The commands summary of Smart-meters and Switches using in the SinBerBEST BIMG Test-Bedding

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This document presents the sub-sets of commands summary to help the engineers of the SinBerBEST BIMG Test-Bedding software development facilitating the communication programming of the smart-meters. To be concise, it is focused on the specific commands of the smart-meters that are used for the BIMG Test-Bedding data collecting and controlling, the command execution order in the smart-meters data collecting and controlling as well as the notices in the BIMG Test-Bedding control processes. The detailed commands explanations please refer to the relevant manuals (in the attached documents).

As the control commands are still undergoing the integration-test in the BIMG Test-Bedding dry lab, this document is only a draft and may be amended or extended later.

Chapter 1: Smart-meter SENTRON PAC3200

The smart-meters deployed in the SinBerBEST BIMG Test-Bedding AC bus side are SENTRON PAC3200, which are 380 V three-phase power monitoring device using for AC grid.

At present, the BIMG server communicates with PAC3200 by means of Ethernet (LAN, i.e. RJ45). The control commands of PAC3200 are a sub-set of Mod-Bus TCP standard.

1. Communication work principal

When PAC3200 is power on, it starts up with self-initialization process. After that, it automatically goes into slave mode and waits for the BIMG server sending request command. Each time the PAC3200 receiving a correct request, it returns a response to the BIMG server. So the data collecting rate depends on the BIMG server rather than PAC3200. Usually, the data collecting rate is no more than 1.5 per (request & response round) /second. If the data collecting rate is too fast for a PAC3200, it may cause jam inside the PAC3200.

2. The communication protocol of PAC3200 using in the SinBetBEST BIMG Test-Bedding

When PAC3200 is powered on, it starts up with self-initialization process. After that process, it automatically goes into slave mode and waits for the BIMG server, which is working in master mode, sending request command. Each time the PAC3200 receiving a correct request, it returns a response. So the data collecting rate depends on the BIMG server rather than PAC3200. Usually, the data collecting rate is no more than 1.5 per request & response round /second. If the data collecting rate is too fast for a PAC3200, it may cause a jam inside the PAC3200.

At present, the SinBerBEST BIMG Test-Bedding employs a very basic communication protocol of PAC3200 and the protocol will be extended later. There are two query commands only:

Query command 1: Normal data query

The request command in Java format is:

```
byte[] requestTimerRefreshArray = new byte[]{86,80,0,0,0,6,(byte)255,03,0,01,0,70};
```

(detailed request command explanation please see the document of Mod-Bus standard)

This request command is to retrieve the data in the following table (note: the response of PAC3200 is a byte[]; the table only lists the useful data in the byte[]):

Offset	Bytes	Name	Format	Unit	Value range	Access
1*2+7	2*2	Voltage Va-n	Float	V	-	R
3*2+7	2*2	Voltage Vb-n	Float	V	-	R
5*2+7	2*2	Voltage Vc-n	Float	V	-	R
7*2+7	2*2	Voltage Va-b	Float	V	-	R
9*2+7	2*2	Voltage Vb-c	Float	V	-	R
11*2+7	2*2	Voltage Vc-a	Float	V	-	R
13*2+7	2*2	Current a	Float	A	-	R
15*2+7	2*2	Current b	Float	A	-	R
17*2+7	2*2	Current c	Float	A	-	R
19*2+7	2*2	Apparent Power a	Float	VA	-	R
21*2+7	2*2	Apparent Power b	Float	VA	-	R
23*2+7	2*2	Apparent Power c	Float	VA	-	R
25*2+7	2*2	Active Power a	Float	W	-	R
27*2+7	2*2	Active Power b	Float	W	-	R
29*2+7	2*2	Active Power c	Float	W	-	R
31*2+7	2*2	Reactive Power a	Float	var	-	R
33*2+7	2*2	Reactive Power b	Float	var	-	R
35*2+7	2*2	Reactive Power c	Float	var	-	R
37*2+7	2*2	Power Factor a	Float	-	0 ... 1	R
39*2+7	2*2	Power Factor b	Float	-	0 ... 1	R
41*2+7	2*2	Power Factor c	Float	-	0 ... 1	R
43*2+7	2*2	THD-R Voltage a	Float	%	0 ... 100	R
45*2+7	2*2	THD-R Voltage b	Float	%	0 ... 100	R
47*2+7	2*2	THD-R Voltage c	Float	%	0 ... 100	R
49*2+7	2*2	THD-R Current a	Float	%	0 ... 100	R
51*2+7	2*2	THD-R Current b	Float	%	0 ... 100	R
53*2+7	2*2	THD-R Current c	Float	%	0 ... 100	R
55*2+7	2*2	Frequency	Float	Hz	45 ... 65	R
57*2+7	2*2	Average Voltage Vph-n	Float	V	-	R
59*2+7	2*2	Average Voltage Vph-ph	Float	V	-	R
61*2+7	2*2	Average Current	Float	A	-	R
63*2+7	2*2	Total Apparent Power	Float	VA	-	R
65*2+7	2*2	Total Active Power	Float	W	-	R
67*2+7	2*2	Total Reactive Power	Float	var	-	R
69*2+7	2*2	Total Power Factor	Float		-	R

