Anode Meter

User manual

Version 1.1.56

12 August 2017

Notice

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1. Introduction

The anode meter is a light weight device used to measure the voltage drop across a short section of anode rod, the Copper or Aluminium rod supplying current to one of the carbon anode in a pot in an Aluminium smelter potline. From this measurement the current flowing through the anode rod can be calculated.

This manual is intended for the users of the meter, including the operators who take the readings, the engineers and technicians who configure and maintain the meters, and the IT people who configure the backend database and gateway server backends.

A separate manual (The Anode Meter Technical Manual) is intended for those working on the meter hardware and firmware.

1.1 History

More than 20 years ago C-Born Software Systems developed a light-weight electronic anode meter (also known as a “Pot Rod”) to replace the heavy and inaccurate analog meter in use for the 30 years before that. These meters were heavily used, and an external data collection “brick” was added to help automate the reading process. In 1997 they put forward a design proposal for a “Smart Anode Meter” which would condense the data collection electronics into the meter head, but the Aluminium industry was going through tough times financially, and the proposal remained on the backburner until 2011, when funding became available to commence development work on it. The new “Smart” meter originally used the same shaft and head design as the older ones, with a larger head to contain the advanced electronics and battery. The head design then underwent several evolutionary redesigns, based on feedback from test sites, including the addition of pivoting capability and tungsten-carbide probe tips.

1.2 Overview

The basic function of the Anode Meter is to measure and record the current flowing through each individual anode in a pot in an Aluminium (Aluminum!) potline. This is typically done by measuring the voltage drop across a short section of the Anode Rod, although other methods such as Hall Effect sensing may also be used.

In operation the meter is configured to match the layout of the specific site, and the operator is then free to rapidly collect readings, either in Ad Hoc fashion or to an automatically loaded schedule, with immediate feedback as each reading is successfully acquired coming from the ultra-bright LEDs mounted on the reading head itself. Readings are displayed on the LCD readout as they are acquired, in units of raw mV, calibrated line current, percentage of nominal or otherwise as required. However for routine scheduled readings it is not necessary for the operator to re-focus on the display to know a good (or bad) reading has been taken, and so much faster progress can be made.

The meter has practically unlimited internal capacity for readings, coming with an 8GB microSD card (removable) as standard storage. Collected readings can be automatically collected and stored in a database when the meter is plugged into the USB port for recharging, and new schedules (and configuration if required) loaded onto the meter at the same time. If the database system is not available, the data can be stored in a local directory on the PC as a CSV format file. Use of a WiFi connection for data collection may be available on user request.

The meter has been designed to be lightweight and comfortable to use, with a carbon-fibre shaft and 3D printed ABS fittings to reduce weight and torque on the operator’s wrist, and a pivoting head and tungsten-carbide probe tips to minimize the force required to get a good reading. In practice plants have reported extended periods taking aroung 12,000 readings per shift with these meters.

The system has been designed to be flexible from both a software and hardware perspective. The current heads have a single high-precision analog input for readings voltage, but alternate designs could provide two

high-inputs and a large range of devices, via an I2C or 1-Wire bus. Other heads have been built with provision for reading Clamp-Drop voltage, and with Hall-Effect sensors.

The software on-board the meter can be configured using the configuration files, but is also relatively easy to customize to suit any novel requirements sites may envisage. For example, we have the same boards here running battery-test rigs, weighing scales, and monitoring filament pressure on a 3D printer.

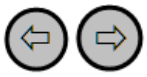
2. Meter

2.1 User Operation

2.1.1 Startup and Shutdown

 The meter is powered up by pressing the Select button .

It will normally power itself down automatically after 1 hour (configurable) without seeing any user input or readings being taken.

 It can be powered down if required by holding down both the Left and Right buttons. This will allow the meter to do a controlled shutdown, closing files correctly to avoid data loss, and notifying the user on the display.

 If for any reason the meter becomes “locked up” and fails to respond, a “hard shutdown” can be forced, shutting off the meter power immediately. This is done by simultaneously pressing the three keys Left, Right and Up. This may result in loss of data.

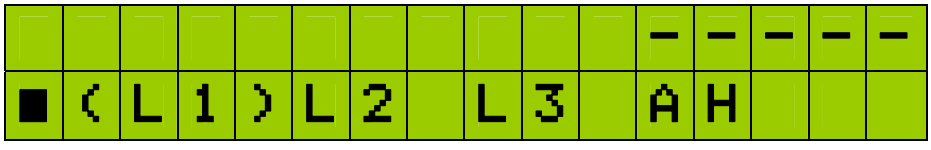
 In some circumstances the meter may power up, the LCD backlight comes on, but the screen text is not visible. This may happen if a the display is replaced, or the microSD card is changed. This is because the LCD Bias is controlled from software, with the level saved on the microSD card, and the required level can vary a lot between displays. If this happens, shut the meter off (2 or 3 button method) and power it up whilst holding the Left button down. After it starts a message should display on the screen, cycling in and out o view. When it is clearly visible, press the Select button. You will be taken to the **`Setup Mode`** LCD Bias setting screen, where you can fine-tune the bias level and then scroll down and save the settings. Refer to the **`Setup Mode`** section 2.3.1 for details.

2.1.2 Normal Operation

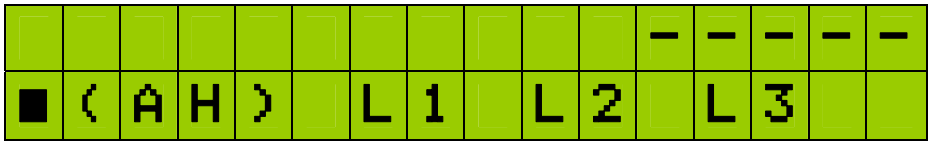
2.1.2.1 Ad-Hoc Readings

When taking Ad-Hoc readings the meter still uses the configuration file describing the site layout, but the operator is free to enter the pots they wish to measure, without requiring a schedule file to be loaded.

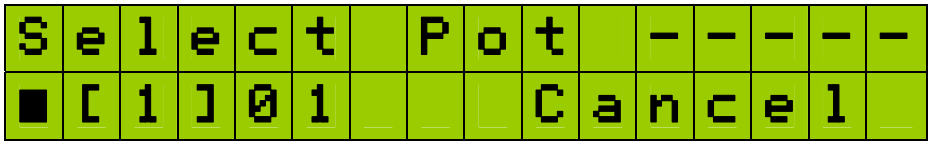
From opening the main screen,



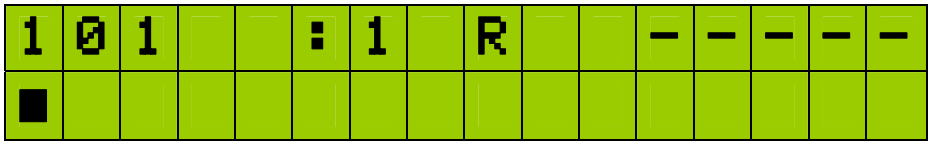
press the Right or Left button until AH is selected, as below, then press the Select button.



Use the Left, Right, Up and Down buttons to select the number of the first Pot you want to measure, and then the Select button to start collecting the measurements.



The display shows the number of the current pot being read, followed by the number of the next anode to be read. The “R” or “C” indicates whether a Rod or Clamp reading is expected.

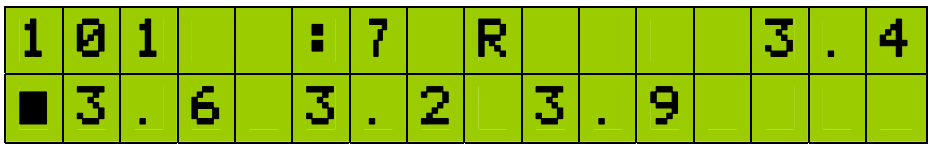


Take a reading by firmly pressing the head probes against the anode rod to be measured. The sharp tungsten-carbide tips and pivoting head reduce the pressure required, reducing stress on both the meter and the operator. Don’t try to twist the head to scrape at any resistive buildup on the rod, as it is not designed for this, just apply enough pressure so that you get a good reading.

The top right section of the display will show the immediate reading being taken, the Green LED on the meter head will light to signify a stable reading has been obtained, and the meter will advance to the next anode. If the reading is not stable, the Red LED will flash, and the reading should be taken again.

If the reading obtained is outside the expected range of values, the Red and Green LEDs will flash alternately, signifying a problem (for example a burn-off), but the reading will still be stored and the anode number advanced.

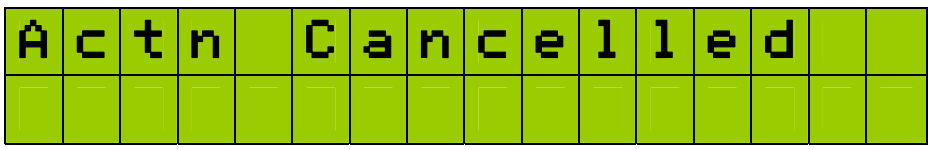
The bottom line of the display shows the last threee readings taken. After reading the first six anodes on pot 101, the display may look something like this:



After the last anode on the pot has been read in, the head LEDs will perform a slow alternate Red/Green flash, and the display will briefly display a “Sched. Complete” message before moving on the to next pot.

While taking readings, the Left and Right buttons can be pressed at any time to move to the previous/next anode in sequence, so anodes may be skipped or re-read.

A Long Press on the Up button will briefy display



and the meter will return to the main screen. On returning to Ad-Hoc measurement mode the previously active pot number will be retained as the defult.

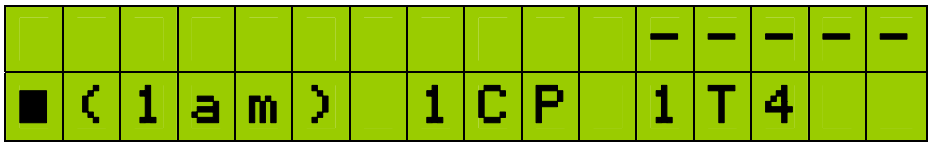
2.1.2.2 Scheduled Readings

Pot reading schedules provide a flexible system for taking readings for specific purposes, such as anodes that have been set in the last 24 hours, all pots in room 2, etc. The schedules are normally generated from the

main database, although they can be manually generated. Information on the schedule file format is given in section 2.3.2.2.1 on page 21.

While the meter is connected to USB, its schedules can be updated by the system, allowing coordination between meters. So if another meter comes in which has already taken a scheduled set of readings, the schedules on any other meters that could have taken the readings can be updated to reflect this.

From the main home screen, selecting for example L1 rather than AH will either display a message that no schedules have been loaded, or a screen to allow selection of the schedule to be read in



The schedule names will vary depending on what schedules have been loaded, and the names chosen by the site. The ones above could represent “Line 1 all metering”, “Line 1 Complete Pots”, “Line 1 Twenty-four hour”, for example.

Once a schedule is selected, the pots from the schedule will be displayed for reading in the same fashion as in Ad-Hoc mode, working through until the schedule has been completed.

2.1.2.3 Uploading Data

Anode readings collected are stored on the meter in a file named AnodeDrops.csv, described in section 2.3.2.2.2 on page 22.

If the gateway service is running, when the meter is connected to USB the readings will be collected from the meter and either stored in the database, or if the service is running in local mode then in a directory on the local PC as set by the service configuration, as a CSV file.

Otherwise the meter can be set to Disk-Drive mode and the AnodeDrops.csv file copied to the PC manually using Windows Explorer.

2.1.3 Setup Mode

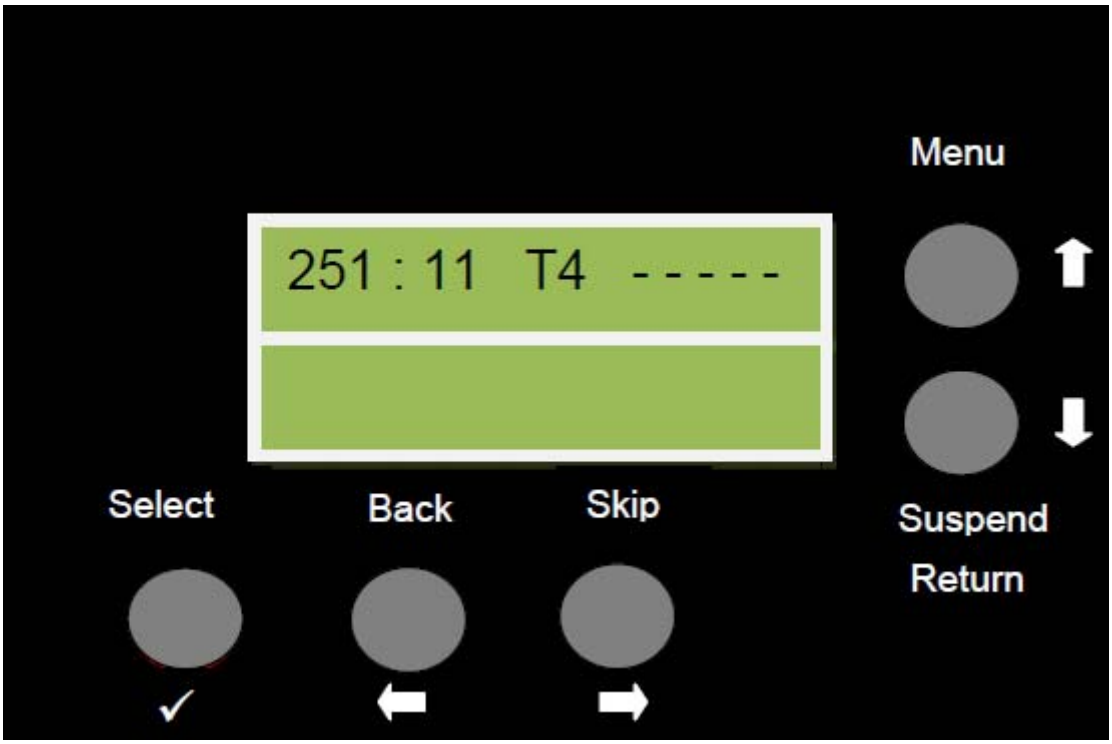
`Setup Mode` is used to acess a range of meter information and settings which are not part of the normal operation of collecting anode readings. Some of these settings may be usefully acccessed to improve operator comfort. These include LED and backlight intensity and perhaps LCD Bias. For more information on **`Setup Mode`** see section 2.3.1.

To enter **`Setup Mode`**, long-press (hold down) Up and Down keys simultaneously from normal operating mode.

