KeysightTechnologies B1530A Waveform Generator/ Fast Measurement Unit

KEYSIGHT TECHNOLOGIES

User's Guide

Notices

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http://about.keysight.com/en/companyinfo/environment/

When Servicing B1530A

When the B1530A needs any service, return it to your nearest Keysight Technologies. Then do not return the B1530A only. The following equipment and accessories are required for servicing.

- B1500A with all plug-in modules installed
- B1531A RSU
- Connection cable set

The connection cable set means one of the following.

- 16493R-003 3 m Cable between WGFMU and RSU
- 16493R-004 5 m Cable between WGFMU and RSU
- 16493R-006 1.5 m Cable between WGFMU and RSU
- 16493R-001 and 002 60 cm Cable and 2.4 m Cable between WGFMU and RSU
- 16493R-001 and 005 60 cm Cable and 4.4 m Cable between WGFMU and RSU

For more information, see Keysight B1500A manual.

In This Manual

This manual provides the information about Keysight Technologies B1530A Waveform Generator/Fast Measurement Unit (WGFMU) and consists of the following chapters.

- Chapter 1, Introduction

  Describes product overview of WGFMU.

- Chapter 2, Installation

  Explains how to set up the measurement environment using WGFMU.

- Chapter 3, Using Instrument Library

  Describes how to use the instrument library and provides programming examples.

- Chapter 4, Instrument Library Reference

  Provides reference information of the instrument library designed for WGFMU.

NOTE

For the specifications of the B1530A, see Data Sheet.

To get the latest Data Sheet, go to www.keysight.com/find/b1500a and click “Technical Support” and “Specifications”.

Contents

1 Introduction

This chapter introduces Keysight B1530A waveform generator/fast measurement unit (WGFMU) which is a plug-in module for the Keysight B1500A Semiconductor Device Analyzer and Keysight B1531A remote-sense and switch unit (RSU) which is the required accessory for the WGFMU, and consists of the following sections.

- "Overview"
- "WGFMU"
- "RSU"
- "Accessories and Options"

NOTE

Differences from Other Modules in Measurement Control

Keysight B1500A supports several plug-in modules, HRSMU, MFCMU, SPGU, WGFMU and such. The plug-in modules are supported by the EasyEXPERT software which is the system software of the B1500A. However the WGFMU is not supported by the EasyEXPERT Classic Test operation.

The WGFMU can be controlled by the programs which use the Instrument Library furnished with the B1530A. The library contains about 80 API (application programming interface) needed to control the WGFMU and which can be used as subprograms in your measurement control program.

The B1530A also provides the sample application tests for EasyEXPERT and sample programs for Windows PC, which internally use the Instrument Library. You can perform measurements as shown in Table 1-1 by using the samples or the measurement control programs you create.

Table 1-1 **How to Control WGFMU**

Platform	Description
B1500A	Run the sample application tests on the EasyEXPERT.
Windows PC	Run the sample application tests on the Desktop EasyEXPERT.
	Execute the sample programs on the Windows environment.
	Use the WGFMU Instrument Library and create your program.

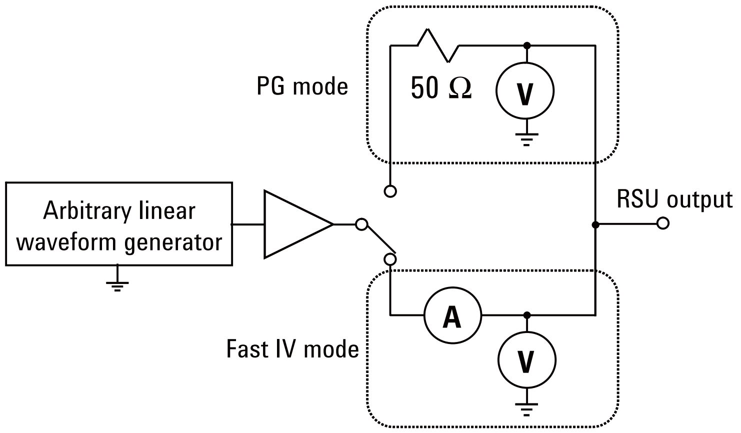
Overview

The WGFMU is the first self-contained module to offer the combination of arbitrary linear waveform generation (ALWG) with synchronized fast current or voltage (IV) measurement, which enables accurate high-speed IV characterization. The simplified measurement circuit diagram is shown in Figure 1-1.

Each WGFMU channel provides two operation modes: Fast IV mode (current or voltage measurement) and PG mode (pulse generator). The Fast IV and PG modes can run independently on each channel. In Fast IV mode, the channels can create arbitrary waveforms via the ALWG function and can measure current or voltage. For example, the channel can make current measurements with 2 nA resolution and with sampling speeds as fast as 5 ns. In PG mode, the channels can create narrower pulses with the ALWG function than they can in Fast IV mode and they can measure voltage; also, in this mode the WGFMU channels have a 50 Ω output impedance to prevent reflection-induced waveform degradations.

The WGFMU is a new type of measurement unit that integrates ALWG capability with high-speed IV measurement. The ALWG function allows you to generate not only DC, but also various types of AC waveforms (such as pulses, staircase sweeps, and staircase pulsed sweeps) with 10 ns programmable resolution.

Figure 1-1 **Simplified Circuit Diagram of WGFMU and RSU**



Followings are the typical specifications of WGFMU and RSU.

- Number of channels: 2 channels per module
- Function:

  Voltage output and current or voltage sampling measurement with minimum sampling interval of 5 ns
- Voltage output range: 3 V, 5 V, 10 V, or −10 V
- Voltage measurement range: 5 V or 10 V
- Current measurement range: 1 μA, 10 μA, 100 μA, 1 mA, or 10 mA
- Operation mode: PG mode, Fast IV mode, or DC mode
- PG mode:

  ALWG voltage output and voltage measurement (VFVM).

  Output level: −5 V to 5 V for open load, −2.5 V to 2.5 V for 50 Ω load

  Minimum pulse width: 100 ns
- Fast IV mode:

  ALWG voltage output and current or voltage measurement (VFIM or VFVM).

  Output level: 0 to −10 V, 0 to 10 V, or −5 V to 5 V

  Minimum pulse width: 300 ns
- DC mode:

  DC voltage output and current or voltage measurement (VFIM or VFVM).

  Output level: 0 to −10 V, 0 to 10 V, or −5 V to 5 V
- SMU mode:

  Input voltage to the *From SMU* terminal: maximum ±25 V

  Output level: maximum ±25 V

  Maximum current: 100 mA

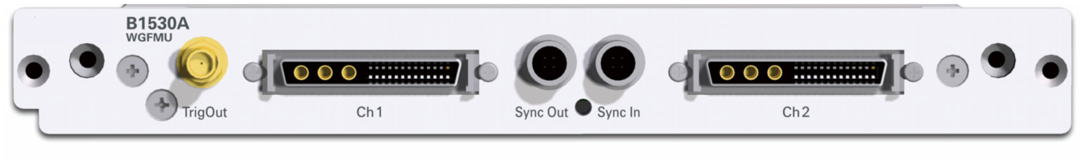
NOTE

WGFMU+RSU does not have the compliance feature which is known as the built-in output limiter of the SMU (source/monitor unit) modules. Instead it covers the full scale of the current measurement range for the full scale of the voltage output range. Then it may be hard to continue the voltage output of the setting value because of too small impedance of a DUT (device under test).

WGFMU

Keysight B1530A WGFMU has two measurement channels and the terminals for synchronizing the operation between WGFMUs or with an external equipment.

Figure 1-2 **B1530A WGFMU Connector Panel**



Ch 1, Ch 2

Measurement channel. Connect to the RSU. Each channel can work simultaneously in the same or different operation mode: Fast IV or PG mode. The channel also can be the DC voltage source.

Up to five WGFMU modules can be installed in one B1500A, for a total of ten channels. If the B1500A contains the WGFMU, sum of *Rating* for all module types in the mainframe must be < 60.

where *Rating* = *Number of modules* × *Rating for each module type*

Rating for each module type: HPSMU 14, MPSMU 2, HRSMU 2, MFCMU 7, HV-SPGU 12, WGFMU 10

Sync Out

WGFMU synchronization signal output terminal. Five pin connector. Connect to the Sync In terminal of the secondary WGFMU.

Sync In

WGFMU synchronization signal input terminal. Five pin connector. Connect to the Sync Out terminal of the primary WGFMU.

NOTE

About primary and secondary WGFMU

The primary WGFMU means the module installed in the lower slot. And the secondary WGFMU means the module following to the primary WGFMU. For the connection example, see Table 2-2.

CAUTION

To Connect Sync Out, Sync In, and Trig Out terminals

Connect the Sync Out/In and Trig Out terminals to the specified terminal properly. Connecting to the other terminal may result in damage to the WGFMU.

TrigOut

Trigger output terminal. SMA female connector. Connect to the trigger input terminal of an equipment synchronized with the WGFMU Ch1 or Ch2 output.

- Trigger mode:
    - No trigger, default setting
    - Event trigger output
    - Execution trigger output
    - Sequence trigger output
    - Pattern trigger output
- Output signal: TTL level pulse signal
- Polarity: Positive or negative, selectable
- Pulse width:

    Adjustable for the event trigger

    10 ns for the execution, sequence, and pattern triggers

NOTE

About pulse width

If the trigger input terminal of the external equipment is not high impedance, you may need to adjust the pulse width. For example, if the input impedance is 50 Ω, the duration of TTL high level should be ≤ 5 μs for the trigger (pulse) period > 10 μs, or the duty of the high level pulse should be ≤ 50 % for the period ≤ 10 μs.

