SIC824B

Bluetooth Potentiostat Module

REV 1.1

Features Summary

Potentiostat

- **Electrode Connection**
  - 3-electrode system: 1xWE, 1xRE, 1xCE
- **Biasing Potential**
  - 3 selectable ranges
    - -1.6V to 0V
    - -0.8V to +0.8V
    - 0V to +1.6V
  - Resolution: 5 mV/step
- **Current Input Range**
  - Customized by hardware fix. (maximum ± 500 µA)
- **Data Conversion**
  - Minimum sampling period 20 ms
  - Resolution: up to 16-bit
  - Accuracy: ± 0.1% of current range
- **Compatible Analysis Techniques**
  - Open Circuit Potential (OCP)
  - Voltammetry
  - Amperometry
  - Compliance voltage ± 2.2 to ± 3V (V_{WE} - V_{CE})

Components

- Voltammetry controller
- Regulator
- Voltage Reference
- 8-Bit DACs
- 12-bit ADC up to 16-bit with hardware over sampling

Applications

- Chemical sensor
- Biosensor

Connectivity

- RF interface based on 2.4 GHz Bluetooth® 5.2 specification, IEEE 802.15.4-2011

Memory

1 MB flash memory

- 616 KB reserved memory for operation
- 8 KB reserved memory for calibration
- 376 KB free space for user memory

Operating Conditions

- 3.7V power supply (rechargeable battery)
- Operating temperature 0 to 50°C
- Storage temperature -20 to 60°C

Module Information

- **Battery:** > 320 mAh rechargeable battery
- **Charging Cable:** Micro USB
- **LED status**: Bluetooth connection, Measurement stage, Battery level
- **Delivery form**: Device size 90 mm x 40 mm x 18 mm
- **Connector Adapter**
  - 2 pcs of CN3: 2.54 mm pitch, maximum recommended electrode thickness is 0.3 mm

Revision History

Revision	Date	Change/Update Comment
1.0	9 Nov 2023	1st Release
1.1	13 Mar 2025	Update module image

Ordering information

Part No.	Description	Package	Standard Packing
SP-05	SIC824B Bluetooth Potentiostat module	PCB	1 set/ box

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0. Notation

0.1 Styles and Fonts for key words

This part defines styles and fonts used for the key words throughout this document. The key words are names of signal, register, pin, state of operation and command. The styles, fonts, and their indications are shown in Table 0-1.

Table 0-1: Style and Fonts key word

Symbol	Indication
Signal	Signal name
Register	Register name or Bit name
pin RX	Pin name
"State of Operation"	State of operation
Command	Command name for RF interface
"Flag"	Flag name in response state

- To refer to a register address and a value in a register, a hexadecimal number proceeding with letter "0x" is used, for example 0x0A.
- To refer to a bit located in a register address, a symbol "." following by a number reflecting the bit location starting from 0 to 7 is used. For example, 0x0A.0 refers to bit 0, least significant bit, in the register 0x0A.
- To refer to a set of consecutive bits located in a register address, a format ".[msb:lsb]" is used after a register value. For example, a value of 0x0A.[3:0] refers to bit 3 ,2, 1, and 0 in the register 0x0A.
- To refer to a binary value in some registers, the letter "b" is placed at the end of the binary number, for example "1010b".
- To refer to logic level, the number in single quote '1' and '0' are used to refer to binary logic level.

0.2 Abbreviation

Table 0-2: Abbreviation

Abbreviation	Term
ADC	Analog to digital converter
AFE	Analog-Front-End
ASK	Amplitude shift keying
CE	Counter Electrode (electrochemical analysis)
CMD	Command
CRC	Cyclic redundancy check
DAC	Digital to analog convertor
DBCC	Data Block Check Character
EEPROM	Electrically Erasable Programmable Read-Only Memory
FBCC	Frame Block Check Character
LSB	Least significant bit
MSB	Most significant bit
POR	Power on Reset
PWE	Pulse Width Encoding
RE	Reference Electrode (electrochemical analysis)
RF	Radio Frequency
Rx	Receiver
Tx	Transmitter
WE	Working Electrode (electrochemical analysis)

1. Functional Overview

SIC824B is a Portable Potentiostat module with Bluetooth® 5.2 designed for electrochemical measurement sensor. The module has 3 channels – Reference Electrode (RE), Counter Electrode (CE), Working Electrode (WE). The module is powered by battery.

1.1 Block Diagram

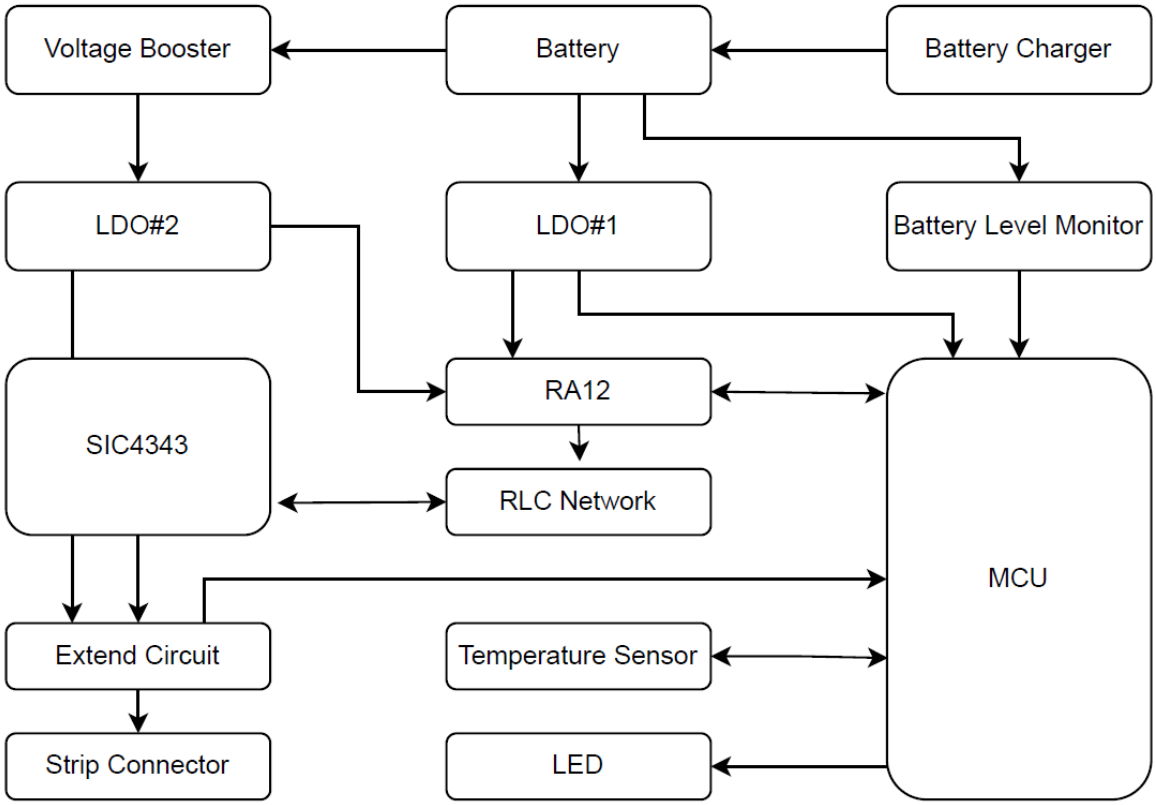


Figure 1-1: SIC824B block diagram

1.1.1 MCU

The microcontroller is dual-core MCUs with Bluetooth 5.2 support. The microcontroller (MCU) is responsible for controlling the system operations, monitoring the battery levels, and regulating the potentiostat flow. By receiving command from Bluetooth communication, the MCU is able to determine the battery levels and adjust the system and potentiostat flow accordingly. This critical role ensures that the system operates at optimal performance and prevents potential damage caused by low battery levels. Through its careful regulation of the potentiostat flow, the MCU helps to maintain stability and reliability, making it an essential component of the overall system's performance. Therefore, the MCU's ability to control the potentiostat flow is crucial to ensuring the system operates efficiently and effectively.

1.1.2 RA12 and RLC network

RA12 chip reader is designed for inter-communication between the MCU and SIC4343. The MCU uses high frequency 13.56 MHz and ISO1443A protocols to send and receive commands. The RLC network is used to emulate the RF network, enabling effective communication between the devices.

1.1.3 SIC4343 and extended circuit

SIC4343 and extended circuit are designed to control biasing voltage of SIC824B potentiostat module with 8-bit resolution. The module can bias in 3 voltage range which are 0 V to 1.6 V, -0.8 V to +0.8 V, -1.6 V to 0 V selectable in software.

1.1.4 Temperature sensor

A temperature sensor is used to measure the environmental temperature during the start and the end of operation.

1.1.5 Power supply

The primary power source for the system is a rechargeable Lithium-ion battery. The battery's power supply is regulated to ensure stable and reliable power delivery to the microcontroller (MCU), RA12, and to extend the system's range circuit.

1.2 Machine State Diagram

When no power is supplied the machine is in the ***"Power Off"*** state. When power is supplied the machine initialize the system and start Bluetooth advertising at ***"Start Advertise"*** state. Then immediately change state to ***"Wait Command"*** state. For normal operation, the state receiving command and changes to ***"Processing"*** state, if success then turn back into ***"Wait Command"***.

While error occurred the **"Error"** flag is raised, the ***Start Operate command*** is disabled until to flag was cleared. The **"Error"** flag could be clear under two conditions: First using ***Get Stop Operate*** command while in ***"Wait Command"*** state or, second use push wakeup Button to reset the **"Error"** flag. When the flag is reset its turn into ***"Wait Command"*** state again.

To disconnect or reconnect Bluetooth connection, the use can normally disconnect Bluetooth or simply push the Wakeup Button. The state will return to ***"Start Advertise"*** state ready for next connection. Please note that the state will automatically change into "***Wait Command***".

Last the machine also support power saving mode, for this machine it's called ***"Shutdown"*** state. When there is no activity[1] for the specific period which default at 60 seconds, the machine will automatically turn into power saving mode. Also, the user

[1] No Activity means that no Bluetooth connection, no advertising and no potentiostat operation.

can force shutdown[2] the machine by long pressing the wakeup button until RED LED is on.