Name	Default Value	Allowed Values	Description
BackLight	25	0-100	LCD Backlight brightness, %
GreenLed	20	0-50	Green LED brightness, %
RedLed	20	0-50	Red LED brightness, %
LcdBias	75	0-100	LCD Bias Voltage, adjust until display is clear
MeasMode	0	0,1,2,3	0=Rod-Drop, 1=Clamp-Drop, 2=Rod-then-Clamp, 3=Clamp-then-Rod
LogRawData	0	0,1	1=Record all readings in log file

2.1.4 Quick Reference Guide

Quick Reference Guide



	Select ✓	- Press and hold [2 Seconds] to view schedule status and charge volts - Press and release to make selection
	Left Back	- Press and hold for 2 seconds to skip back a pot - Press and release to skip back an anode
	Right Skip	- Press and hold for 2 seconds to skip forward to next pot - Press and release to skip forward to next anode - Long hold – display meter status
	Up Menu	- Press and hold for 2 seconds to return to the room menu - Press and hold again for 2 seconds to return to front menu - Press and release to count up pot numbers in [Ad Hoc]
	Down Suspend Return	- Press and hold for 2 seconds suspend scheduled metering and go to [Ad Hoc] - Press and hold for again for 2 seconds to return to scheduled metering - Press and release to count pot stall numbers in [Ad Hoc]
		- Press and hold both left and right arrow buttons to turn meter off. Press select (✓) button to turn meter back on
		- Am = All Metering (L1) = Line 1 - t = 24 Hour Metering

Whilst a user is metering, if they get part way through their metering and wish to do an [Adhoc] they simply press and hold the down button for 2 seconds which puts

them into [Adhoc] mode.
Once complete if the Down button is again held down for approx 2 seconds the schedule that they had paused will be resumed. The schedule will resume at the next pot after the pot that the metering was suspended at.
Whilst a user is metering if they get part way through a pot, by holding the button left it will skip back to the start of that pot.
Also by holding the right button when on the first anode for a pot will move you onto the next pot in the schedule.
If they hold left at the start of a pot it will skip to the previous pot.

To download the metering from the meter to the computer, simply place the meter into the stand plug the USB cable into the socket on the base of the hand piece. Metering will download automatically.

2.2 Configuration

The majority of the meter's configuration is stored on files on the microSD card. Some of the configuration settings can be changed locally on the meter, but the majority are loaded from the database or edited directly on the meter file system in "Disk Drive Mode" using the configuration program.

For settings which can be changed on the meter itself, refer to section 2.3.1.2 (page 14)

For details on the configuration files, which may be edited with a text editor, refer to section 2.3.2.1 (page 16)

Information on using the configuration editor PC program is in section 3.3 (page 45)

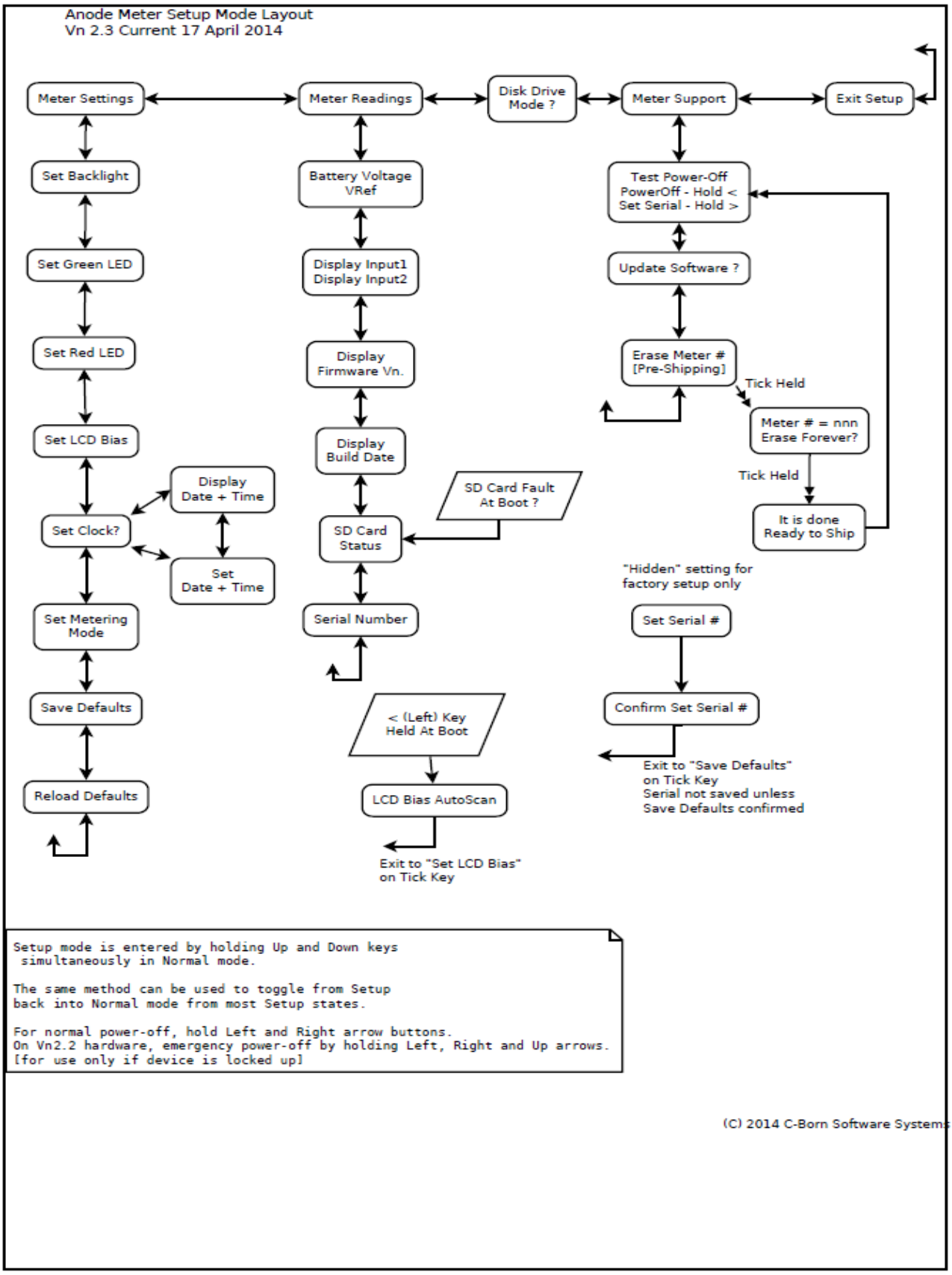
2.3 Setup and Maintenance

2.3.1 Setup Mode

`Setup Mode` is used to acess a range of meter information and settings which are not part of the normal operational mode of collecting anode readings. The options available may vary from time-to-time,and according to the specific meter configuration and firmware version. A state diagram for accessing the various modes is provided below.

To enter **`Setup Mode`**, long-press (hold down) Up and Down keys simultaneously from normal operating mode.

2.3.1.1 Setup Mode State Diagram



2.3.1.2 Meter Settings

Allows the user to adjust the meter for the conditions at a specific site, and for personal preferences. With the Red and Green LED and LCD backlight brightness, the levels should be set as low as possible consistent with comfortable operation, in order to maximize battery life.

The LCD Bias setting should normally not need to be changed unless the LCD is replaced, however large changes in ambient temperature may mean the settings can be adjusted for comfort. Note that the bias setting also has an effect on the display persistence, and so with some fast moving displays (eg cursor on clock-setting) a slight adjustment can improve readability.

“Metering Mode” is normally Rod-drop only however the device can be set up to read clamp-Drop voltages only, or to alternate between Rod and Clamp (with either reading being taken first) .

When “Log Raw Data” is set, all readings are recorded in a log file. This can be helpful in diagnosing why a meter is not latching in readings, for example. We may ask for this file to help in such situations.

After any change is made, the “Save Defaults” option should be used to save these settings to permanent storage, otherwise they will be lost on a power-cycle.

The “Reload Defaults” option restores the default settings from the firmware, not the microSD.

2.3.1.3 Meter Readings

“Battery Voltage” displays the current battery voltage (immediate and filtered), the onboard 2.5V reference voltage, and the main PCB 3.3V rail level. A fully charged battery will be around 4.1 volts. The meter will not start up when the battery is below 3.7V, although if already running it will operate down to 3.5V, where a shutdown is enforced. This is to allow the operator to complete a set of readings when the battery is marginal.

The “Display Input” display shows the two hi-resolution analog inputs. At present only the first of these is connected or used, however there is the option to use the second with alternate heads. If the “Select” button is pressed while on this display the first input is dislayed to maximum resolution, rather that truncated. The top line is the immediate reading while the lower is filtered.

“Firmware Vn” shows the main board type (currently EMX or G120) and the firmware version. Any application software loaded must match the firmware version to run. We are currently on firmware 4.2.10.1 (this corresponds to Microsoft .NET compact framework 4.2), and will probably move to 4.3.x.x in the near future.

“Built” shows the time and date that the running application code was compiled.

The next entry shows whether a microSD card is inserted, recognized, formatted correctly, etc.

The “Serial” number displayed is a number unique to each meter. It may also be recorded on the main PCB, the head PCB, and the label inside the box.

2.3.1.4 Disk Drive Mode

Pressing the Select button caused the meter to go into “Disk Drive Mode”, where it appears as a USB mass storage device to a PC. If not already connected to a USB port, there will be a countdown from 10 to give you time to plug it in. In this mode a PC can see the meter’s files and manipulate them. Be careful not to move or delete anything unless you know what you are doing, or the meter may not be able to start up and run correctly.

Pressing the Select button again disconnects and the meter reverts to its normal mode, where the USB is used to connect to the gateway service on the PC.

2.3.1.5 Meter Support

Meter support provides various support and testing functions for the meter. Only a couple of these need to be detailed here.

2.3.1.5.1 Battery Test

Starting a battery test puts the meter into a mode that disables sleep/hibernation or power-down when the meter is not active, and records the battery voltage at one minute intervals. The meter can still be used normally while in this mode, although battery life will be less that in normal mode. The meter should be allowed to run until it shuts itself down, in order to get a complete test result.

The file created is used to predict the battery life remaining during future runs, which should always be longer (sometimes much longer) than achieved in the test run.

A battery test should normally only be necessary after a new battery is installed, or if the remaining life predictions become noticeably incorrect due to a battery losing condition as it ages.

2.3.1.5.2 IFU (In Field Update)

Procedure

In Field Update is the process of updating the Anode Meter's software from the uSD card. At present the new software can be installed by either:

```
1. Putting the meter into "Disk Drive Mode" and dragging the files
across from the USB-attached PC

2. Removing the uSD card and attaching it to the PC, and copying the
files that way.


In the future the update files may be automatically copied across when
the device is attached to the PC.

Of these methods, at present 1 is preferred as it doesn't require
opening the Anode Meter box.
```

Once the update files are present on the meter, they can be installed by putting the meter into "Setup Mode", selecting "Meter Support", and then down to "Update Software?" Selecting this should result in:

```
"FW Ok"

"Update ?"
```

and selecting again will start the update process. Once complete, the meter will reboot and come up running the new software.

[File Structure

The general file layout is:

```
SDCard
  |
  +-- Config
  +-- Log
  +-- Measurements
  +-- Schedules
  |
  +-- Updates
        |
        +-- EMX
```

```
|    |
|    +-- SDK_4.2.10.1
|    |          |
|    |          +-- Config.hex
|    |              Config.sig
|    |              Firmware.hex
|    |              Firmware.sig
|    |              Firmware2.hex
|    |              Firmware2.sig
|    |
|     +-- App_4.2.10.1_20131210.hex
|
+-- G120
```

where SDCard is the top level of the SDCard. When the running software is asked to update, it checks in the EMX directory (G120 for a G120 based board) for an application name begining with "App_" followed by an SDK version number, eg "4.2.10.1", and ending in ".hex". Characters between the SDK version and the file suffix aren't used by the code, but can be used to label the software version. So the format is App_xxxx_yyyy.hex, where xxxx is the SDK version and yyyy is any label, eg App_4.2.10.1_20131210.hex

The running application checks the SDK version of the new application to be installed (eg 4.2.10.1), and if it is the same as its own, it only needs to install that file. However if it is a different version, is needs to install the SDK firmware as well. In that case, it looks for a subdirectory with the same SDK name as the application, and if found it installs the "Config", "Firmware" and "Firmware2" hex files from it as well.

At this stage only a single Application file is allowed. In a future revision we may allow multiple files, and give the user a list to select from.

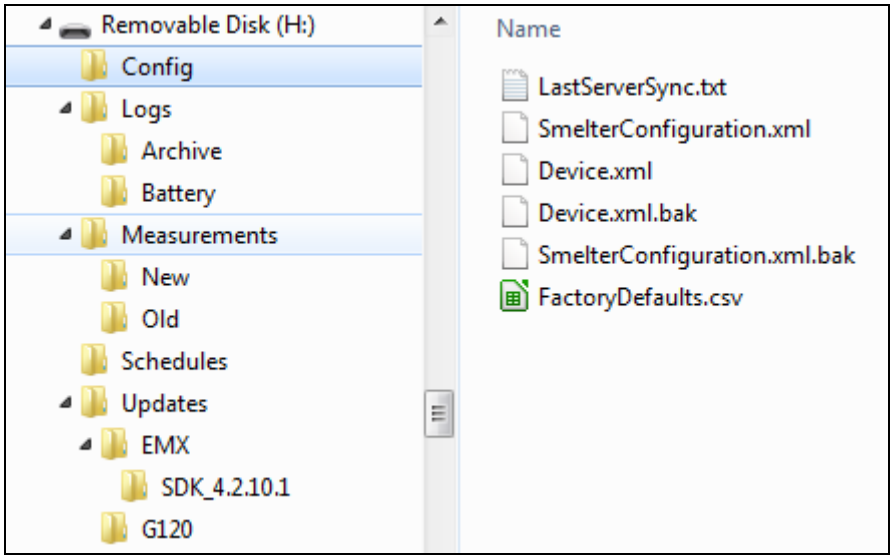
2.3.2 Data Files

Meter File System

The meter's file system is stored on a microSD card in FAT32 format, with a typical file layout as shown here. It can be read by setting the meter into "Disk Drive Mode", or by removing the uSD card and placing it into an external reader.

2.3.2.1 Configuration

There are three primary configuration files in the "Config" directory - **SmelterConfiguration.xml**, **Device.xml** and **FactoryDefaults.csv**. Their contents and use is subject to change, depending on the version of Firmware provided, so be aware that the following description may not be up to date.



