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Communication Specification of ForceSensorController

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MITSUMI ELECTRIC CO.,LTD.
Semiconductor Business Div.

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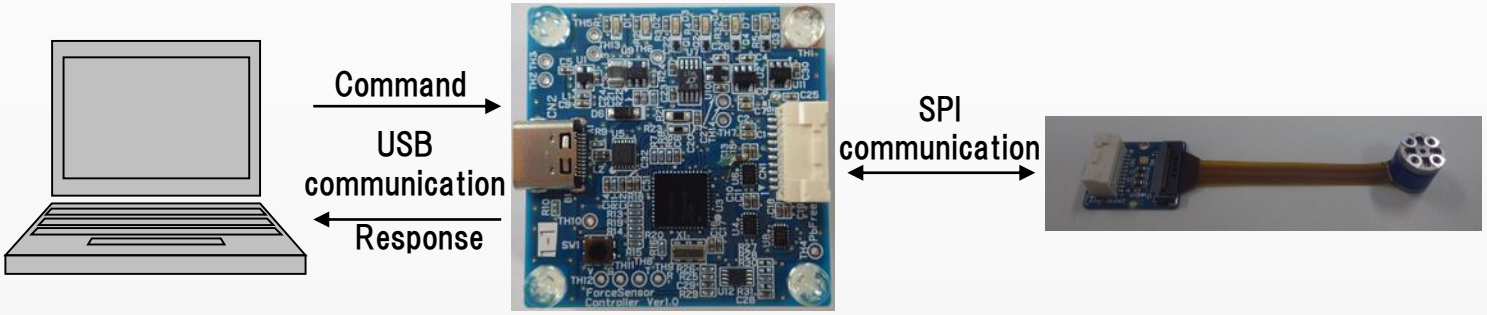
■ Description

The Host must send the request command (hereinafter referred to as the command) to ForceSensorController (hereinafter referred to as the controller). The controller executes the command and returns the result response (hereinafter referred to as the response).

The basic operation is a repetition of this interactive form.

By a command from the host...
・The controller performs SPI communication to the sensor.
・The controller switches the board settings.



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■ Serial communication setting

Serial communication settings for USB communication are as follows.

Item	Set value
Baud rate	1,000,000 bps
Data length	8 bit
Parity	nothing
Stop bit	1 bit
Data transmission direction	LSB first
Flow control	nothing
RTS	Invalid
Delimiter	CR

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■ Communication data format

1. Command format

Byte	Name	Data
0	Instruction Code	0x54
1	Command Data Length	N>=1
2	Command ID	
3	Command Option[0]	
:	:	
N+1	Command Option[N-2]	

Instruction Code:
Indicates the command type. This case is 0x54.

Command Data Length:
The total length of Command ID and Command Option.

Command ID:
Identification code of the command instructed to the controller.
Refer to the command list.

Command Option:
If there is a parameter associated with Command ID, it is appended.
For multiple byte data, the byte order is big-endian.

2. Response format

Byte	Name	Data
0	Response Status	(OK=0x00, NG≠0x00)
1	Response Data Length	N>=0
2	Response Data[0]	
:	:	
N+1	Response Data[N-1]	

Response Status:
This is the result of executing the command. Refer to the Status Code list.

Response Data:
If there is anything order than Status Code, it is appended.
For multiple byte data, the byte order is big-endian.

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■ Command list

Command Name	Command ID	Operation
Board Select	0x10	Command to select controller Establish connectivity by selecting Board ID of controllers. Be sure to execute this command before communicating with the controller.
Firmware Version	0x15	Command to read controller firmware version
Power Switch	0x36	Command to switch ON/OFF of the power supplies (LDOs) on the controller
Axis Select	0x1C	Command to select axis to be accessed
Idle	0x94	Command to shift the sensor to Idle state Only this command has a different format from other commands.
Bootload	0xB0	Command to read the matrix correction coefficients from the sensor by the controller
Coefficient	0x27	Command to transfer the matrix correction coefficients held by the controller to the host
Interval Measure	0x43	Command to set data acquire interval
Interval Restart	0x44	Command to set temperature update interval
Start	0x23	Command to start measurement
Stop	0x33	Command to stop measurement

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■ Response Status list

Status Code	Detail	
0x00	OK	No error
0x01	Illegal Command	Illegal command (Response to an illegal timing)
0x03	Illegal Command Parameter	Illegal command (Response to an illegal parameter)
0x08	Sensor Access Error	Failed access to the sensor
0x10	Not Support Command	Not support command (Response to an illegal command ID)

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■ Board Select command

Command to select the controller.
The controllers are designed with multi-slave connection in mind, and Board ID are assigned to them.
Select Board ID to establish connectivity with the controllers.
*Board ID is fixed to 0x00 because the controllers can be multi-slave-connected via the virtual COM port.
Be sure to perform this command before communicating with the controller.