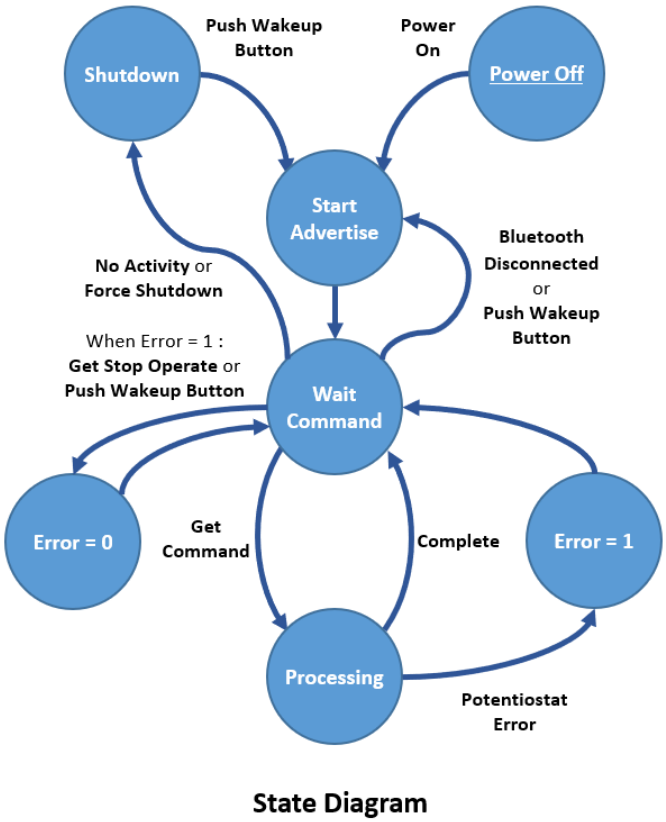


Figure 1-2 State Diagram

1.3 Firmware Upgrade

The SIC824B firmware is upgradable through USB. Please contact SIC's support team or sales team for further support <info@sic.co.th>

[2] Force Shutdown when long press the wakeup button until RED LED occurred the power saving mode active.
When continuing to hold until the GREEN LED occurred the power saving mode active and remove all the result in memory.

2. Mechanical Drawing

2.1 SIC824B Module

Figure 2-1 and Figure 2-2 shows the module outline of SIC824B. The dimension is 90mmx40mmx18mm

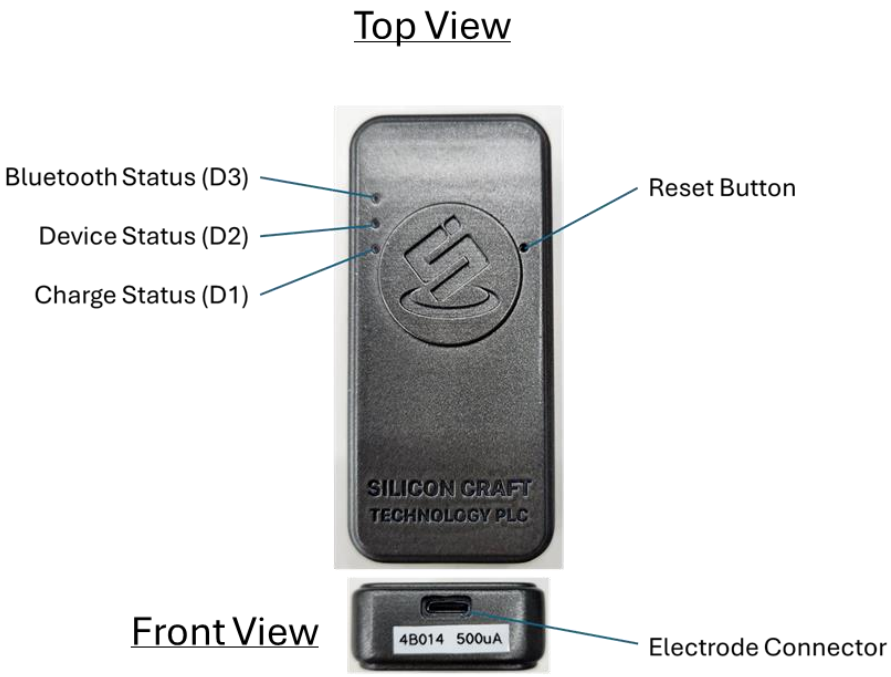


Figure 2-1: Top and Front view of SIC824B module

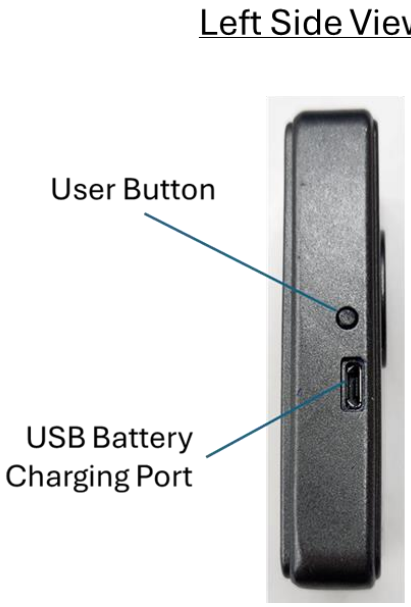
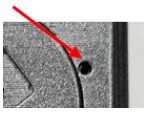


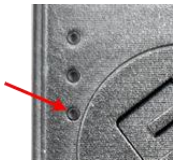
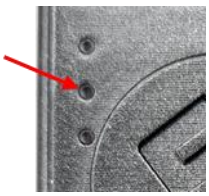
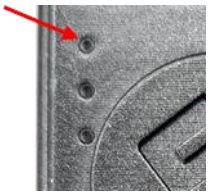
Figure 2-2: Left side view of SIC824B module

2.2 Button Event

Button	Image	Device state	Bluetooth	Event	Action
User Button		ON	Connected	Short press	Clear error
		ON	Not connected	Short press	Start advertising
		ON	Any	Long press (3 s)	Force device to sleep
		Sleep	-	Short press	Wake up device and start advertising
		Sleep	-	Long press (3 s)	Wake up device and start advertising
Reset Button		ON	Any	Short press	Reset the device
USB battery charging port		-	-	-	USB battery charging port
Electrode connector		-	-	-	Electrode connector

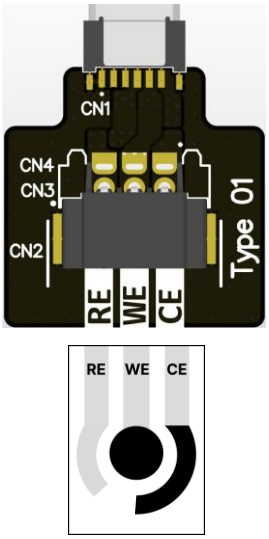
Remark: **Device will be in sleep mode after 3 seconds in idle state.**

2.3 LED Status

LED	Image	Color	Status	Description
Charge Status (D1)		Amber	On	Charging
			Off	Not charging
Device Status (D2)		Red	Blink constantly	Error occurred
			Double blink continuously	Low battery
		Green	Blink	Operating
			Off	No operation /Operation is completed
Bluetooth Status (D3)		Blue	Double blink continuously	Advertising
			On	Bluetooth connected
			Off	Not connect and not advertising

2.4 Connector

Adapter type 1 is for voltammetry and amperometry analysis mode



Adapter type 2 is for OCP (open circuit potential) analysis mode

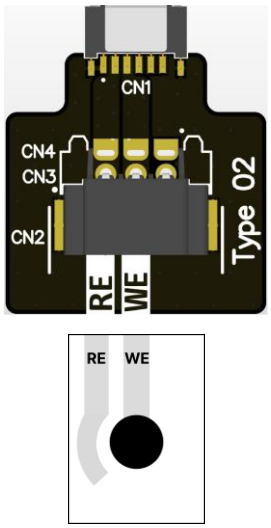


Figure 2-3: SIC824B connector adapters outline and electrode example

Figure 2-3 shows the module outline of connector adapters and electrode example. PCB dimension is 22 mm in width and 31.40 mm in length including the connector. There are 2 types of connectors as detail in Table 2-1.

Table 2-1: Detail of connectors

Type	Connector	Number of Contact	Contact side	Electrode Pitch (mm)	Recommended Electrode Thickness (mm)	Electrode Width (mm)
1 Voltammetry Amperometry mode	CN3	3 positions	Top	2.54	0.127 – 0.3	10.36 (max)
2 OCP mode	CN3	2 positions	Top	2.54	0.127 – 0.3	10.36 (max)

3. Specification

3.1 Absolute Maximum Rating

Conditions above the listed maximum ratings may cause permanent damage to the device. Exposure to the absolute maximum rating conditions for an extended period may affect the device reliability. Only one absolute maximum rating can be applied at a time.

Table 3-1: Absolute Maximum Rating

Parameter	Rating
Operating temperature range	0 °C to +55 °C
Storage temperature range	-40 °C to +85 °C

3.2 Electrical Specification

Table 3-2: AFE Characteristic

Parameter	Description	Min	Typ	Max	Unit	Conditions
T_{op}	Operating Temperature	0	+25	+60	°C	
f_{op}	RF operating frequency		2.4		GHz	
$f_{mod,0}$	Modulation frequency data '0'	132.7	134.2	135.7	kHz	
$f_{mod,1}$	Modulation frequency data '1'	122.2	124.2	126.2	kHz	f_{op} = 134.2 kHz

Table 3-3: EEPROM Characteristic

Parameter	Description	Min	Typ	Max	Unit	Conditions
MEM	Memory		1360		bits	MPT functionality
T_{ret}	EEPROM Data Retention	10			Years	T_{op} = +55°C
N_{CY}	EEPROM write cycles	100k			Cycles	T_{op} = +55°C

3.3 Power Supply

3.7 V Lithium-Polymer minimum 320 mAh

4. Communication

4.1 Bluetooth Communications

Bluetooth communication with the Generic Attribute Profile (GATT) service is a protocol used to establish a communication channel between Bluetooth-enabled devices. GATT defines a hierarchical data structure that enables the exchange of data between Bluetooth devices.

GATT service defines the rules for data exchange and enables the communication between the Bluetooth devices. It is comprised of a set of attributes that contain data and are organized in a hierarchical structure. The attributes define the type of data, such as text or numeric, and its properties, such as read-only or writable.

When two devices are connected via Bluetooth and are paired, one device takes on the role of the GATT server, while the other device acts as the GATT client. The server stores data in the attributes, and the client can read or write data to the attributes. This communication process is facilitated by the GATT protocol.

The GATT service is widely used for communication between Bluetooth devices, particularly in applications where low-power consumption is critical, such as IoT devices, wearables, and other battery-powered devices. By utilizing the GATT service, Bluetooth-enabled devices can exchange data efficiently and effectively, making it a popular choice for a wide range of applications.

4.2 Profile Selection

Service	**SIC824B**
16 bits	0xAF90
128 bits	B84AAF90-DACF-485B-A7C1-39C2A35BD539

Characteristic	**Tx**
Characteristic size	255
Properties	Read, Notify
Description	Send respond back to mobile application
16 bits UUID	0xAF91
128 bits UUID	B84AAF91-DACF-485B-A7C1-39C2A35BD539

Characteristic	**Rx**
Characteristic size	255
Properties	Write
Description	Receive command from mobile application
16 bits UUID	0xAF92
128 bits UUID	B84AAF92-DACF-485B-A7C1-39C2A35BD539

Characteristic	**Output**
Characteristic size	255
Properties	Notify
Description	Send streaming data to mobile application
16 bits UUID	0xAF93
128 bits UUID	B84AAF93-DACF-485B-A7C1-39C2A35BD539

4.3 Communication Profile

The communication profile or frame protocol packet is used to define the arrangement of data packet uses between the Application and the Device itself.