Query command 2: Energy data query

The request in Java format is:

```java
byte[] requestTimerEnergyArray = new byte[]{87,87,0,0,0,6,(byte)255,03,3,33,0,40};
```

(detailed request command explanation please see the document of Mod-Bus standard)

This request command is to retrieve the data in the following table (note: the response of PAC3200 is a byte[]; the table only lists the useful data in the byte[]):

Offset	Bytes	Name	Format	Unit	Value range	Access
2*(801-801)+9	4*2	Active Energy Import Tariff 1	Double	Wh	Overflow 1.0e+12	RW
2*(805-801)+9	4*2	Active Energy Import Tariff 2	Double	Wh	Overflow 1.0e+12	RW
2*(809-801)+9	4*2	Active Energy Export Tariff 1	Double	Wh	Overflow 1.0e+12	RW
2*(813-801)+9	4*2	Active Energy Export Tariff 2	Double	Wh	Overflow 1.0e+12	RW
2*(817-801)+9	4*2	Reactive Energy Import Tariff 1	Double	varh	Overflow 1.0e+12	RW
2*(821-801)+9	4*2	Reactive Energy Import Tariff 2	Double	varh	Overflow 1.0e+12	RW
2*(825-801)+9	4*2	Reactive Energy Export Tariff 1	Double	varh	Overflow 1.0e+12	RW
2*(829-801)+9	4*2	Reactive Energy Export Tariff 2	Double	varh	Overflow 1.0e+12	RW
2*(833-801)+9	4*2	Apparent Energy Tariff 1	Double	VAh	Overflow 1.0e+12	RW
2*(837-801)+9	4*2	Apparent Energy Tariff 2	Double	VAh	Overflow 1.0e+12	RW

To better understanding the above request commands of PAC3200, the available measured variables of SENTRON PAC3200 are listed in table below:

Available measured variables of SENTRON PAC3200

Offset	Number of registers	Name	Format	Unit	Value range	Access
1	2	Voltage Va-n	Float	V	-	R
3	2	Voltage Vb-n	Float	V	-	R
5	2	Voltage Vc-n	Float	V	-	R
7	2	Voltage Va-b	Float	V	-	R
9	2	Voltage Vb-c	Float	V	-	R
11	2	Voltage Vc-a	Float	V	-	R
13	2	Current a	Float	A	-	R
15	2	Current b	Float	A	-	R
17	2	Current c	Float	A	-	R
19	2	Apparent Power a	Float	VA	-	R
21	2	Apparent Power b	Float	VA	-	R
23	2	Apparent Power c	Float	VA	-	R
25	2	Active Power a	Float	W	-	R
27	2	Active Power b	Float	W	-	R
29	2	Active Power c	Float	W	-	R
31	2	Reactive Power a	Float	var	-	R
33	2	Reactive Power b	Float	var	-	R
35	2	Reactive Power c	Float	var	-	R
37	2	Power Factor a	Float	-	0 ... 1	R
39	2	Power Factor b	Float	-	0 ... 1	R

