Application Note - Implementation of the European Fuel Cell Dynamic Load Cycle (FC-DLC) in Scribner Fuel Cell Test Systems

Source: Tsotridis, G., Pilenga, A., Marco, G. D., and Malkow, T., "EU Harmonised Test Protocols for PEMFC MEA Testing In Single Cell Configuration For Automotive Applications; JRC Science for Policy Report" 2015; EUR 27632 EN, doi 10.2790/54653.

Introduction

Automotive PEMFC stacks are subjected to a range of operating conditions including high load (high current density / low voltage during acceleration), low load (small or near-zero current density / high voltage or OCV during idling or deceleration), rapid changes in load, as well as periods of steady-state operation (*e.g.*, when cruising).

Load cycling imposes a variable load on the fuel cell to simulate real-world driving conditions in a controlled setting, with the objective of evaluating the durability of the fuel cell to dynamic loading. This is often referred to as a "dynamic load cycle" or "simulated drive cycle." When a drive cycle such as the EU FC-DLC is repeatedly applied to the cell for 500 hours, it corresponds to a vehicle utilization of ~ 80 min/day over one year (annual mileage ~ 16,000 km).

In this Application Note, we describe how to implement the EU FC-DLC in a Scribner fuel cell test setup. Scribner has developed worksheets and tools that make implementation of the EU FC-DLC simple and easy.

Required Items

- 840/850/890 Fuel Cell Test System & *FuelCell*® software ver. 4.4e or later
- Single cell fuel cell – 5 or 25 cm^2 or other size
- Excel® worksheet "*EU FC Dynamic Load Cycle for Arb Ctrl.xlsx*". Contact Scribner fuelcellsupport@scribner.com to obtain a copy of this worksheet.
- Ultra-high purity (99.990%) H_2, Air and N_2
- High purity water (ASTM Grade 1, 18 Ω-cm)
- Back pressure unit (optional)

Procedure

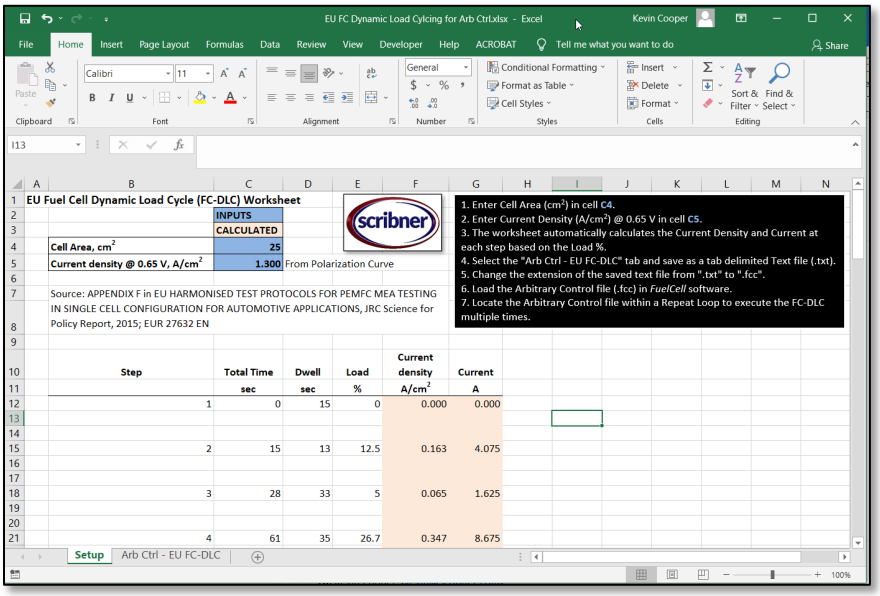
Implementation of the EU FC-DLC requires determining the performance (*i.e.*, current density) of the cell at 0.65 V. As described in the protocol:

> *The 100% current load value to be used in the FC-DLC is defined by the average current density of the ascending and descending polarization curve measurements to yield a cell voltage of 0.65V*