The packet is categorized into 3 main types. The Command Packet, for transmits command from Application to Device. The Success Response Packet, for returning the successful response from Device to Application. And the Error Response Packet, for returning the error response.

The Header of the Packet is consisting of 'STX', 'LEN(H)', 'LEN(L)', 'CMT/PMT/EMT', and 'CM'. The Payload is the 'DATA' itself. The Trailer are 'ETX', and 'BCC' (Table 4-1).

4.3.1 Command Packet

The Command Packet use from transmits 'command' from the Application to Device. The main differentiation to the other packets is the 'CMT' which go by '0x43'. The protocol is shown in Table 4-1, and described in Table 4-2.

Command Packet

Table 4-1 Frame Protocol Packet for Command Transmits from Application to Device

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	1 byte	N Bytes	0x03	1 byte

Table 4-2 Detail of Frame Protocol Packet for Command Transmits from Application to Device

Field	Size(bytes)	Description
STX	1	Start of transmit Value: 02h
LEN(H)[3]	1	Length high byte. Length include 'CMT' until the end of 'DATA' in bytes.
LEN(L)	1	Length low byte. Length include 'CMT' until the end of 'DATA' in bytes.
CMT	1	Command mode Value: 43h
CM	1	Command. Table 4-3.
DATA	N	Data maximum 231 bytes
ETX	1	End of transmit value: 03h
BCC[4]	1	BCC means the XOR values in byte of 'STX' until the end of 'ETX'

[3] LEN(H) and LEN(L) are length of data start counting from CMT to DATA
[4] BCC is checksum, calculate from STX to ETX.

Table 4-3 Command Name List

CM	Command List
0x01	Get Info
0x02	Get Status
0x03	Set Config
0x04	Get Config
0x05	Start Operate
0x06	Stop Operate

4.3.2 Response Packet

The Response Packet use from receiving the response from the Device to Application. The protocol is almost identical to Command Packet. As already mentioned, the main differences are 'PMT' or '0x50' for the success response, and 'EMT' or '0x45' for error response. The success response is described in Table 4-4 and

Table 4-5. The error response is in Table 4-6 and Table 4-7.

The error response payload is identical to all commands, so for the simplicity purpose the error response will not be mentioned if not necessary.

Success Response Packet

Table 4-4 Frame Protocol Packet for Success Response from Device to Application

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	1 byte	N Bytes	0x03	1 byte

Table 4-5 Detail of Frame Protocol Packet for Success Response from Device to Application

Field	Size(bytes)	Description
STX	1	Start of transmit Value: 02h
LEN(H)	1	Length high byte. Length include 'PMT' until the end of 'DATA' in bytes.
LEN(L)	1	Length low byte. Length include 'PMT' until the end of 'DATA' in bytes.
PMT	1	Positive operation Value: 50h
CM	1	Command. Table 4-3.
DATA	N	Data
ETX	1	End of transmit value: 03h
BCC	1	BCC means the XOR values in byte of 'STX' until the end of 'ETX'

Error Response Packet

Table 4-6 Frame Protocol Packet for Error Response from Device to Application

STX	LEN(H)	LEN(L)	EMT	CM	EF	DATA	ETX	BCC
0x02	1 byte	1 byte	0x45	1 byte	1 byte	N Bytes	0x03	1 byte

Table 4-7 Detail of Frame Protocol Packet for Error Response from Device to Application

Field	Size(bytes)	Description
STX	1	Start of transmit Value: 02h
LEN(H)	1	Length high byte. Length include 'EMT' until the end of 'DATA' in bytes.
LEN(L)	1	Length low byte. Length include 'EMT' until the end of 'DATA' in bytes.
EMT	1	Error operation Value: 45h
CM	1	Command. Table 4-3.
EF	1	Error flag. Table 4-8.
DATA	N	Data
ETX	1	End of transmit value: 03h
BCC	1	BCC means the XOR values in byte of 'STX' until the end of 'ETX'

Related List

Table 4-8 Error Detail List

EF	Description	EF	Description
0x01	Reception of Undefined Command	0x09	Insufficient Resource
0x02	Command Parameter Error	0x0A	Storage Error
0x03	Command Sequence Error	0x0B	Storage Empty
0x04	Command Data Package Error	0x0C	Calibrate Data Corrupt
0x05	Sensor error	0x0D	Potentiostat Busy
0x06	Overflow Package	0x0E	No Leak Current Data
0x07	Battery low	0x0F	Authenticate Error
0x08	Battery Empty		

4.4 Get Info (CM = 0x01)

A command to query the device information. This command response contains information for identifying hardware devices and firmware. All information in this command response are constants. Thus, the user can only send the "Get Information" command when the device is connecting.

Command Packet

Table 4-9 Get Info Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x01	-	0x03	1 byte

Response Packet

Table 4-10 Get Info Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x01	Table 4-11	0x03	1 byte

Table 4-11 Get Info Success Response Payload

DATA Field	Size(bytes)	Description
FW Version	2	Firmware version number
Device Version	2	Size of result storage memory
Bluetooth address	6	48-Bit Bluetooth address
SIC4340 UID	7	56-Bit SIC4343 unique ID
RFU	1	00h
User Memory Size	4	Size of result storage memory

4.5 Get Status (CM = 0x02)

A command to query the device status. This command is used to check device status.

Command Packet

Table 4-12 Get Status Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x02	-	0x03	1 byte

Response Packet

Table 4-13 Get Status Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x02	Table 4-14	0x03	1 byte

Table 4-14 Get Status Success Response Payload

DATA Field	Size(bytes)	Description
BLE Status	1	Connectivity. 00h: Disconnect / 01h: Connect
Current State	1	Operation state. Table 4-15
Battery Status	1	Battery percentage and state of charge. Table 4-16
Last Result Mode	1	Last Potentiostat operate mode. Table 4-17
Temperature Start	2	Value is Celsius Multiply by 100
Temperature Stop	2	Value is Celsius Multiply by 100
Last ADC Result Length	4	Length of last operate result in user memory storage
Total Step	4	Total potential changes (sweep) in step
Count Step	4	Number of potential changes (sweep) in step

Related List

Table 4-15 State ID List

CODE	State
0x00	Idle
0x01	Running

Table 4-16 Battery Status

CODE	Description
Bit 7	Charging Status (1 = Charge)
Bit 6 - 0	Battery Percentage

Table 4-17 Mode ID List

CODE	Mode
0x01	CA
0x02	LSV
0x03	CV
0x04	DPV
0x05	SWV
0x06	OCP
Other	Unknown

4.6 Set Config (CM = 0x03)

Set configuration command is for setting Potentiostat mode and parameters for an operation. Different Potentiostat Mode will differs the command parameter accordingly. This command has single-common success response for all Potentiostat Mode. The common attributes of the command will be compiled in the 4.6.7 Common of all Mode.

To better understanding the parameters and the configuration of Potentiostat please refer to Appendix A: Potentiostat . The Pre-Treatment is common in all mode of Potentiostat. The parameter of Pre-Treatment please refer to the Figure 4-1.

Potentiostat Characteristic (Pre-Treatment)

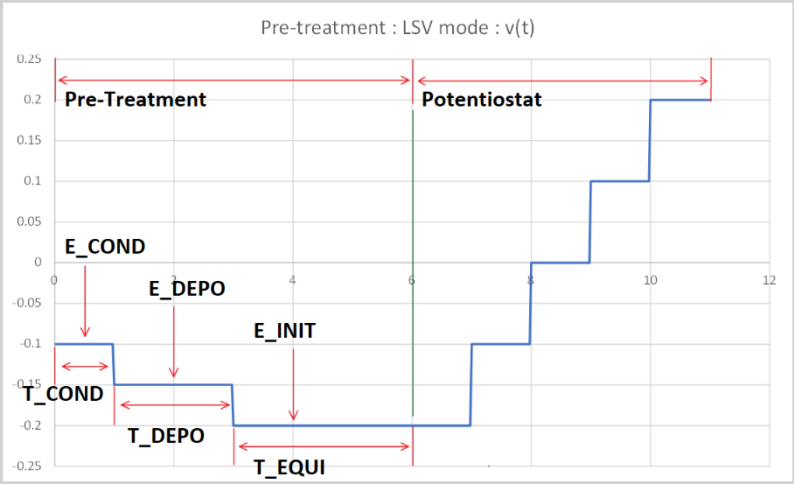


Figure 4-1 Pre-Treatment Parameter for Configuration

4.6.1 CA (Chronoamperometry) Mode

The parameters of CA Mode Potentiostat please refer to the Figure 4-2.

Potentiostat Characteristic

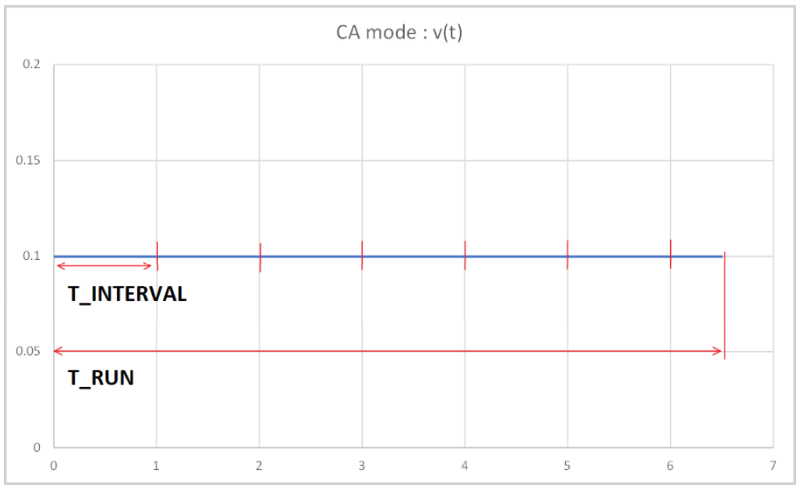


Figure 4-2 CA Mode Characteristics

Command Packet

Table 4-18 Set Config (CA) Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x03	Table 4-19	0x03	1 byte

Table 4-19 Set Config (CA) Command Payload

DATA Field	Size(bytes)	Description
MODE	1	Operation mode: **CA value 01h**
RANGE	1	Potentiostat operate voltage range Table 4-34
FEATURE	4	Potentiostat feature option Feature **List** **Table** 4-35
E_COND	2	Condition potential (mV)
E_DEPO	2	Deposition potential (mV)
T_COND	2	Condition duration (seconds)
T_DEPO	2	Deposition duration (seconds)
T_EQUI	2	Equilibrium duration (seconds)
E_INIT	2	Initial potential (mV)
T_RUN	2	Reaction running time (second)
T_INTERVAL	2	Measure interval time (millisecond)

4.6.2 LSV (Linear sweep voltammetry) Mode

The parameters of LSV Mode Potentiostat please refer to the Figure 4-3.