2.3.2.1.1 SmelterConfiguration.xml

This file describes the configuration of the smelter, including number of lines, anode numbering system, rod characteristics, scaling, timezone and shift hours, etc. Normally the same file would be used for all meters at a plant, and it is normally downloaded/updated from the database over the USB gateway automatically.

We can provide an editor program (**AnodeMeterConfig**) to help with creating and maintaining this file. It is also useful for manually configuring the meters, for sites that have not yet installed a database and gateway server.

Note that not all of the information provided in this file is currently used by the meter.

Information is hierarchical, so one *Location* may have multiple *Lines*, each *Line* multiple *Rooms*, each *Room* multiple *Sections*, and each *Section* multiple *Pots*.

Per Location

LocationTag – A 3 character code to identify the site, eg “PTH” for PtHenry

WorkShiftHours – Number of hours worked per shift, eg “12”

FirstShiftStartMinutes - eg “420” for a 7am shift start

DefaultLineName – The name of the default line as per the line names, eg “2”

Measurement

ScaleFactor -Scale factor to multiply rod-drop raw mV reading by

Offset -Offset added to scaled reading – normally would expect to be 0

DisplayFormatString – Used to format displayed reading, eg “F1”

Units -Units displayed next to reading, if room. (eg mV)

ClampScaleFacor - ScaleFactor used for Clamp Drop readings

ClampUnits - Units to display for Clamp Drop readings

DefaultUserMode - “AdHoc” or prescribed

Per Line

Name - Line name, eg “2”

AnodesPerPot - Number of anodes per pot for this line

MeteringDirection – Metering direction for line, “Clockwise” or “AntiClockwise”

Anodebar

NominalAmperage - Nominal amperage per bar to be measured, eg “5000”

Material - Bar material, either “Copper” or “Aluminium”

CrossSectionalAreaMillimeters - of bar, eg 10322

MeasurementDistanceMilliMeters – Distance between probe tips, eg “95”

Per Room

Name - Name of the room, eg “4”

Per Section

Name - Name of the section, eg “SEC3”

AnodeOrderRule – Rule name describing anode order in pot, eg “CPattern”

Pots - Comma separated list of pots in this section, eg “601,602,603,604,605…”

Note that Pot numbers must be unique for the whole location. This can be achieved by prefixing the number with a number of letter code based on the line number, for example.

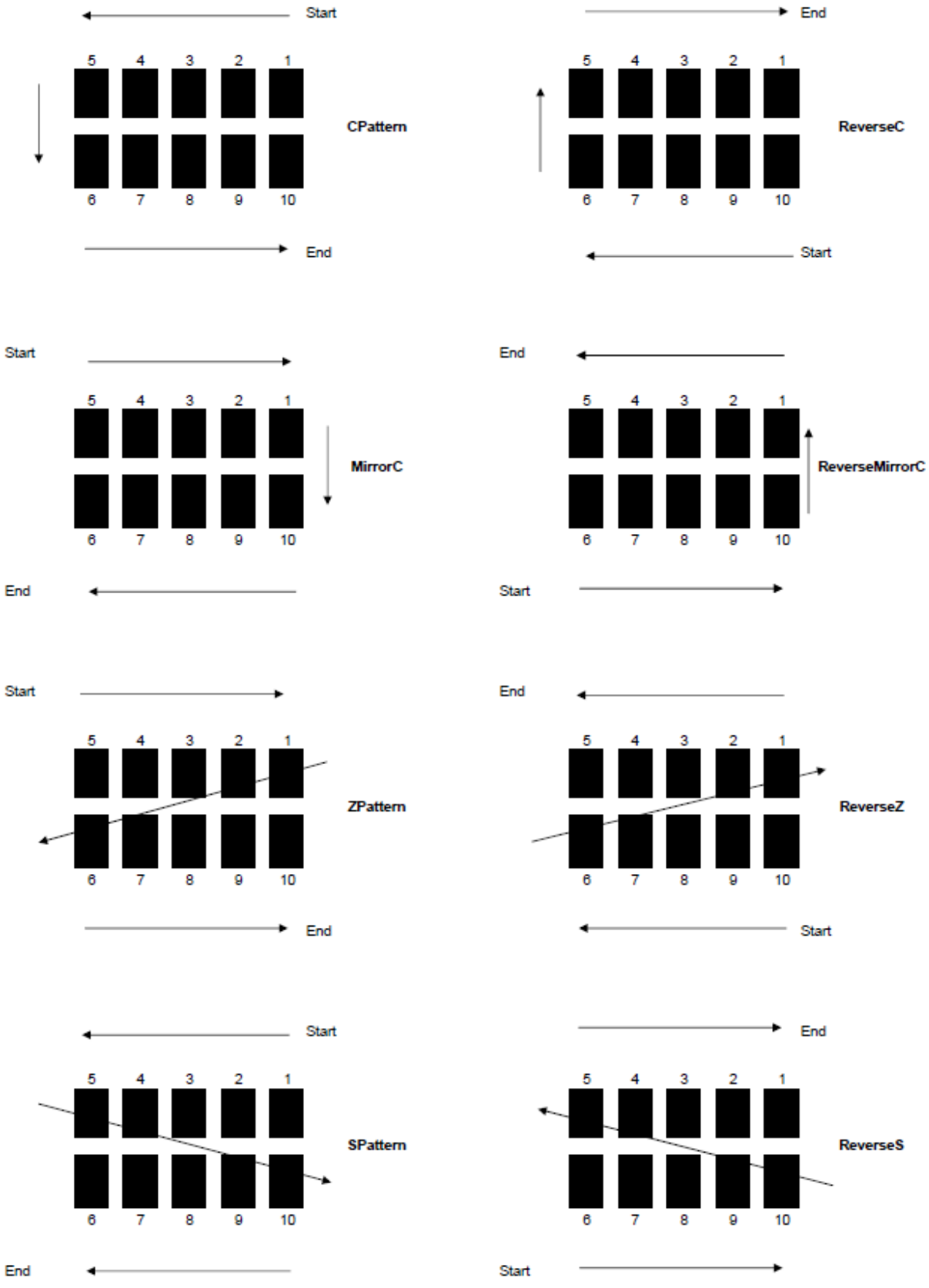
2.3.2.1.1.1 AnodeOrderRule

The AnodeOrderRule requires some further explanation. There are eight possible values for this, describing the eight possible ways to number anodes within a pot, based on reading starting location. The names used are:

```
CPattern
ReverseC
MirrorC
ReverseMirrorC
ZPattern
ReverseZ
SPattern
ReverseS
```

The following diagram illustrates the eight different order patterns, and how their names were derived, on a hypothetical 10-anode pot. Note that the pattern is used to determine the sequence in which the anode numbers are read, and does not signify the physical numbering of anodes in a pot.
For example, the anode numbering may actually run from low to high on both sides of the pot starting at the same end.

Anode Order Patterns



2.3.2.1.2 FactoryDefaults.csv

This file contains configuration information specific to each meter, such as the LCD bias voltage required so that the display is readable, the brightness of the LEDs and LCD backlight, etc. It was originally intended to only store hardware specific information here, but over time other information has crept in. This may be moved to a more logical place at some stage!

Some of the information here is also saved in non-volatile memory on the meter processor module, for example the LCD bias, so the display can still be seen when the uSD card is removed.

Most of the entries in this file are updated by the meter firmware, how some are used or changed infrequently and are not currently handled this way, so require manual editing. The file format is currently CSV, however in future it may change to a .INI style, so be aware.

A typical FactoryDefaults.csv file may look like this:

```
BackLight,25
GreenLed,25
RedLed,25
LcdBias,85
Serial,0
```

Currently allowed entries include the following:

Name	Default Value	Allowed Values	Description
BackLight	25	0-100	LCD Backlight brightness, %
GreenLed	20	0-50	Green LED brightness, %
RedLed	20	0-50	Red LED brightness, %
LcdBias	75	0-100	LCD Bias Voltage, adjust until display is clear
Serial	2500	Nnnn	Meter serial number, set at factory.
MeasMode	0	0,1,2,3	0=Rod-Drop, 1=Clamp-Drop, 2=Rod-then-Clamp, 3=Clamp-then-Rod
LogRawData	0	0,1	1=Record all readings in log file
SleepDelay	300 300,1800	X X,Y	X = Number of seconds without activity before meter hibernates, when not connected to USB Y (if present) = Wake up and check battery at this interval
ConnectedSleepDelay	60 60,600		As per SleepDelay, but used when meter connected to USB
MaskT4	0 (1 for PTD)	0,1	Mask T4 (24hr) readings if same as CP (complete). Default true for PTD. See documentation for details

2.3.2.1.3 Device.xml

This file currently only contains the meter number, which is automatically allocated by the database and gateway server system, and a firmware release date, which is now redundant. The meter number is a 3 digit

number unique to each meter at a specific site. This is different to the meter serial number, which is unique to each meter built. The meter number can be set by manually editing this file if the database/gateway system is not installed. Meters are typically delivered with this file erased.

Typical contents:

```
<?xml version="1.0" encoding='UTF-8'?>
<DeviceDetails>
   <DeploymentDate Value="2013-08-27" />
   <MeterNumber Value="000" />
   <SoftwareVersion Value="2.0" />
</DeviceDetails>
```

2.3.2.2 Measurements

2.3.2.2.1 Schedules.csv

A schedule file allows the meter to inform the operator of the pots and anodes which are to be read, as described in section 2.1.2.2. The file is normally generated by a script on the database, and downloaded over the USB connection from the gateway PC. Typical contents of the file may be like this:

```
2014-05-14 07:00:00
101,T4,1Am,L1,M,N,11,12
103,T4,1Am,L1,M,N,7,8
104,T4,1Am,L1,M,N,5,6
105,T4,1Am,L1,M,N,7,8
106,T4,1Am,L1,M,N,5,6
107,T4,1Am,L1,M,N,1,2
110,T4,1Am,L1,M,N,19,20
111,T4,1Am,L1,M,N,21,22
112,T4,1Am,L1,M,N,23,24
113,T4,1Am,L1,M,N,13,14
114,RT,1Am,L1,M,N,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24
115,RT,1Am,L1,M,N,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24
116,RT,1Am,L1,M,N,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24
117,RT,1Am,L1,M,N,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24
124,PE,1Am,L1,M,N,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24
130,AM,1Am,L1,M,N,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24
138,AM,1Am,L1,M,N,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24
252,T4,2Am,L1,M,N,11,12
```

Shift Time stamp for schedule

Decoding the fields

Example:

```
113,T4,1Am,L1,M,N,13,14
114,RT,1Am,L1,M,N,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24
```

- **113** is the Pot Number,
- **T4** indicates that reason this metering is requested. T4 is for a *Twenty-Four Hour* reading, i.e. meter these anodes to check on load-up because they were set 24 hours ago. These reason codes were once display on the Anode-Meter while the associated Pot was being metered. Due to display space limitations this is no longer the case, so at present this field does not impact on operation. Other possible reasons include:
  - RT Routine scheduled metering
  - AM Anode Missing
  - NP New Pot

  - PE Pending Extra
  - SE Shift After Extra
  - HR High Reader (previous result)
  - LR Lower Reader (previous result)
  - HC High COV (previous result)
- **1AM** is a schedule name. In this case it indicates that the schedule is for Room one and includes **ALL METERING**. The anode meter splits the downloaded schedule into sub-schedules grouped by this field. When choosing which schedule to execute, the AnodeMeter operator will be presented with a list of these sub-schedules from which they will choose one. The actual tag used here is inconsequential, so long as it has some meaning for the operators. Names used at PTH followed the convention of having a numeric Room number (1 or 2) as the first character and then a 2 character code defining *work section*. At PTH, this provided a mechanism to allocate work to a specific pot attendant.

  Codes here include:
  - AM All Metering in the room
  - Et East work section
  - Cr Centre work section
  - Wr West work section
- **L1** is the Line Number (not used by Meter)
- **M** for anode **M**etering or **C** for clamp-drop metering
- **N** a flag indicating that this pot has **NOT** been metered yet (not used by Meter)
- **Anode-List** a comma separated list of anode positions to be metered

2.3.2.2.2 AnodeDrops.csv

This file contains the collected meter readings in CSV format, and is normally automatically uploaded via the USB connection and stored in the database or local file, as described in section 2.1.2.3.

Typical file contents

```
2014-07-28 23:13:04,3014,3T4:RodDrops,1,32.30,32.12,,,,,,,,,,,,,,,,,,,,,,,,,,,,
2014-07-28 23:13:12,3015,3T4:RodDrops,1,,,32.12,32.12,,,,,,,,,,,,,,,,,,,,,,,,,
2014-07-28 23:13:20,3016,3T4:RodDrops,1,,,,,31.93,31.75,,,,,,,,,,,,,,,,,,,,,,
2014-07-28 23:15:19,3009,3T4:RodDrops,1,,,,,,,31.19,31.19,,,,,,,,,,,,,,,,,,,,
2014-07-28 23:15:28,3010,3T4:RodDrops,1,,,,,,,,,31.00,31.00,,,,,,,,,,,,,,,,,,
2014-07-28 23:15:36,3011,3T4:RodDrops,1,,,,,,,,,,,31.00,31.00,,,,,,,,,,,,,,,,
2014-07-28 23:15:43,3012,3T4:RodDrops,1,,,,,,,,,,,,,31.00,31.00,,,,,,,,,,,,,,,
2014-07-28 23:15:51,3013,3T4:RodDrops,1,,,,,,,,,,,,,,,31.00,31.00,,,,,,,,,,,,,
2014-07-28 23:16:06,3014,3T4:RodDrops,1,31.00,30.91,,,,,,,,,,,,,,,,,,,,,,,,,,
2014-07-28 23:16:13,3015,3T4:RodDrops,1,,,30.96,30.87,,,,,,,,,,,,,,,,,,,,,,,,
2014-07-28 23:16:26,3016,3T4:RodDrops,1,,,,,30.82,30.82,,,,,,,,,,,,,,,,,,,,,,
2014-07-28
23:18:56,4034,4CP:RodDrops,1,30.08,30.26,30.08,30.08,30.12,30.08,30.12,30.08,30.08,30.17,30.08,30.08,30.08,30.08,30.08,30.08,29.89,29
.89,29.89,29.89,29.89,29.89,29.89,29.89,29.89,29.98,29.70,30.08,30.08,30.08,30.08
2014-07-28
23:22:13,4033,4CP:RodDrops,1,29.89,29.89,29.89,29.89,29.89,29.89,29.89,29.89,29.89,30.12,29.89,29.89,29.89,29.89,29.89,29.89,29.84,29
.89,29.89,29.84,29.84,29.80,29.89,29.84,29.89,29.94,29.89,29.89,29.89,29.89,29.89,29.89
2014-07-29
22:10:33,1001,AH:RodDrops,1,29.89,29.89,29.89,29.89,0.00,31.00,31.38,31.38,31.38,31.38,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.5
6,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56
2014-07-29
22:10:33,1001,AH:RodDrops,1,29.89,29.89,29.89,29.89,0.00,31.00,31.38,31.38,31.38,31.38,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.5
6,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56,31.56
```

The fields are:

```
Reading Date/Time
Pot Number
Reading Type
“RodDrops” or “ClampDrops”
List of anode readings
```

2.3.2.3 Log Files

The meter keeps log files documenting various occurrences. Startup with meter number and software versions, exceptions taken during code execution, etc. These can be useful for diagnostic purposes. Log files are stored on the meter, and also uploaded to the database for further analysis.