41	2	Power Factor c	Float	-	0 ... 1	R
43	2	THD-R Voltage a	Float	%	0 ... 100	R
45	2	THD-R Voltage b	Float	%	0 ... 100	R
47	2	THD-R Voltage c	Float	%	0 ... 100	R
49	2	THD-R Current a	Float	%	0 ... 100	R
51	2	THD-R Current b	Float	%	0 ... 100	R
53	2	THD-R Current c	Float	%	0 ... 100	R
55	2	Frequency	Float	Hz	45 ... 65	R
57	2	Average Voltage Vph-n	Float	V	-	R
59	2	Average Voltage Vph-ph	Float	V	-	R
61	2	Average Current	Float	A	-	R
63	2	Total Apparent Power	Float	VA	-	R
65	2	Total Active Power	Float	W	-	R
67	2	Total Reactive Power	Float	var	-	R
69	2	Total Power Factor	Float		-	R
71	2	Amplitude Unbalance - Voltage	Float	%	0 ... 100	R
73	2	Amplitude Unbalance - Current	Float	%	0 ... 200	R
75	2	Maximum Voltage Va-n	Float	V	-	R
77	2	Maximum Voltage Vb-n	Float	V	-	R
79	2	Maximum Voltage Vc-n	Float	V	-	R
81	2	Max. Voltage Va-b	Float	V	-	R
83	2	Max. Voltage Vb-c	Float	V	-	R
85	2	Max. Voltage Vc-a	Float	V	-	R
87	2	Maximum Current a	Float	A	-	R
89	2	Maximum Current b	Float	A	-	R
91	2	Maximum Current c	Float	A	-	R
93	2	Maximum Apparent Power a	Float	VA	-	R
95	2	Maximum Apparent Power b	Float	VA	-	R
97	2	Maximum Apparent Power c	Float	VA	-	R
99	2	Maximum Active Power a	Float	W	-	R
101	2	Maximum Active Power b	Float	W	-	R
103	2	Maximum Active Power c	Float	W	-	R
105	2	Maximum Reactive Power a	Float	var	-	R
107	2	Maximum Reactive Power b	Float	var	-	R
109	2	Maximum Reactive Power c	Float	var	-	R
111	2	Maximum Power Factor a	Float		0 ... 1	R
113	2	Maximum Power Factor b	Float		0 ... 1	R
115	2	Maximum Power Factor c	Float		0 ... 1	R
117	2	Maximum THD-R Voltage a	Float	%	0 ... 100	R
119	2	Maximum THD-R Voltage b	Float	%	0 ... 100	R
121	2	Maximum THD-R Voltage c	Float	%	0 ... 100	R
123	2	Maximum THD-R Current a	Float	%	0 ... 100	R
125	2	Maximum THD-R Current b	Float	%	0 ... 100	R
127	2	Maximum THD-R Current c	Float	%	0 ... 100	R
129	2	Max. Frequency	Float	Hz	45 ... 65	R
131	2	Max. Average Voltage Vph-n	Float	V	-	R
133	2	Max. Average Voltage Vph-ph	Float	V	-	R
135	2	Max. Average Current	Float	A	-	R
137	2	Max. Total Apparent Power	Float	VA	-	R
139	2	Max. Total Active Power	Float	W	-	R
141	2	Max. Total Reactive Power	Float	var	-	R
143	2	Maximum Total Power Factor	Float		-	R
145	2	Minimum Voltage Va-n	Float	V	-	R