Potentiostat Characteristic

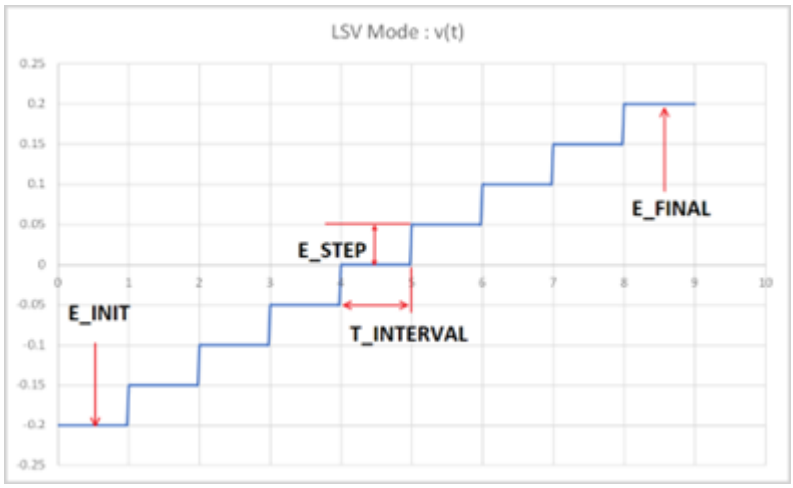


Figure 4-3 LSV Mode Characteristics

Command Packet

Table 4-20 Set Config (LSV) command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x03	Table 4-21	0x03	1 byte

Table 4-21 Set Config (LSV) command Payload

DATA Field	Size(bytes)	Description
MODE	1	Operation mode: **LSV value 02h**
RANGE	1	Potentiostat operate voltage range Table 4-34
FEATURE	4	Potentiostat feature option Feature **List** **Table** 4-35
E_COND	2	Condition potential (mV)
E_DEPO	2	Deposition potential (mV)
T_COND	2	Condition duration (seconds)
T_DEPO	2	Deposition duration (seconds)
T_EQUI	2	Equilibrium duration (seconds)
E_INIT	2	Initial potential (mV)
E_STEP	2	Step potential (mV)
E_FINAL	2	Final potential (mV)
T_INTERVAL	2	Measure interval time (millisecond)

4.6.3 CV (Cyclic voltammetry) Mode

The parameters of CV Mode Potentiostat please refer to the Figure 4-4.

Potentiostat Characteristic

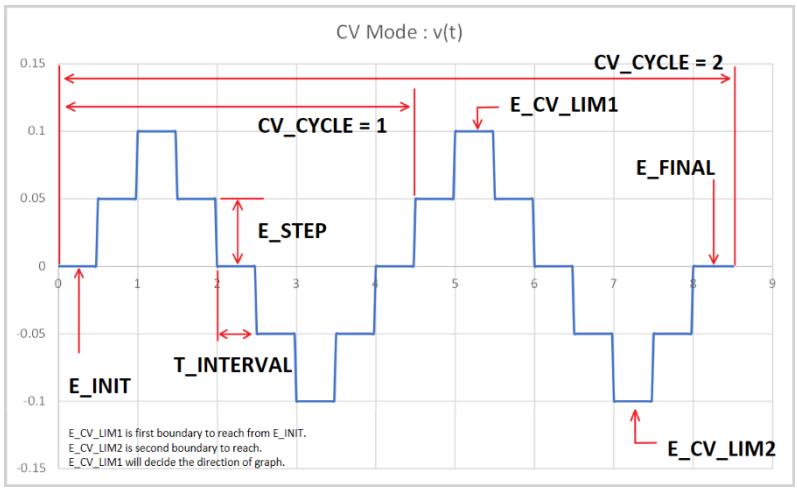


Figure 4-4 CV Mode Characteristic

Command Packet

Table 4-22 Set Config (CV) Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x03	Table 4-23	0x03	1 byte

Table 4-23 Set Config (CV) Command Payload

DATA Field	Size(bytes)	Description
MODE	1	Operation mode: **CV value 03h**
RANGE	1	Potentiostat operate voltage range Table 4-34
FEATURE	4	Potentiostat feature option Feature **List** **Table** 4-35
E_COND	2	Condition potential (mV)
E_DEPO	2	Deposition potential (mV)
T_COND	2	Condition duration (seconds)
T_DEPO	2	Deposition duration (seconds)
T_EQUI	2	Equilibrium duration (seconds)
E_INIT	2	Initial potential (mV)
E_STEP	2	Step potential (mV)
E_CV_LIM1	2	First Mid-point Potential (mV)
E_CV_LIM2	2	Second Mid-point Potential (mV)

CV_CYCLE (unit)	2	Number of cycles to run
T_INTERVAL	2	Step Duration (millisecond)

4.6.4 DPV (Differential Plus Voltammetry) Mode

The parameters of DPV Mode Potentiostat please refer to the Figure 4-5 and Figure 4-6.

Potentiostat Characteristic

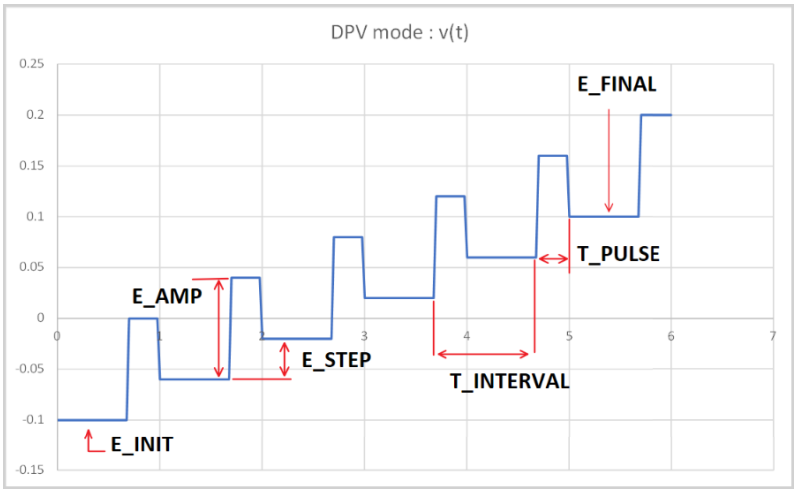


Figure 4-5 DPV Mode Characteristic

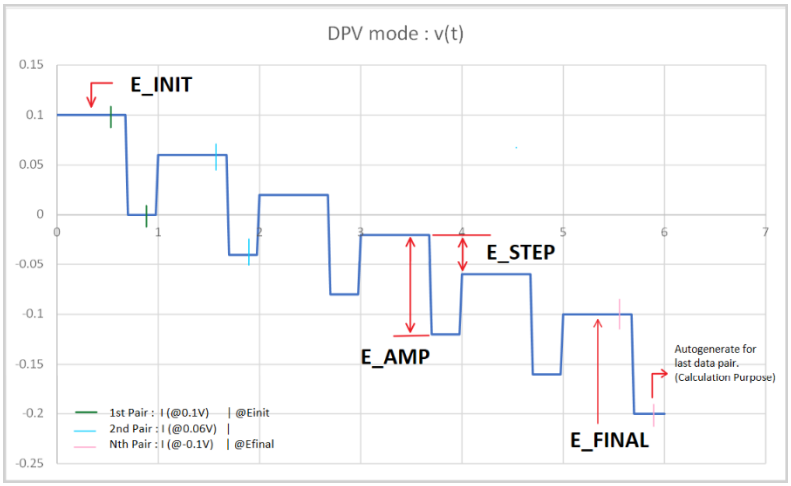


Figure 4-6 DPV Mode Sampling Characteristic

Command packet

Table 4-24 Set Config (DPV) Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x03	Table 4-25	0x03	1 byte

Table 4-25 Set Config (DPV) Command Payload

DATA Field	Size(bytes)	Description
CM	1	Command Value: **03h**
MODE	1	Operation mode: **DPV value 04h**
RANGE	1	Potentiostat operate voltage range Table 4-34
FEATURE	4	Potentiostat feature option Feature **List** Table 4-35
E_COND	2	Condition potential (mV)
E_DEPO	2	Deposition potential (mV)
T_COND	2	Condition duration (seconds)
T_DEPO	2	Deposition duration (seconds)
T_EQUI	2	Equilibrium duration (seconds)
E_INIT	2	Initial potential (mV)
E_STEP	2	Step potential (mV)
E_FINAL	2	Final Potential (mV)
E_AMP	2	Pulse Amplitude (mV)
T_PULSE	2	Time of Pulse Amplitude side of the period (milliseconds)
T_INTERVAL	2	Time of one period (milliseconds)

4.6.5 SWV (Square Wave Voltammetry) Mode

The parameters of SWV Mode Potentiostat please refer to the Figure 4-7 and Figure 4-8.

Potentiostat Characteristic

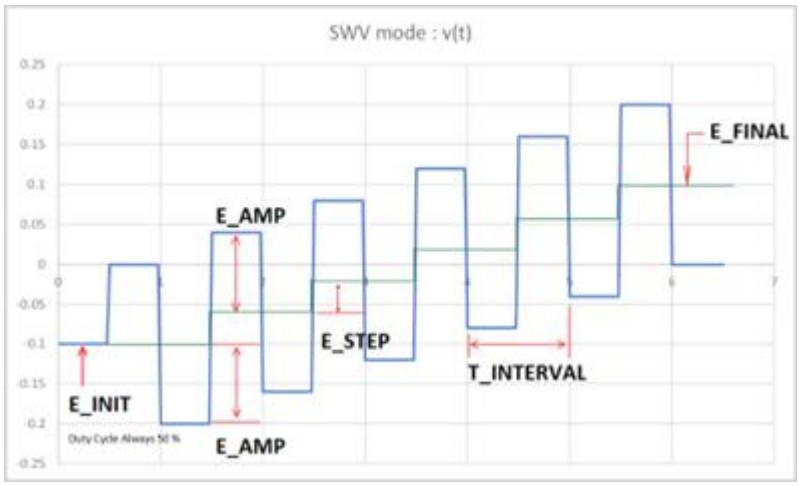


Figure 4-7 SWV Mode Characteristic

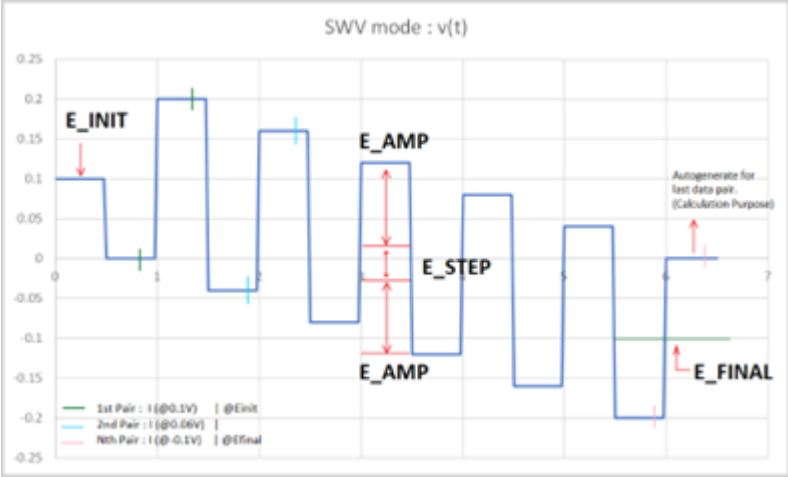


Figure 4-8 SWV Mode Sampling Characteristic

Command Packet

Table 4-26 Set Config (SWV) Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x03	Table 4-27	0x03	1 byte

Table 4-27 Set Config (SWV) Command Payload

DATA Field	Size(bytes)	Description
MODE	1	Operation mode: **SWV value 05h**
RANGE	1	Potentiostat operate voltage range Table 4-34
FEATURE	4	Potentiostat feature option Feature **List** Table 4-35
E_COND	2	Condition potential (mV)
E_DEPO	2	Deposition potential (mV)
T_COND	2	Condition duration (seconds)
T_DEPO	2	Deposition duration (seconds)
T_EQUI	2	Equilibrium duration (seconds)
E_INIT	2	Initial potential (mV)
E_STEP	2	Step potential (mV)
E_FINAL	2	Final Potential (mV)
E_AMP	2	Pulse Amplitude (mV)
T_INTERVAL	2	Half Period of Pulse (milliseconds) Fixed 50% Duty Cycle

4.6.6 OCP (Open Circuit Potentiometry) Mode

The parameters of OCP Mode Potentiostat please refer to the Figure 4-9.

