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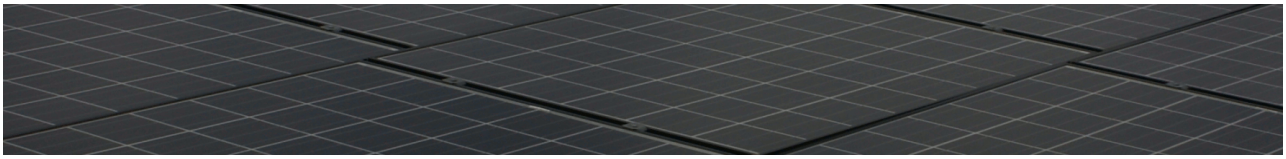

WattPlot™'s Inaccurate Data Storage

For a product which touts that it stores every single bit, and logs and archives **all** (emphasis theirs) the data p by the ***Mate*** display controller in its proprietary and compressed data file, we'd think they'd make sure it really Well, we believe in open and interoperable software. That means we have to test that when we process data *WattPlot* program's output, we produce the correct data as well.

During a test of event data capture and analysis, and verification that the *greenMonitor* data agreed with what *WattPlot* software reported, we found that a significant amount of information was missing. We can't claim to l compatible if we don't know whose fault it is, so we set out to solve the mystery.

These are the events as reported by the *WattPlot* software --

```
09/10/26 08:12:41 MX-3 Bulk
09/10/26 08:40:56 FX-1 Support, Using AC
09/10/26 08:40:56 FX-2 Pass Through, Using AC
09/10/26 08:41:02 FX-1 Pass Through, Using AC
09/10/26 08:41:08 FX-1 Charging, Using AC
09/10/26 08:41:26 FX-1 Pass Through, Using AC
09/10/26 09:42:06 MX-3 Silent
```

Next, we located the data for the time between when inverters resumed "Use" mode and when the inverters h stabilized. There is often a brief period of time during which the chargers will turn on, and we wanted to verify correct data was being captured. The data from that period was then saved to an EPD file and converted into a for viewing. What we found was that several records we expected to see in the EPD file were missing.

Here is the CSV file that was produced by *WattPlot* --

```
"FX","26 Oct 08:40 to 08:43"
"FX Mode","Inverter Amps","Charger Amps","Buy Amps","Sell Amps","AC Input","AC Output","Batt VI
"Inv On, AC Dropped",2,0,0,0,126,120,48.8,08:40
"Inv On, AC Dropped",2,0,0,0,126,120,48.8,08:40
"Inv On, AC Dropped",2,0,0,0,126,120,48.8,08:40
"Support, Using AC",2,0,0,0,124,120,48.8,08:40
"Support, Using AC",3,0,0,0,125,123,48.8,08:40
"Support, Using AC",2,0,0,0,126,124,48.8,08:40
"Support, Using AC",2,0,0,0,126,124,48.8,08:40
"Support, Using AC",2,0,0,0,126,124,48.8,08:40
"Support, Using AC",1,0,0,0,125,123,48.8,08:40
"Inv/Pass Thru, Using AC",0,0,1,0,124,122,48.8,08:40
"Charging, Using AC",0,2,4,0,123,121,49.2,08:41
"Charging, Using AC",0,2,5,0,124,122,49.2,08:41
"Charging, Using AC",0,3,5,0,124,122,49.2,08:41
"Charging, Using AC",0,4,6,0,125,123,49.2,08:41
"Charging, Using AC",0,5,7,0,125,123,49.6,08:41
"Charging, Using AC",0,6,9,0,125,123,49.6,08:41
"Charging, Using AC",0,7,9,0,125,123,49.6,08:41
"Charging, Using AC",0,8,10,0,125,123,49.6,08:41
"Charging, Using AC",0,9,11,0,125,123,49.6,08:41
"Charging, Using AC",0,9,12,0,125,122,50.0,08:41
"Charging, Using AC",0,10,13,0,124,122,50.0,08:41
"Charging, Using AC",0,11,14,0,124,122,50.0,08:41
"Charging, Using AC",0,11,14,0,124,122,50.0,08:41
"Charging, Using AC",0,11,14,0,124,122,50.0,08:41
"Charging, Using AC",0,11,13,0,124,122,50.0,08:41
"Charging, Using AC",0,11,13,0,124,122,50.0,08:41
"Charging, Using AC",0,11,13,0,124,122,50.0,08:41
"Pass Through, Using AC",0,11,13,0,124,122,50.0,08:41
```

```
"Pass Through, Using AC",0,4,6,0,125,124,50.0,08:41
"Pass Through, Using AC",0,0,2,0,127,126,50.0,08:41
"Pass Through, Using AC",0,0,2,0,124,123,49.6,08:43
"Pass Through, Using AC",0,0,2,0,124,123,49.6,08:43
"Pass Through, Using AC",0,0,2,0,124,123,49.6,08:43
```

These are the events that we were trying to verify. The times are off by about 7 seconds from what *WattPlot* r
and we think we know why. I'll explain at the end.