147	2	Minimum Voltage Vb-n	Float	V	-	R
149	2	Minimum Voltage Vc-n	Float	V	-	R
151	2	Min. Voltage Va-b	Float	V	-	R
153	2	Min. Voltage Vb-c	Float	V	-	R
155	2	Min. Voltage Vc-a	Float	V	-	R
157	2	Minimum Current a	Float	A	-	R
159	2	Minimum Current b	Float	A	-	R
161	2	Minimum Current c	Float	A	-	R
163	2	Minimum Apparent Power a	Float	VA	-	R
165	2	Minimum Apparent Power b	Float	VA	-	R
167	2	Minimum Apparent Power c	Float	VA	-	R
169	2	Minimum Active Power a	Float	W	-	R
171	2	Minimum Active Power b	Float	W	-	R
173	2	Minimum Active Power c	Float	W	-	R
175	2	Minimum Reactive Power a	Float	var	-	R
177	2	Minimum Reactive Power b	Float	var	-	R
179	2	Minimum Reactive Power c	Float	var	-	R
181	2	Minimum Power Factor a	Float	-	0 ... 1	R
183	2	Minimum Power Factor b	Float	-	0 ... 1	R
185	2	Minimum Power Factor c	Float	-	0 ... 1	R
187	2	Min. Frequency	Float	Hz	45 ... 65	R
189	2	Min. Average Voltage Vph-n	Float	V	-	R
191	2	Min. Average Voltage Vph-ph	Float	V	-	R
193	2	Min. Average Current	Float	A	-	R
195	2	Min. Total Apparent Power	Float	VA	-	R
197	2	Min. Total Active Power	Float	W	-	R
199	2	Min. Total Reactive Power	Float	var	-	R
201	2	Minimum Total Power Factor	Float	var	-	R
203	2	Limit Violations*	Unsigned long	-	Byte 3 Bit 0 Limit 0	R
205	2	Device Diagnostics and Device Status*	Unsigned long	-	Byte 0 System status	R
207	2	Status of the digital outputs*	Unsigned long	-	Byte 3 Bit 0 Output 0	R
209	2	Status of the digital inputs*	Unsigned long	-	Byte 3 Bit 0 Input 0	R
211	2	Active Tariff	Unsigned long	-	0 = Tariff 1 1 = Tariff 2	R
213	2	Working hours counter	Unsigned long	s	0 ... 999999999	RW
215	2	Universal counter	Unsigned long	-	0 ... 999999999	RW
217	2	Relevant Parameter Changes Counter	Unsigned long	-	-	R
219	2	Counter All Parameter Changes	Unsigned long	-	-	R
221	2	Counter Limit Violations	-	-	-	R
501	2	Demand Active Power - Import	Float	W	-	R
503	2	Demand Reactive Power - Import	Float	var	-	R
505	2	Demand Active Power - Export	Float	W	-	R
507	2	Demand Reactive Power - Export	Float	var	-	R
509	2	Maximum Active Power Reading during the period	Float	W	-	R

511	2	Minimum Active Power Reading during the period	Float	W	-	R
513	2	Maximum Reactive Power Reading during the period	Float	var	-	R
515	2	Minimum Reactive Power Reading during the period	Float	var	-	R
517	2	Demand Period	Unsigned long	s	-	R
519	2	Time Since Start of the active demand period	Unsigned long	s	-	R
801	4	Active Energy Import Tariff 1	Double	Wh	Overflow 1.0e+12	RW
805	4	Active Energy Import Tariff 2	Double	Wh	Overflow 1.0e+12	RW
809	4	Active Energy Export Tariff 1	Double	Wh	Overflow 1.0e+12	RW
813	4	Active Energy Export Tariff 2	Double	Wh	Overflow 1.0e+12	RW
817	4	Reactive Energy Import Tariff 1	Double	varh	Overflow 1.0e+12	RW
821	4	Reactive Energy Import Tariff 2	Double	varh	Overflow 1.0e+12	RW
825	4	Reactive Energy Export Tariff 1	Double	varh	Overflow 1.0e+12	RW
829	4	Reactive Energy Export Tariff 2	Double	varh	Overflow 1.0e+12	RW
833	4	Apparent Energy Tariff 1	Double	VAh	Overflow 1.0e+12	RW
837	4	Apparent Energy Tariff 2	Double	VAh	Overflow 1.0e+12	RW

Abbr. in the "Access" column	Abbreviation
R	Read; read access
W	Write; write access
RW	Read and Write; read and write access

Chapter 2: DC-meter AcuDC243

The DC-meters deployed in the SinBerBEST BIMG Test-Bedding DC bus side are DC-meter AcuDC243, which are 380 VDC power monitoring device using for DC grid.