Command format

Byte	Name	Data
0	Instruction Code	0x54
1	Command Data Length	0x02
2	Command ID	0x10
3	Board ID	0x00

Board ID: 0x00

Response format

Byte	Data
0	Response Status
1	Response Data Length

Response Status:
Refer to the Response Status list

Response Data Length:0x00

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■ Firmware Version command

Command to read controller firmware version.

Command format

Byte	Name	Data
0	Instruction Code	0x54
1	Command Data Length	0x01
2	Command ID	0x15

Response format

Byte	Data
0	Response Status
1	Response Data Length
2-5	Firmware Version

Response Status:
Refer to the Response Status list

Response Data Length:
When Status is “OK”: 0x04
When Status is “NG”: 0x00

Firmware Version:
Indicates the 4-digit firmware version
Depending on the communication specifications of the controller, the response is as follows.
・For SPI communication specification: 2.0.0.x

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■ Power Switch command

Command to switch ON/OFF of the power supplies (LDOs) on the controller
VDD45 is the analogue power supply of the sensor, and VDD12 is the digital power supply of the sensor.
*Do not set LDOs other than VDD45, VDD12 to ON.

Command format

Byte	Name	Data
0	Instruction Code	0x54
1	Command Data Length	0x03
2	Command ID	0x36
3	LDO ID	See the table on the right
4	ON/OFF	See the table on the right

Corresponding table of Power, LDO ID, and ON/OFF

Power	LDO ID	OFF	ON
VDD12	0x00	0x00	!0x00
VDD33	0x01	0x00	!0x00
VDD58	0x02	0x00	!0x00
VDD65	0x03	0x00	!0x00
VDD45	0x05	0x00	!0x00

Response format

Byte	Data
0	Response Status
1	Response Data Length

Response Status:
Refer to the Response Status list.

Response Data Length:0x00

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■ Axis Select command

Command to select the axis to be accessed to individually access the AFE corresponding to each axis of the sensor.
In order for the sensor to be in Idle state, the AFEs corresponding to each axis must be individually set to Idle state.
Therefore, select the axis to be accessed before issuing Idle command.
Select the axis to be accessed by this command, and then set AFE of the axis selected by Idle command to Idle state.

Command format

Byte	Name	Data
0	Instruction Code	0x54
1	Command Data Length	0x02
2	Command ID	0x1C
3	Axis ID	See the table on the right

Corresponding table of Axis ID

Axis	Axis ID
Fx	0x00
Fy	0x01
Fz	0x02
Mx	0x03
My	0x04
Mz	0x05

Response format

Byte	Data
0	Response Status
1	Response Data Length

Response Status:
Refer to the Response Status list.

Response Data Length: 0x00

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■ Idle command

Command to shift the sensor to Idle state.
In order for the controller to read out the matrix correction coefficients, the sensor must be in Idle state.
To set the sensor to Idle state, individually set the AFEs corresponding to the respective axes to Idle state.
Before executing this command, be sure to use Axis Select command to select the axis to be accessed.
It takes 10msec until AFE is turned Idle. Set a wait time of 10msec prior to executing Bootload command.
Instruction Code of this command is different, and the command format is different from the previous one.
The response format is the same as for other commands.

Flow until the matrix coefficients are read:
AxisSelect(Fx select) → Idle → AxisSelect(Fy select) → Idle → ····· → AxisSelect(Mz select) → Idle → 10msec wait → Bootload

Command format

Byte	Name	Data
0	Instruction Code	0x53
1	Command Data Length	0x02
2	SPI Write Command	0x57
3	Idle Command	0x94

Response format

Byte	Data
0	Response Status
1	Response Data Length

Response Status:
Refer to the Response Status list.

Response Data Length:0x00

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■ Bootload command

Command to read the matrix correction coefficients from the sensor by the controller.
*Read the matrix correction coefficients before starting measurement.

Command format

Byte	Name	Data
0	Instruction Code	0x54
1	Command Data Length	0x01
2	Command ID	0xB0

Response format

Byte	Data
0	Response Status
1	Response Data Length

Response Status:
Refer to the Response Status list.