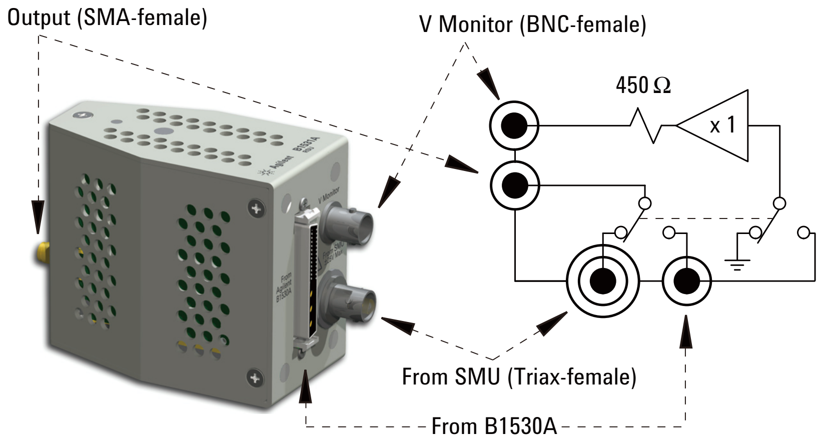
For the execution, sequence, and pattern triggers, use the negative trigger for the trigger period < 20 ns.

RSU

Keysight B1531A RSU is supplied for each channel of each WGFMU module. The RSU is designed to be mounted on the wafer prober close to the device under test (DUT) to optimize measurement performance. In addition to its primary measurement functions, the RSU has a triaxial connector that can be used with a source/monitor unit (SMU). This permits switching between the WGFMU and SMU without having to change any cabling.

Normally, the RSU makes the path from the SMU input terminal to the RSU output terminal. When the WGFMU channel performs the voltage output or the IV measurement, the RSU makes the path from the WGFMU input terminal to the RSU output terminal.

Figure 1-3 **B1531A Remote-sense and Switch Unit (RSU)**



NOTE

To avoid unintentional results

Timing between channels can be affected by electrostatic discharge. To avoid unintentional results, keep hands off of terminals while measurement is being performed.

Output

RSU output terminal to be connected to the DUT interface. SMA female connector. Connect to a DC probe or a RF probe.

Maximum output voltage is ±10 V when the WGFMU output appears and ±25 V when the SMU output appears.

From SMU

SMU connection terminal. Triaxial BNC female connector. Connect to the Force terminal of a SMU installed in the B1500A with the WGFMU if you want to use the SMU.

NOTE

To connect SMU

To connect a cable between the *From SMU* terminal and a SMU, disconnect DUT from *Output*. Otherwise changing the cable connection may damage the DUT.

CAUTION

To apply SMU output

Maximum input voltage to the From SMU terminal is ±25 V. Do not apply voltage which exceeds this limit. Or the RSU will be damaged.

V Monitor

Voltage monitor terminal. BNC female connector. Connect an oscilloscope if you want to monitor the output waveform.

If the RSU makes the path to the From SMU terminal, the V Monitor terminal will be internally connected to ground.

If the RSU makes the path to the From Keysight B1530A terminal, the V Monitor terminal will be internally connected to the 450 Ω output impedance and the ×1 amplifier. So if an oscilloscope channel with high impedance is connected to the V Monitor terminal, the oscilloscope will measure and show 5 V (=5×1) when the WGFMU outputs 5 V.

If an oscilloscope channel with 50 Ω input impedance is connected to the V Monitor terminal, the oscilloscope will measure and show 0.5 V (=5×0.1) when the WGFMU outputs 5 V.

From Keysight B1530A

WGFMU connection terminal. Connect to the WGFMU Ch 1 or Ch 2 terminal.

CAUTION

The B1500A must be turned off before connecting/disconnecting the cable between the RSU and the WGFMU Ch 1/Ch 2 terminal.

Accessories and Options

Keysight B1530A is furnished with the following accessories.

- Keysight B1531A Remote Sense and Switch Unit, RSU, 2 ea.
- Sync terminal connection cable, 1 ea.
- Instrument Library and Sample Program CD, 1 ea.
- User's Guide, 1 ea.

Table 1-2 lists the options and the available accessories for Keysight B1530A

Table 1-2 **Options and Accessories**

Model number	Option item	Description
B1530A		Waveform Generator/Fast Measurement Unit, WGFMU
	B1530A-001	WGFMU-to-RSU cable set, 0.6 m and 2.4 m, 2 sets
	B1530A-002	WGFMU-to-RSU cable, 3 m, 2 ea.
	B1530A-003	WGFMU-to-RSU cable, 5 m, 2 ea.
	B1530A-004	WGFMU-to-RSU cable set, 0.6 m and 4.4 m, 2 sets
	B1530A-005	WGFMU-to-RSU cable, 1.5 m, 2 ea.
	B1530A-0KN	Sample Program Learning Kit
B1531A		Remote-sense and Switch Unit, RSU
16493R		WGFMU Cables and Accessories
	16493R-001	WGFMU-to-RSU cable, 0.6 m
	16493R-002	WGFMU-to-RSU cable, 2.4 m
	16493R-003	WGFMU-to-RSU cable, 3 m
	16493R-004	WGFMU-to-RSU cable, 5 m
	16493R-005	WGFMU-to-RSU cable, 4.4 m
	16493R-006	WGFMU-to-RSU cable, 1.5 m
	16493R-101	SSMC short-open cable for current return path, 50 mm
	16493R-102	SSMC short-open cable for current return path, 75 mm
	16493R-202	SMA-SSMC cable between RSU and DC probe, 200 mm
	16493R-302	SMA-SMA cable between RSU and RF probe, 200 mm
	16493R-801	WGFMU connector adapter (female-female)
	16493R-802	Magnet stand for RSU
	16493R-803	Sync terminal connection cable

2 Installation

This chapter covers the following topics. The RF probes and the DC probes will be required to make contact with the device under test (DUT). To perform the measurement, complete the instructions described in this chapter.

- "RF Probes"
- "DC Probes"
- "To Connect Measurement Cables"
- "To Perform Self-Test"
- "To Install Instrument Library"

See Keysight B1500 manual for inspection of the delivered goods and installation of the B1500A.

NOTE

About WGFMU module installation

Module installation of WGFMU must be performed by Keysight Technologies service personnel. Contact Keysight Technologies for the module installation.

CAUTION

Using torque wrench and open-end wrench

For the RF measurements, it is important to carefully contact and fasten the connectors of the RF cables. The condition of the cable connections may change the measurement result characteristics. Therefore treat the RF cables carefully, especially the RF connectors, and use the torque wrench and the open-end wrench when you fasten the RF connectors. The recommended tools are listed in Table 2-1.

CAUTION

Using cable tie

Use a cable tie to secure the cables. Then, do not tug the cable tie. You must treat the RF cables carefully to avoid the damage.

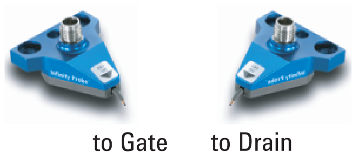
Table 2-1 **Recommended Tools**

Keysight part number	Description
8710-1582	Torque wrench, 5 lb.
8710-1765	Torque wrench, 8 lb.
5185-2174	Open-end wrench, 5/16 inch
5188-4367	Open-end wrench, 11/32 inch

RF Probes

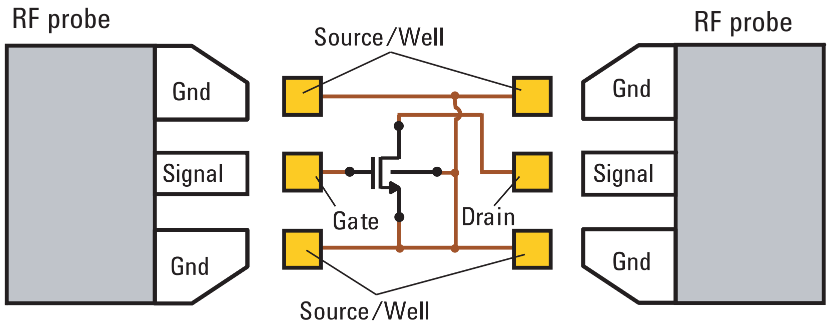
The RF measurement system supports the measurement of the three-terminal MOSFET (source and well (substrate) are shorted) by using the RF probes as shown in Figure 2-1. One measurement path is for the gate terminal and the other path is for the drain terminal. Moreover the source/well terminal must be electrically connected to the ground via the shielding of the measurement path (RF probes and measurement cables). See Figure 2-2.

Figure 2-1 **RF Probes**



Prepare two RF probes to perform the RF measurement. The RF probe must have the signal line and the ground lines as shown in Figure 2-2. The signal line is to contact the gate or drain pad, and the ground lines are to contact the source/well pads. For the RF probe and its installation, consult your favorite prober vender. Figure 2-1 shows the RF probes of Cascade Microtech, Inc.