2.3.2.3.1 Battery Log Files

The current software records battery voltage every minute, to help analysis meter use and power consumption. This function may not be retained in future, depending on how useful it proves.

However the battery life reference log, taken when a “Battery Test” is performed, is in the same format and used to enable the meter to predict remaining battery life.

2.3.2.3.2 Raw Data Log File

When enabled, all of the meter readings are saved in a log file. This may be analysed later for diagnostic purposes, for example finding out why an anode isn’t being captured, due to unstable current, and perhaps defining an action to be taken to detect and record this situation.

2.3.2.4 Update

Refer to section 2.3.1.5.2 on page 15 for more information on the current software update files and function.

2.4 Hardware

2.4.1 Battery

The meters use a type 18650 3.7V Lithium cell. These typically have a nameplate rating of 3000–4500mAh, however in testing we have found a huge variation in the performance of these cells, even between units bought in a single batch. After a lot of research and testing, we located a call that seems to be the best fit for the meter’s power usage profile, with consistent capacity. Using these cells we can get 10-13 hours life from the meters running at full capacity, compared with <1 hour from a lot of the other brands. As the meters normally drop to low-power mode when not in active use, actual life between charges can be much longer.

The downside with these cells (known as “LG Pink” batteries) is that they are physically 3mm shorter that the standard cells, which means that when installed in the battery holder they barely make contact, and can lose contact so that the meter shuts off with only a slight bump.

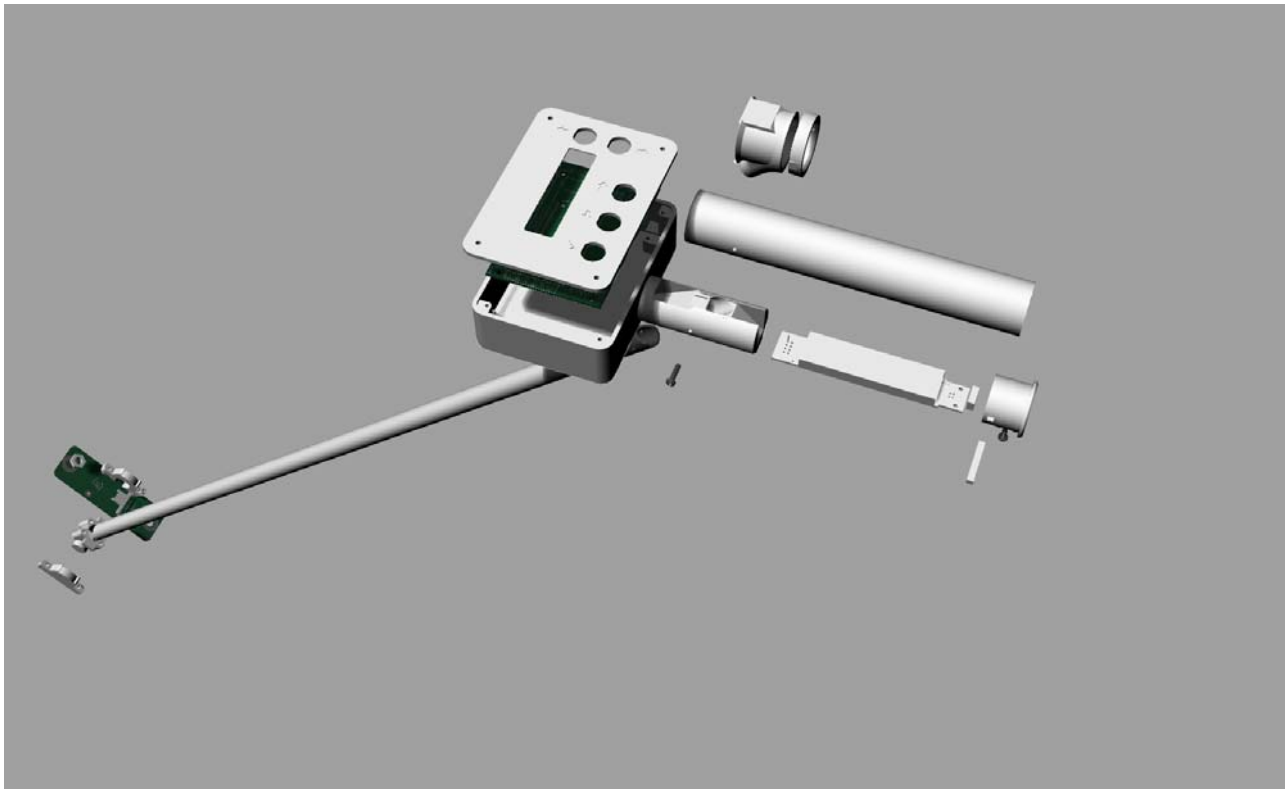
To get around this, we have been supplying the cells with a spacer at the –ve end, bound to the cell with the standard battery shrink-wrap.

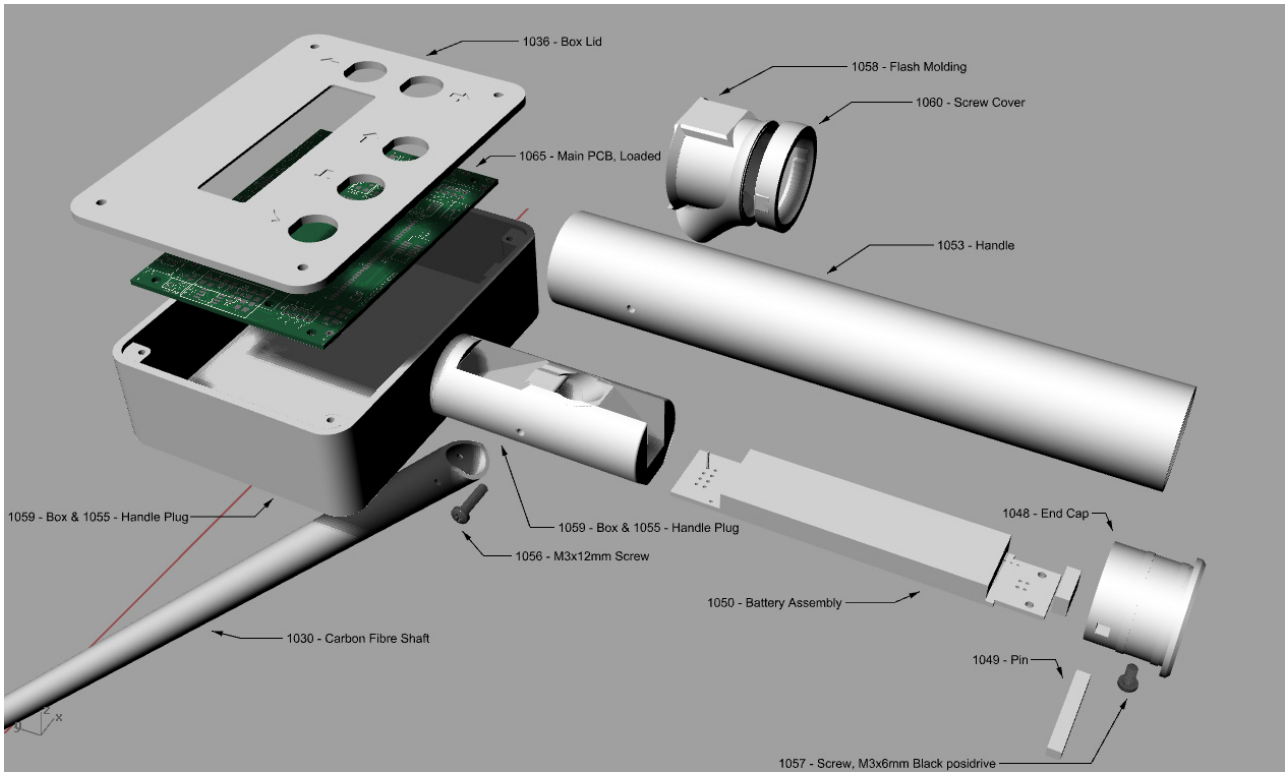
Each cell we supply is individually numbered and has been life-tested, with performance data available on request. When a new cell is installed in a meter we recommend doing a “battery test”, so that the remaining lifetime display on the meter will be accurate. (See section 2.3.1.5.1 on page 15)