One of the records shown in the *WattPlot* event log is missing from here. That's because the system was con
with our unique feature to suppress quickly changing events so the event log isn't cluttered.

```
10/26/2009 08:12:30: Charger 'Charger': The charger is now AWAKE.
10/26/2009 08:40:49: Inverter 'Slave': Operating mode is now 'Pass Thru'
10/26/2009 08:40:55: Inverter 'Master': Operating mode is now 'Pass Thru'
10/26/2009 08:41:05: Inverter 'Master': Operating mode is now 'Charge'
10/26/2009 08:41:17: Inverter 'Master': Operating mode is now 'Pass Thru'
10/26/2009 09:48:43: Charger 'Charger': The charger is now AWAKE.
```

This is the actual raw ***Mate*** data. The *greenMonitor* software comes with tools that can be used to extract a pı
range of records from a compressed ***Mate*** data file. The range of times for these records, limited to the maste
in the pair, was 08:40:46 to 08:41:20, a period of exactly 34 seconds -- and you can count the records for you
There are 35 of them. The first is 08:40:46 and the last is 08:41:20.

```
1,02,00,00,123,120,00,02,000,01,488,024,000,041
1,02,00,00,123,120,00,02,000,01,488,024,000,041
1,02,00,00,124,120,00,08,000,02,488,024,000,049
1,03,00,00,125,123,00,08,000,02,488,024,000,054
1,02,00,00,126,124,00,08,000,02,488,024,000,055
1,02,00,00,126,124,00,08,000,02,488,024,000,055
1,02,00,00,125,123,00,08,000,02,488,024,000,053
1,01,00,00,125,123,00,08,000,02,488,024,000,052
1,00,00,01,124,122,00,10,000,02,488,024,000,043
1,00,00,01,123,121,00,10,000,02,492,024,000,036
1,00,00,02,123,121,00,10,000,02,492,024,000,037
1,00,00,02,122,121,00,10,000,02,492,024,000,036
1,00,00,02,122,120,00,03,000,02,492,024,000,037
1,00,01,03,122,121,00,03,000,02,492,024,000,040
1,00,02,04,123,121,00,03,000,02,492,024,000,043
1,00,02,05,124,122,00,03,000,02,492,024,000,046
1,00,03,05,124,122,00,03,000,02,492,024,000,047
1,00,04,06,125,123,00,03,000,02,492,024,000,051
1,00,05,07,125,123,00,03,000,02,496,024,000,057
1,00,06,09,125,123,00,03,000,02,496,024,000,060
1,00,07,09,125,123,00,03,000,02,496,024,000,061
1,00,08,10,125,123,00,03,000,02,496,024,000,054
1,00,09,11,125,123,00,03,000,02,496,024,000,056
1,00,09,12,125,122,00,03,000,02,500,024,000,042
1,00,10,13,124,122,00,03,000,02,500,024,000,034
1,00,11,14,124,122,00,03,000,02,500,024,000,036
1,00,11,14,124,122,00,03,000,02,500,024,000,036
1,00,11,14,124,122,00,03,000,02,500,024,000,036
1,00,11,13,124,122,00,03,000,02,500,024,000,035
1,00,11,13,124,122,00,03,000,02,500,024,000,035
1,00,11,13,124,122,00,10,000,02,500,024,000,033
1,00,04,06,125,124,00,10,000,02,500,024,000,040
1,00,00,02,127,126,00,10,000,02,500,024,000,036
1,00,00,02,124,123,00,10,000,02,496,024,000,044
```

The records in italics are the ones that are completely missing. How did this happen? We think the problem is
files themselves. We figured this one out when working on the *gmRemote* command for *greenMonitor v1.00.6*
WattPlot software works under the assumption that records are produced every second. The new *gmRemote*
was accurately time stamping records when they were received, and rotating the files according to the selecte
interval, but if each `Remote_#.dat` file didn't contain the precisely correct number of records (according to *Inta*
concept of "correct") the *WattPlot Monitor* command failed to process the files. So the *gmRemote* command h
lying and rebundle records according to what the *WattPlot Monitor* command expected.