Figure 2-2 **Contact Pad and Probe Tip**



DC Probes

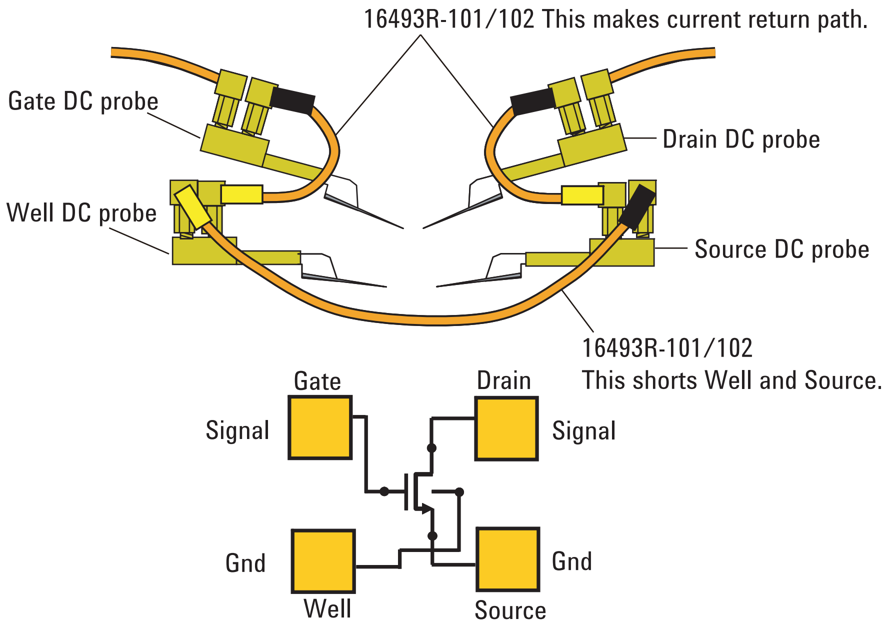
The MOSFET contact pads for DC measurement shown in Figure 2-3, are more popular than the RF contact pads shown in Figure 2-2. If device under test is configured with DC contact pads, use DC probes instead of RF probes. The DC probes are better suited for contact with the DC contact pads than the RF probes. See Figure 2-3 for the contact pads and the DC probes.

Prepare four DC probes and three connection cables to connect the DC probes together. The model number of connection cable is 16493R-101 or 16493R-102.

- 16493R-101: 50 mm length SSMC short-open cable
- 16493R-102: 75 mm length SSMC short-open cable

For more information, see "Connecting DC Probes" on page 2-12.

Figure 2-3 **Contact Pad and DC Probe Connection**



To Connect Measurement Cables

This section covers the instructions to make connection between WGFMU and RF/DC probes. Before starting the instructions, complete the installation of the B1500A installed with the WGFMU. See Keysight B1500 manual.

While performing the following instructions, turn the B1500A off and disconnect the power cable.

- "Connecting RSU"
- "Connecting RF Probes"
- "Connecting DC Probes"

CAUTION The B1500A must be turned off before connecting/disconnecting the cable between the RSU and the WGFMU Ch 1/Ch 2 terminal.

NOTE **For unused channels**

Measurement terminals can be opened. Cable connection is not required. With the open condition, the channels will pass the self-test and skip the self-calibration. But controlling the channel will cause a run-time error.

NOTE **Cables used for the same measurement**

Connect all measurement cables to the appropriate terminals, tie them up together, and make them stable by taping or something. This is important to reduce an environmental noise.

Connecting RSU

Prepare the required accessories and connect cables between RSU and WGFMU or SMU. See Table 2-2 for a connection example. This example connects three RSUs.

Required accessories:

- WGFMU-to-RSU cable (D-sub), 1 ea. per one RSU

  1.5 m, 3 m, or 5 m cable (16493R-006, 003, or 004)

  The 16493R-801 adapter is required and mounted on a shielding box to make connection to the RSU in the shielding box. Then the 60 cm and 2.4 m cables (16493R-001 and 002) or the 60 cm and 4.4 m cables (16493R-001 and 005) are required instead of the 1.5 m, 3 m, or 5 m cable.

- Sync connection cable (furnished with B1530A), 1 ea. between two WGFMUs
- Magnet stand (16493R-802), 1 ea. per one RSU, optional. The magnet stand is useful for fixing RSU. See Figure 2-4 for dimensions.
- Triaxial cable (SMU to RSU), 1 ea. per one RSU, optional

  1.5 m or 3 m cable (16494A-001 or 002)

  The 16495H-001 or 16495J-001 connector plate is required and mounted on a shielding box to make connection to the RSU in the shielding box. Then the 80 cm or 40 cm cable (16494A-003 or 004) is additionally required.

- 16495K-001 plate with cable holder

  Instead of using both 16493R-801 and 16495H/J-001.

NOTE

Keysight 16493R-801 adapter, 16495H/J-001 plate, and 16495K-001 plate

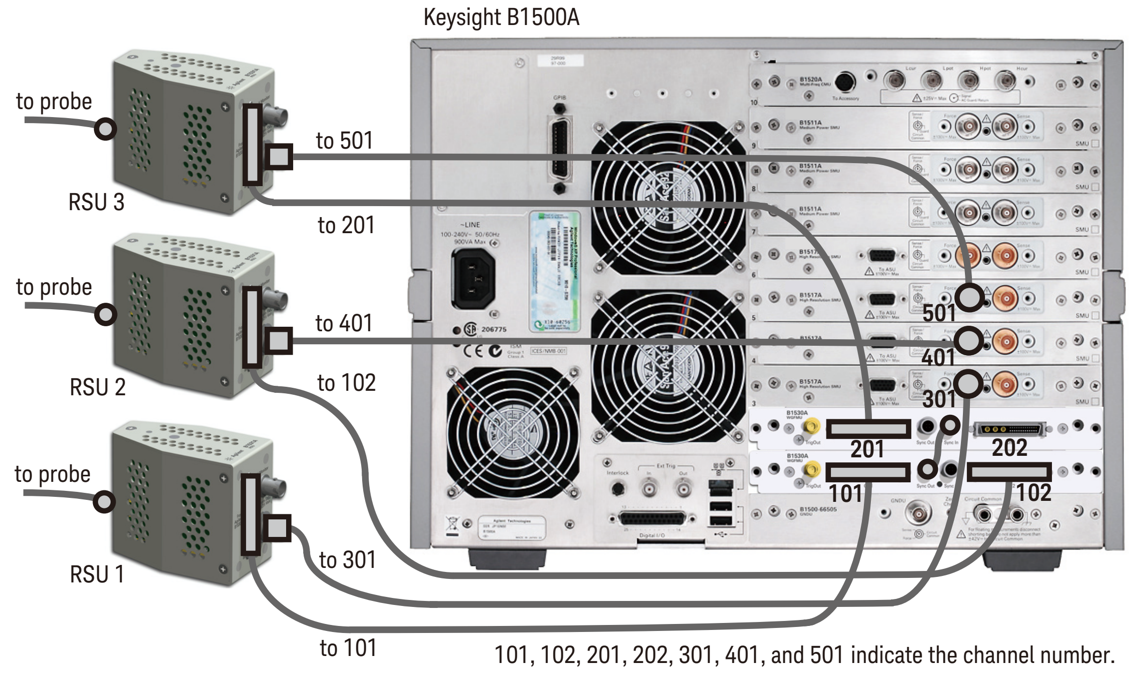
The 16493R-801 is used to connect the cable from WGFMU and the cable from RSU. Make an opening and screw holes on the shielding box. See Figure 2-5 for the dimensions of adapter and for the opening and screw holes which are required to mount the adapter on the shielding box.

The 16495H/J-001 is used to connect the cable from SMU and the cable from RSU.

Instead of using both 16493R-801 and 16495H/J-001, the 16495K can be used to pass the cables into the shielding box.

See *Keysight 16495 Installation Guide* for the dimensions of plate and for the opening and screw holes which are required to mount the plate on the shielding box.

Table 2-2 RSU Connection Example



From	Cable	To	Slot number
SMU (RSU3)	1.5 m or 3 m triaxial cable (16494A-001 or 002)	Force	5 (SMU)
SMU (RSU2)		Force	4 (SMU)
SMU (RSU1)		Force	3 (SMU)
WGFMU (RSU3)	1.5 m, 3 m, or 5 m WGFMU-to-RSU cable (16493R-006, 003, or 004)	Ch 1	2 (WGFMU)
WGFMU (RSU2)		Ch 2	1 (WGFMU)
WGFMU (RSU1)		Ch 1	1 (WGFMU)
Sync Out [a]	Sync connection cable, furnished with B1530A	Sync In [b]	1 and 2

a. Sync Out connector of WGFMU installed in the slot 1.
b. Sync In connector of WGFMU installed in the slot 2.

Procedure:

1. Mount 16343R-801 adapter, 16495H/J-001 plate, or 16495K-001 plate on the shielding box. Then consult your prober vender or the vender of shielding box.
2. Set RSU to the appropriate place. RSU must be fixed to the best position for accessing its connectors.

   Dimensions of RSU are 45.2 mm (W) × 70.0 mm (H) × 82.0 mm (D) excluding the connectors.

   If you use 16493R-802 magnet stand, see Figure 2-4 for dimensions.
3. If adapter or plate is used, connect the required cables to the following connectors.

   In the shielding box:

   - D-sub connector on the adapter, for 60 cm cable
   - Triaxial connector on the plate, for 80 cm or 40 cm cable, optional for SMU

   Out of the shielding box:

   - D-sub connector on the adapter, for 2.4 m or 4.4 m cable
   - Triaxial connector on the plate, for 1.5 m or 3 m cable, optional for SMU
4. If the 16495K is used, pass the required cables through the cable hole of the 16495K, adjust the cable length in the shielding box, and cover the cable holder of the 16495K.
5. Connect the WGFMU-to-RSU cable to the *From Keysight B1530A* terminal of RSU.
6. Optional for SMU. Connect the triaxial cable to the *From SMU* terminal of RSU.
7. Connect the WGFMU-to-RSU cable to the *Ch 1* or *Ch2* terminal of WGFMU.
8. Optional for SMU. Connect the triaxial cable to the *Force* terminal of SMU.
9. If multiple WGFMUs are installed and used, connect the Sync connection cable between the *Sync Out* terminal of the primary WGFMU and the *Sync In* terminal of the secondary WGFMU. See Table 2-2 for a connection example.

NOTE

Primary WGFMU and secondary WGFMU

The primary WGFMU means the module installed in the lower slot. And the secondary WGFMU means the module following to the primary WGFMU.

