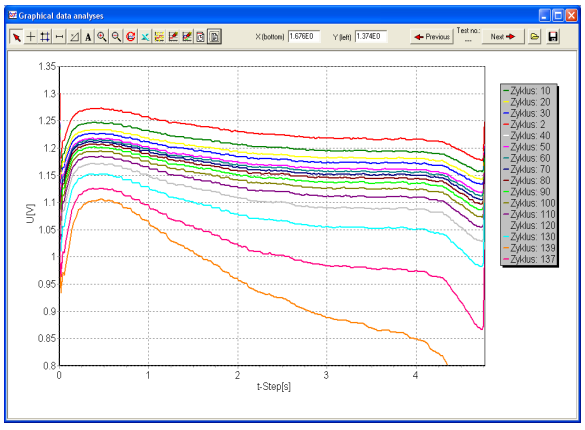


**Figure 6: Voltage for different cycles**

Figure 6 shows the voltage profile for different cycles.