We believe that every now and again, the *WattPlot* software goes "Oops!" and realizes it lost some time. And where 08:42 went to. "Oops!" It's probably also where the missing records went to as well, but we can't be sur

So how does time just get lost? The ***Mate***™ Display Controller is not a precision time piece. It tries to produce once a second, but over the course of 86,400 seconds in a day, even a tiny error can creep in. In addition, the Display Controller skips records when it receives a command or a button is pressed. The EPD files don't conta accurate time information, so they have no way of accurately noting which records were lost and when.

When a battery voltage isn't a battery voltage

If you think this is merely an academic exercise, in December, 2009 a problem with the accuracy of the *FLEX* data arose. From time to time, -25.6 amp values were being recorded for one of an *OutBack Power Systems'* customer's shunts. I've seen similar odd behavior, and thought very little of it. Until I reviewed the December p logs for my own system and saw a 25.6 volt battery value, along with a 76.7 volt value. Fortunately, because *greenMonitor* software ***does*** store all of the data, I was able to locate the exact records. With *Version 1.00.6* approaching General Availability, I'd also been running *WattPlot* to verify that the two products remained com 8:48 pm, December 25th 2009, the *FLEXnet DC* on my system recorded a 25.6 volt reading. What did *WattPl*

```
"DC-4","25 Dec 20:48 to 20:48"

"? shunt","? shunt","? shunt","Batt VDC","Batt SOC","Batt Temp","Time"

0.2,-0.1,-0.1,51.2,100,15,20:48
0.1,-0.1,-0.1,51.2,100,15,20:48
0.1,-0.1,-0.1,51.2,100,15,20:48
0.1,-0.1,-0.2,51.2,100,15,20:48
0.1,-0.1,-0.2,51.1,100,15,20:48
0.1,-0.1,-0.1,51.2,100,15,20:48
0.1,-0.1,-0.1,51.2,100,15,20:48
0.0,-0.1,-0.2,51.2,100,15,20:48
0.1,-0.1,-0.1,51.1,100,15,20:48
0.1,-0.2,-0.2,51.2,100,15,20:48
0.1,-0.1,-0.1,43.1,100,15,20:48
0.1,-0.1,-0.1,43.1,100,15,20:48
0.1,-0.1,-0.1,51.1,100,15,20:48
0.2,-0.1,-0.2,51.2,100,15,20:48
0.1,-0.1,-0.1,51.2,100,15,20:48
0.1,-0.1,-0.1,51.2,100,15,20:48
0.2,0.0,-0.1,51.2,100,15,20:48
0.0,-0.2,-0.2,51.1,100,15,20:48
```

With *WattPlot*, the problem is masked because *WattPlot* ***does not store the actual data***, in spite of their mar claims that they do. The only way to store the actual data is to use the uncompressed OBM file format, which very large amounts of disk storage. The data stored in the EPD file is inaccurate and incomplete.

What did *greenMonitor* record?

```
12/25/2009 20:48:26|1,00,00,02,123,122,00,10,000,02,512,024,000,031
12/25/2009 20:48:26|2,00,00,01,124,123,00,10,000,02,512,024,000,033
12/25/2009 20:48:26|D,00,00,00,021,121,00,00,000,00,512,219,000,047
12/25/2009 20:48:26|d,0001,0002,0002,07,00098,512,100,000,50,15,101
12/25/2009 20:48:27|1,00,00,02,123,122,00,10,000,02,512,024,000,031
12/25/2009 20:48:27|2,00,00,01,124,123,00,10,000,02,512,024,000,033
12/25/2009 20:48:27|D,00,00,00,021,121,00,00,000,00,512,219,000,047
12/25/2009 20:48:27|d,0001,0001,0001,08,00219,256,100,000,50,15,100
12/25/2009 20:48:28|1,00,00,02,123,122,00,10,000,02,512,024,000,031
12/25/2009 20:48:28|2,00,00,01,124,123,00,10,000,02,512,024,000,033
12/25/2009 20:48:28|D,00,00,00,021,121,00,00,000,00,512,219,000,047
12/25/2009 20:48:28|d,0001,0001,0001,09,00206,256,100,000,50,15,097
12/25/2009 20:48:29|1,00,00,02,123,122,00,10,000,02,512,024,000,031
12/25/2009 20:48:29|2,00,00,01,124,123,00,10,000,02,512,024,000,033
12/25/2009 20:48:29|D,00,00,00,021,121,00,00,000,00,512,219,000,047
12/25/2009 20:48:29|d,0001,0001,0001,10,01197,511,100,000,50,15,093
```

There it is -- every single bit of data, something *Intallact* claims to do, but doesn't. Using our compressed data each days' timestamped, accurate and complete data doesn't require almost 17MB of disk storage, as it would with *WattPlot*, it only required 1.2MB, a compression rate of approximately 93%.