CAUTION

To connect Sync Out and Sync In terminals

Connect the Sync Out/In and Trig Out terminals to the specified terminal properly. Connecting to the other terminal may result in damage to the WGFMU.

NOTE

To use V Monitor

If you want to monitor the RSU output signal, prepare 50 Ω BNC coaxial cables, and make connection from the *V Monitor* terminal to the 50 Ω input channel of your oscilloscope. Then the voltage at the *V Monitor* terminal will be 1/10 of the RSU output signal.

If you use a high impedance channel or a voltage meter, the voltage is the same.

Figure 2-4 **16493R-802 Magnet Stand**

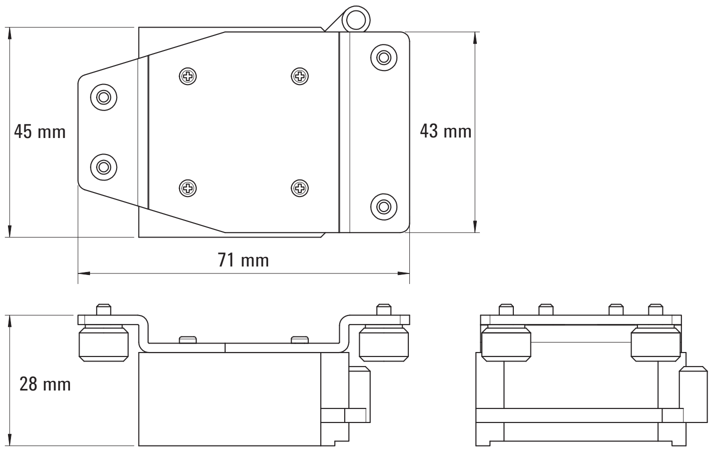
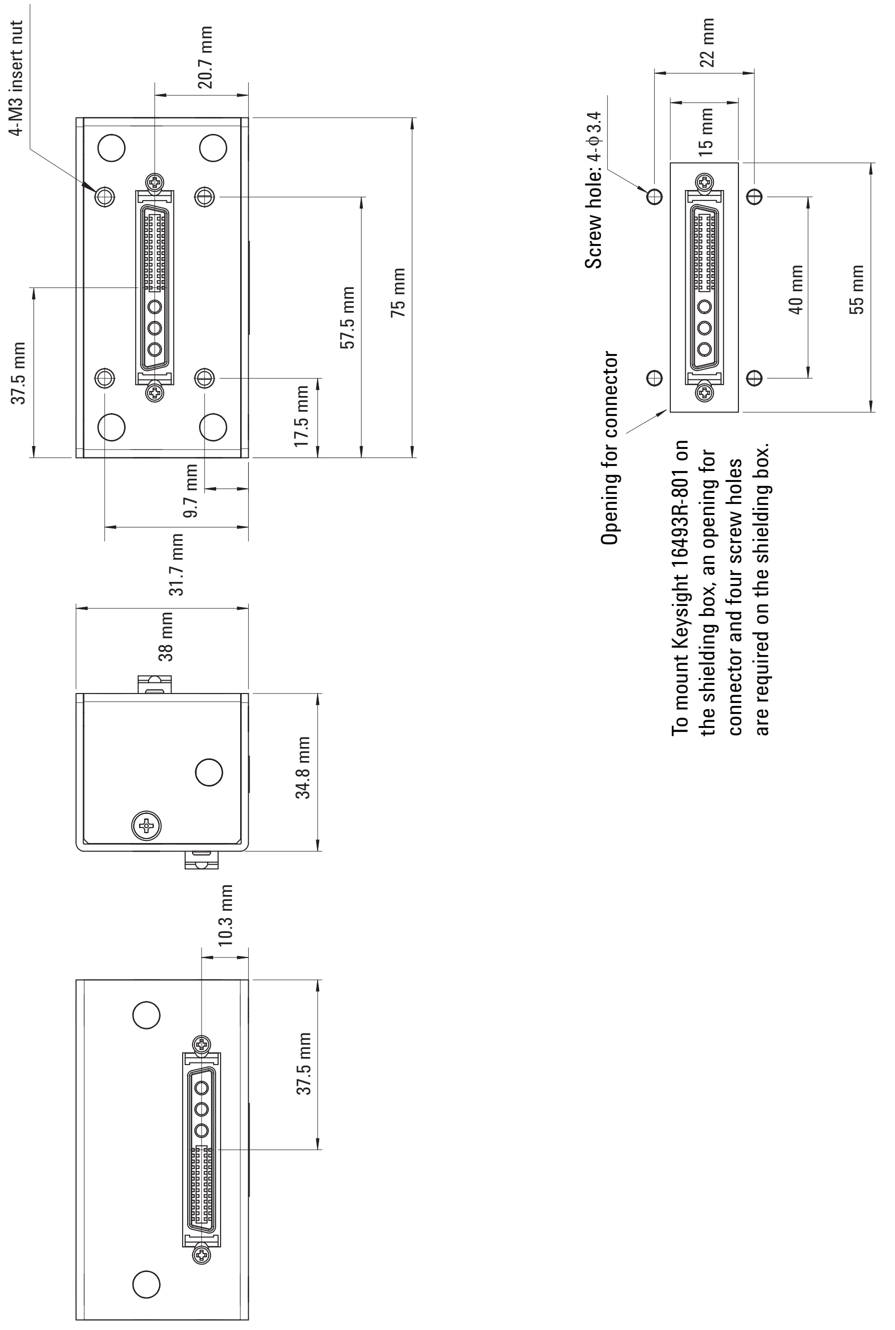


Figure 2-5 **16493R-801 Adapter**



Connecting RF Probes

Only for the RF probe users. Connect the following cables as shown in Figure 2-6. Use a torque wrench and an open-end wrench to fasten the SMA connectors.

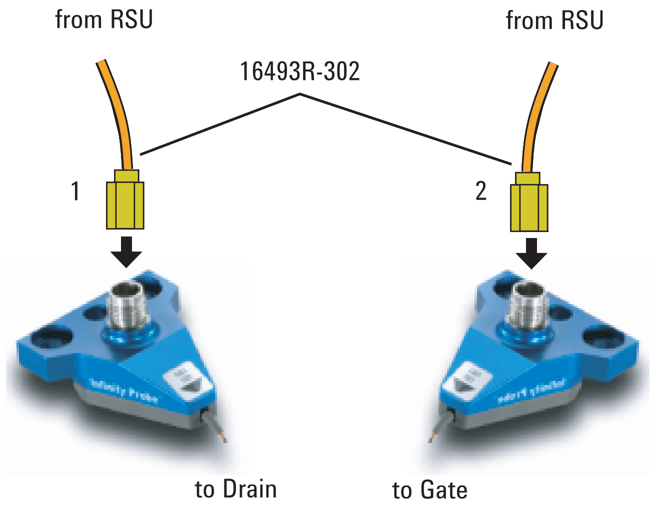
Required accessories:

- RF prober, 2 ea.
- 16493R-302 20 cm length SMA-SMA cable, 2 ea.

Procedure:

1. Connect a SMA-SMA cable between a RSU (ex: RSU1) and the Drain RF probe. And set the Drain RF probe to the appropriate place.
2. Connect the other SMA-SMA cable between the other RSU (ex: RSU2) and the Gate RF probe. And set the Gate RF probe to the appropriate place.

Figure 2-6 **RF Probe Connections**



Connecting DC Probes

Only for the DC probe users. Connect the following cables as shown in Figure 2-7. Use a torque wrench and an open-end wrench to fasten the SMA connectors.

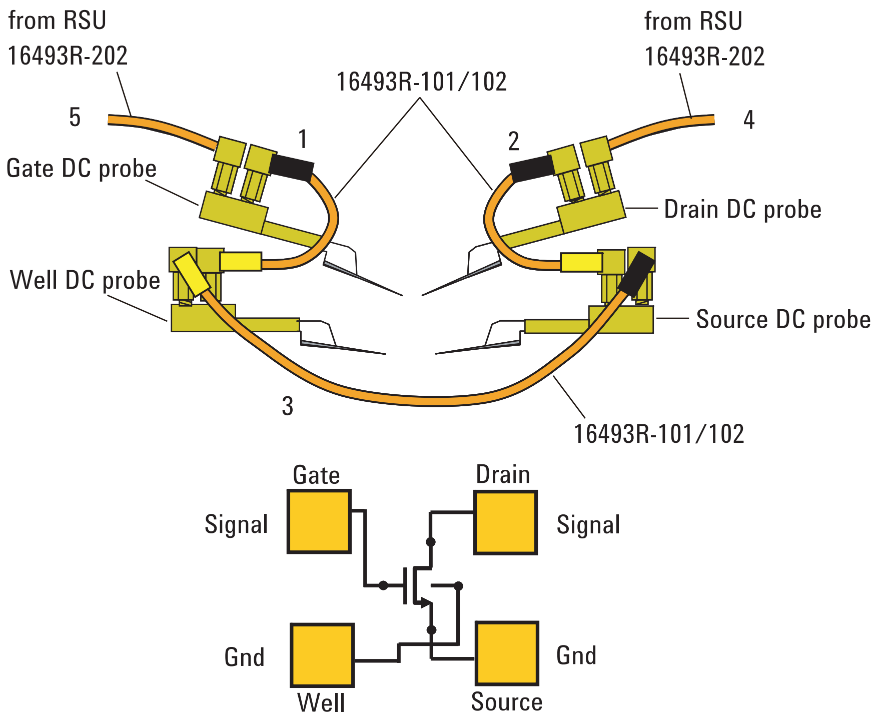
Required accessories:

- DC prober, 4 ea.
- 16493R-202 20 cm length SMA-SSMC cable, 2 ea.
- 16493R-101: 50 mm length SSMC short-open cable or

  16493R-102: 75 mm length SSMC short-open cable, total 3 ea.