Potentiostat Characteristic

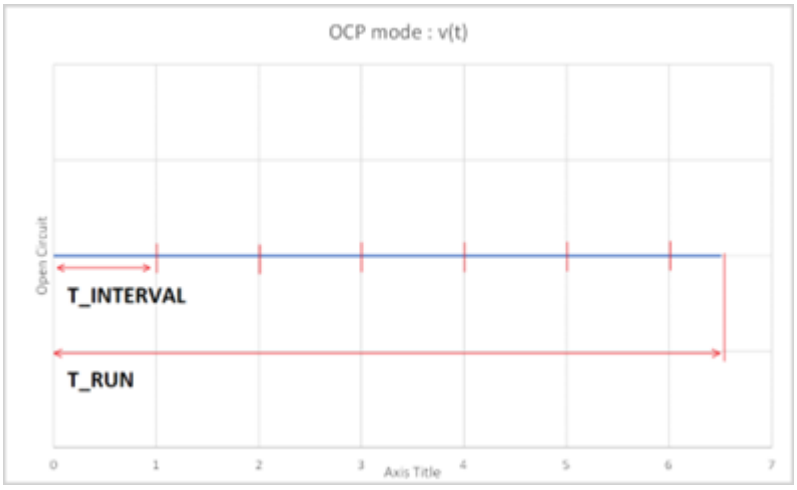


Figure 4-9 OCP Mode Characteristic

Command Packet

Table 4-28 Set Config (OCP) Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x03	Table 4-29	0x03	1 byte

Table 4-29 Set Config (OCP) Command Payload

Field	Size(bytes)	Description
MODE	1	Operation mode: **OCP value 06h**
RANGE	1	Potentiostat operate voltage range Table 4-34
FEATURE	4	Potentiostat feature option Feature **List** Table 4-35
T_RUN	2	Reaction running time (second)
T_INTERVAL	2	Measure interval time (millisecond)

4.6.7 Common of all Mode

The tables shown below (Table 4-30, and Table 4-31) is mainly for the overview and visualization purpose. The data is identical from what mentioned above. The common response packet is also shown in Table 4-32, and Table 4-33.

Command Packet

Table 4-30 Set Config Command Packet Overview

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x03	Table 4-31	0x03	1 byte

Table 4-31 Set Config Command Payload Overview

CA	LSV	CV	DPV	SWV	OCP	Size (Bytes)
0x01	0x02	0x03	0x04	0x05	0x06	1
RANGE	RANGE	RANGE	RANGE	RANGE	RANGE	1
FEATURE	FEATURE	FEATURE	FEATURE	FEATURE	FEATURE	4
E_COND	E_COND	E_COND	E_COND	E_COND	T_RUN	2
E_DEPO	E_DEPO	E_DEPO	E_DEPO	E_DEPO	T_INTERVAL	2
T_COND	T_COND	T_COND	T_COND	T_COND		2
T_DEPO	T_DEPO	T_DEPO	T_DEPO	T_DEPO		2
T_EQUI	T_EQUI	T_EQUI	T_EQUI	T_EQUI		2
E_INIT	E_INIT	E_INIT	E_INIT	E_INIT		2
T_RUN	E_STEP	E_STEP	E_STEP	E_STEP		2
T_INTERVAL	E_FINAL	E_CV_LIM1	E_FINAL	E_FINAL		2
	T_INTERVAL	E_CV_LIM2	E_AMP	E_AMP		2
		CV_CYCLE	T_PULSE	T_INTERVAL		2
		T_INTERVAL	T_INTERVAL			2

Common Response Success Packet

Table 4-32 Set Config Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x03	-	0x03	1 byte

Common Response Error Packet

Table 4-33 Set Config Error Response Packet

STX	LEN(H)	LEN(L)	EMT	CM	EF	DATA	ETX	BCC
0x02	1 byte	1 byte	0x45	0x03	1 byte	-	0x03	1 byte

Range List

Table 4-34 Range State List

CODE	Range
0x01	-1.6 to 0 V
0x02	-0.8 to 0.8 V
0x03	0 to 1.6 V

Feature List

Table 4-35 Feature List

CODE	Description
Bit 31-28	Reserved
Bit 27	If active: Raw Data is used instead of Average data
Bit 26	Reserved
Bit 25	If active: No voltage biasing in pre-treatment condition stage
Bit 24	If active: No voltage biasing in equilibrium stage
Bit 23-0	Reserved

4.7 Get Config (CM = 0x04)

Get configuration command is for read the set mode and set parameters. This command has single common command packet for all Potentiostat Mode shown in Table 4-36.

Common Command Packet

Table 4-36 Get Config Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x04	-	0x03	1 byte

4.7.1 CA (Chronoamperometry) Mode

The definition of CA is further explained in Appendix A: Potentiostat and the configuration is explained in Figure 0-2 CA Mode Parameters for Configuration

For the characteristic and parameter of CA please refer to the Figure 4-2.

Response Packet

Table 4-37 Get Config (CA) Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x04	Table 4-38	0x03	1 byte

Table 4-38 Get Config (CA) Success Response Payload

DATA Field	Size(bytes)	Description
MODE	1	Operation mode: **CA value 01h**
RANGE	1	Potentiostat operate voltage range Table 4-34
FEATURE	4	Potentiostat feature option Feature **List** Table 4-35.
E_COND	2	Condition potential (mV)
E_DEPO	2	Deposition potential (mV)
T_COND	2	Condition duration (seconds)
T_DEPO	2	Deposition duration (seconds)
T_EQUI	2	Equilibrium duration (seconds)
E_INIT	2	Initial potential (mV)
T_RUN	2	Reaction running time (second)
T_INTERVAL	2	Measure interval time (millisecond)

4.7.2 LSV (Linear sweep voltammetry) Mode

The definition of LSV is further explained in Appendix A: Potentiostat and the configuration is explained in Figure 0-3 LSV Mode Parameters for Configuration.

For the characteristic and parameter of LSV please refer to the Figure 4-3.

Response Packet

Table 4-39 Get Config (LSV) Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x04	Table 4-40	0x03	1 byte

Table 4-40 Get Config (LSV) Success Response Payload

DATA Field	Size(bytes)	Description
MODE	1	Operation mode: **LSV value 02h**
RANGE	1	Potentiostat operate voltage range Table 4-34
FEATURE	4	Potentiostat feature option Feature **List** Table 4-35.
E_COND	2	Condition potential (mV)
E_DEPO	2	Deposition potential (mV)
T_COND	2	Condition duration (seconds)
T_DEPO	2	Deposition duration (seconds)
T_EQUI	2	Equilibrium duration (seconds)
E_INIT	2	Initial potential (mV)
E_STEP	2	Step potential (mV)
E_FINAL	2	Final potential (mV)
T_INTERVAL	2	Measure interval time (millisecond)

4.7.3 CV (Cyclic voltammetry) Mode

The definition of CV is further explained in Appendix A: Potentiostat and the configuration is explained in Figure 0-4 CV Mode Parameters for Configuration.Figure 4-4 CV Mode Characteristic

For the characteristic and parameter of CV please refer to the Figure 4-4.

Response Packet

Table 4-41 Get Config (CV) Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x04	Table 4-42	0x03	1 byte

Table 4-42 Get Config (CV) Success Response Payload

DATA Field	Size(bytes)	Description
MODE	1	Operation mode: **CV value 03h**
RANGE	1	Potentiostat operate voltage range Table 4-34
FEATURE	4	Potentiostat feature option Feature **List** Table 4-35
E_COND	2	Condition potential (mV)
E_DEPO	2	Deposition potential (mV)
T_COND	2	Condition duration (seconds)
T_DEPO	2	Deposition duration (seconds)
T_EQUI	2	Equilibrium duration (seconds)
E_INIT	2	Initial potential (mV)
E_STEP	2	Step potential (mV)
E_CV_LIM1	2	First Mid-point Potential (mV)
E_CV_LIM2	2	Second Mid-point Potential (mV)
CV_CYCLE (unit)	2	Number of cycles to run
T_INTERVAL	2	Step Duration (millisecond)

4.7.4 DPV (Differential Plus Voltammetry) Mode

The definition of DPV is further explained in Appendix A: Potentiostat and the configuration is explained in Figure 0-5 DPV Mode Parameters for Configuration.

For the characteristic and parameter of DPV please refer to the Figure 4-5, and Figure 4-6.

Response Packet

Table 4-43 Get Config (DPV) Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x04	Table 4-44	0x03	1 byte

Table 4-44 Get Config (DPV) Success Response Payload

DATA Field	Size(bytes)	Description
MODE	1	Operation mode: **DPV value 04h**
RANGE	1	Potentiostat operate voltage range Table 4-34
FEATURE	4	Potentiostat feature option Feature **List** Table 4-35
E_COND	2	Condition potential (mV)
E_DEPO	2	Deposition potential (mV)
T_COND	2	Condition duration (seconds)
T_DEPO	2	Deposition duration (seconds)
T_EQUI	2	Equilibrium duration (seconds)
E_INIT	2	Initial potential (mV)
E_STEP	2	Step potential (mV)
E_FINAL	2	Final Potential (mV)
E_AMP	2	Pulse Amplitude (mV)
T_PULSE	2	Time of Pulse Amplitude side of the period (milliseconds)
T_INTERVAL	2	Time of one period (milliseconds)

4.7.5 SWV (Square Wave Voltammetry) Mode

The definition of SWV is further explained in Appendix A: Potentiostat and the configuration is explained in Figure 0-7 SWV Mode Parameters for Configuration.