A System Failure *WattPlot* Missed

My own system is two-and-a-half years old now, and the cabinet cooling fan recently died. I've been busy wo clients on their systems, as well as getting a bit of Spring lawn and garden work handled here at the house ar procrastinated on replacing the fan. ***BIG*** mistake. Renewable energy systems need to be cared for when you monitoring software first reports an error, and perhaps I need to treat myself more like a client of *greenHouse Computers* and less like the owner of the company. The result -- at 17:00:18 on March 26, 2010, the slave in again reported a "Communications Error". The master inverter had stopped communicating with the *Hub 10* i cabinet. This is not an error that should be ignored, or that your monitoring software should fail to log.

```
03/26/2010 17:00:18: Inverter 'Slave': Operating mode is now 'Comm Error'
```

What did *WattPlot* do? ***NOTHING!***

```
10/03/27 00:22:32              ** Communications timed-out but TCP link OK - will wait
10/03/26 17:03:23              TCP/IP connection closed by MATE server: 192.168.0.1
10/03/26 01:00:39       DC-4   WARNING: 'Midnight' reset at 01:00 AM - Check MATE clock settir
```

It's hard for me to imagine that any software product which makes such a big deal about "saving every bit" of completely misses such a critical error, but it did. *WattPlot* can detect that I didn't change the *Mate* for Daylight Time (we don't make that check because our software is network enabled and the time where the system is lo differ by up to 23 hours from where the system is being monitored), but it cannot detect that a complete syste about to happen? That's simply unacceptable.

What did *WattPlot* record in the EPD file?

```
"FX-2","26 Mar  17:00 to 17:03"

"FX Mode","Inverter Amps","Charger Amps","Buy Amps","Sell Amps","AC Input","AC Output","Batt VI

"Inv/Pass Thru, Using AC",0,0,0,0,123,123,54.4,17:00
"Inv/Pass Thru, Using AC",0,0,0,0,123,123,54.4,17:00
"Inv/Pass Thru, Using AC",0,0,0,0,123,123,54.4,17:00
"??, Using AC",0,0,0,0,123,123,54.4,17:03
"??, Using AC",0,0,0,0,123,123,54.4,17:03
"??, Using AC",0,0,0,0,123,123,54.4,17:03
```

There isn't even enough information to know what the "??" means. It turns out that it means *WattPlot* has no records are received, because the *Hub 10* completely stopped sending data at 17:00:41, just 23 seconds afte initial *Comm Error* was received.

What did *greenMonitor's gmServer* command record?

```
03/26/2010 17:00:18|2,00,00,00,123,123,00,92,000,02,544,152,000,048
03/26/2010 17:00:18|D,00,22,16,082,156,00,00,000,02,548,283,000,085
03/26/2010 17:00:18|d,0223,0215,0003,07,00099,547,099,000,50,37,144
```

The "92" is the value indicating a "Comm Error". And if you look, you'll see that there was no record for the m inverter. In fact, over the next 30 seconds, the *Hub 10* would slowly stop sending data to the ***Mate*** display co the other devices in the system, first losing the master *GVFX 3648*, then the *FLEXnet DC*, then the *MX-60*, ur slave inverter was reported, followed by it no longer being reported either.

```
03/26/2010 17:00:31|2,00,00,00,123,123,00,92,000,02,544,152,000,048
03/26/2010 17:00:31|D,00,22,16,082,156,00,00,000,02,548,283,000,085
03/26/2010 17:00:31|d,0223,0215,0003,06,00003,547,099,000,50,37,128
03/26/2010 17:00:34|2,00,00,00,123,123,00,92,000,02,544,152,000,048
03/26/2010 17:00:34|D,00,22,16,082,156,00,00,000,02,548,283,000,085
03/26/2010 17:00:34|d,0223,0215,0003,07,00099,547,099,000,50,37,144
03/26/2010 17:00:35|2,00,00,00,123,123,00,92,000,02,544,152,000,048
03/26/2010 17:00:35|D,00,22,16,082,156,00,00,000,02,548,283,000,085
03/26/2010 17:00:35|d,0223,0215,0003,08,00281,547,099,000,50,37,138
03/26/2010 17:00:35|2,00,00,00,123,123,00,92,000,02,544,152,000,048
03/26/2010 17:00:35|D,00,22,16,082,156,00,00,000,02,548,283,000,085
03/26/2010 17:00:35|d,0223,0215,0003,09,00272,547,099,000,50,37,139
03/26/2010 17:00:37|2,00,00,00,123,123,00,92,000,02,544,152,000,048
03/26/2010 17:00:37|D,00,22,16,082,156,00,00,000,02,548,283,000,085
03/26/2010 17:00:37|d,0223,0215,0003,10,01532,547,099,000,50,37,131
03/26/2010 17:00:37|2,00,00,00,123,123,00,92,000,02,544,152,000,048
```

```
03/26/2010 17:00:37|D,00,22,16,082,156,00,00,000,02,548,283,000,085
03/26/2010 17:00:37|d,0223,0215,0003,11,01478,547,099,000,50,37,141
03/26/2010 17:00:39|2,00,00,00,123,123,00,92,000,02,544,152,000,048
03/26/2010 17:00:39|D,00,22,16,082,156,00,00,000,02,548,283,000,085
03/26/2010 17:00:39|2,00,00,00,123,123,00,92,000,02,544,152,000,048
03/26/2010 17:00:39|D,00,22,16,082,156,00,00,000,02,548,283,000,085
03/26/2010 17:00:41|2,00,00,00,123,123,00,92,000,02,544,152,000,048
03/26/2010 17:00:41|2,00,00,00,123,123,00,92,000,02,544,152,000,048
```