  For the external view and the internal connection, see Figure 2-8.

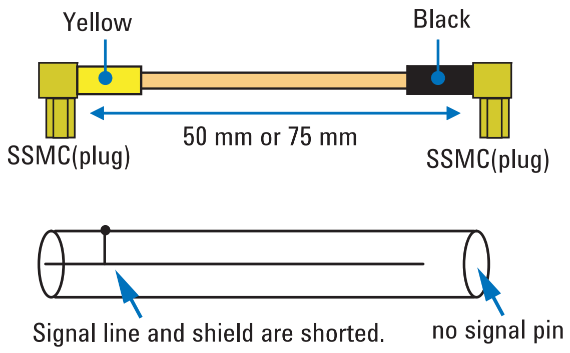
Figure 2-7 **DC Probe Connections**



Procedure:

1. Connect a SSMC short-open cable between the Gate DC probe and the Well DC probe, and set the DC probes to the appropriate place. Then, the black sleeve plug must be the Gate side. This electrically connects the Well probe needle, Well probe shield, and Gate probe shield together.
2. Connect a SSMC short-open cable between the Drain DC probe and the Source DC probe, and set the DC probes to the appropriate place. Then, the black sleeve plug must be the Drain side. This electrically connects the Source probe needle, Source probe shield, and Drain probe shield together.
3. Connect the last SSMC short-open cable between the Well DC probe and the Source DC probe, and set the DC probes to the appropriate place. Then, the black sleeve plug must be the Source side. This electrically connects the Well probe needle, Well probe shield, and Source probe shield together.
4. Connect a SMA-SSMC cable between a RSU (ex: RSU1) and the Drain DC probe. And set the Drain DC probe to the appropriate place.
5. Connect the other SMA-SSMC cable between the other RSU (ex: RSU2) and the Gate DC probe. And set the Gate DC probe to the appropriate place.

Figure 2-8 **SSMC Short-Open Cable**



To Perform Self-Test

After completing the measurement cable connections, check the operation of the Keysight B1500A as shown below.

1. Open the measurement terminals at the DUT interface.
2. Connect the power cable to the B1500A. And connect it to an AC power outlet.
3. Turn the B1500A on. The power-on self-test will run automatically. And wait until the Start EasyEXPERT window appears. The WGFMU and the RSU are recognized by the EasyEXPERT software revision A.03.20 or later.
4. Click the Start EasyEXPERT button. And wait until the EasyEXPERT main screen or workspace selection screen is displayed.
5. If the workspace selection screen is displayed, follow the instruction on the screen and open the EasyEXPERT main screen.
6. On the EasyEXPERT main screen, click the Configuration button. The Configuration window appears.
7. On the Configuration window, click the Module tab. The window shows the slot configuration and the self-test results. The Status of all modules must be PASS.

For more details, see EasyEXPERT manual.

If the B1500A or any module fails the self-test, contact Keysight Technologies.

To Install Instrument Library

This section describes the instructions to install the Keysight B1530A WGFMU Instrument Library to an instrument controller (Windows PC).

- "System Requirements"
- "Installing Instrument Library"
- "Before Programming"

System Requirements

The following system environments are required for the instrument controller. The system requirements are effective as of June 2011. For the latest information, go to www.keysight.com and type in B1530A in the Search field at the top of the page.

- Computer and peripherals

  Required specifications depend on the application development environment (programming software shown below). See manual of the programming software you use.

- Operating system

  Microsoft Windows XP Professional SP3 or later, Windows Vista Business SP2 or later (32bit only), and Windows 7 Professional SP1 or later (32 bit and 64bit)

- GPIB (IEEE 488) interface and software

  Keysight 82350B GPIB interface and Keysight IO Library Suite 15.0 or later

- Programming software

  Microsoft Visual Studio 2005 Express edition or later, Visual C++ .NET, Visual C# .NET, Visual Basic .NET, Visual Basic 6.0, VBA, or TransEra HTBasic for Windows (release 8.3 or later)

Installing Instrument Library

The installation flow is shown below. If you have already installed the GPIB interface, Keysight IO Library Suite, and programming software on your computer, skip steps 1 through 4.

1. Install the GPIB interface to a computer to be an instrument controller.

   See manual of the GPIB interface. Note the model number of the GPIB interface, as you may need it to configure the interface (in step 3).

2. Install the Keysight IO Library Suite.

   Follow the setup program instructions.

3. Configure and check the GPIB interface.

   See manual of the Keysight IO Library Suite.

4. Install the programming software.

   Follow the setup program instructions.

5. Install the Keysight B1530A WGFMU Instrument Library.

   a. Insert the Keysight B1530A Instrument Library and Sample Program CD to the CD-ROM drive.

   b. Execute setup.exe of the Instrument Library and follow the instructions of the setup wizard.

   c. Wait for installation to complete, and remove the CD from the CD-ROM drive.

Before Programming

Before starting the programming using an instrument controller, perform following.

1. Terminate the Keysight EasyEXPERT software on the B1500A as follows.

   a. Select *File* > *Exit* on the EasyEXPERT main window.

   b. Click [x] at the upper right corner of the Start EasyEXPERT button.

2. Open the Keysight Connection Expert window on the B1500A by clicking *Keysight IO Control* icon on the Windows task bar and selecting *Keysight Connection Expert*.

3. Change the following setup items as shown below. The setup window can be opened by highlighting *GPIB0* in the *Instrument I/O on this PC* area, and clicking *Change Properties...* button.

GPIB address	B1500A's GPIB address (ex: 17)
System Controller	No
Auto-discover	No

   The factory shipment initial values are 17, No, and No, respectively.

4. Reboot the B1500A if the System Controller setting is changed from Yes to No.

NOTE

Start EasyEXPERT button

After rebooting the B1500A, leave the Start EasyEXPERT button on the B1500A's screen. The button must be displayed on the screen or minimized to the Windows task bar. The Start EasyEXPERT service must be run to control the B1500A from an external computer.

NOTE

B1500A in remote mode

Once the B1500A receives a GPIB command, the Start EasyEXPERT button is minimized to the Windows task bar, and the FlexGUI window is opened. This window is the status indicator of the B1500A in the GPIB remote state and provides some graphical user interface. For details, see *Keysight B1500 Series Programming Guide*.

3 Using Instrument Library

This chapter introduces programming summary and example programs by using the Keysight B1530A WGFMU Instrument Library and consists of the following sections. For the details of the functions, see Chapter 4, “Instrument Library Reference.”

- “Programming Overview”
- “Programming Examples”
- “If You Perform DC Measurement”

CAUTION

Before turning the B1500A on

Connect the cable between the RSU and the WGFMU Ch 1/Ch 2 terminal. This prevents the RSU from damage.

NOTE

After turning the B1500A on

Use EasyEXPERT to confirm that the B1500A, the WGFMU, and the RSU pass the self-test. If anything fails the self-test, perform the self-test again. If it fails again, contact your nearest Keysight Technologies.

NOTE

Before starting measurement

Perform the self-calibration of the WGFMU and the RSU. This minimizes the measurement error.

Programming Overview

WGFMU control program can be created by using the functions listed in Table 3-1. Execute the functions in this order.

The WGFMU online session is started by the WGFMU_openSession function and is ended by the WGFMU_closeSession function. This means that the functions for the step 1 to 3 can be used in the offline condition which the WGFMU is not connected.

The WGFMU channel output and measurement control data can be created by the step 1 to 3. And you can check the data by using the WGFMU_exportAscii function before opening the session. This function creates a csv (comma separated value) data file which can be opened by a spreadsheet software. You can verify the timing, waveform pattern, and sequence by using a graph on the spreadsheet software.

Table 3-1 **Summary of Execution Flow**

Step	Action	Function
	Optional. Starts error and warning logging	WGFMU_openLogFile
	Optional. Clears instrument library	WGFMU_clear
1	Creates pattern data	See Table 3-2.
2	Defines several events	See Table 3-3.
3	Creates WGFMU channel output and measurement control data	WGFMU_addSequence
		WGFMU_addSequences
4	Opens session	WGFMU_openSession
	Optional. Initializes WGFMU channels	WGFMU_initialize
5	Sets measurement condition	See Table 3-4.
6	Enables WGFMU channels	WGFMU_connect
7	Starts output and measurement	WGFMU_execute
8	Disables WGFMU channels	WGFMU_disconnect
9	Closes session	WGFMU_closeSession
	Optional. Stops error and warning logging	WGFMU_closeLogFile

Table 3-2 **To Create Pattern Data**

Function		Description
WGFMU_createPattern		Creates waveform pattern
	WGFMU_addVector	
	WGFMU_addVectors	
	WGFMU_setVector	
	WGFMU_setVectors	
WGFMU_createMergedPattern		Creates pattern by merging patterns
WGFMU_createMultipliedPattern		Creates pattern by multiplying pattern
WGFMU_createOffsetPattern		Creates pattern by adding offset to pattern

Table 3-3 **To Define Measurement Events, Range Events, and Trigger Events**

Function	Description
WGFMU_setMeasureEvent	Defines a measurement event which is a sampling measurement performed by the WGFMU channel while it outputs a waveform pattern.
WGFMU_setRangeEvent	Defines a range event which is the range change operation for the current measurement performed by the WGFMU channel while it outputs a waveform pattern.
WGFMU_setTriggerOutEvent	Defines a trigger output event which is the trigger output operation performed by the WGFMU channel while it outputs a waveform pattern.