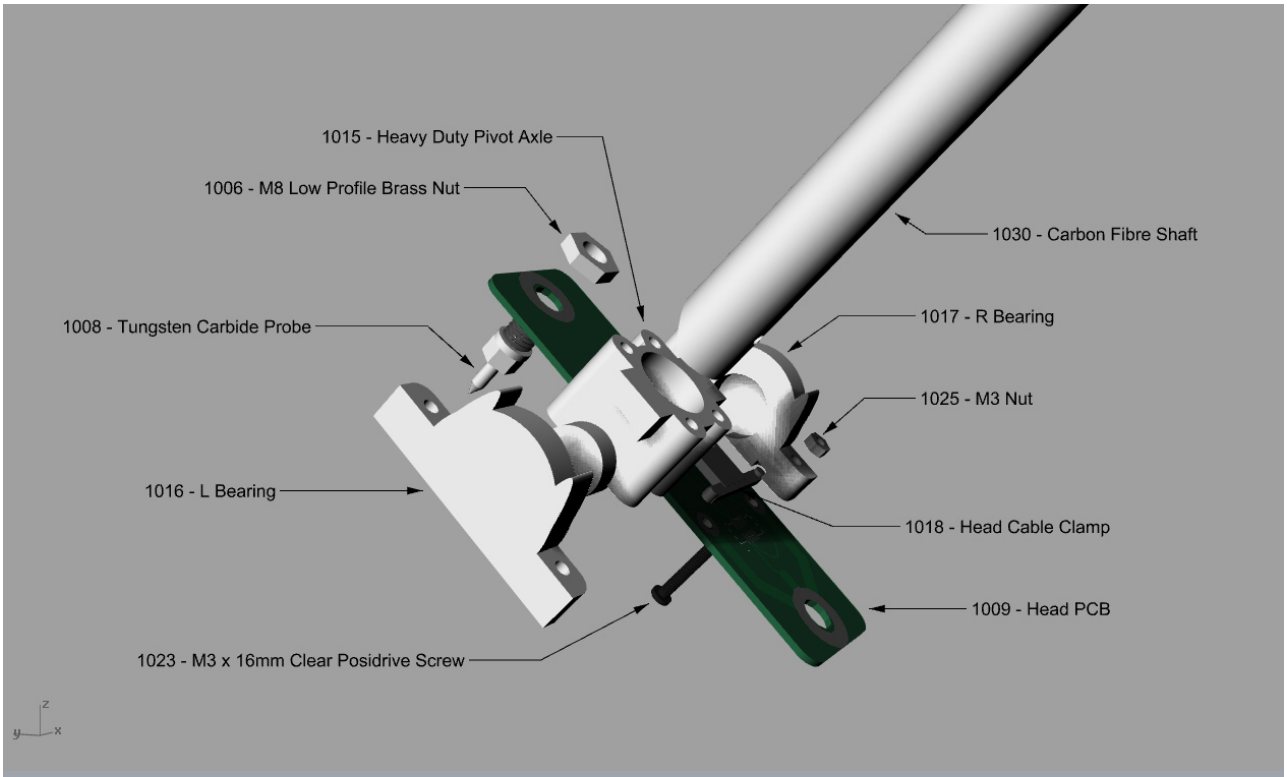
2.4.2 Components

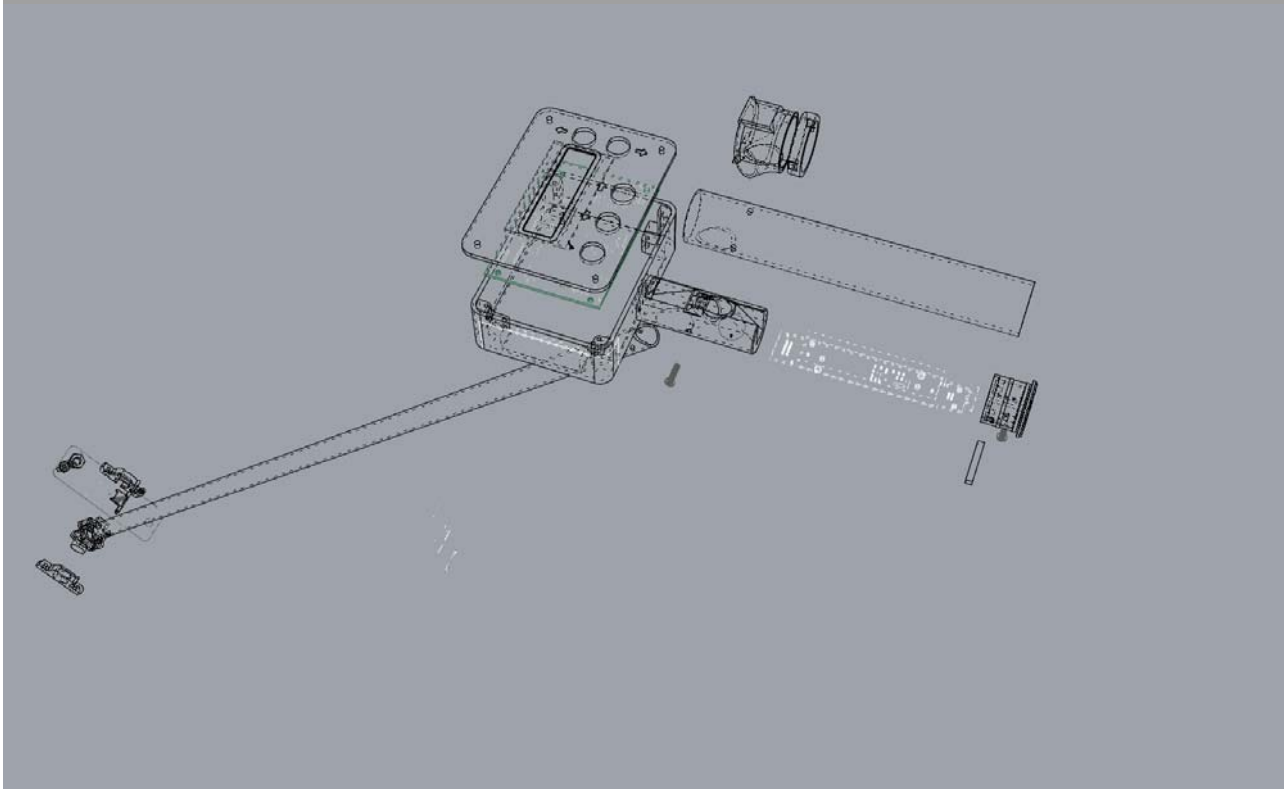
2.4.3 Exploded diagrams

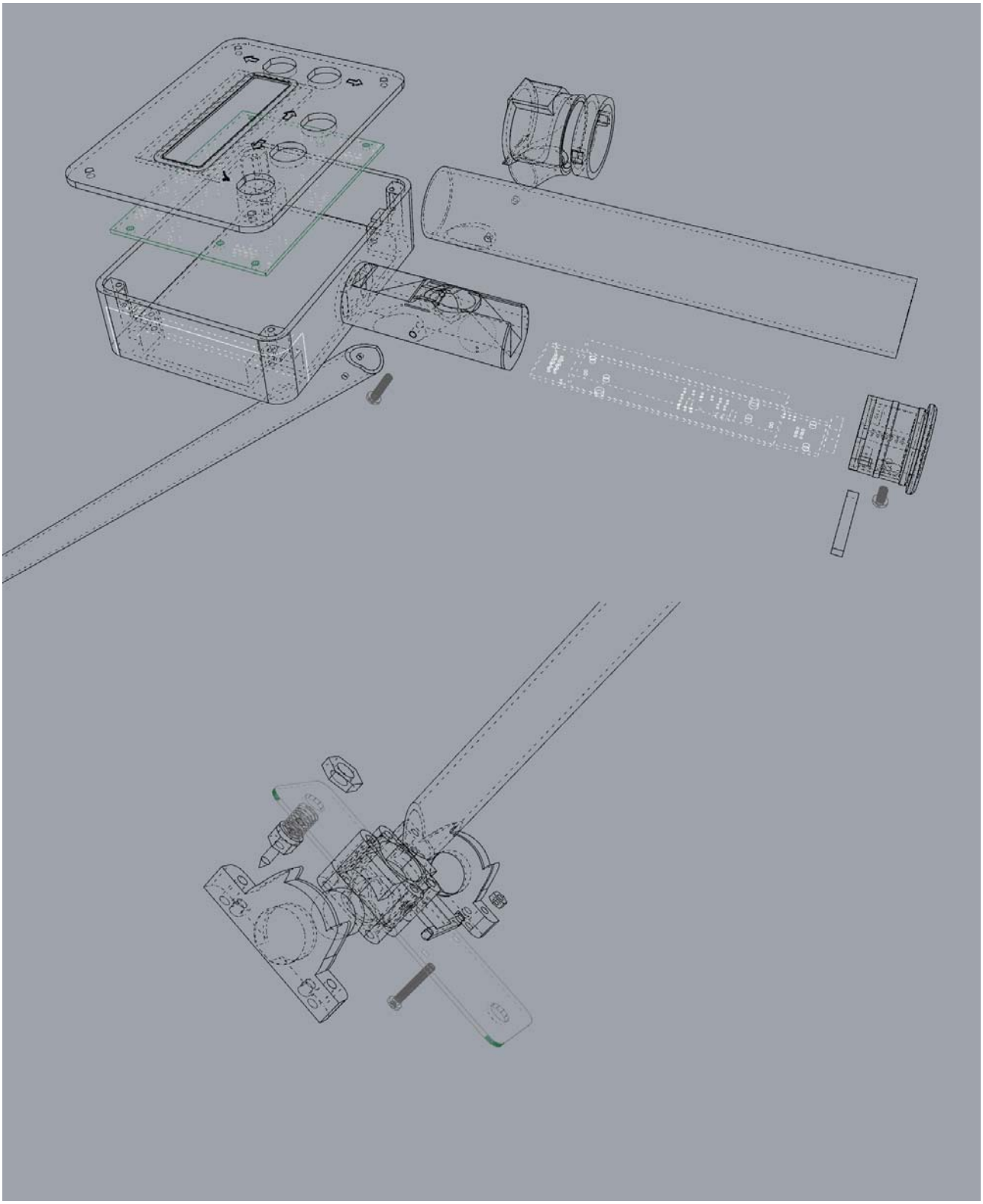
The following drawings show the components of the meter, and how they fit together.











2.4.4 Parts List

Part #	Item	Description
1003	Probe Pin	Tungsten Carbide Tipped Probe Pin
1004	Probe Pin Holder	Aluminium Probe Holder
1006	Nut	M8 Low Profile Brass Nut
1008	Probe	Head Probe
1009	Head PCB	PCB, 2mm thick, unloaded
1010	LED	Green SMT Hi Intensity LED
1011	LED	Red SMT Hi Intensity LED
1012	Socket	"Gadgeteer" 10-way SMT socket
1013	Head PCB	Loaded head PCB (no probes)
1015	Heavy Duty Pivot Axle	ABS Printed fitting
1016	L Bearing	ABS Printed fitting
1017	R Bearing	ABS Printed fitting
1018	Head cable clamp	ABS Printed fitting
1023	Screw	M3x16mm Clear Posidrive
1025	Nut	M3
1027	Screw	M3x6mm Black Posidrive
1028	Head Assembly	Head-Assembly Construction
1029	Head Assembly	Complete Head Assembly (w/o probes)
1030	Shaft	1m 15mm OD carbon fiber shaft
1031	IDC (Shaft Cable)	"Gadgeteer" 10-way IDC header
1032	Ribbon Cable (Shaft)	Hi-density 10-way ribbon
1033	Shaft Assembly	Complete Shaft Assembly
1036	Lid	Box Lid
1037	Button	Jaycar Button
1038	Ribbon Cable (LID)	Lid standard ribbon
1039	IDC (Lid)	Lid IDC Header
1041	Lid Assembly	Complete Lid Assembly
1042	PCB	Battery PCB (Unloaded)
1043	Header (Battery board)	IDC Pin header, 8-way
1044	Battery Holder	Battery holder
1045	Battery	18650 3.7V 3000mAh Lithium Battery
1047	USB (Battery board)	USB connector
1048	End-cap	ABS End cap
1049	Pin	ABS pin
1050	Battery Assembly	Complete battery assembly
1051	IDC (Battery cable)	IDC Socket
1052	Ribbon cable, battery	Ribbon cable to main board
1053	Handle	PVC Handle
1054	Handle Grip	Rubber outer handle grip
1055	Handle-Plug	ABS fitting, handle-case-shaft
1056	Screw	M3x12mm lock plug to shaft
1057	Screw	M3x6mm Black Posidrive Batt. Retainer
1058	Flash molding	ABS print external handle to box
1059	Box	Polycase Box
1060	Screw cover	ABS print screw cover
1061	Handle Assembly	Complete Handle Assembly
1062	PCB	Main PCB

1063	EMX	EMX Module
1064	Parts	Misc. Electronic components (itemize later)
1065	Main PCB Loaded	Main PCB, loaded
1066	LCD	LCD Display
1067	uSD Card	8GB microSD (not Kingston)
1069	Main PCB Assembly	Complete Main PCB

2.4.5 Troubleshooting

Specifications

Physical	
Length	770mm, 900mm, 1100mm (Custom lengths avail.)
Weight	500gm (with Battery)
Probe Spacing	95mm (Custom design and spacing on request)
Probe Material	Tungsten Carbide
Shaft	15mm Carbon Fibre
Head	Pivoting Fibreglass PCB
Electrical	
ADC - Chan 1	16 bit (62µV), 14 Readings/Sec, 15ppm/˚C Drift 0.05% Gain Error, 20V Protection
ADC – Chan 2	(Optional – as Ch1)
Battery	Rechargeable 3.7V Li-Ion 3000mAh (18650)
Display	16x2 Backlit LCD
Indicators	Hi-intensity red & green LEDs
Real time clock	Yes
Power Supply	Inductorless design for operation in potroom magnetic field
Connections	
USB	Data IO + charge
WiFi	Optional
Serial	2x RS232 (3.3v)
UEXT	Optional extended IO
Storage	
MicroSD	8GB
Software	
Internal Firmware	.Net Micro Framework C#, VS2010 Upgradeable Customizable
Host (PC)	Download schedules Upload Readings Database Interface Software Updates

3. Infrastructure

3.1 Gateway Server

The Gateway Server is a program running on a PC which acts as a gateway between the meters and the database, or to a local directory on the PC or network. It is normally run as a service, but can also be run in attached mode from a command line.

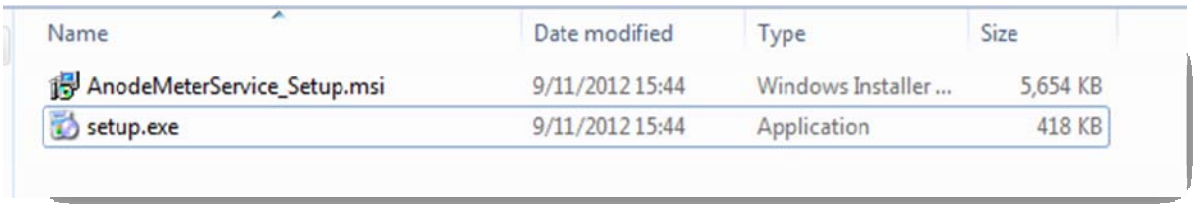
3.1.1 Anode Meter Service Installation

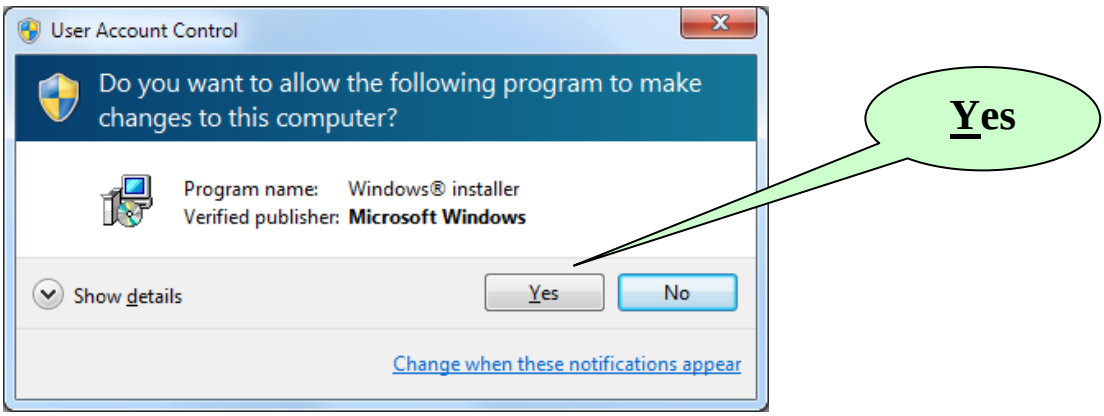
3.1.1.1 USB

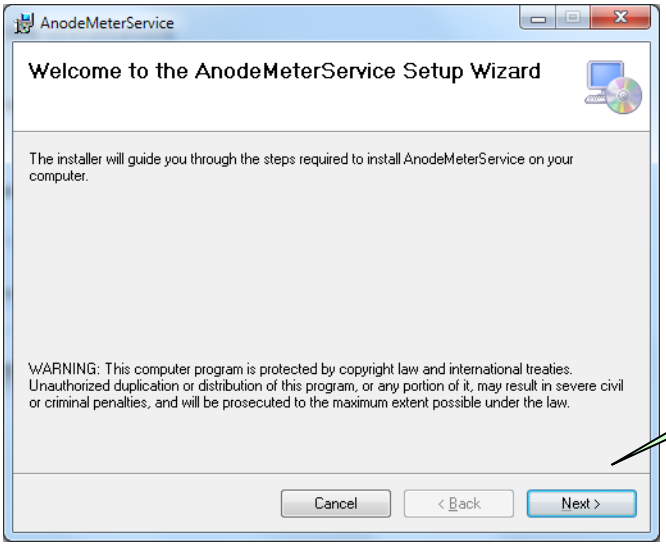
3.1.1.1.1 Installing the USB Drivers

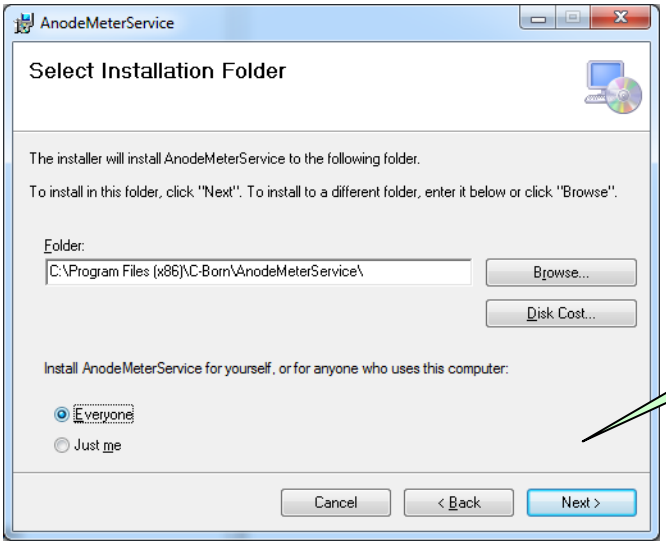
USB Driver Installation – Stage 1

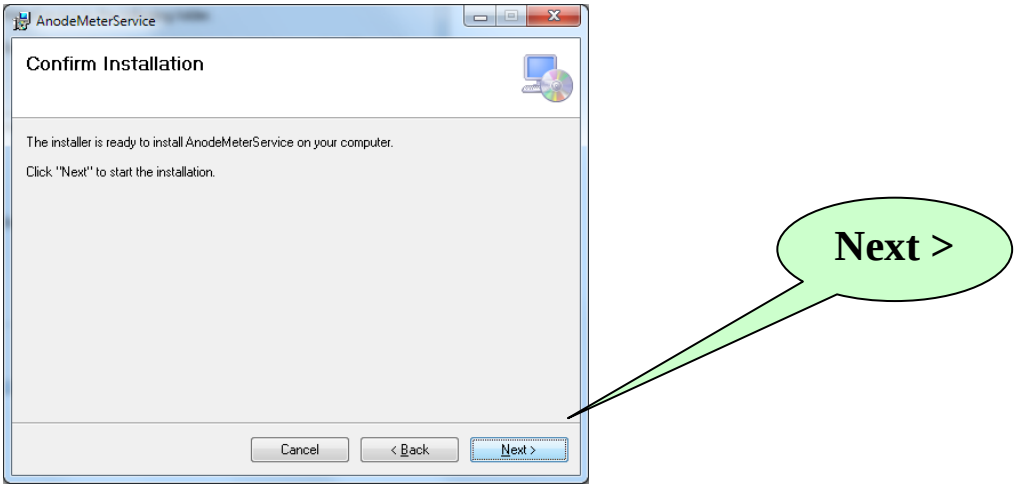
- Open the Anode Meter setup file and run the setup.exe program