Response Data Length:0x00

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■ Coefficient command

Command to transfer the matrix correction coefficients held by the controller to the host.
*Execute Bootload command beforehand.
Combine Axis ID and Coefficient ID to read them.

Command format

Byte	Name	Data
0	Instruction Code	0x54
1	Command Data Length	0x03
2	Command ID	0x27
3	Axis ID	See the table on the right
4	Coefficient ID	See the table on the right

Corresponding table of Axis ID

Axis	Axis ID
Fx	0x00
Fy	0x01
Fz	0x02
Mx	0x03
My	0x04
Mz	0x05

Corresponding table of Coefficient ID

Coefficient	Coefficient ID
Coefficient1	0x00
Coefficient2	0x01
Coefficient3	0x02
Coefficient4	0x03
Coefficient5	0x04
Coefficient6	0x05

Response format

Byte	Data
0	Response Status
1	Response Data Length
2-5	Coefficient Data

Response Status:
Refer to Response Status list.

Response Data Length:
When Status is “OK”: 0x04
When Status is “NG”: 0x00

Coefficient Data:
- Signed 32-bit data
- Byte order: Big endian
  When output is in the order of 0x12 0x34 0x56 0x78,
  the coefficient is 0x12345678.

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■ Interval Measure command

Command to set the interval at which the controller acquires data from the sensor.
The setting valid range should be from 0usec to 10sec (10,000,000usec) in usec units.
If this command is not executed, 0usec setting is applied.
When a very short interval, the data acquisition time, matrix operation time, and data output time occur as actual operations, so the interval does not necessarily match the setting.
Since the data update interval of the sensor is 781.25usec (typ.), setting of 1000usec or more is recommended.
This command is valid only prior to executing Start command.

Command format

Byte	Name	Data
0	Instruction Code	0x54
1	Command Data Length	0x04
2	Command ID	0x43
3-5	Interval	

Interval:
- Setting effective range: 0～10,000,000usec
- Unsigned 32-bit data
- Byte order: Big endian
  When setting of 1000usec(0x3E8),
  set in the order of 0x00 0x03 0xE8.

Response format

Byte	Data
0	Response Status
1	Response Data Length

Response Status:
Refer to the Response Status list.

Response Data Length:0x00

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■ Interval Restart command

Command to set the interval at which the controller updates the temperature correction of the sensor.
The set interval is managed by the number of times data is acquired.
The valid setting range is 0 to 10,000,000. If this command is not executed, the setting value is 0.
When the set value is 0, the temperature is updated only for the first time, and no temperature update is performed thereafter.
When the set value is 1, the temperature value is updated every time data is acquired.
The time required for updating the temperature of the force sensor is 7500usec (typ.). Note that the data acquired during this time is the same data.
This command is valid only prior to executing Start command.

Command format

Byte	Name	Data
0	Instruction Code	0x54
1	Command Data Length	0x04
2	Command ID	0x44
3-5	Interval	

Interval:
- Setting effective range: 0～10,000,000
- Unsigned 24-bit data
- Byte order: Big endian
  When setting of 1000times(0x3E8),
  set in the order of 0x00 0x03 0xE8.

Response format

Byte	Data
0	Response Status
1	Response Data Length

Response Status:
Refer to the Response Status list.

Response Data Length:0x00

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■ Start command

Commands to start acquisition of force data.
Retrieves data at Interval Measure intervals and repeats outputting the matrix operation result.
The first AD conversion takes about 7.5msec. Data within 10msec. is an incorrect value, so discard it.
The first response is Status only, and force data is added to the second and subsequent responses.
＊After this command is executed, only Stop command is accepted.

Command format

Byte	Name	Data
0	Instruction Code	0x54
1	Command Data Length	0x02
2	Command ID	0x23
3	Option	0x00

Response format

Byte	Data
0	Response Status
1	Response Data Length
2	0x80
3	0x00
4-6	Fx Data
7-9	Fy Data
10-12	Fz Data
13-15	Mx Data
16-18	My Data
19-21	Mz Data
22-24	Time

Option:
Be sure to set the value to 0x00.

Response Status:
Refer to the Response Status list.

Response Data Length:
When Status is “OK”: 0x17
(0x00 for the first time because only Status is responded.)
When Status is “NG”: 0x00

Fx to Mz Data:
- Force Moment data (Fx,Fy,Fz: Force/ Mx,My,Mz: Moment)
- Signed 24-bit data
- Byte order: Big endian
  0x12 0x34 When output is in the order of 0x56,
  the data is 0x123456
- The first time Start command is accepted, only Status is returned.