For the characteristic and parameter of SWV please refer to the Figure 4-7 and Figure 4-8.

Response Packet

Table 4-45 Get Config (SWV) Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x04	Table 4-46	0x03	1 byte

Table 4-46 Get Config (SWV) Success Response Payload

DATA Field	Size(bytes)	Description
MODE	1	Operation mode: **SWV value 05h**
RANGE	1	Potentiostat operate voltage range Table 4-34
FEATURE	4	Potentiostat feature option Feature **List** Table 4-35.
E_COND	2	Condition potential (mV)
E_DEPO	2	Deposition potential (mV)
T_COND	2	Condition duration (seconds)
T_DEPO	2	Deposition duration (seconds)
T_EQUI	2	Equilibrium duration (seconds)
E_INIT	2	Initial potential (mV)
E_STEP	2	Step potential (mV)
E_FINAL	2	Final Potential (mV)
E_AMP	2	Pulse Amplitude (mV)
T_INTERVAL	2	Half Period of Pulse (milliseconds)

4.7.6 OCP (Open Circuit Potentiometry) Mode

The definition of OCP is further explained in Appendix A: Potentiostat and the configuration is explained in Figure 0-9 OCP Mode Parameters for Configuration.

For the characteristic and parameter of OCP please refer to the Figure 4-9.

Response Packet

Table 4-47 Get Config (OCP) Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x04	Table 4-48	0x03	1 byte

Table 4-48 Get Config (OCP) Success Response Payload

DATA Field	Size(bytes)	Description
MODE	1	Operation mode: **OCP value 06h**
RANGE	1	Potentiostat operate voltage range Table 4-34
FEATURE	4	Potentiostat feature option Feature **List** Table 4-35
T_RUN	2	Reaction running time (second)
T_INTERVAL	2	Measure interval time (millisecond)

4.7.7 Unknown Mode

All the others mode that is not available yet.

Response Packet

Table 4-49 Get Config (Unknown) Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x04	Table 4-50	0x03	1 byte

Table 4-50 Get Config (Unknown) Success Response Payload

DATA Field	Size(bytes)	Description
MODE	1	Operation mode: all values except 01h to 06h

4.8 Start Operate (CM = 0x05)

A command to start potentiostat process.

Command Packet

Table 4-51 Start Operate Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x05	Table 4-52	0x03	1 byte

Table 4-52 Start Operate Command Payload

DATA Field	Size(bytes)	Description
Option	1	Option status. Table 4-54.

Response Packet

Table 4-53 Start Operate Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x05	-	0x03	1 byte

Related List

Table 4-54 Option Status

CODE	Description
0x00	Disable Streaming
0x01	Enable Streaming

4.9 Stop Operate (CM = 0x06)

A command to stop potentiostat process. This command is used to stop the potentiostat process and clear the error state.

Command Packet

Table 4-55 Stop Operate Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x06	-	0x03	1 byte

Response Packet

Table 4-56 Stop Operate Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x06	-	0x03	1 byte

4.10 Get Result (CM = 0x07)

A command to get the last potentiostat operating results. There are two formats of the resulting packet. The first format for a constant voltage operating mode (CA Mode). The second format is for a variable voltage operating mode (Others Mode).

Common Command Packet

Table 4-57 Get Result Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x07	Table 4-58	0x03	1 byte

Table 4-58 Get Result Command Payload

DATA Field	Size(bytes)	Description
Package ID	2	Packet ID of the data packet requested by users.

4.10.1 CA Mode

Response Packet

Table 4-59 Get Result (CA) Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x07	Table 4-60	0x03	1 byte

Table 4-60 Get Result (CA) Success Response Payload

DATA Field	Size(bytes)	Description
Current Package ID	2	Packet ID of the current data packet.
Total Package ID	2	Total data packet number.
Data 0: ADC	2	Result data to transfer.
Data 1: ADC	2	Result data to transfer.
…	…	
Data N: ADC	2	Last Result data to transfer. Maximum N is 114.

4.10.2 Others Mode

Response Packet

Table 4-61 Get Result (Others) Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x07	Table 4-62	0x03	1 byte

Table 4-62 Get Result (Others) Success Response Packet

DATA Field	Size(bytes)	Description
Current Package ID	2	Packet ID of the current data packet.
Total Package ID	2	Total data packet number.
Data 0: Voltage	2	Bias voltage data to transfer of Data 0.
Data 0: ADC	2	Result data to transfer of Data 0.
Data 1: Voltage	2	Bias voltage data to transfer of Data 1.
Data 1: ADC	2	Result data to transfer of Data 1.
…	…	
Data N: Voltage	2	Last bias voltage. Maximum N is 56.
Data N: ADC	2	Last Result data to Transfer. Maximum N = 56.

4.11 Get Last Result Configuration (CM = 0x08)

A command to get the last potentiostat operating parameters. When the potentiostat has finished operating, the results and configuration parameters of that operation are saved in storage.

The packet of this command is identical to normal ‘Get Config’ command. The only difference is the CM value. For the command Packet and response packet please refer to Topic “4.7 Get Config (CM = 0x04)”.

4.12 Get Factory Data (CM = 0x09)

Getting Factory data from the device.

Command Packet

Table 4-63 Get Factory Data Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x09	Table 4-64	0x03	1 byte

Table 4-64 Get Factory Data Command Payload

DATA Field	Size(bytes)	Description
Request Package ID	2	Packet ID of the data packet requested by users.

Response Packet

Table 4-65 Get Factory Data Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x09	Table 4-66	0x03	1 byte

Table 4-66 Get Factory Data Success Response Payload

DATA Field	Size(bytes)	Description
Current Package ID	2	Packet ID of the current data packet.
Total Package ID	2	Total data packet number.
Data		Maximum data size is limited by phone

4.13 Start Measure Leak Current (CM = 0x0A)

Measure Leak Current of a device for the calibration purpose.

Command Packet

Table 4-67 Start Measure Leak Current Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x0A	-	0x03	1 byte

Response Packet

Table 4-68 Start Measure Leak Current Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x0A	-	0x03	1 byte

4.14 Get Measured Leak Current (CM = 0x0B)

Get a measured Leak Current data of a device.

Command Packet

Table 4-69 Get Measured Leak Current Command Packet

STX	LEN(H)	LEN(L)	CMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x43	0x0B	-	0x03	1 byte

Response Packet

Table 4-70 Get Measured Leak Current Success Response Packet

STX	LEN(H)	LEN(L)	PMT	CM	DATA	ETX	BCC
0x02	1 byte	1 byte	0x50	0x0B	Table 4-71	0x03	1 byte

Table 4-71 Get Measured Leak Current Success Response Payload

DATA Field	Size(bytes)	Description
Leakage for Range 1 ADC Code	2	Open circuit ADC result of range 1.
Leakage for Range 2 ADC Code	2	Open circuit ADC result of range 2.
Leakage for Range 3 ADC Code	2	Open circuit ADC result of range 3.

