

故障注入器协议

一、一般命令格式

Request

1st byte	Command ID	Value
2nd byte	Parameter 0	Value
3rd byte	Parameter 1	Value
4th byte	Parameter 2	Value
5th byte	Parameter 3	Value
6th byte	Parameter 4	Value
7th byte	Parameter 5	Value
8th byte	Parameter 6	Value

Respond

1st byte	Command ID	Value
2nd byte	Parameter 0	Value
3rd byte	Parameter 1	Value
4th byte	Parameter 2	Value
5th byte	Parameter 3	Value
6th byte	Parameter 4	Value
7th byte	Parameter 5	Value
8th byte	Parameter 6	Value

workMode:0-standalone,1-master,2-slave1...15-slave14

PinNumber:0-63 电流通道，64-79 电压通道

withLoad: 0-不带载，1-带载

二、Command Result

0x0	Command OK
0x1	失败
0x21	Wrong parameter for slave address (> 16)
0x22	Unknown command
0x23	Wrong data type when writing to flash
0x24	Wrong parameter for LED test
0x25	Wrong number in IP address (must be < 256)
0x26	Wrong parameter for CAN baud rate
0x27	Wrong parameter for CAN termination
0x28	Wrong parameter for type of CAN identifier
0x29	Parameter for cascade channel too large (must be < 15)
0x2a	Wrong parameter for resistor cascade
0x2b	not used
0x2c	Wrong address for flash read access (must be < 513)
0x2d	Wrong data length for flash read access (must be < 17)
0x2e	Wrong address for flash write access (must be < 513)
0x2f	Wrong data length for flash write access (must be < 17)
0x30	PLD error
0x31	Error EEPROM checksum
0x32	CAN controller unreachable
0x41	Simulation command returns plausibility error
0x42	Reference relay not detected
0x43	Value of "duration_time" not equal "0xffff", although error should be pending infinitely.
0x44	Simulation command was not recognized
0x45	PLD error: Command could not be executed
0x46	Value of "duration time" exceeds valid range (1 to 5000 or 0xFFFF)
0x47	Recent error simulation still active, end with Reset_all_errors
0x48	Maximum number of relays reached
0x49	Error with multi-error flag
0x4a	Specified channel number exceeds valid range
0x4b	Frequency or duty cycle exceeds valid range
0x4c	System temperature > 60 °C
0x4d	Temperature of resistor cascade > 60 °C
0x4e	MOSFET temperature > 60 °C
0x4f	Sensor for system temperature broken
0x50	Sensor for resistor cascade temperature broken
0x51	Sensor for MOSFET temperature broken
0x52	Rail voltage erroneous (possible short-circuit)
0x53	Invalid value for resistance

三、故障注入配置命令

1、复合故障

```
CommandResult = MultipleErrors(unsigned char workMode,  
                                unsigned char PinNumber,  
                                unsigned char errorType,  
                                unsigned char withLoad );  
errorType:0-开路， 1-对+A 短路， 2-对-A 短路， 3-对+B 短路,4-对-B 短路
```

Request

1st byte	Command ID	0x00
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	PinNumber
4th byte	Parameter 2	errorType
5th byte	Parameter 3	withLoad
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x00
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	PinNumber
4th byte	Parameter 2	Command result
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

2、快速切换故障

```
CommandResult =FastSwitch(unsigned char workMode,  
                             unsigned char PinNumber,  
                             unsigned char errorType,  
                             unsigned char withLoad );
```

errorType:0-开路， 1-对+A 短路， 2-对-A 短路， 3-对+B 短路,4-对-B 短路

Request

1st byte	Command ID	0x01
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	PinNumber
4th byte	Parameter 2	errorType
5th byte	Parameter 3	withLoad
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x01
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	PinNumber
4th byte	Parameter 2	Command result
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

3、快速切换（漏电模拟）

```
CommandResult = FastSwitch Leakage (unsigned char workMode,  
                                     unsigned char PinNumber,  
                                     unsigned char errorType,  
                                     unsigned char withLoad );
```

errorType:0-引脚间漏电， 1-带电阻带载 ,2-对+A 漏电， 3-对-A 漏电， 4-对+B 漏电,5-对-B 漏

电，6-测电流

Request

1st byte	Command ID	0x02
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	PinNumber
4th byte	Parameter 2	errorType
5th byte	Parameter 3	withLoad
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x02
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	PinNumber
4th byte	Parameter 2	Command result
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

4、高电压故障

CommandResult =HighVoltageErrors(unsigned char workMode,
 unsigned char PinNumber,
 unsigned char errorType,
 unsigned char withLoad);
errorType:0-开路 ,1-对+C 短路, 2-对- C 短路, 3-引脚间短路

Request

1st byte	Command ID	0x03
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	PinNumber

Respond

1st byte	Command ID	0x04
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

6、配置完成

CommandResult =ErrorsConfigFinsh (unsigned char workMode);

Request

1st byte	Command ID	0x05
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	durationTime_0 (低字节)
4th byte	Parameter 2	durationTime_1(高字节)
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x05
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

四、功能命令

1、启动故障

CommandResult =ActiveFailure (unsigned char workMode,
unsigned short durationTime);