At present, the BIMG server dose not directly link with AcuDC243 but through Raspberry PI. The Raspberry PI connects with the AcuDC243 using its USB/SPI interface and the communication protocol of AcuDC243 in using is the Mod-Bus RTU (a version for serial port communication protocol standard). Mod-Bus RTU is relatively complicated as it needs to deal with the CRC communication error check as well as other issues. However, these tasks have been done in the firmware/software of Raspberry PI.

The BIMG server links with the Raspberry PI by means of Ethernet (LAN, i.e. RJ45) or WiFi. And the communication protocol is derived and simplified based on the Mod-Bus RTU protocol in the AcuDC243 user’s manual.

1. Data Query

Query command1: Normal data query

The request command in Java format is:

```java
byte[] requestTimerRefreshArray = new byte[]{1,3,2,0,0,20,0,0};
```

(detailed request command explanation please see the document of Mod-Bus RTU standard)

This request command is to retrieve the data in the following response byte[]:

Offset	Bytes	Name	Format	Unit	Value range	Access
0	3	Reserved (Adr,Fun,CT)	-	-	-	-
3	4	Voltage	Float	V	5~1200	R
7	4	Current	Float	A	20~5000	R
11	4	Power	Float	kW/100	-	R
15	4	Reserved	-	-	-	R
19	4	Reserved	-	-	-	R
23	2	Reserved (CRC)				

Query command 2: Energy data query

The request in Java format is:

```java
byte[] requestTimerEnergyArray = new byte[]{1,3,3,0,0,16,0,0};
```

(detailed request command explanation please see the document of Mod-Bus RTU standard)

This request command is to retrieve the data in the following response byte[]:

Offset	Bytes	Name	Format	Unit	Value range	Access
0	3	Reserved (Adr,Fun,CT)	-	-	-	-
3	4	Export Energy	Long	kWh/100	0~999999999	R
7	4	Import Energy	Long	kWh/100	0~999999999	R
11	4	Total Energy	Long	kWh/100	0~999999999	R
15	4	Net Energy	Long	kWh/100	0~999999999	R
19	2	Reserved (CRC)				

Query command 3: Time running query

The request in Java format is:

```java
byte[] requestTimerRunningArray = new byte[]{1,3,2,0x80,0,8,0,0};
```

(detailed request command explanation please see the document of Mod-Bus RTU standard)

This request command is to retrieve the data in the following response byte[]:

Offset	Bytes	Name	Format	Unit	Value range	Access
0	3	Reserved (Adr,Fun,CT)	-	-	-	-
3	4	Meter Running Time	Long	Hour/100	0~999999999	R
7	4	Load Running Time	Long	Hour/100	0~999999999	R
11	2	Reserved (CRC)				

2. Switch Monitoring and Relay Control

Being integrated with the DC-meter AcuDC243, the Raspberry PI also can implement the switch monitoring and relay control function on the DC grid node (or branch) in which the DC-meter AcuDC243 is sited.

Query command1: Switch monitoring query

The request command in Java format is:

```java
byte[] requestSwitchStatusArray = new byte[]{1,2,0,0,0,2,0,0};
```

(detailed request command explanation please see the document of Mod-Bus RTU standard)

This request command is to retrieve the data in the following response byte[]:

Offset	Bytes	Name	Format	Unit	Value range	Access
0	3	Reserved (Adr,Fun,CT)	-	-	-	-
3	1	Switch Status	bit	-	0—Switch1 off, Switch2 off; 1—Switch1 on, Switch2 off; 2—Switch1 off, Switch2 on; 3—Switch1 on, Switch2 on; Other values—reserved	R
4	2	Reserved (CRC)				

Query command2: Relay status query

The request command in Java format is:

```java
byte[] requestRelayStatusArray = new byte[]{1,1,0,0,0,2,0,0};
```