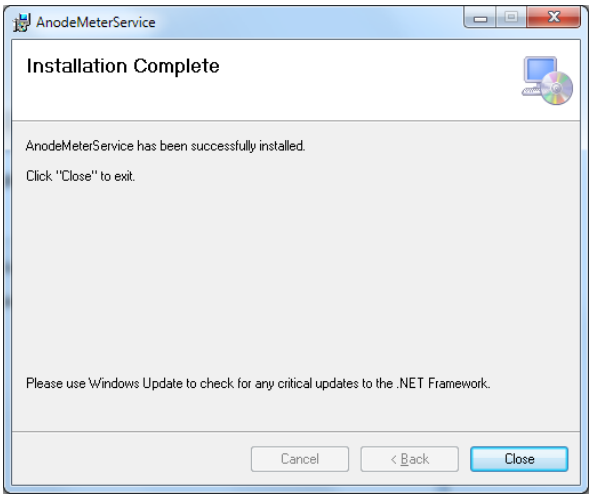












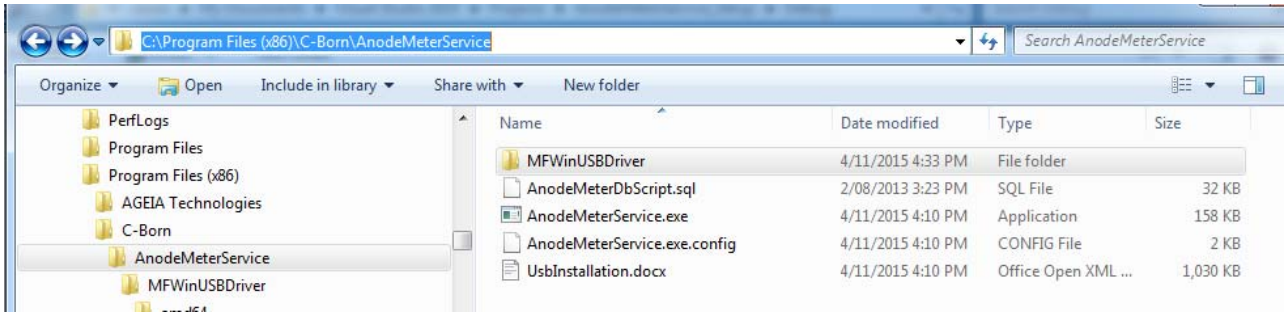
Close to finish the installation.

The service and drivers have been copied to the PC. We now need to complete the USB driver installation for the meters.

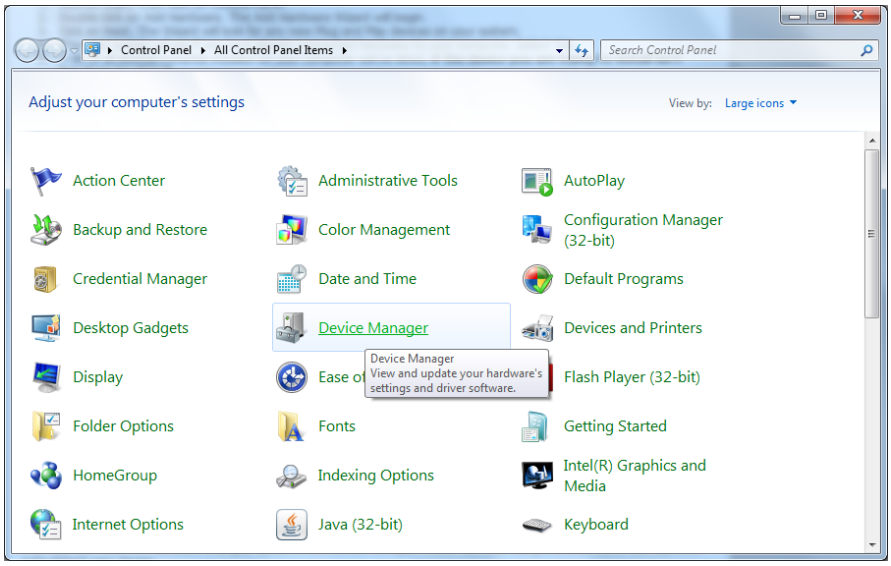
USB Driver Installation – Stage 2

<u>Important!</u> If you are installing on Windows 10 you will need to have the machine running in a special mode to install the drivers. To do this please follow the directions given in section 3.1.2 (Page 5) before coming back here and proceeding with the installation.

Verify the following directory and files have been installed

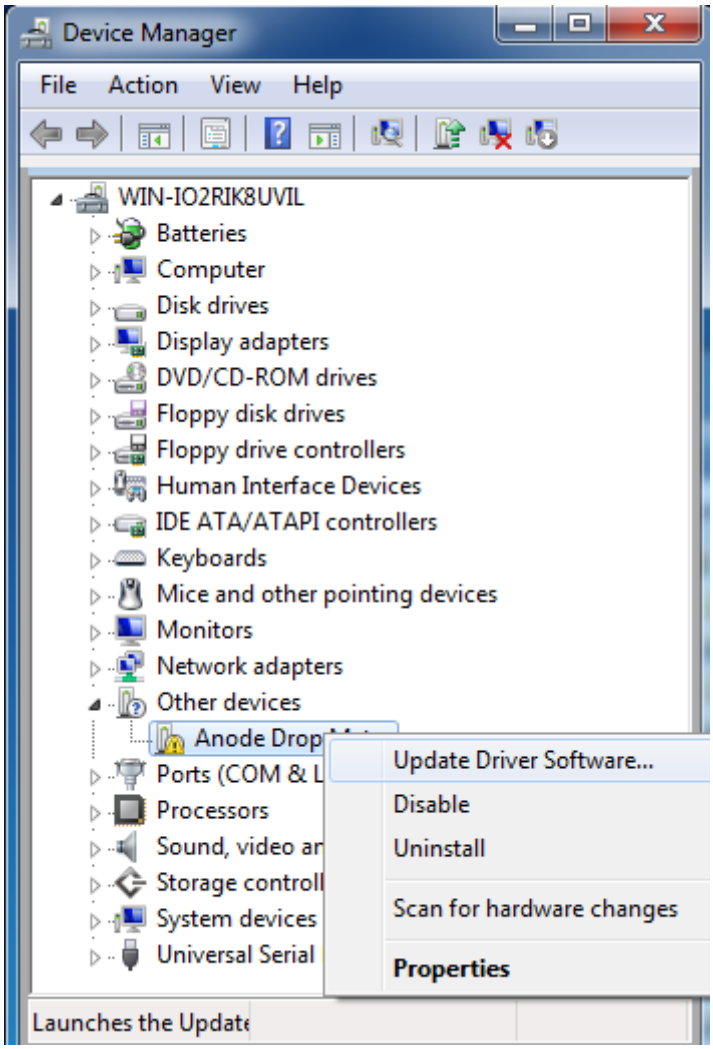


Start Device Manager

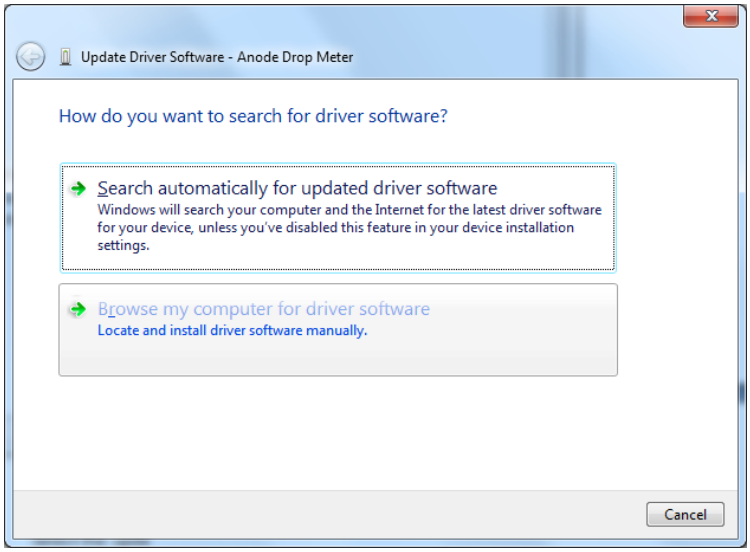


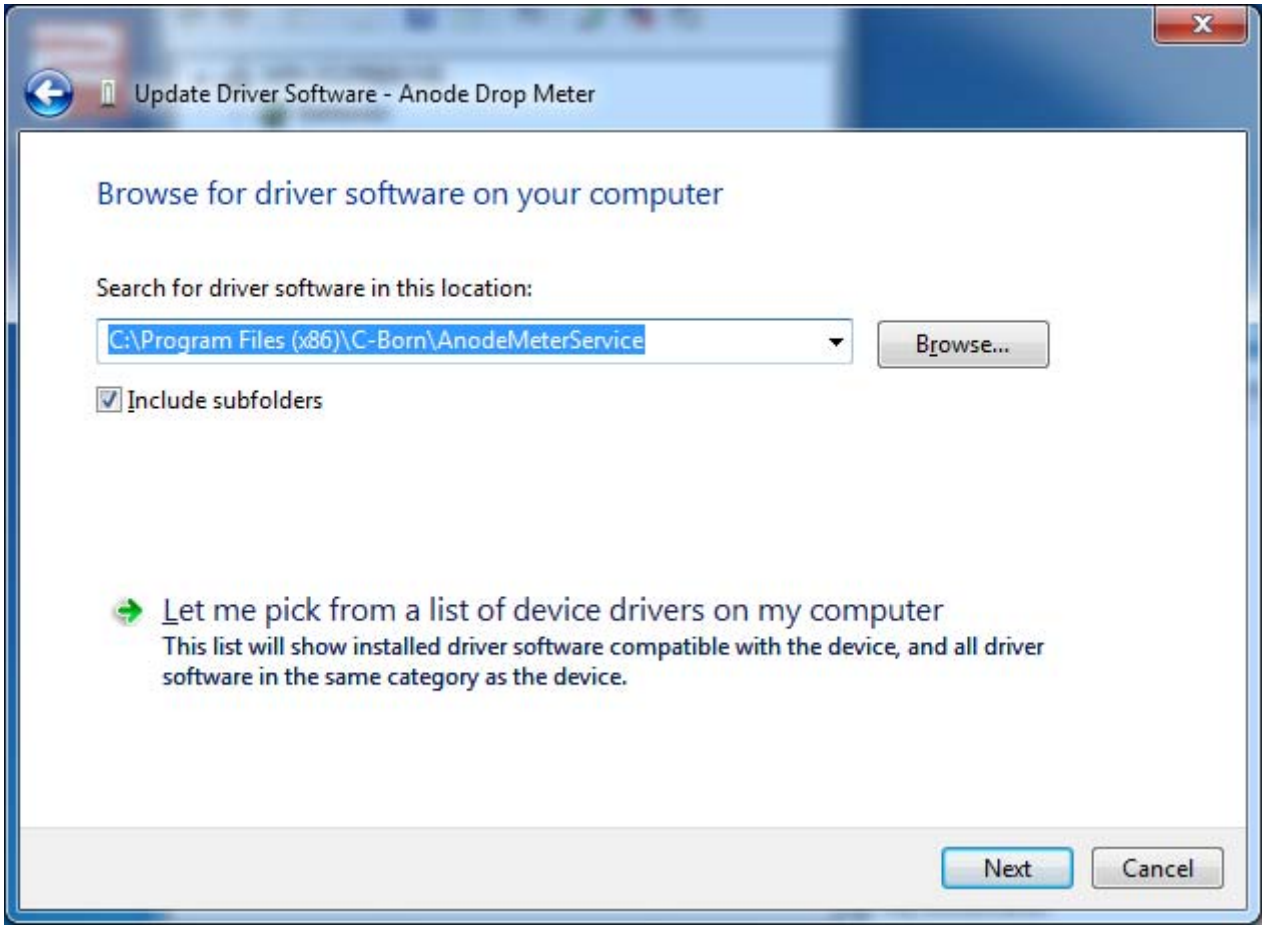
Plug the Anode Meter into a USB port on the PC

In Device Manager, Right click on the Anode Drop Meter and select “Update Driver Software…”