Time:
- Time elapsed since the last data acquisition[usec]
- Unsigned 24-bit data
- Byte order: Big endian
  When output in the order of 0x00 0x03 0xE8, the time is 1000usec
  at 0x0003E8.

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■ Stop command

Command to stop the acquisition of force data.

Command format

Byte	Name	Data
0	Instruction Code	0x54
1	Command Data Length	0x01
2	Command ID	0x33

Response format

Byte	Data
0	Response Status
1	Response Data Length

Response Status:
Refer to the Response Status list.

Response Data Length:0x00

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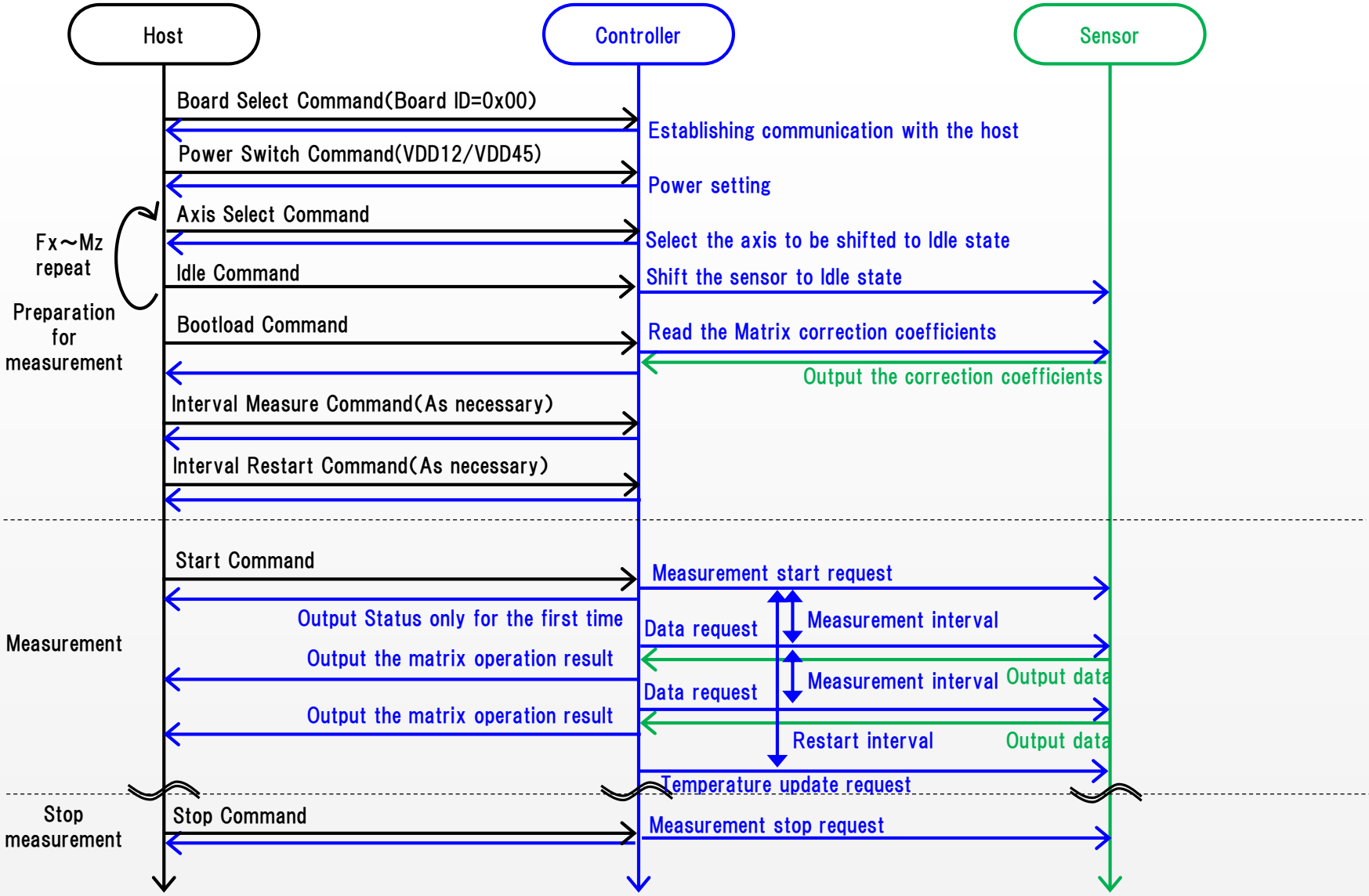
■ Operation flow



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