(detailed request command explanation please see the document of Mod-Bus RTU standard)

This request command is to retrieve the data in the following response byte[]:

Offset	Bytes	Name	Format	Unit	Value range	Access
0	3	Reserved (Adr,Fun,CT)	-	-	-	-
3	1	Relay Status	bit	-	0—Relay1 off, Relay 2 off; 1— Relay 1 on, Relay 2 off; 2— Relay 1 off, Relay 2 on; 3— Relay 1 on, Relay 2 on; Other values—reserved	R
4	2	Reserved (CRC)				

Control command: Relay control commands

There are four relay control commands. These are (in Java format)

- **Relay1 off and Relay2 off:**

```
byte[] requestRelayControlOffOffArray = new byte[]{1,5,0,0,0,0,0,0};
```

- **Relay1 on and Relay2 off:**

```
byte[] requestRelayControlOffOffArray = new byte[]{1,5,0,0,0,0xff,0,0};
```

- **Relay1 off and Relay2 on:**

```
byte[] requestRelayControlOffOffArray = new byte[]{1,5,0,0,0xff,0,0,0};
```

- **Relay1 on and Relay2 on:**

```
byte[] requestRelayControlOffOffArray = new byte[]{1,5,0,0,0xff,0xff,0,0};
```

(detailed request command explanation please see the document of Mod-Bus RTU standard)

Chapter 3: Switch (or AC Contactor) Monitoring and Relay Control

In the SinBerBEST BIMG Test-Bedding, all of the switches (or AC contactor) and relays control are implemented by Remote Control Unit (RTU) other than directly link with the BIMG server. At present, the RTU is developed on Raspberry PI B which supports communication media in Ethernet (LAN, i.e. RJ45) and WiFi. To simplify design, the communication protocol of the RTU is derived and simplified based on the Mod-Bus RTU, (which is same to the previous chapter).

Query command1: Switch monitoring query

The request command in Java format is:

```
byte[] requestSwitchStatusArray = new byte[]{1,2,0,0,0,2,0,0};
```

(detailed request command explanation please see the document of Mod-Bus RTU standard)

This request command is to retrieve the data in the following response byte[]:

Offset	Bytes	Name	Format	Unit	Value range	Access
0	3	Reserved (Adr,Fun,CT)	-	-	-	-
3	1	Switch Status	bit	-	0—Switch1 off, Switch2 off; 1—Switch1 on, Switch2 off; 2—Switch1 off, Switch2 on; 3—Switch1 on, Switch2 on; Other values—reserved	R
4	2	Reserved (CRC)				

Query command2: Relay status query

The request command in Java format is:

```
byte[] requestRelayStatusArray = new byte[]{1,1,0,0,0,2,0,0};
```

(detailed request command explanation please see the document of Mod-Bus RTU standard)

This request command is to retrieve the data in the following response byte[]:

Offset	Bytes	Name	Format	Unit	Value range	Access
0	3	Reserved (Adr,Fun,CT)	-	-	-	-
3	1	Relay Status	bit	-	0—Relay1 off, Relay 2 off; 1— Relay 1 on, Relay 2 off; 2— Relay 1 off, Relay 2 on; 3— Relay 1 on, Relay 2 on; Other values—reserved	R
4	2	Reserved (CRC)				

Control command: Relay control commands

There are four relay control commands. These are (in Java format)

- **Relay1 off and Relay2 off:**

```
byte[] requestRelayControlOffOffArray = new byte[]{1,5,0,0,0,0,0,0};
```

- **Relay1 on and Relay2 off:**

```
byte[] requestRelayControlOffOffArray = new byte[]{1,5,0,0,0,0xff,0,0};
```

- **Relay1 off and Relay2 on:**

```
byte[] requestRelayControlOffOffArray = new byte[]{1,5,0,0,0xff,0,0,0};
```

- **Relay1 on and Relay2 on:**

```
byte[] requestRelayControlOffOffArray = new byte[]{1,5,0,0,0xff,0xff,0,0};
```

(detailed request command explanation please see the document of Mod-Bus RTU standard)