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Appendix A: Potentiostat

5.1 Pre-treatment

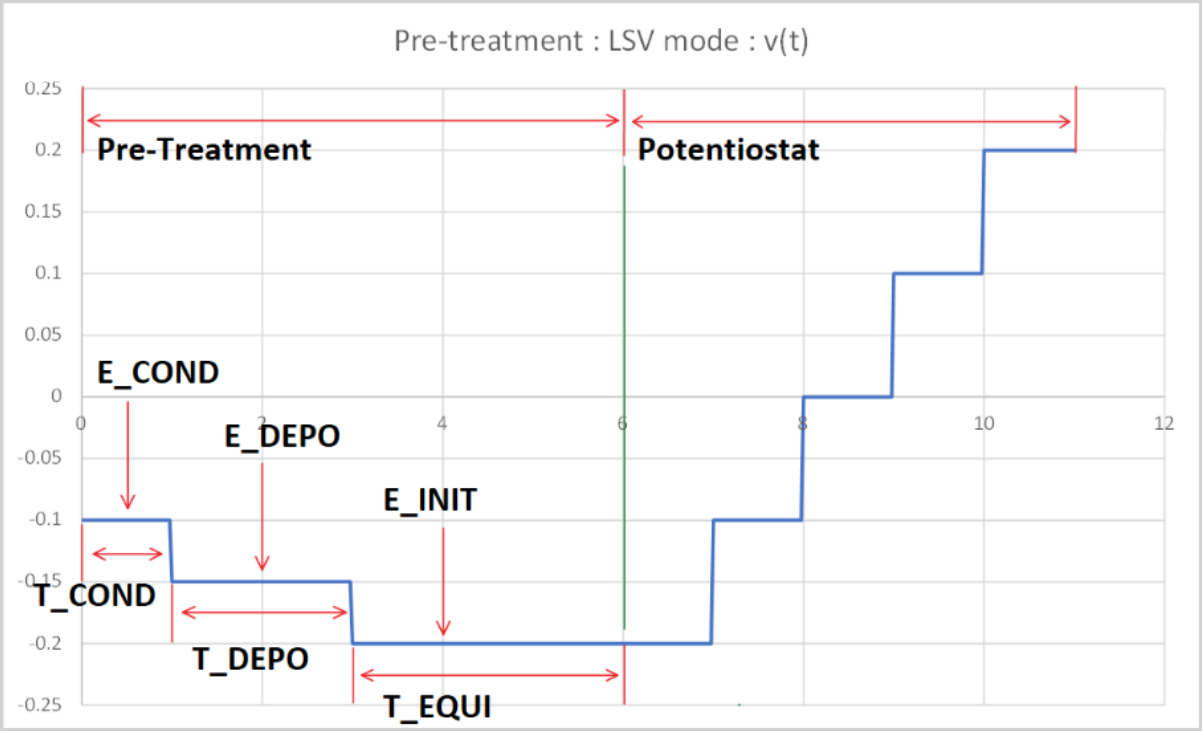

Figure 0-1 Pre-Treatment Parameters for Configuration

5.2 CA

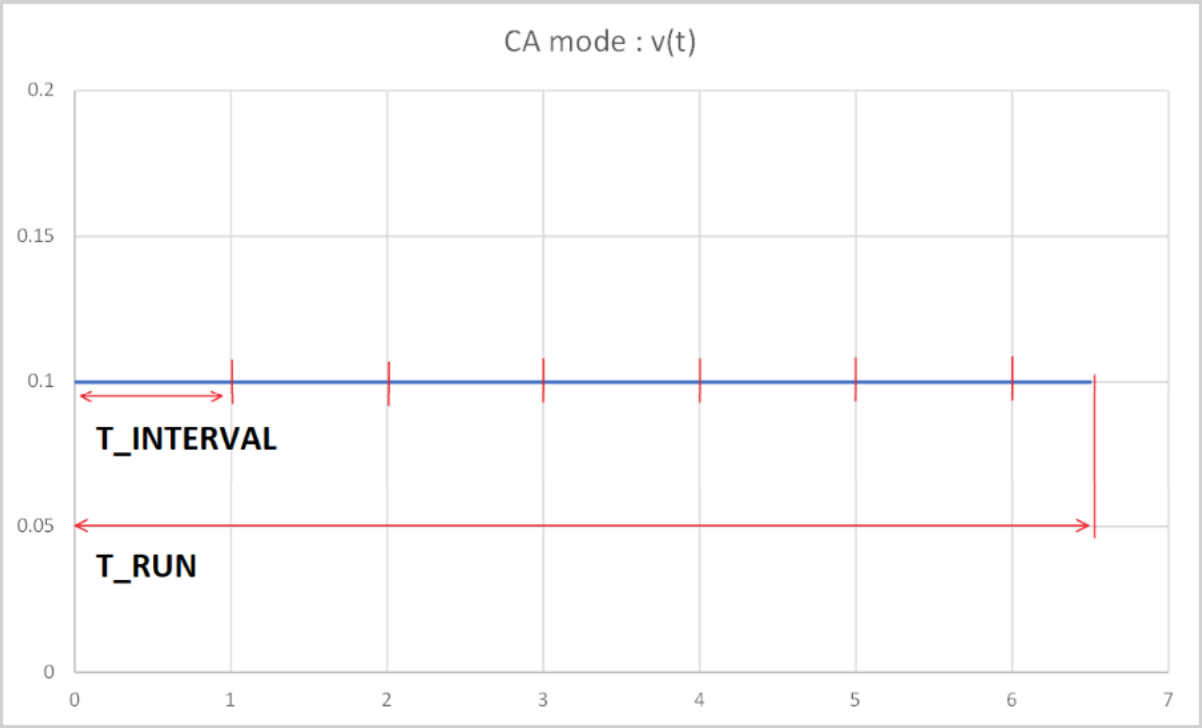

Figure 0-2 CA Mode Parameters for Configuration

5.3 LSV

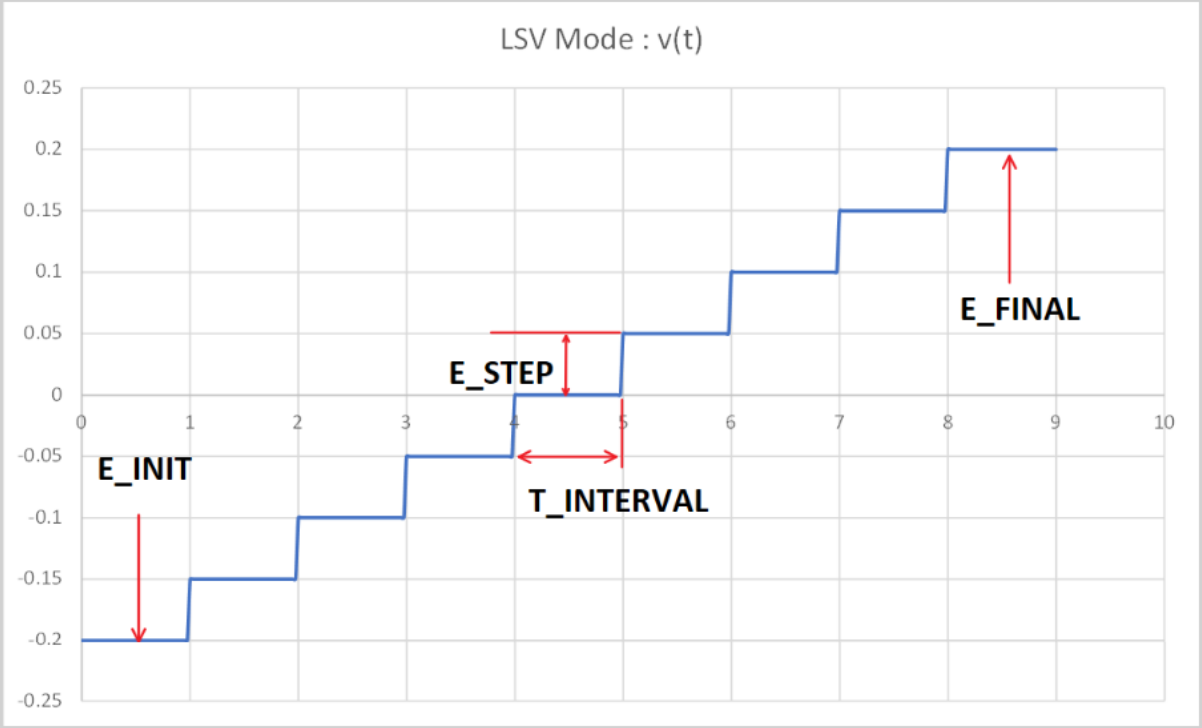

Figure 0-3 LSV Mode Parameters for Configuration

5.4 CV

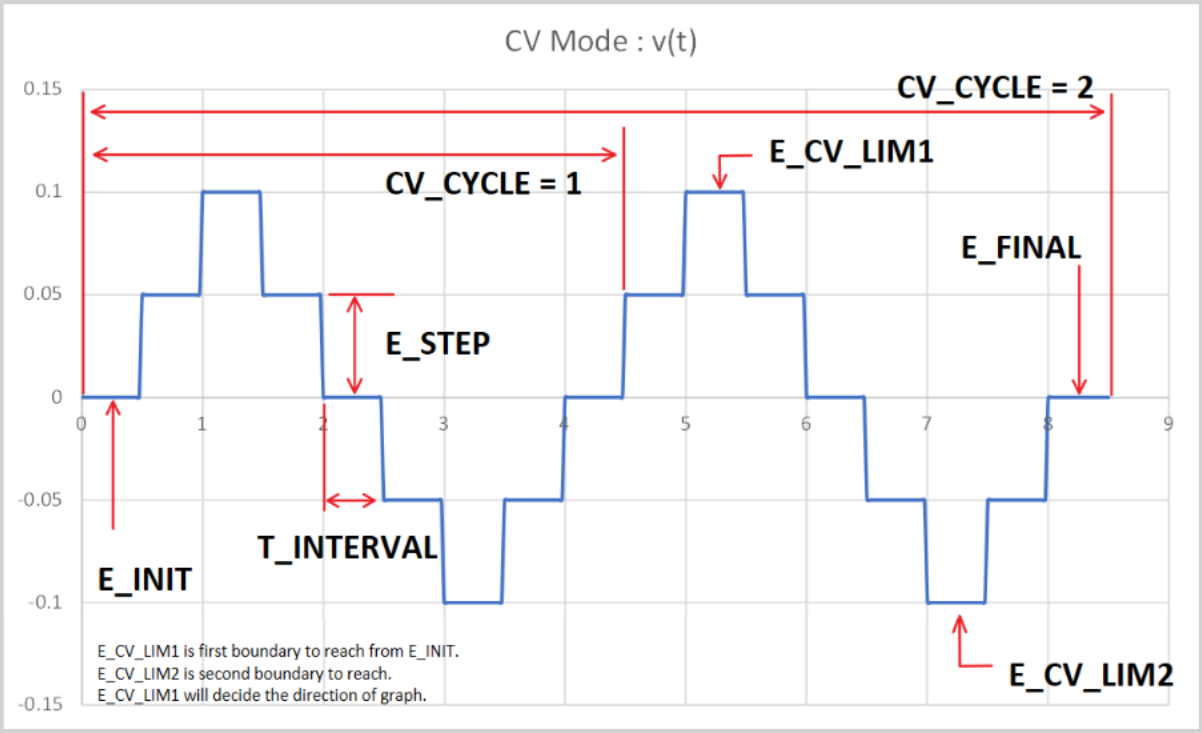

Figure 0-4 CV Mode Parameters for Configuration