Table 3-4 **To Set Measurement Condition**

Step	Action	Function
1	Sets operation mode	WGFMU_setOperationMode
2	Sets voltage output range	WGFMU_setForceVoltageRange
3	Enables measurement ability	WGFMU_setMeasureEnabled
4	Sets measurement mode	WGFMU_setMeasureMode
5	Sets measurement range	WGFMU_setMeasureCurrentRange
		WGFMU_setMeasureVoltageRange
6	Reads the measurement data (time and voltage or current) for the measurement point defined in the sequences set to the specified WGFMU channel.	WGFMU_getMeasureValueSize
		WGFMU_getMeasureValues
		WGFMU_getMeasueValue

Table 3-5 lists a part of useful functions. For all functions, see Chapter 4, "Instrument Library Reference."

Table 3-5 **Other Useful Functions**

Function	Description
WGFMU_update	Applies WGFMU setup
WGFMU_updateChannel	
WGFMU_abort	Stops WGFMU operation
WGFMU_abortChannel	
WGFMU_getChannelIdSize	Reads channel id of WGFMU channels installed in the B1500A
WGFMU_getChannelIds	
WGFMU_doSelfCalibration	Performs self-calibration
WGFMU_doSelfTest	Performs self-test
WGFMU_exportAscii	Creates a setup summary report and saves it to a csv (comma separated values) file

Programming Examples

This section describes simple programming examples using the WGFMU Instrument Library and Microsoft Visual C++ programming software. This section covers the following topics and the examples shown in Table 3-6.

- "To Create Your Project Template"
- "To Create Measurement Program"

Table 3-6 **Summary of Programming Examples**

Section title	Description
Example 1	This example creates a waveform data and applies the waveform voltage.
Example 2	Sampling measurement code and data storage code are added to Example 1.
Example 3	Error handling is added to Example 2 and the data storage code is deleted.
Example 4	Error handling is added to Example 2 and the data storage code is deleted.
Example 5	Error handling is added to Example 2 and the data storage code is deleted.
Example 6	This example is similar to Example 2 but uses two WGFMU channels.
Example 7	Data retrieving is changed from Example 6.
Example 8	Data retrieving is changed from Example 6.
Example 9	This example performs Id-Vg measurement and saves measurement result data.
Example 10	Source output control code for SMU is added to the code similar to Example 3.
Example 11	Sampling measurement code for SMU is added to the code similar to Example 3.

To Create Your Project Template

This section describes how to create a project template using Microsoft Visual C++ programming software. Before starting programming, create your project template, and keep it as your reference. It will remove the conventional task in the future programming.

Step 1. Connect the B1500A to your instrument controller via GPIB.

Step 2. Launch the programming software and create a new project. Then, select the Win32 project or the console application for the new project template selection. They will simplify the programming. Of course, other project template can be used.

Step 3. Define the following to the project properties or the project options. See manual or on-line help of the programming software for defining them.

1. Additional include file search path:

   <user path>\Agilent\B1530A\include which stores the wgfmu.h file

   <user path>\VISA\winnt\include which stores the VISA related include files, optional

2. Additional library search path:

   <user path>\Agilent\B1530A\lib which stores the wgfmu.lib file

   <user path>\VISA\winnt\lib\msc which stores the VISA related library files for Microsoft Visual C++, optional

3. Additional project link library:

   wgfmu.lib

   visa32.lib, optional. Needed to execute Example 10 or 11.

<user path> indicates the folder the software is installed.

Step 4. Open a source file (.cpp) in the project, and enter a program code as template. See Table 3-7 for example.

Step 5. Save the project as your template (e.g. \test\my_temp).

Table 3-7 **Example Program Code for Project Template**

```
#include   "stdafx.h"
#include   <stdio.h>
#include   <stdlib.h>
#include   <visa.h>      //optional
#include   "wgfmu.h"

void checkError(int ret)                                                // 7
{
  if(ret < WGFMU_NO_ERROR) {
    throw ret;
  }
}

int checkError2(int ret)                                                //14
{
  if( ret < WGFMU_NO_ERROR ) {
   int size;
   WGFMU_getErrorSize(&size);
   char* msg = new char[size + 1];
   WGFMU_getError(msg, &size);
   fprintf(stderr, "%s", msg );
   delete [] msg;
  }
  return ret;
}
```

Line	Description
1 to 5	Required to use the WGFMU instrument library. The header files contain various necessary information such as function declaration and macro definitions. You may add the include statements to call another header files which may be needed by the codes you added. Also, the include statements may be written in a header file which will be called by the source file (e.g. #include <stdio.h> may be written in the stdafx.h header file which will be called by the source file).
7 to 12	Checks if the passed “ret” value indicates normal status, and returns to the line in the try statement in the measurement program code. If the value indicates an error status, go to the catch statement.
14 to 25	Checks if the passed “ret” value indicates normal status, and returns to the line in the measurement program code. If the value indicates an error status, the error message will be displayed.

```
static const int VISA_ERROR_OFFSET = WGFMU_ERROR_CODE_MIN - 1;

void checkError3(int ret)                                                   //29
{
  if(ret < WGFMU_NO_ERROR && ret >= WGFMU_ERROR_CODE_MIN || ret < VISA_ERROR_OFFSE
T) {
    throw ret;
  }
}

void writeResults(int channelId, const char* fileName)                      //36
{
  FILE* fp = fopen(fileName, "w");
  if(fp != 0) {
    int measuredSize, totalSize;
    WGFMU_getMeasureValueSize(channelId, &measuredSize, &totalSize);
    for(int i = 0; i < measuredSize; i++) {
      double time, value;
      WGFMU_getMeasureValue(channelId, i, &time, &value);
      fprintf(fp, "%.9lf, %.9lf\n", time, value);
    }
    fclose(fp);
  }
}

void writeResults2(int channelId, int offset, int size, const char* fileName)  //51
{
  FILE* fp = fopen(fileName, "w");
  if(fp != 0) {
    int measuredSize, totalSize;
    WGFMU_getMeasureValueSize(channelId, &measuredSize, &totalSize);
    for(int i = offset; i < offset + size; i++) {
      double time, value;
      WGFMU_getMeasureValue(channelId, i, &time, &value);
      fprintf(fp, "%.9lf, %.9lf\n", time, value);
    }
    fclose(fp);
  }
}
```

Line	Description
29 to 34	Checks if the passed “ret” value indicates normal status, and returns to the line in the measurement program code. If the value indicates an error status, go to the catch statement.
36 to 49	Reads all vector data and saves it to a csv file specified by the *fileName* variable. The vector data will be the voltage measured by *channelId* and its time data.
51 to 64	Reads a part of the measurement result data and saves it to a csv file specified by the *fileName* variable. The data contains *size* each of vector data begun from the index specified by *offset*. The vector data will be the voltage measured by *channelId* and its time data.

```
void writeResults3(int channelId1, int channelId2, int offset, int size, const
char* fileName)                                                          //66
{
  FILE* fp = fopen(fileName, "w");
  if(fp != 0) {
    int measuredSize, totalSize;
    WGFMU_getMeasureValueSize(channelId2, &measuredSize, &totalSize);
    for(int i = offset; i < offset + size; i++) {
      double time, value, voltage;
      WGFMU_getMeasureValue(channelId2, i, &time, &value);
      WGFMU_getInterpolatedForceValue(channelId1, time, &voltage);
      fprintf(fp, "%.9lf, %.9lf\n", voltage, value);
    }
    fclose(fp);
  }
}

int main()                                                               //82
{
  // Insert your code here
}
```

Line	Description
66 to 80	Reads a part of the measurement result data and saves it to a csv file specified by the *fileName* variable. The data contains *size* each of vector data begun from the index specified by *offset*. The vector data will be the voltage applied by *channelId1* and the voltage measured by *channelId2*.
84	Measurement program code must be inserted.

To Create Measurement Program

Create the measurement program as shown below. The following procedure needs your project template. If the procedure does not fit your programming environment, arrange it to suit your environment.

Step 1. Plan the automatic measurements. Then decide the following items:

- Measurement devices

  Discrete, packaged, on-wafer, and so on.

- Parameters/characteristics to be measured

  h_{FE}, Vth, sheet resistance, and so on.

- WGFMU source output waveform

  Pulse voltage, arbitrary linear waveform voltage, or DC voltage.

- Measurement condition

  Current measurement or voltage measurement, sampling interval, measurement timing, and so on.

Step 2. Make a copy of your project template (e.g. \test\my_temp to \device_001\my_temp).

Step 3. Rename the copy (e.g. \device_001\my_temp to \device_001\ex1).

Step 4. Launch the programming software.

Step 5. Open the project (e.g. \device_001\ex1).

Step 6. Open the source file that contains the template code as shown in Table 3-7, and complete the main program. Then use the WGFMU instrument library functions.

Step 7. Insert the code to display, store, or calculate data into the program, if necessary.

Step 8. Save the project (e.g. \device_001\ex1).

Example 1

This program creates a waveform pattern and sequence data and applies the waveform voltage by using the WGFMU channel 101. See Figure 3-1 for the waveform created by Programming Example 1.

This example program does not need the project template shown in Table 3-7.