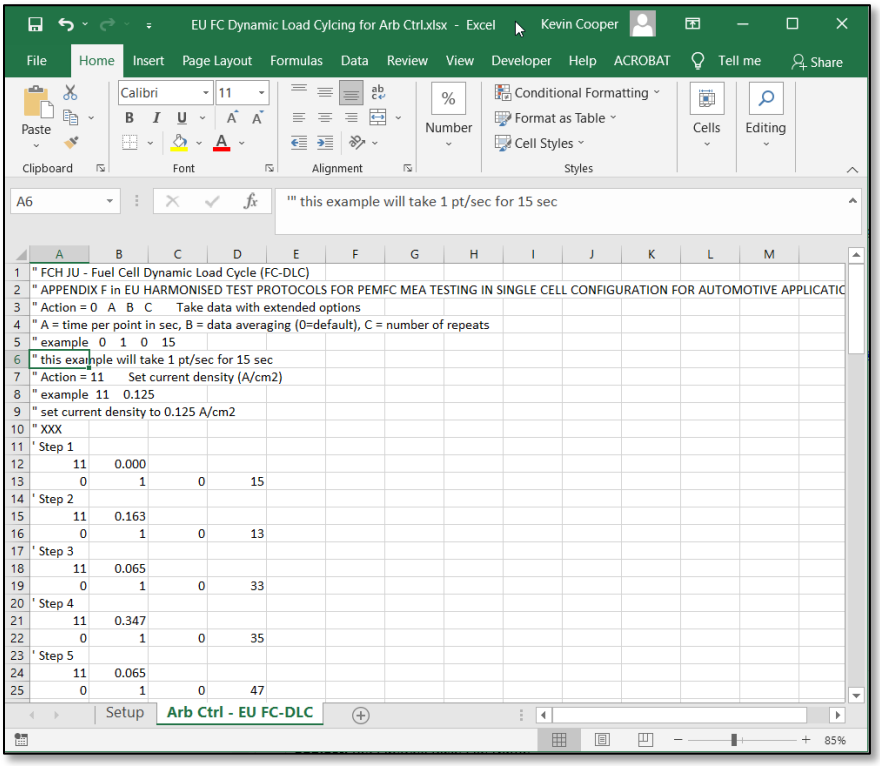
Open the Excel file "*EU FC Dynamic Load Cycle for Arb Ctrl.xlsx*".[1] Follow the instructions to create an Arbitrary Control file (.fcc) that replicates the FC-DLC profile:

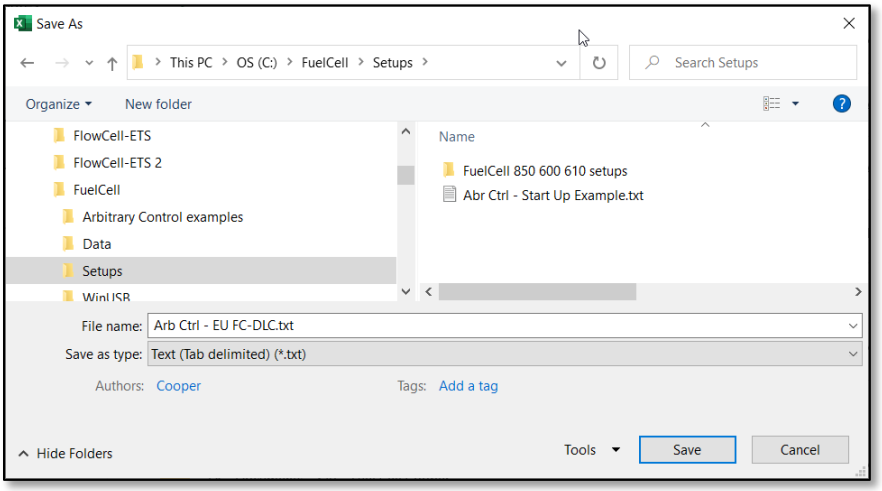
[1] Contact Scribner fuelcellsupport@scribner.com to obtain a copy of the worksheet.

1. Starting on the "Setup" tab, enter the Cell Area (cm²) in cell **C4** and the Current Density (A/cm²) at 0.65 V in cell **C5**. The worksheet will calculate the current density and current at each point based on the % Current Load profile as defined in the protocol (see Appendix below or the Source).