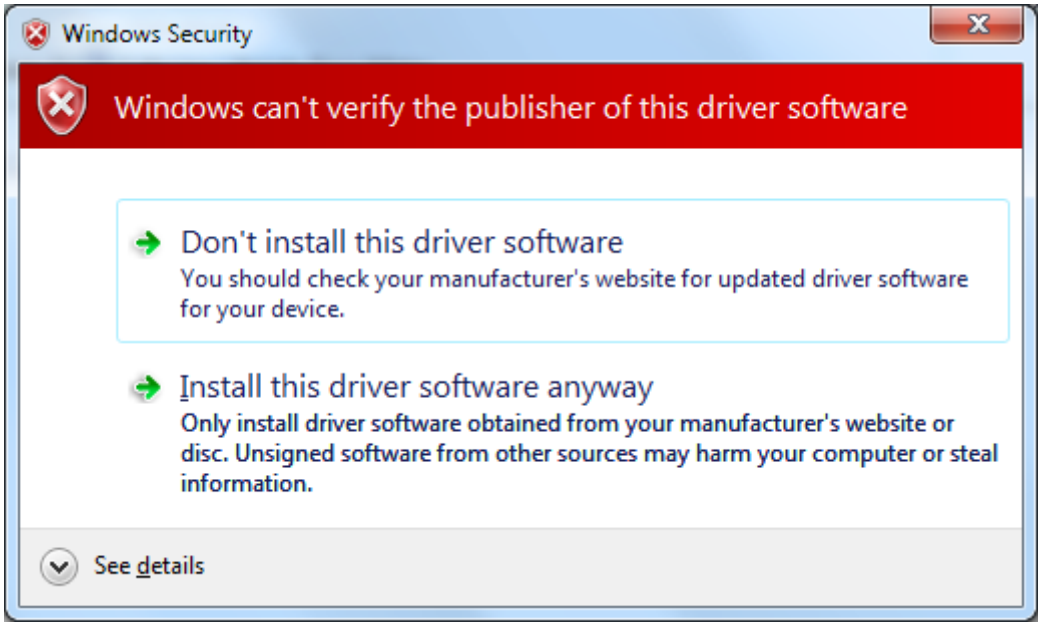


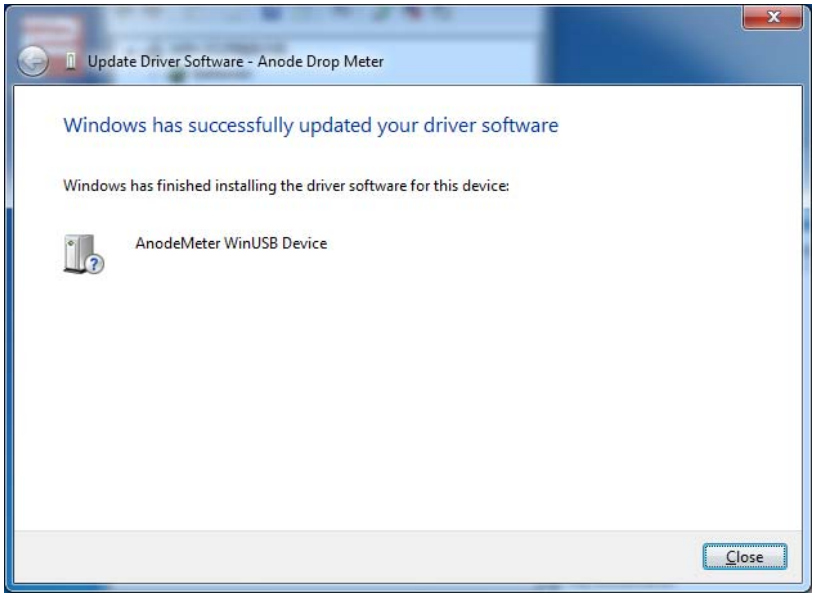
Following the prompts, select “Browse my computer for driver software”





Choose “Install this driver software anyway”

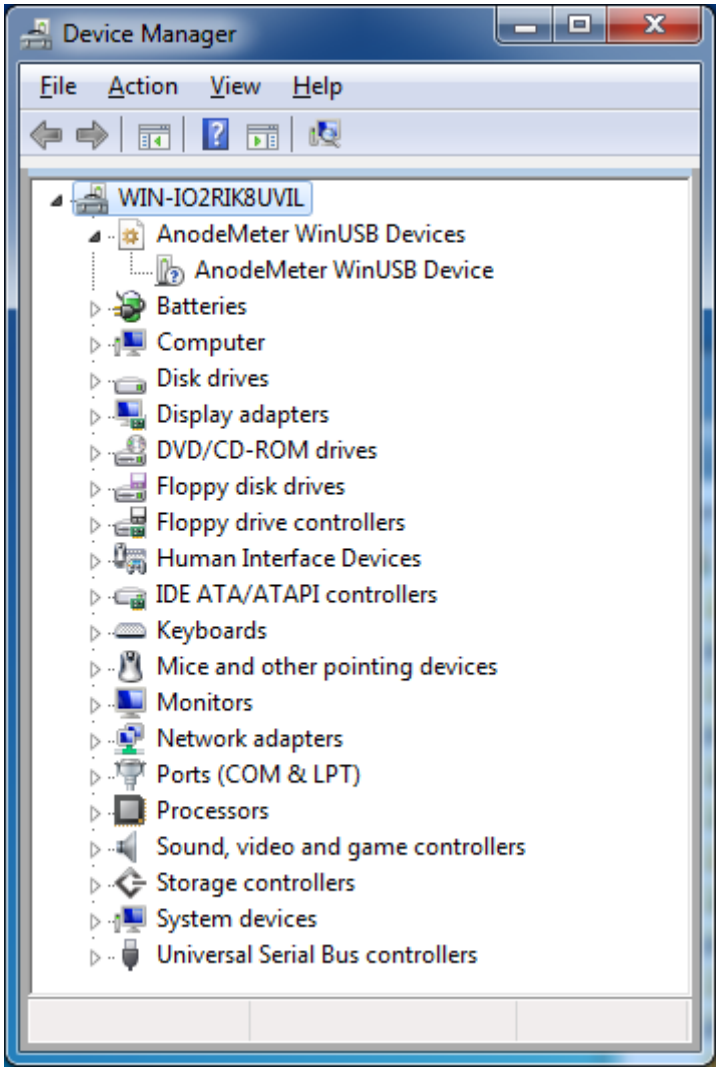




The USB drivers have now been installed.

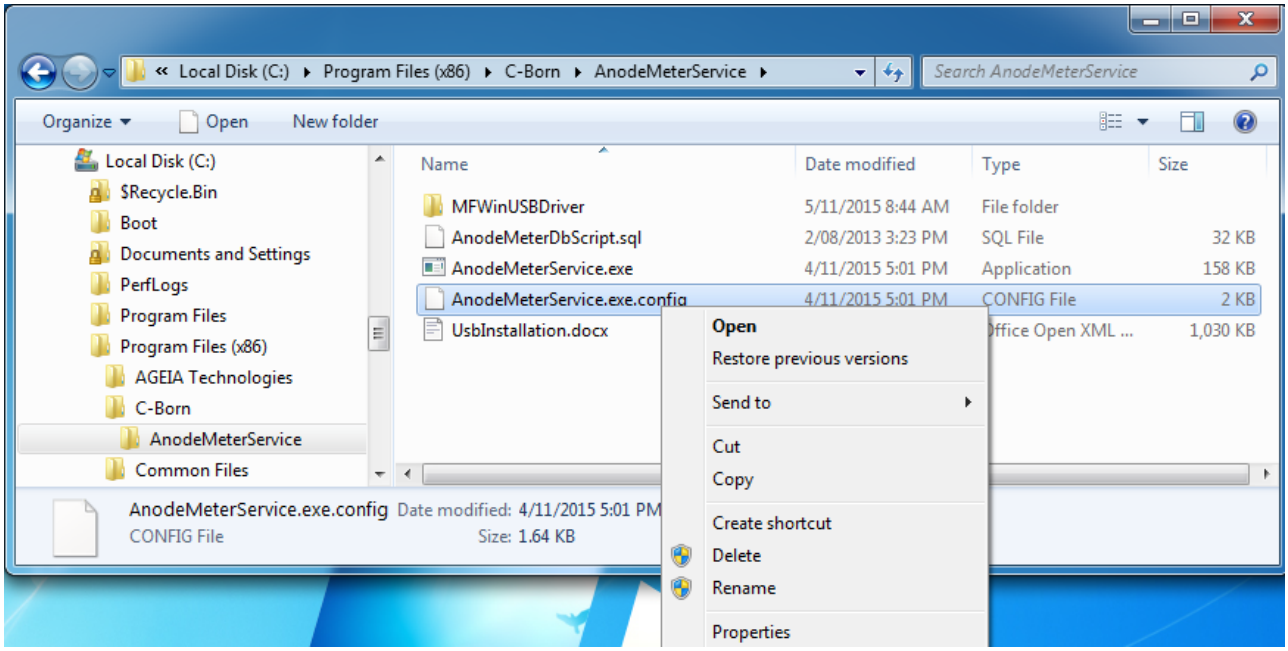
Final Verification

AnodeMeter USBdevice should appear in the Device Manager list of devices



3.1.1.1.2 Installing the Anode Meter Service

Edit the AnodeMeterService.exe.config file to select the correct server



The file requires editing to change the following to the correct computer.

Use notepad to edit the file and change the following values for these fields.

`DBServerName`

`SqlUserName`

`SqlUserPassword`

Save the file.

Note that if the gateway service is to be run in local mode, storing the data as CSV files in a local directory rather than in the database, the following entries need to be edited:

`RunInLocalMode`

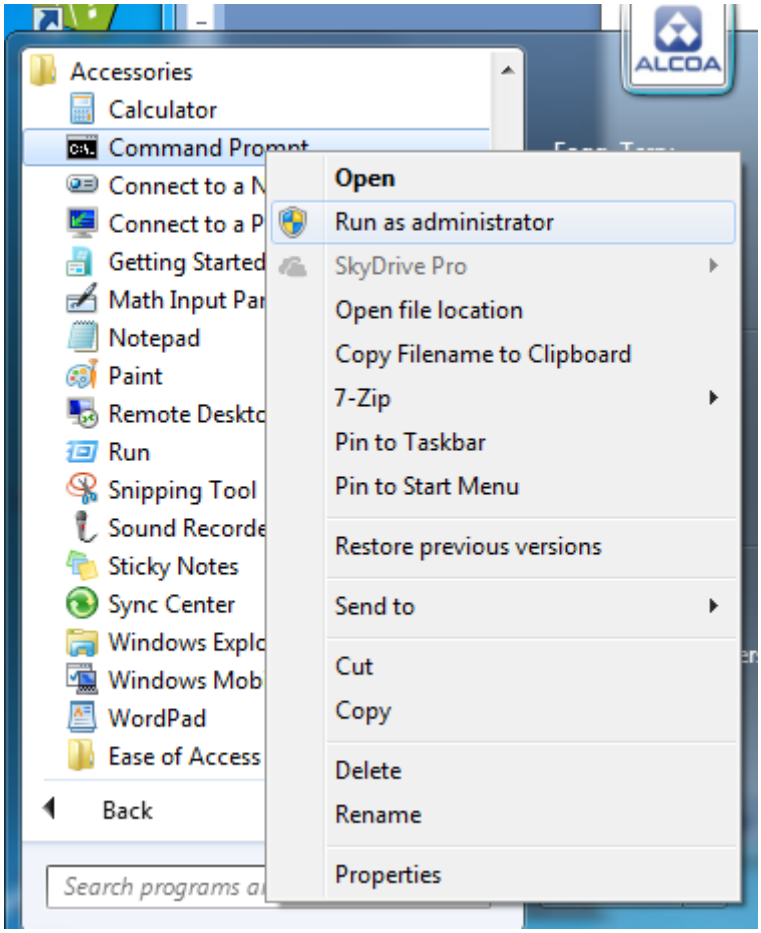
`LocalModeStoragePath`

So that RunInLocalMode is “True”, and LocalModeStoragePath points to the directory for saving the data from the meters.

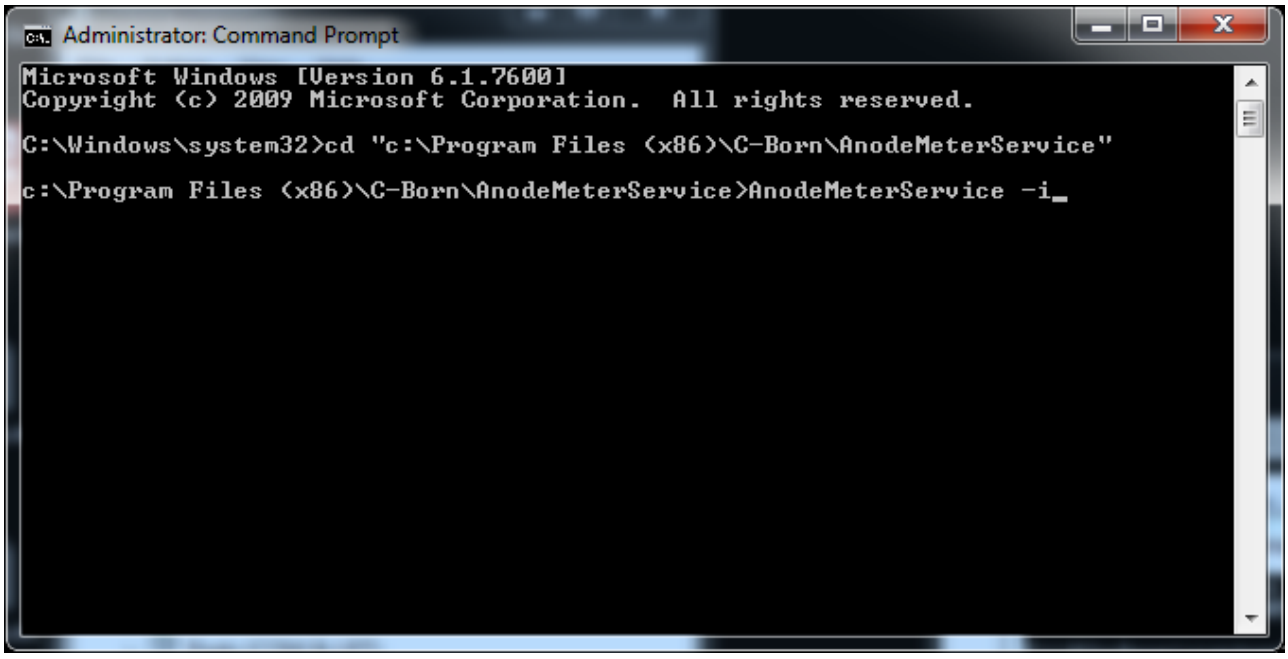
- **Note also that when complete the Configuration Tool (Section 3.3) should be used to modify these settings**.