Figure 3-1 **Waveform created by Programming Example 1 and Measurement Event set by Programming Example 2**

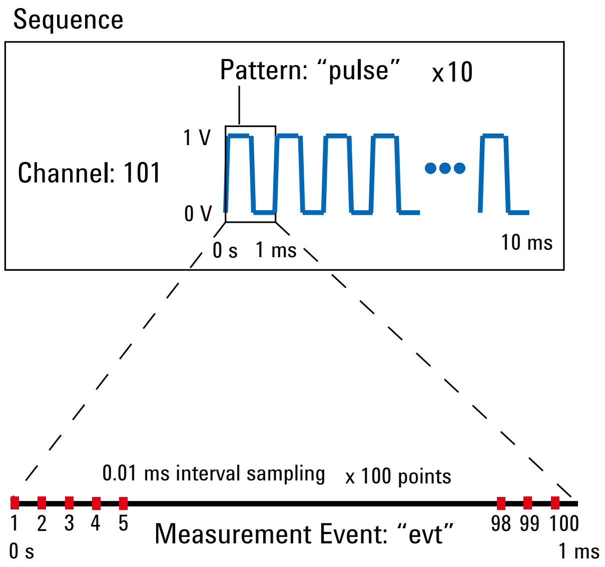


Table 3-8 Programming Example 1

```
#include   "stdafx.h"
#include   <stdio.h>
#include   <stdlib.h>
#include   "wgfmu.h"

int main() // Pulse voltage output
{
  // OFFLINE
  WGFMU_clear();                                                              // 9
  WGFMU_createPattern("pulse", 0);        //  0 ms, 0 V
  WGFMU_addVector("pulse", 0.0001, 1);    //0.1 ms, 1 V
  WGFMU_addVector("pulse", 0.0004, 1);    //0.5 ms, 1 V
  WGFMU_addVector("pulse", 0.0001, 0);    //0.6 ms, 0 V
  WGFMU_addVector("pulse", 0.0004, 0);    //1.0 ms, 0 V
  WGFMU_addSequence(101, "pulse", 10);    //10 pulse output                   //15

  // ONLINE
  WGFMU_openSession("GPIB0::17::INSTR");                                      //18
  WGFMU_initialize();
  WGFMU_setOperationMode(101, WGFMU_OPERATION_MODE_FASTIV);
  WGFMU_connect(101);
  WGFMU_execute();
  WGFMU_waitUntilCompleted();
  WGFMU_initialize(); // WGFMU_disconnect(101);                               //24
  WGFMU_closeSession();
}
```

Line	Description
9	Clears the B1530A instrument library.
10 to 14	Creates a waveform pattern data which is used to apply the voltage pulse.
15	Creates a sequence data.
18 to 19	Opens the session and initializes the all WGFMU channels.
20 to 23	Sets the fast IV mode for the WGFMU of the channel number 101, enables the channel, applies the WGFMU output, and waits until the output is completed.
24 to 25	Initializes the all WGFMU channels and closes the session.

Example 2

This program is almost same as Example 1. Differences are the additional lines 10 and 20. This program performs sampling measurement with the WGFMU output same as Example 1 and saves measurement result data to the specified file. See Figure 3-1 for the waveform and the measurement event set by Programming Example 2.

This program uses a subprogram in the project template shown in Table 3-7.

Table 3-9 Programming Example 2

```
int main() // Pulse voltage output and sampling measurement               // 1
{
  // OFFLINE
  WGFMU_clear();
  WGFMU_createPattern("pulse", 0);       //  0 ms, 0 V
  WGFMU_addVector("pulse", 0.0001, 1);   //0.1 ms, 1 V
  WGFMU_addVector("pulse", 0.0004, 1);   //0.5 ms, 1 V
  WGFMU_addVector("pulse", 0.0001, 0);   //0.6 ms, 0 V
  WGFMU_addVector("pulse", 0.0004, 0);   //1.0 ms, 0 V
  WGFMU_setMeasureEvent("pulse", "evt", 0, 100, 0.00001, 0, WGFMU_MEASURE_EVENT_DA
TA_AVERAGED);  // meas from 0 s, 100 points, 0.01 ms interval, no averaging   //10
  WGFMU_addSequence(101, "pulse", 10);   //10 pulse output

  // ONLINE
  WGFMU_openSession("GPIB0::17::INSTR");
  WGFMU_initialize();
  WGFMU_setOperationMode(101, WGFMU_OPERATION_MODE_FASTIV);
  WGFMU_connect(101);
  WGFMU_execute();                                                            //18
  WGFMU_waitUntilCompleted();
  writeResults(101, "C:/temp/B1530A/data/ex02.csv");                          //20
  WGFMU_initialize(); // WGFMU_disconnect(101);
  WGFMU_closeSession();
}
```

Line	Description
1 to 23	Almost same as Example 1.
10	Sets the sampling measurement timing parameters.
18	Applies the WGFMU output and performs the sampling measurement.
20	Calls the writeResults subprogram in the project template. Saves the measurement result data to the specified file.

Example 3

This program performs measurement as same as Example 2. Then the execution result of each function is checked by using the checkError subprogram in the project template shown in Table 3-7. If an error is detected, this program displays the error message. The result data is not saved.

Table 3-10 **Programming Example 3**

```
int main() // Pulse voltage output and sampling measurement with error check  // 1
{
  try {
    // OFFLINE
    checkError(WGFMU_clear());
    checkError(WGFMU_createPattern("pulse", 0));
    checkError(WGFMU_addVector("pulse", 0.0001, 1));
    checkError(WGFMU_addVector("pulse", 0.0004, 1));
    checkError(WGFMU_addVector("pulse", 0.0001, 0));
    checkError(WGFMU_addVector("pulse", 0.0004, 0));
    checkError(WGFMU_setMeasureEvent("pulse", "evt", 0, 1000, 0.000001, 0, WGFMU_M
EASURE_EVENT_DATA_AVERAGED));
    checkError(WGFMU_setMeasureEvent("pulse", "evt", 0, 100, 0.00001, 0, WGFMU_MEA
SURE_EVENT_DATA_AVERAGED));
    checkError(WGFMU_addSequence(101, "pulse", 10));                             //13

    // ONLINE
    checkError(WGFMU_openSession("GPIB0::17::INSTR"));
    checkError(WGFMU_initialize());
    checkError(WGFMU_setOperationMode(101, WGFMU_MEASURE_MODE_CURRENT));      //18
    checkError(WGFMU_connect(101));
    checkError(WGFMU_execute());
    checkError(WGFMU_waitUntilCompleted());
    checkError(WGFMU_initialize());
    checkError(WGFMU_closeSession());
  }
  catch(int e) {  // handle error                                               //25
    int size;
    WGFMU_getErrorSize(&size);
    char* error = new char[size + 1];
    WGFMU_getError(error, &size);
    fprintf(stderr, "%s", error);
    delete[] error;
  }                                                                              //32
}
```

Line	Description
5 to 23	Almost same as Example 2. Measurement result data is not saved.
11 to 12	Sets the sampling measurement timing parameters. Line 12 causes an overwrite warning.
18	Causes an error because of the invalid value WGFMU_MEASURE_MODE_CURRENT.
25 to 32	Reads and displays error message.

Example 4

This program performs measurement as same as Example 2. Then the execution result of each function is checked by using the checkError2 subprogram in the project template shown in Table 3-7. If an error is detected, this program displays the error message. The result data is not saved.

Table 3-11 **Programming Example 4**

```
int main() // Pulse voltage output and sampling measurement with error check  // 1
{
  // OFFLINE
  checkError2(WGFMU_clear());
  checkError2(WGFMU_treatWarningsAsErrors(WGFMU_WARNING_LEVEL_SEVERE));
  checkError2(WGFMU_createPattern("pulse", 0));
  checkError2(WGFMU_addVector("pulse", 0.0001, 1));
  checkError2(WGFMU_addVector("pulse", 0.0004, 1));
  checkError2(WGFMU_addVector("pulse", 0.0001, 0));
  checkError2(WGFMU_addVector("pulse", 0.0004, 0));
  checkError2(WGFMU_setMeasureEvent("pulse", "evt", 0, 1000, 0.000001, 0, WGFMU_ME
ASURE_EVENT_DATA_AVERAGED));
  checkError2(WGFMU_setMeasureEvent("pulse", "evt", 0, 100, 0.00001, 0, WGFMU_MEAS
URE_EVENT_DATA_AVERAGED));
  checkError2(WGFMU_addSequence(101, "pulse", 10));                          //13

  // ONLINE
  checkError2(WGFMU_openSession("GPIB0::17::INSTR"));
  checkError2(WGFMU_initialize());
  checkError2(WGFMU_setOperationMode(101, WGFMU_OPERATION_MODE_FASTIV));
  checkError2(WGFMU_connect(101));
  checkError2(WGFMU_execute());
  checkError2(WGFMU_waitUntilCompleted());
  checkError2(WGFMU_initialize());
  checkError2(WGFMU_closeSession());                                         //23
}
```

Line	Description
1 to 24	Almost same as Example 2. Measurement result data is not saved.
5	Sets the threshold between warning and error. This sets the severe warning to error.
11 to 12	Sets the sampling measurement timing parameters. Line 12 causes an overwrite warning.

Example 5

This program performs measurement as same as Example 2. After the measurement, this program reads and displays the error summary if it is not empty. The result data is not saved. This program does not use a subprogram in the project template shown in Table 3-7.

Table 3-12 **Programming Example 5**

```
int main() // Pulse voltage output and sampling measurement with error check  // 1
{
  int ret; // just for monitoring execution result by using debugger
  // OFFLINE
  ret = WGFMU_clear();
  ret = WGFMU_createPattern("pulse", 0);
  ret = WGFMU_addVector("pulse", 0.0001, 1);
  ret = WGFMU_addVector("pulse", 0.0004, 1);
  ret = WGFMU_addVector("pulse", 0.0001, 0);
  ret = WGFMU_addVector("pulse", 0.0004, 0);
  ret = WGFMU_setMeasureEvent("pulse", "evt", 0, 1000, 0.000001, 0, WGFMU_MEASURE_
EVENT_DATA_AVERAGED);
  ret = WGFMU_setMeasureEvent("pulse", "evt", 0, 100, 0.00001, 0, WGFMU_MEASURE_EV
ENT_DATA_AVERAGED);
  ret = WGFMU_addSequence(101, "pulse", 10);                                   //13

  // ONLINE
  ret = WGFMU_openSession("GPIB0::17::INSTR");
  ret = WGFMU_initialize();
  ret = WGFMU_setOperationMode(101, WGFMU_MEASURE_MODE_CURRENT);               //18
  ret = WGFMU_connect(101);
  ret = WGFMU_execute();
  ret = WGFMU_waitUntilCompleted();
  ret = WGFMU_initialize();
  ret = WGFMU_closeSession();

  int size;                                                                    //25
  WGFMU_getErrorSummarySize(&size);
  if(size > 0) {
    char* errorSummary = new char[size + 1];
    WGFMU_getErrorSummary(errorSummary, &size);
    fprintf(stderr, "%s", errorSummary);
    delete[] errorSummary;
  }                                                                            //32
}
```

Line	Description
5 to 23	Almost same as Example 2. Measurement result data is not saved.
11 to 12	Sets the sampling measurement timing parameters. Line 12 causes an overwrite warning.
18	Causes an error because of the invalid value WGFMU_MEASURE_MODE_CURRENT.
25 to 32	Reads and displays error summary if it is not empty.