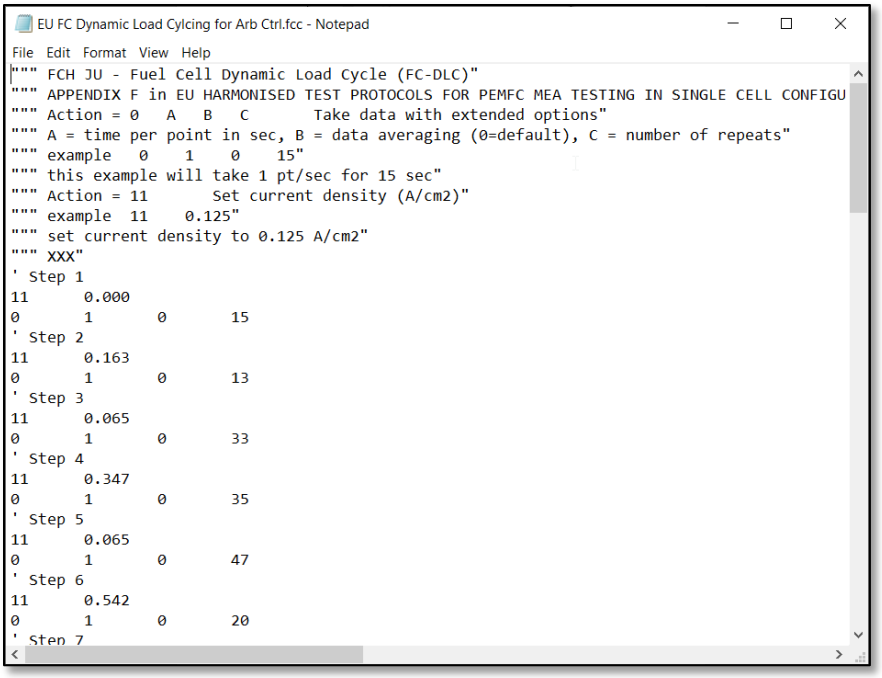


2. Switch to the "Arb Ctrl – EU FC-DLC" tab and save the file as a Text (Tab delimited) file (.txt).

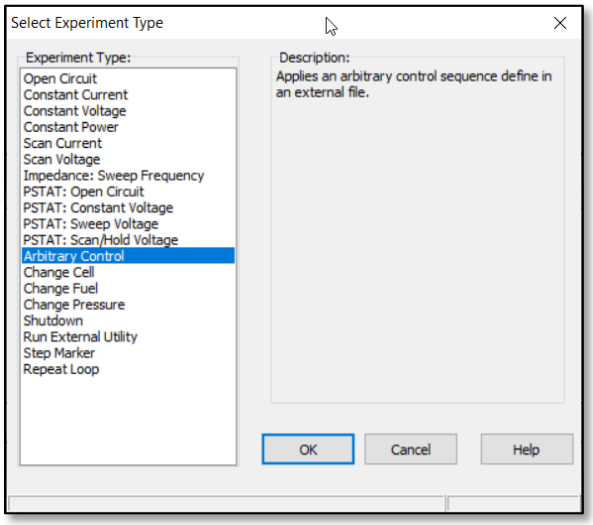




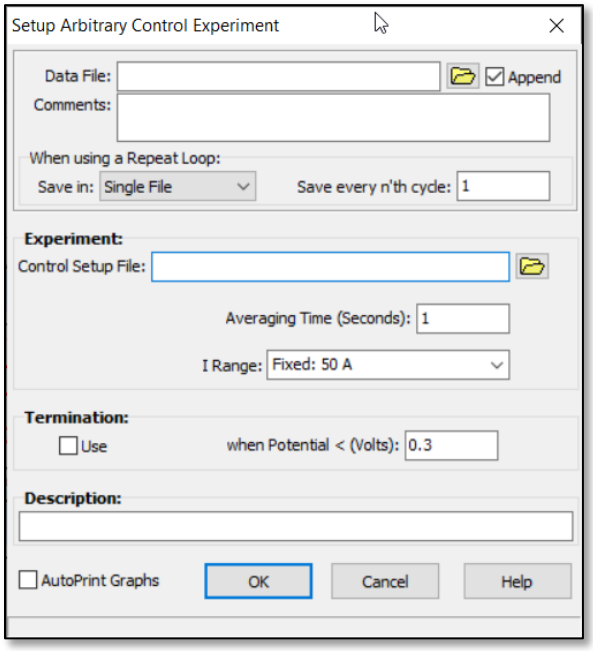
3. Change the extension of the saved text file to that of an Arbitrary Control file (.fcc).