5.5 DPV

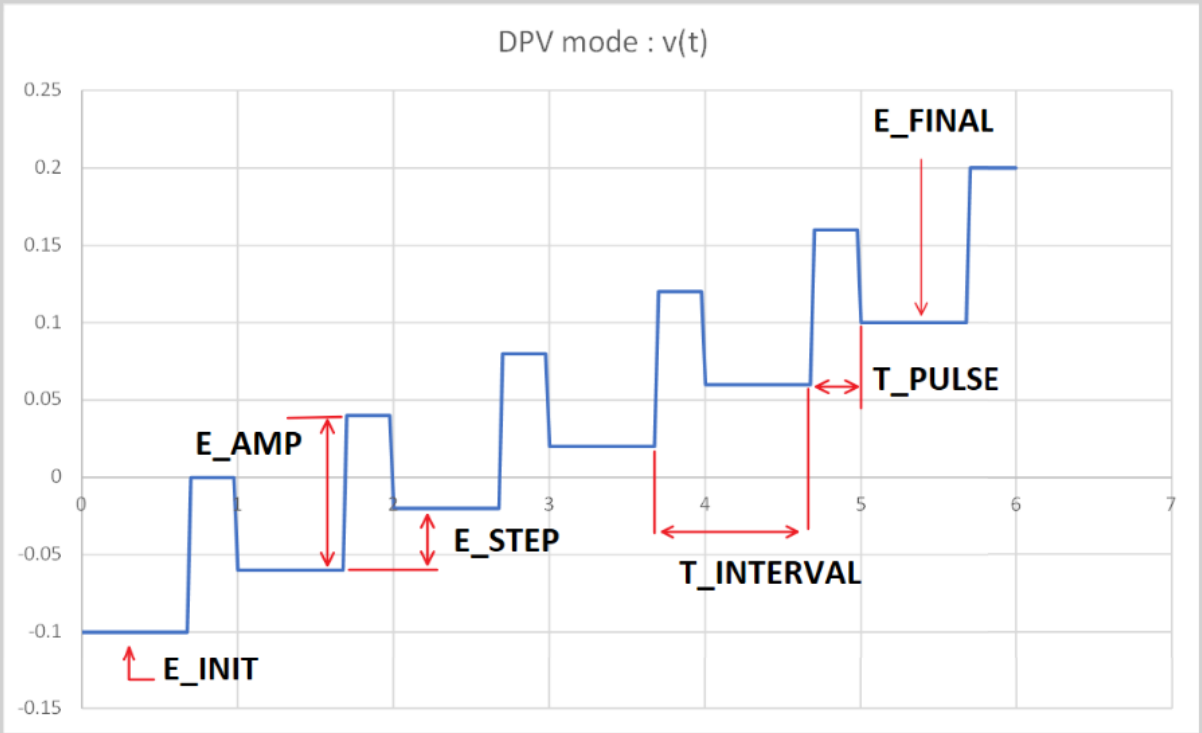

Figure 0-5 DPV Mode Parameters for Configuration

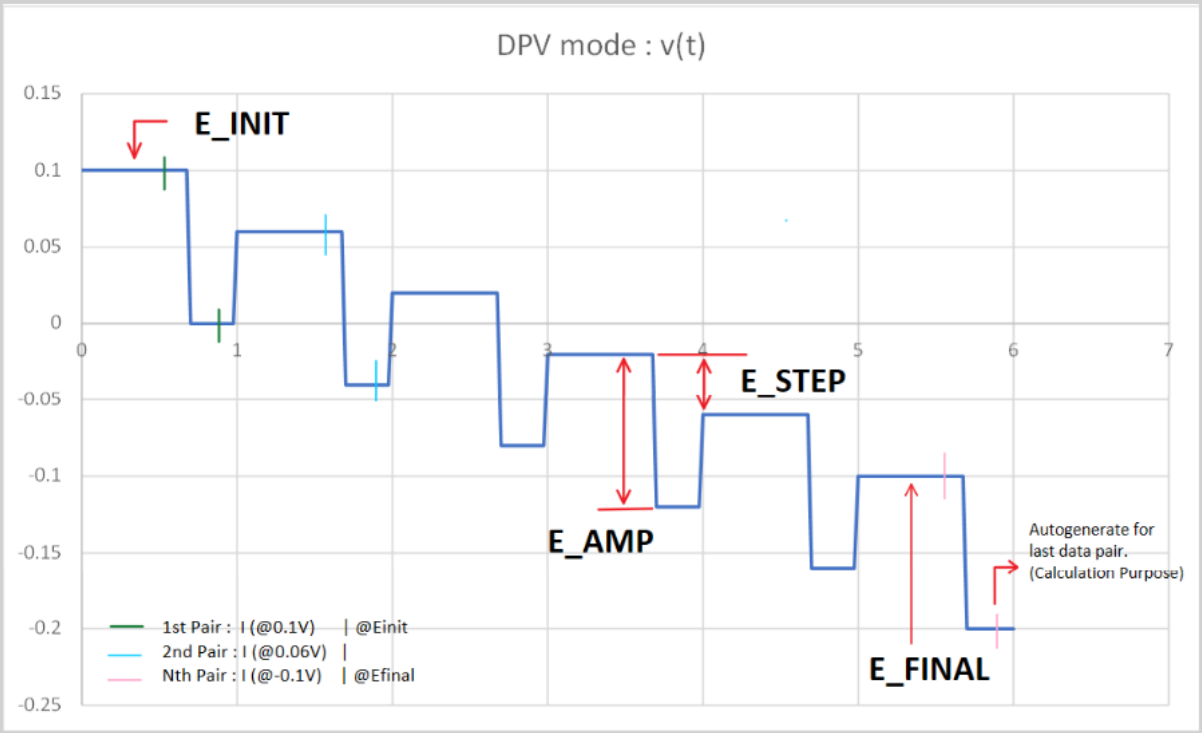

Figure 0-6 DPV Mode Sampling for Calculation

5.6 SWV

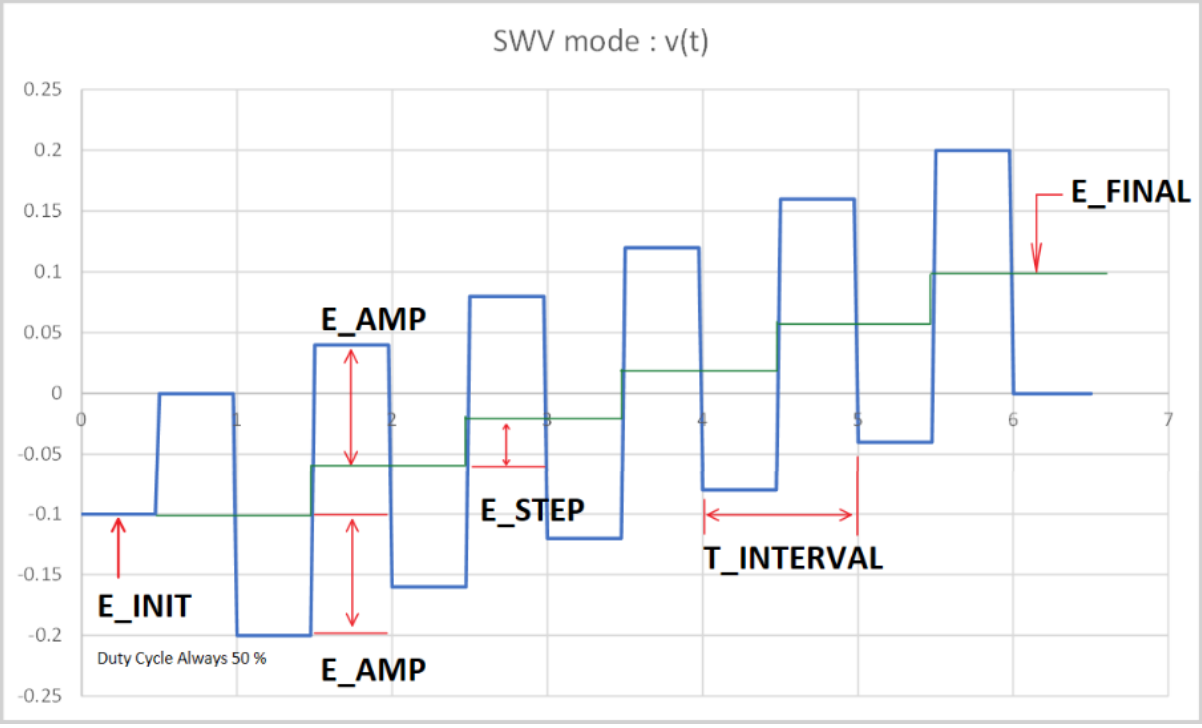

Figure 0-7 SWV Mode Parameters for Configuration

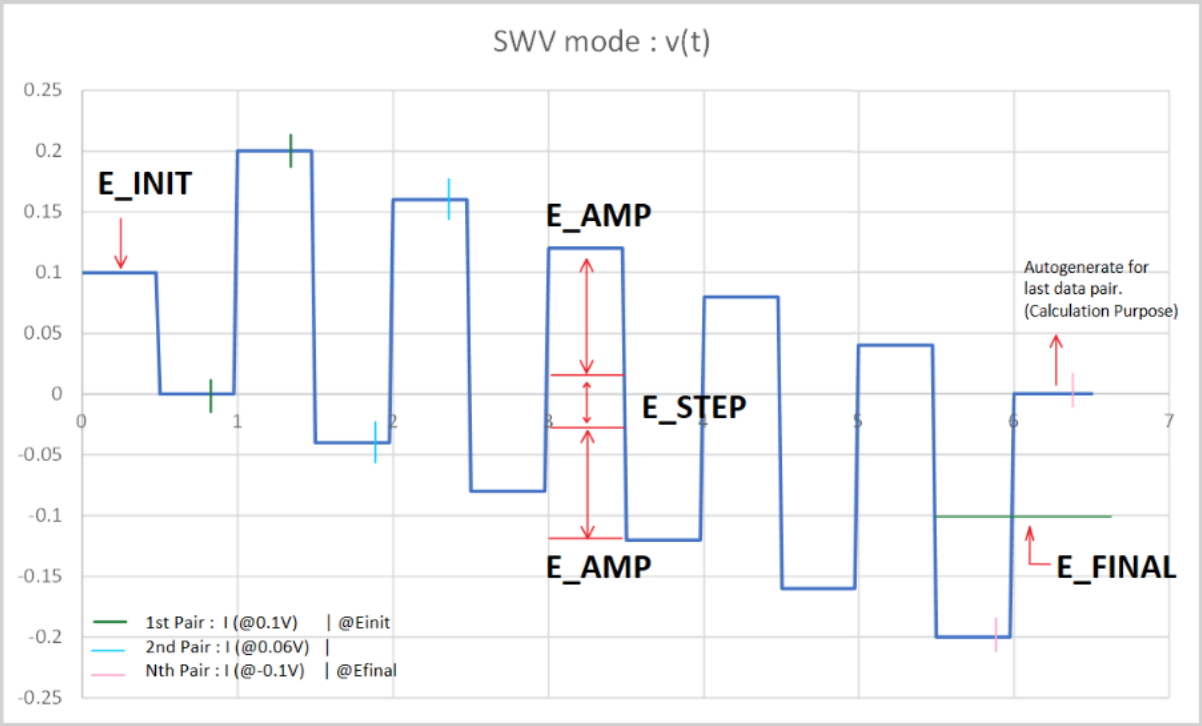

Figure 0-8 SWV Mode Sampling for Calculation

5.7 OCP

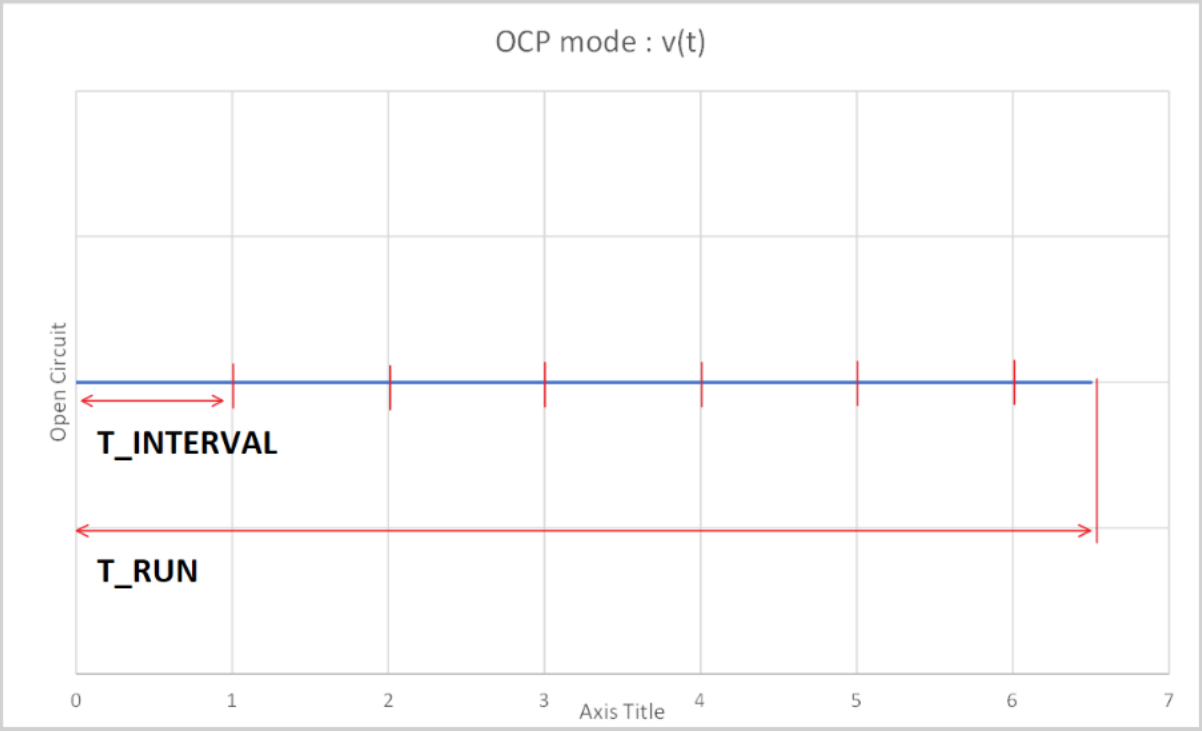

Figure 0-9 OCP Mode Parameters for Configuration