For nearly 30 seconds the ***Mate*** display controller was reporting a "Comm Error" and *WattPlot* never once rep error.

Having robust data capture and playback is needed for problem determination by system maintenance perso also critical for your software developer to have this information so that we can determine how systems perfo seconds before complete failure. At *greenHouse Gas and Electric*, we have the tools for you to detect these errors. At *Intallact*, they ***DON'T***.

When diagnosis is impossible

We recently encountered an *OutBack Power Systems* and *WattPlot* customer that was having a problem with *FLEXnet DC* battery monitor. For some reason, the *FLEXnet DC* was reporting a decline in state of charge o course of the day. The customer performed a fairly extensive data analysis on the shunt values and state of then concluded that the *FLEXnet DC* was using some incorrect model. I asked for the raw data, assuming th had used that to produce the charts, and they instead provided processed data.

After much struggling to convince the customer to send raw data for analysis, they finally sent a CSV output fi *WattPlot* -- the "raw data" format, as *Intallact* calls it.

The important fields are missing from the *FLEXnet DC* EPD file. The only data that are recorded are the thre values, battery voltage and temperature, and the state of charge. What I was looking for is the cumulative da shunts, as well as the total values. The problem is that *WattPlot* doesn't record that data, and without that da impossible to determine if the values are being computed correctly.

I decided that the only way to determine if their *FLEXnet DC* was working correctly was to load the CSV file in spreadsheet and add up the values myself.

Several deficiencies in *WattPlot* contributed to making the problem harder to diagnose than it would have bee *greenMonitor* software. The first is a lack of complete system data. The *FLEXnet DC* EPD file doesn't contai "Extra Data" values that are provided by the *Mate*. The second is poor minimum resolution on the *FLEXnet D* plot. With a minimum resolution of +/- 500 watts, the *FLEXnet DC* pen plot doesn't show systematic errors in values very well. Very low values for a shunt is shown in *WattPlot* as a fuzzy line with poor resolution, but is all of its detail on a *greenMonitor* battery monitor plot.

I eventually concluded that the customer's problems were caused by having a too small battery bank, as well amp error in shunt "A". It was definitely a learning experience, and worth all the time and energy it took, even customer rejected my analysis because of the conflict between *Intallact* and *greenHouse Gas and Electric*.

When being more accurate isn't

One of the first features we helped *Intallact* implement was the voltage and amperage truncation feature. The implemented the feature is a classic example of why you should get your technology from the source, rather t copycat.

The idea behind correcting for amperage truncation is simple enough -- the Mate display controller has a reso amp for many fields. Testing for a new compatibility feature we learned that WattPlot isn't even keeping up wi kilowatt-hour value reported by the charge controllers. Determined to figure out the cause of the discrepancy that WattPlot is simply adding 0.5 to every value that is truncated to a whole number, regardless of the recent history for the device. WattPlot might as well just add 43,200 amp-seconds for each device at the end of the amp-seconds for each of the 86,400 seconds of the day the device is operating.

After three and a half years of wrestling with this problem, we've released two different solutions to the proble

inaccurate current resolution. The first solution combines data from the *FLEXnet DC* battery monitor and inve calculate the inverter output. The second solution uses third party products to measure input and output AC c Whatever is left over must be inverter current. With these solutions we are able to detect current changes as 0.05 amps AC, *20 times more accurate* than the AC current resolution of *WattPlot*.

Note: We now support Revenue Grade watt-hour meters which may also be integrated with your *greenMonito* software, providing the same level of accuracy as the electric utility uses.