Request

1st byte	Command ID	0x10
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	durationTime_0 (低字节)
4th byte	Parameter 2	durationTime_1(高字节)
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x10
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

2、复位继电器

CommandResult =CleanUpRelay(unsigned char workMode);

Request

1st byte	Command ID	0x11
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	Not Used
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x11
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

3、获得 workMode(simulink 不需要支持)

CommandResult =GetWorkMode(unsigned char* workMode);

Request

1st byte	Command ID	0x12
2nd byte	Parameter 0	Not Used
3rd byte	Parameter 1	Not Used
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x12
2nd byte	Parameter 0	Command result
3rd byte	Parameter 1	workMode
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

4、设置 workMode(simulink 不需要支持)

CommandResult =SetWorkMode(unsigned char newWorkMode);

Request

1st byte	Command ID	0x13
2nd byte	Parameter 0	newWorkMode
3rd byte	Parameter 1	0x22
4th byte	Parameter 2	0x33
5th byte	Parameter 3	0x44
6th byte	Parameter 4	0x55
7th byte	Parameter 5	0x66
8th byte	Parameter 6	0x77

Respond

1st byte	Command ID	0x13
2nd byte	Parameter 0	newWorkMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

5、获得 IP 地址(simulink 不需要支持)

CommandResult =GetIp(unsigned char WorkMode, unsigned int* Ip);

Request

1st byte	Command ID	0x14
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	Not Used
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x14
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	Ip_0
5th byte	Parameter 3	Ip_1
6th byte	Parameter 4	Ip_2
7th byte	Parameter 5	Ip_3
8th byte	Parameter 6	Not Used

6、设置 IP 地址(simulink 不需要支持)

CommandResult =SetIp(unsigned char WorkMode ,unsigned int Ip);

Request

1st byte	Command ID	0x15
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	Ip_0
4th byte	Parameter 2	Ip_1

5th byte	Parameter 3	lp_2
6th byte	Parameter 4	lp_3
7th byte	Parameter 5	0x66
8th byte	Parameter 6	0x77

Respond

1st byte	Command ID	0x15
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

7、获得 CAN 发送报文 ID(simulink 不需要支持)

CommandResult =GetCanSendId (unsigned char workMode,unsigned int* CanSendId);

Request

1st byte	Command ID	0x16
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	Not Used
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x16
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	CanSendId_0

5th byte	Parameter 3	CanSendId_1
6th byte	Parameter 4	CanSendId_2
7th byte	Parameter 5	CanSendId_3
8th byte	Parameter 6	Not Used

8、设置 CAN 发送报文 ID(simulink 不需要支持)

CommandResult =SetCanSendId(unsigned char workMode,unsigned int CanSendId);

Request

1st byte	Command ID	0x17
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	CanSendId_0
4th byte	Parameter 2	CanSendId_1
5th byte	Parameter 3	CanSendId_2
6th byte	Parameter 4	CanSendId_3
7th byte	Parameter 5	0x66
8th byte	Parameter 6	0x77

Respond

1st byte	Command ID	0x17
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

9、获得 CAN 接收报文 ID(simulink 不需要支持)

CommandResult =GetCanRecvId (unsigned char workMode,unsigned int* CanRecvId);

Request

1st byte	Command ID	0x18
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	Not Used
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x18
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	CanRecvId_0
5th byte	Parameter 3	CanRecvId_1
6th byte	Parameter 4	CanRecvId_2
7th byte	Parameter 5	CanRecvId_3
8th byte	Parameter 6	Not Used

10、设置 CAN 接收报文 ID(simulink 不需要支持)

CommandResult =SetCanRecvId (unsigned char workMode,unsigned int CanRecvId);

Request

1st byte	Command ID	0x19
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	CanRecvId_0
4th byte	Parameter 2	CanRecvId_1
5th byte	Parameter 3	CanRecvId_2
6th byte	Parameter 4	CanRecvId_3
7th byte	Parameter 5	0x66
8th byte	Parameter 6	0x77

Respond

1st byte	Command ID	0x19
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

11、测试保险丝(simulink 不需要支持)

CommandResult =TestFuses(unsigned char workMode);

bSucceed_Fuses 保险丝状态 0-完好，1-损坏

Request

1st byte	Command ID	0x1A
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	Not Used
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x1A
2nd byte	Parameter 0	workMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	bSucceed_Fuses1
5th byte	Parameter 3	bSucceed_Fuses2
6th byte	Parameter 4	bSucceed_Fuses3
7th byte	Parameter 5	bSucceed_Fuses4
8th byte	Parameter 6	bSucceed_Fuses5

12、自测试(simulink 不需要支持)

```
CommandResult =SelfTest(unsigned char  WorkMode);
```

Request

1st byte	Command ID	0x1B
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	Not Used
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x1B
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

13、重启(simulink 不需要支持)

```
CommandResult =Reset(unsigned char  WorkMode);
```

软件重启

Request

1st byte	Command ID	0x1C
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	0x22
4th byte	Parameter 2	0x33