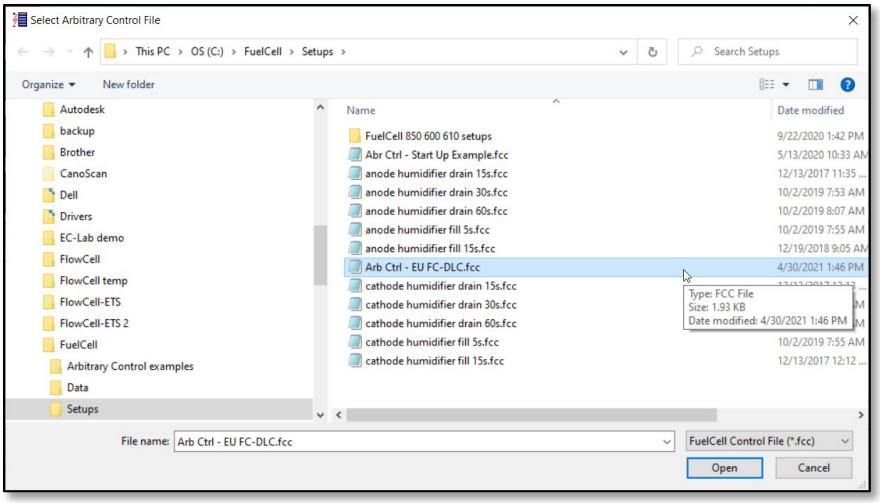


4. In *FuelCell*, insert an Arbitrary Control Experiment:

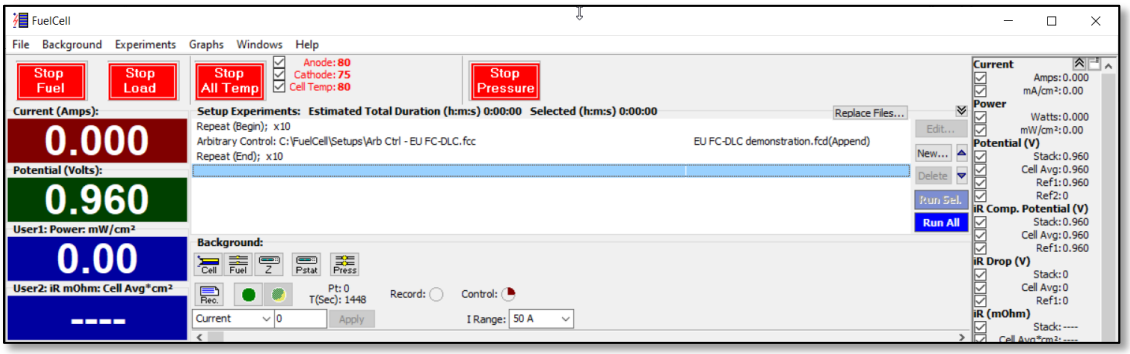


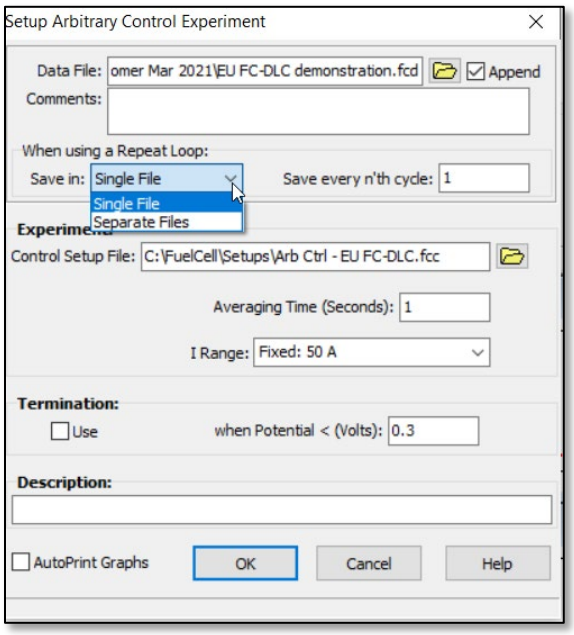
5. In the Experiment section of the Arbitrary Control Experiment, select the saved Arbitrary Control file (.fcc) as the *Control Setup File*:



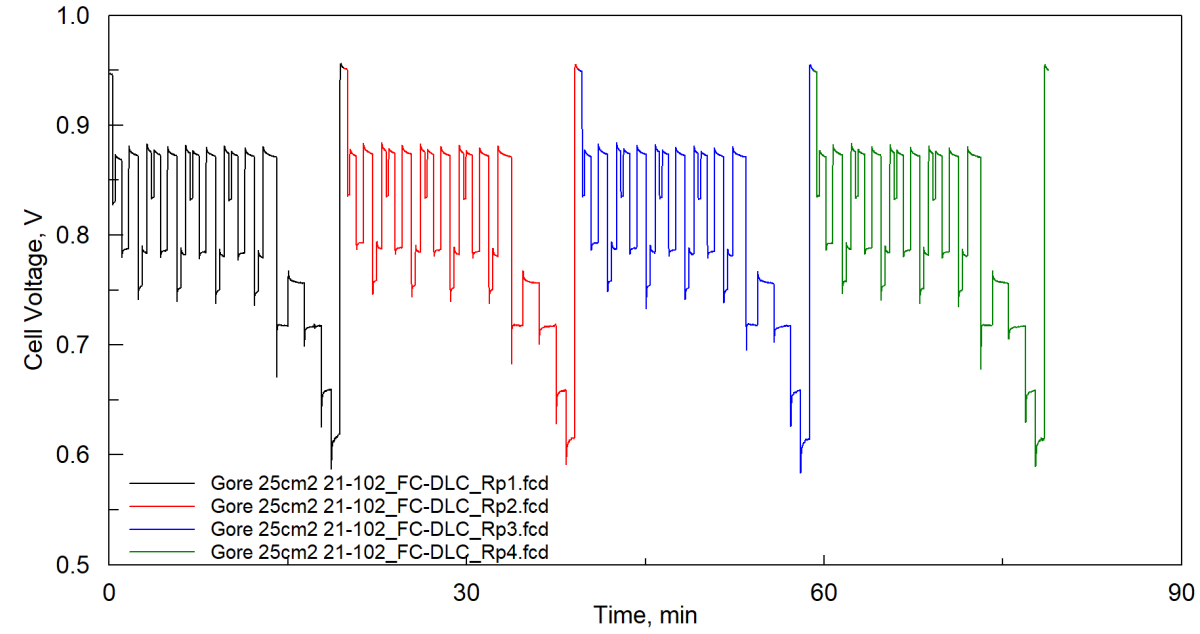


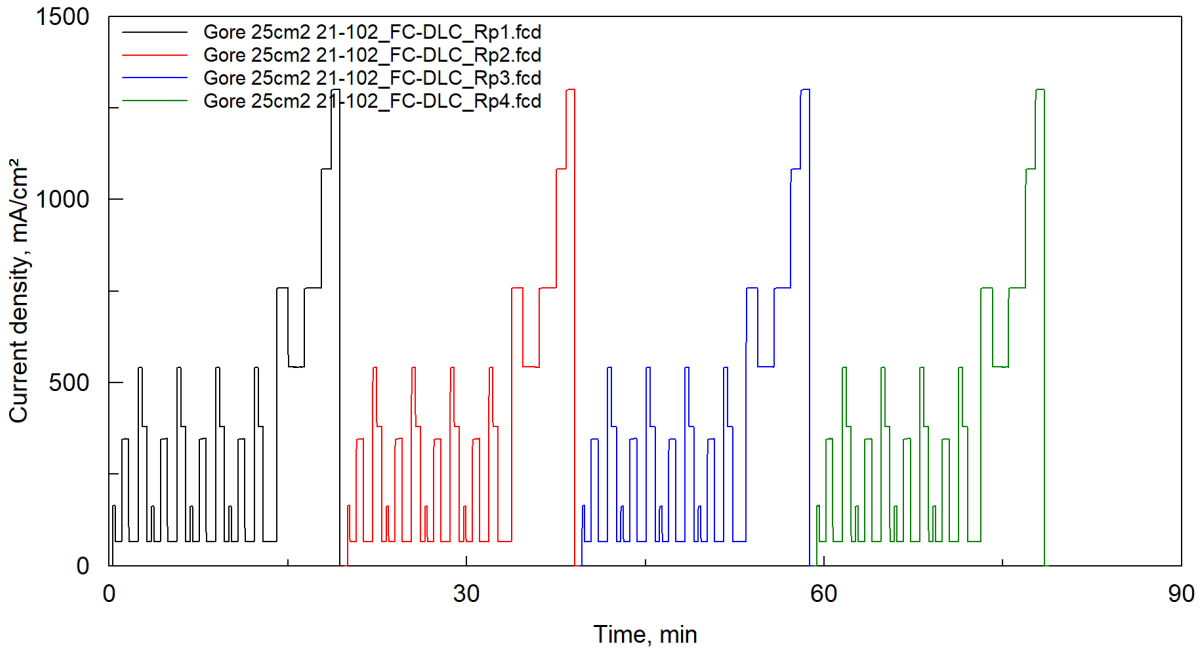
6. Use a Repeat Loop to execute the FC -DLC multiple times. You can select to have all repeat cycles saved as a single file, or each repeat cycle saved as a separate data file:





The figures below show the results of four (4) cycles of the EU FC-DLC for a 25cm² Gore PRIMEA MEA at 80 °C at 200 kPa$_{abs}$, 1.3x H_2 / 2.0x Air, 80 °C / 75 °C dew point (100% / 82% RH on Anode/Cathode respectively). The current density at 0.65 V was 1.3 A/cm² (*i.e.*, the 100% current load).





Appendix – EU FC-DLC from Source.

APPENDIX F: FUEL CELL DYNAMIC LOAD CYCLE– FC-DLC

The proposed Fuel Cell Dynamic Load Cycle (FC-DLC) is defined by 35 Test Points (TP) or steps as described in table F.1 and shown in figure F.1.The test duration of one complete cycle is 1181 seconds.

Table F.1:

FC-DLC test points time/load

Step	Time [sec]	Dwell [sec]	Load [%]
1	0	15	0.0
2	15	13	12.5
3	28	33	5.0
4	61	35	26.7
5	96	47	5.0
6	143	20	41.7
7	163	25	29.2
8	188	22	5.0
9	210	13	12.5
10	223	33	5.0
11	256	35	26.7
12	291	47	5.0
13	338	20	41.7
14	358	25	29.2
15	383	22	5.0
16	405	13	12.5
17	418	33	5.0
18	451	35	26.7
19	486	47	5.0
20	533	20	41.7
21	553	25	29.2
22	578	22	5.0
23	600	13	12.5
24	613	33	5.0
25	646	35	26.7
26	681	47	5.0
27	728	20	41.7
28	748	25	29.2
29	773	68	5.0
30	841	58	58.3
31	899	82	41.7
32	981	85	58.3
33	1066	50	83.3
34	1116	44	100.0
35	1160	21	0.0

The graphical overview of the FC-DCL cycle profile is presented in the figure F.1

The 100% current load value to be used in the FC-DLC is defined by the average current density of the ascending and descending polarization curve measurements to yield a cell voltage of 0.65V

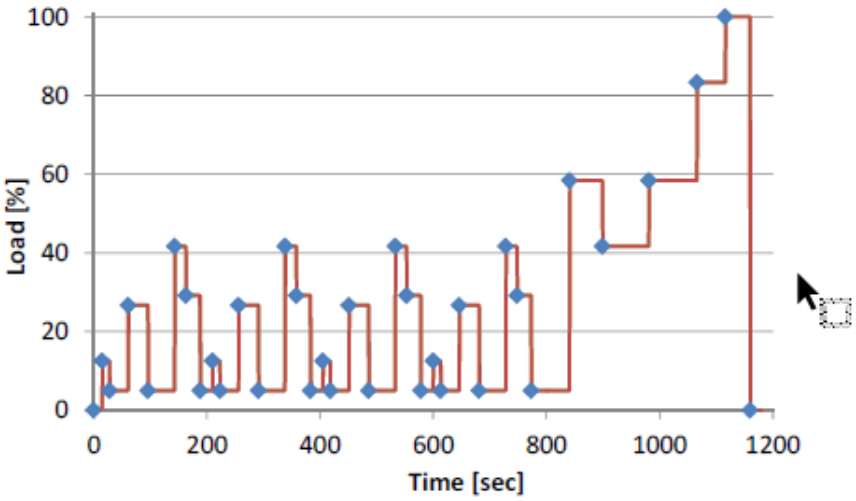


Figure F.1:

Fuel Cells Dynamic Load Cycle profile