Install the program as a service

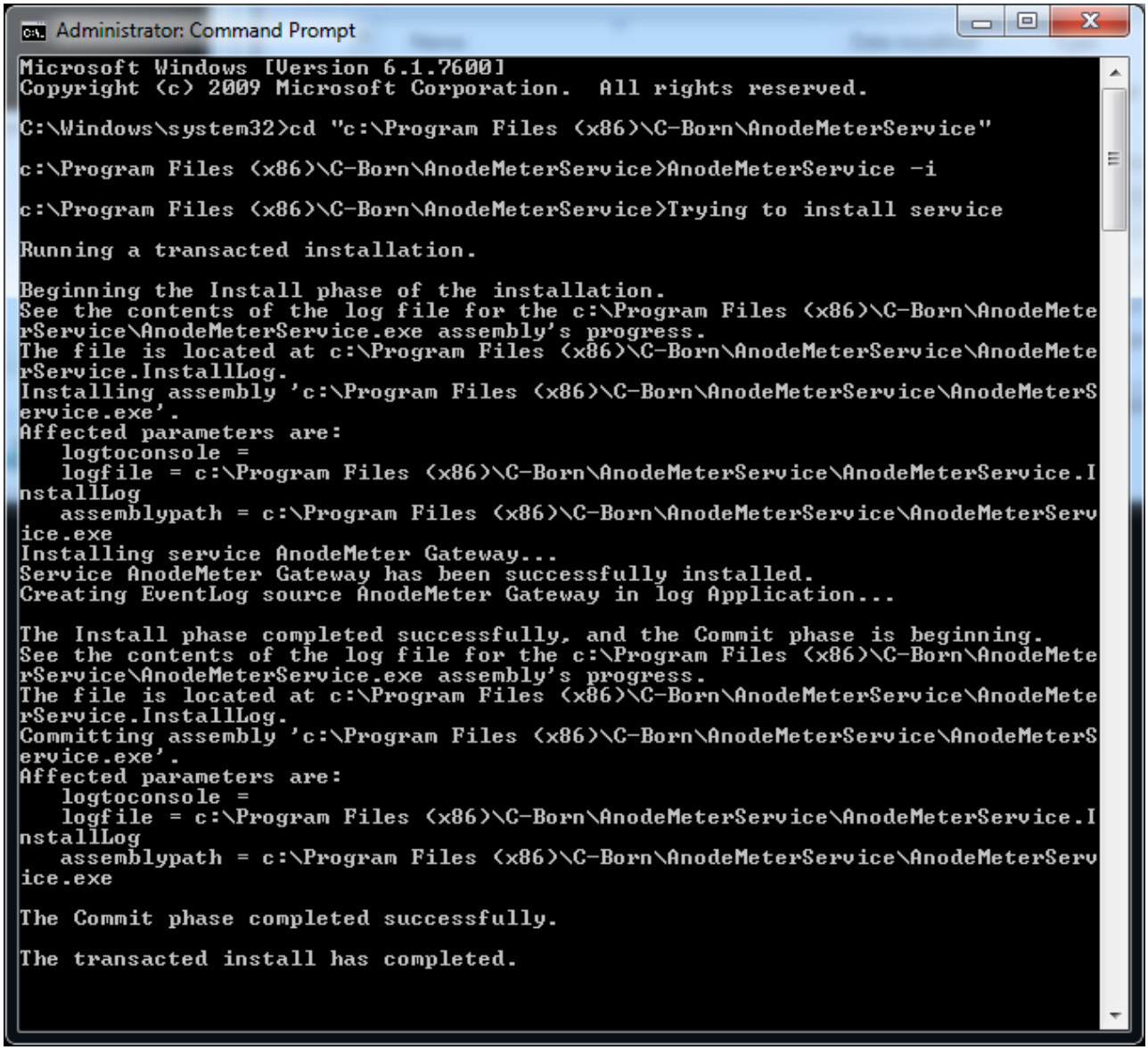
1. Run up a command prompt as Administrator



Navigate to "C:\Program Files (x86)\C-Born\AnodeMeterService and run the following **"AnodeMeterService –i"**

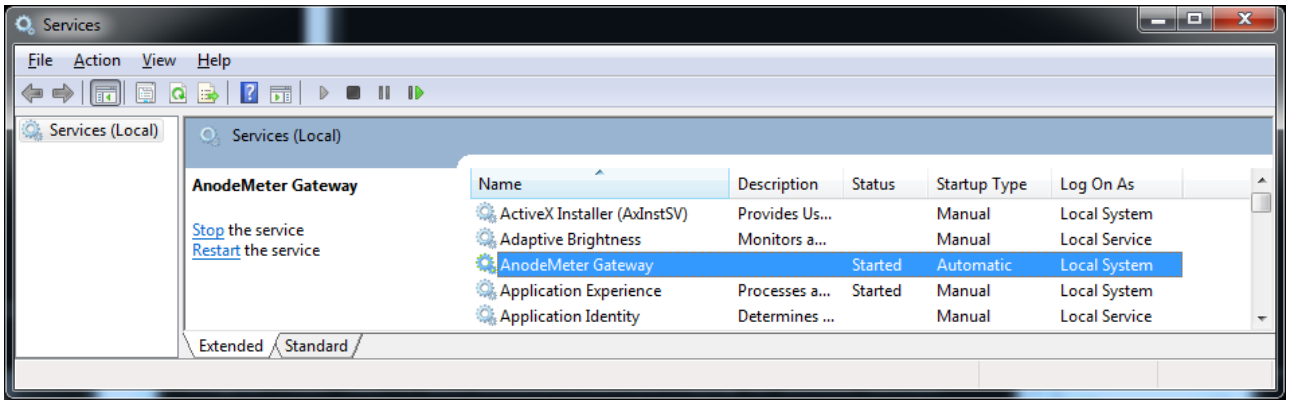


Following a successful installation you should see:

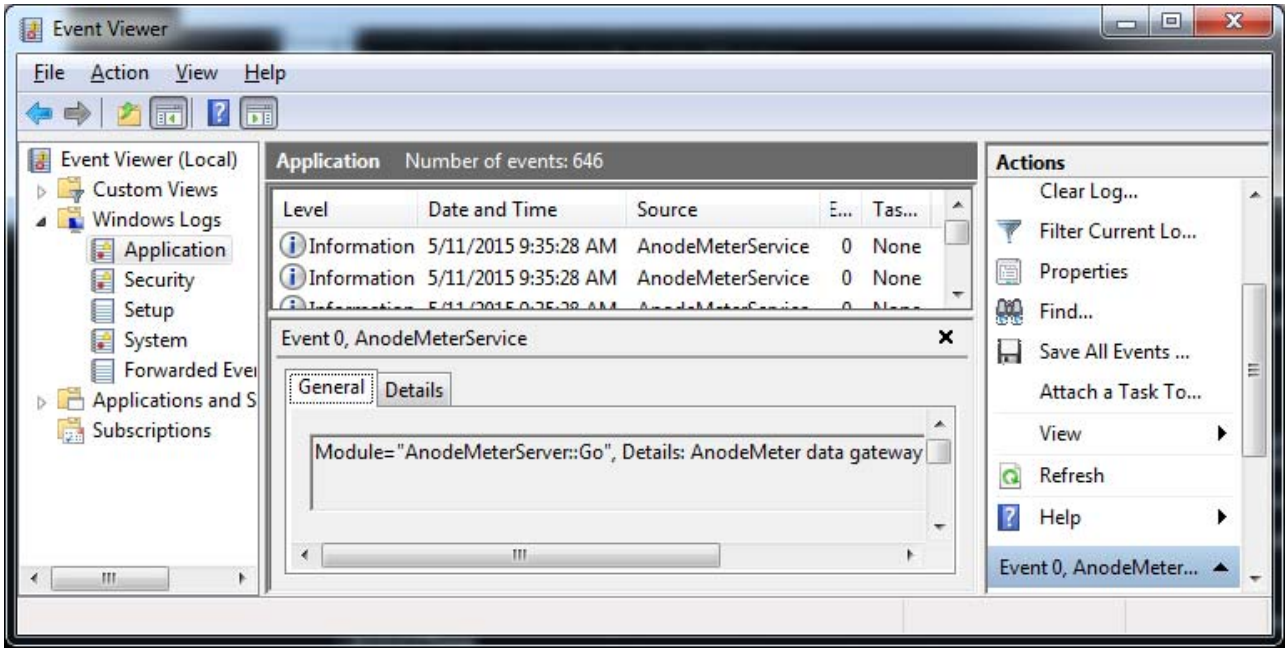


Final Verification

Check that the service is installed and started



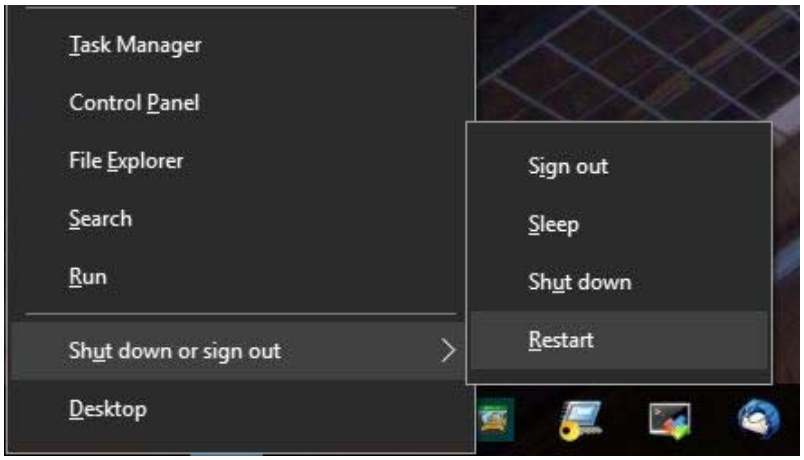
Check for messages in the event log



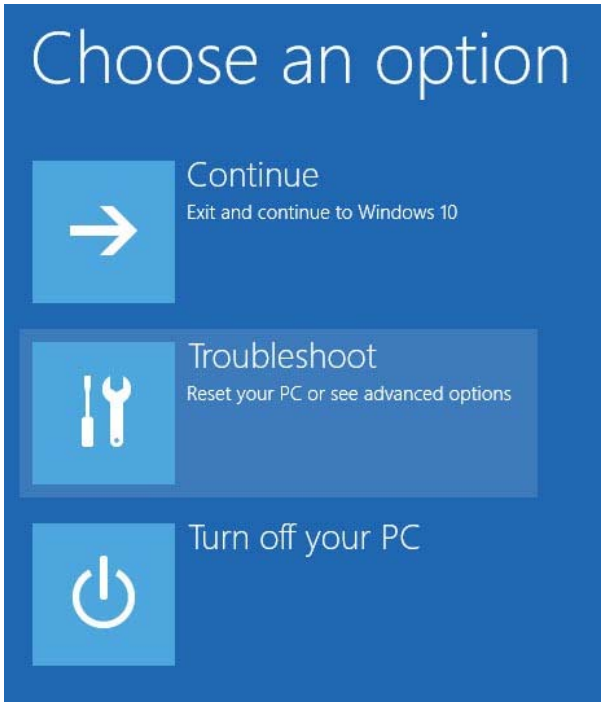
3.1.2 Important Notes for Windows 10 Installation

With Windows 10 Microsoft introduced mandatory signing for driver installation, including the WinUSB drivers used by the meters. In order to install our unsigned drivers we need to follow a special procedure using the Advanced Boot menu, as follows:

Press “Win + X,” navigate to “Shutdown” and then “Shift + Left Click” on the “Restart” option.

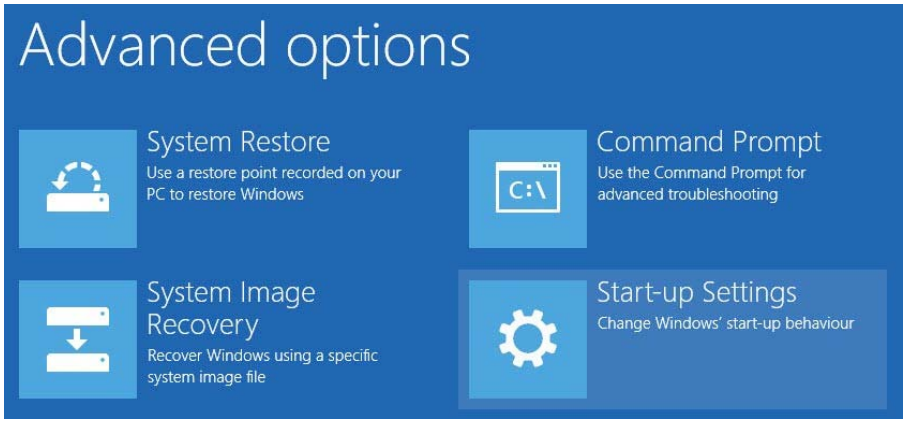


This will restart your system and will take you to the Advanced Boot menu. Here, select the “Troubleshooting” option.

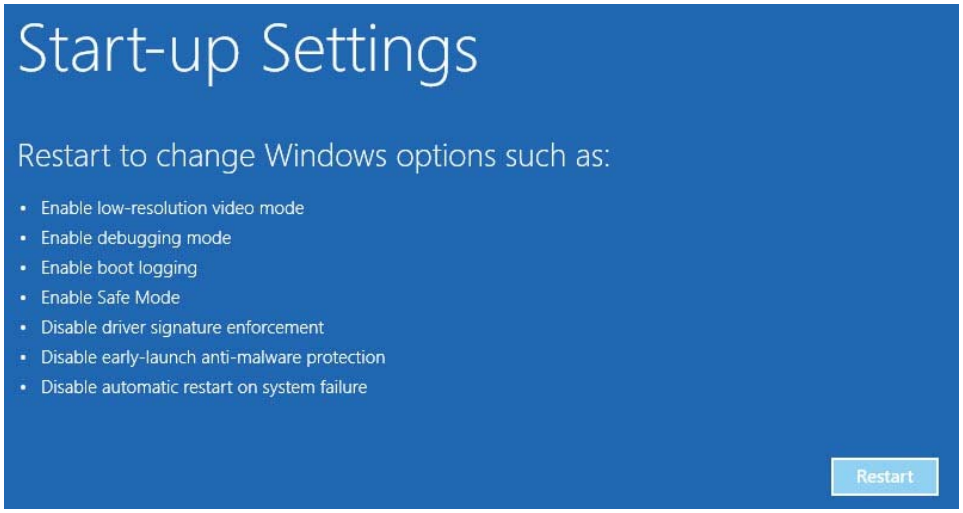


In the Troubleshoot section select the option “Advanced Options.”

Now, select “Start-up Settings.”



The Startup Settings option will allow you to boot your Windows system in different modes. Just click on the “Restart” button to continue.



Click on “Restart” to get to the next menu:

From here press the ‘7’ key (or F7) to reboot with driver signature enforcement disabled.

As soon as you press the key, your system will boot into Windows. You can now proceed with the USB driver installation process.

Driver Signature Enforcement will be automatically enabled after the next reboot.

3.1.3 WiFi

-TBA

3.2 Database

The system has been tested using MS SqlServer . Database configuration will be unique to each plant, however a .SQL configuration script has been provided as a template. We can assist with database integration as required.

For database servers other than MS SqlServer modifications will be required to the gateway service program.

3.3 Configuration Tool

Information on the configuration tool will initially be available as a separate document.

A. References

B. Release Notes

Revision	Date	Changes
1.0.48	13 November 2015	Initial internal draft
1.0.52	10 June 2016	Draft issued for review by client plants
1.1.56	12 August 2017	Added section on installing unsigned USB drivers under Windows 10