5th byte	Parameter 3	0x44
6th byte	Parameter 4	0x55
7th byte	Parameter 5	0x66
8th byte	Parameter 6	0x77

Respond

1st byte	Command ID	0x1C
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

14、获取工作状态

CommandResult =GetWorkState(unsigned char WorkMode, unsigned char * WorkState);

WorkState:0-空闲，1-故障激活中

Request

1st byte	Command ID	0x1D
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	Not Used
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

Respond

1st byte	Command ID	0x1D
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	WorkState

5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

15、设置终端电阻

CommandResult =SetCanTerminate(unsigned char WorkMode, unsigned char TerminateState);
 TerminateState:**0**-不连接，**1**-连接

Request

1st byte	Command ID	0x1E
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	TerminateState
4th byte	Parameter 2	0x33
5th byte	Parameter 3	0x44
6th byte	Parameter 4	0x55
7th byte	Parameter 5	0x66
8th byte	Parameter 6	0x77

Respond

1st byte	Command ID	0x1D
2nd byte	Parameter 0	WorkMode
3rd byte	Parameter 1	Command result
4th byte	Parameter 2	Not Used
5th byte	Parameter 3	Not Used
6th byte	Parameter 4	Not Used
7th byte	Parameter 5	Not Used
8th byte	Parameter 6	Not Used

五、故障激活流程

1、standalone 模式单一故障激活流程

(1) 复位继电器 (standalone)

CleanUpRelay()

(2) 故障配置 (standalone)

MultipleErrors()
or
LooseErrorsWithoutResistance()
or
LooseErrorsWithResistance(PinNumber1)
or
LooseErrorsWithResistance(PinNumber2)
or
HighVoltageErrors(PinNumber 1)
or
HighVoltageErrors (PinNumber 2)
or
LooseAndResistanceConfig()

(3) 故障激活 (standalone)

ActiveFailure()

2、standalone 模式多个故障激活流程

(1) 复位继电器 (standalone)

CleanUpRelay()

(2) 故障配置 (standalone)

```
MultipleErrors(PinNumber1)
or
MultipleErrors(PinNumber2)
or
...
```

(3) 故障激活 (standalone)

```
ActiveFailure()
```

3、Master/slave 模式故障激活流程

(1) 故障通道都发生在 Master

【1】复位继电器 (Master)

```
CleanUpRelay()
```

【2】故障配置 (Master)

```
MultipleErrors()
or
LooseErrorsWithoutResistance()
or
LooseErrorsWithResistance(PinNumber1)
or
LooseErrorsWithResistance(PinNumber2)
or
HighVoltageErrors(PinNumber 1)
or
HighVoltageErrors (PinNumber 2)
or
LooseAndResistanceConfig()
```

【3】故障激活（Master）

ActiveFailure()

（2）故障通道都发生在 1 个 Slave

【1】复位继电器（Master）

CleanUpRelay()

【2】故障配置（Slave）

MultipleErrors()
or
LooseErrorsWithoutResistance()
or
LooseErrorsWithResistance(PinNumber1)
or
LooseErrorsWithResistance(PinNumber2)
or
HighVoltageErrors(PinNumber 1)
or
HighVoltageErrors (PinNumber 2)

【3】故障配置（Master）（可选项）

LooseAndResistanceConfig()

【4】故障激活（Master）

ActiveFailure()

(3) 故障通道都发生在 2 个 Slave

【1】复位继电器 (Master)

CleanUpRelay()

【2】故障配置 (Slave1)

MultipleErrors(PinNumber1)
or
LooseErrorsWithResistance(PinNumber1)
or
HighVoltageErrors(PinNumber 1)

【3】故障配置 (Slave2)

MultipleErrors(PinNumber2..N)
or
LooseErrorsWithResistance(PinNumber2)
or
HighVoltageErrors (PinNumber 2)

【4】故障配置 (Master) (可选项)

LooseAndResistanceConfig()

【5】故障激活 (Master)

ActiveFailure()

六、以太网附加

以太网没有 CAN 一包只能发送 8 字节的限制，可以设计成批量发送请求帧或命令帧的方式。

1、 帧协议格式

Request

帧同步	长度	数据域	结束字
2 字节	2 字节	8*n	2 字节
55AA	数据域长度	请求帧 1...请求帧 n	AA55

Respond

帧同步	长度	数据域	结束字
2 字节	2 字节	8*n	2 字节
AA55	数据域长度	响应帧 1...响应帧 n	AA55

七、例子（软件思路）

1、standalone 模型故障注入器通道 1，启动快速切换（漏电模拟）中的对+A 漏电故障 10ms，漏电阻 10 欧姆

（1）发送报文队列

复位命令： 0x11 0x00 0x00 0x00 0x00 0x00 0x00 0x00
对+A 漏电故障： 0x02 0x00 0x01 0x02 0x00 0x00 0x00 0x00
配置漏电阻： 0x04 0x00 0x00 0x00 0x00 0x01 0x0A 0x00
配置完成： 0x05 0x00 0x0A 0x00 0x00 0x00 0x00 0x00
启动故障： 0x10 0x00 0x0A 0x00 0x00 0x00 0x00 0x00

(2) 发送程序流程图