Example 6

This program creates the waveform pattern and sequence data, applies the waveform voltage by using the channel1 and channel2, performs sampling measurement, and saves measurement result data to the specified file. See Figure 3-2 for the waveforms and the measurement events set by Programming Example 6. This program uses the project template shown in Table 3-7.

Figure 3-2 **Waveforms and Measurement Events set by Programming Example 6**

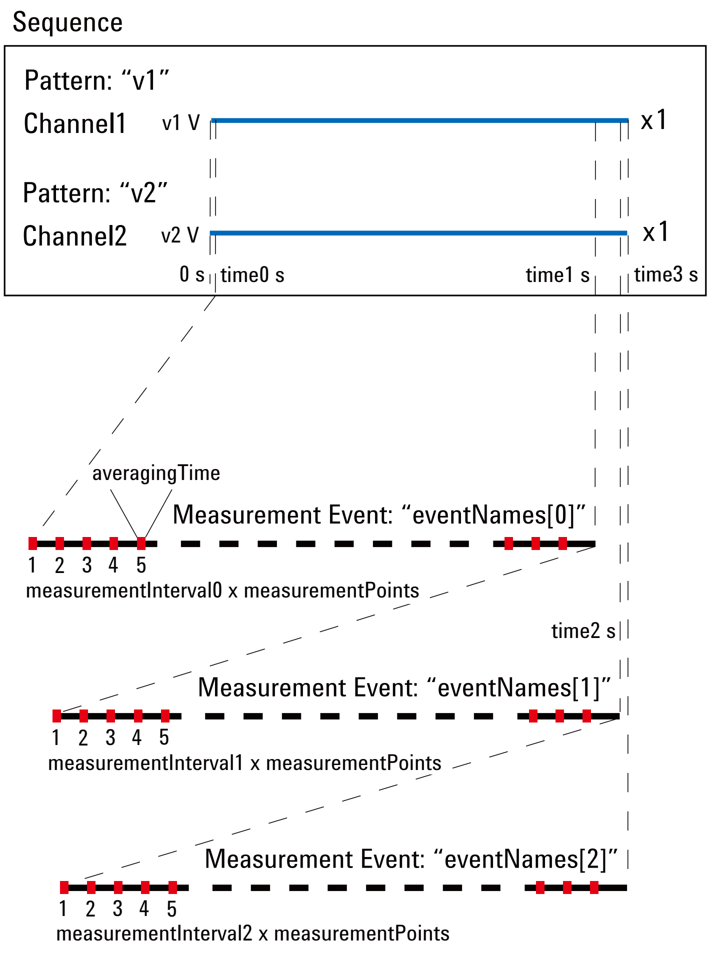

Sequence
Pattern: "v1"
Channel1
v1 V
x1
Pattern: "v2"
Channel2
v2 V
x1
0 s
time0 s
time1 s
time3 s
averagingTime
Measurement Event: "eventNames[0]"
1 2 3 4 5
measurementInterval0 x measurementPoints
time2 s
Measurement Event: "eventNames[1]"
1 2 3 4 5
measurementInterval1 x measurementPoints
Measurement Event: "eventNames[2]"
1 2 3 4 5
measurementInterval2 x measurementPoints

Table 3-13 Programming Example 6

```
int main()                                                                  // 1
{
  int measurementPoints = 32768;
  double measurementInterval0 = 100e-6;
  double measurementInterval1 = 10e-6;
  double measurementInterval2 = 1e-6;
  double averagingTime = 10e-9;
  double time0 = 1e-6;
  double time1 = time0 + measurementInterval0 * measurementPoints + averagingTime;
  double time2 = time1 + measurementInterval1 * measurementPoints + averagingTime;
  double time3 = time2 + measurementInterval2 * measurementPoints + averagingTime;
  double v1 = 0.5;
  double v2 = 1.0;
  int channel1 = 101;
  int channel2 = 102;
  int status;
  double elapsedTime, totalTime;
  int measuredSize, totalSize;
  int measuredEventSize, totalEventSize;
  const char* eventNames[] = { "10kHz", "100kHz", "1MHz" };

  // OFFLINE
  WGFMU_clear();                                                            //23
  WGFMU_createPattern("v1", v1);
  WGFMU_addVector("v1", time3, v1);
  WGFMU_createPattern("v2", v2);
  WGFMU_addVector("v2", time3, v2);
  WGFMU_setMeasureEvent("v2", eventNames[0], time0, measurementPoints, measurement
Interval0, averagingTime, WGFMU_MEASURE_EVENT_DATA_AVERAGED);
  WGFMU_setMeasureEvent("v2", eventNames[1], time1, measurementPoints, measurement
Interval1, averagingTime, WGFMU_MEASURE_EVENT_DATA_AVERAGED);
  WGFMU_setMeasureEvent("v2", eventNames[2], time2, measurementPoints, measurement
Interval2, averagingTime, WGFMU_MEASURE_EVENT_DATA_AVERAGED);
  WGFMU_addSequence(channel1, "v1", 1);
  WGFMU_addSequence(channel2, "v2", 1);                                     //32
```

Line	Description
3 to 20	Declares variables used in this program and defines value.
23 to 27	Clears the B1530A instrument library and creates waveform patterns “v1” and “v2”.
28 to 32	Defines the measurement events eventNames[0] to [2] for the pattern “v2”, and creates the sequence data for the channel1 and channel2.

```
  // ONLINE
  WGFMU_openSession("GPIB0::17::INSTR");                                       //35
  WGFMU_initialize();
  WGFMU_setOperationMode(channel1, WGFMU_OPERATION_MODE_FASTIV);
  WGFMU_setOperationMode(channel2, WGFMU_OPERATION_MODE_FASTIV);
  WGFMU_setMeasureMode(channel2, WGFMU_MEASURE_MODE_CURRENT);
  WGFMU_connect(channel1);                                                     //40
  WGFMU_connect(channel2);
  WGFMU_execute();

  WGFMU_waitUntilCompleted();
  writeResults(channel2, "C:/temp/B1530A/data/ex06.csv");                      //45

  WGFMU_initialize();
  WGFMU_closeSession();
)
```

Line	Description
35 to 36	Opens the session and initializes the all WGFMU channels.
37 to 38	Sets the fast IV mode for the channel1 and channel2.
39	Sets the measurement mode for the channel2.
40 to 42	Enables the channels, applies the WGFMU outputs, and performs the sampling measurement.
44	Waits until the operation is completed.
45	Calls the writeResults subprogram in the project template. Saves the measurement result data to the specified file.
47 to 48	Initializes the all WGFMU channels and closes the session.

Example 7

The code shown in Table 3-14 can be replaced with the lines 44 to 45 of Example 6.

Table 3-14 **Programming Example 7**

```
do {                                                                       //1
  WGFMU_getChannelStatus(channel2, &status, &elapsedTime, &totalTime);
  WGFMU_getMeasureValueSize(channel2, &measuredSize, &totalSize);
  WGFMU_getCompletedMeasureEventSize(channel2, &measuredEventSize, &totalEventSize
);
  fprintf(stderr, "%cStatus: %d, Time: %lf/%lf, Value: %d/ %d, Event: %d/%d", 13,
status, elapsedTime, totalTime, measuredSize, totalSize, measuredEventSize, totalE
ventSize);
} while(status != WGFMU_STATUS_COMPLETED || elapsedTime != totalTime || measuredSi
ze != totalSize || measuredEventSize != totalEventSize);

writeResults(channel2, "C:/temp/B1530A/data/ex07.csv");                         //8
```

Line	Description
1 to 6	Waits until that WGFMU_STATUS_COMPLETED is returned to the status variable, the elapsedTime value is equal to totalTime, the measuredSize value is equal to totalSize, or the measuredEventSize is equal to totalEventSize.
8	Calls the writeResults subprogram in the project template. Saves the measurement result data to the specified file.

Example 8

The code shown in Table 3-15 can be replaced with the lines 44 to 45 of Example 6.

Table 3-15 Programming Example 8

```
int completed;
int index;
int offset;
int size;
do {                                                                        //5
  WGFMU_isMeasureEventCompleted(channel2, "v2", "100kHz", 0, 0, 0, &completed, &in
dex, &offset, &size);
} while(completed != WGFMU_MEASURE_EVENT_COMPLETED);

writeResults2(channel2, offset, size, "C:/temp/B1530A/data/ex08.csv");      //9
```

Line	Description
5 to 7	Waits until that WGFMU_MEASURE_EVENT_COMPLETED is returned to the completed variable.
9	Calls the writeResults2 subprogram in the project template. Saves the measurement result data to the specified file.

Example 9

This program performs Id-Vg measurement by using two WGFMU channels gateChannel and drainChannel and saves measurement result data to the specified file. See Figure 3-3 for the waveforms and the measurement events set by Programming Example 9. This program uses the project template shown in Table 3-7.

Figure 3-3 **Waveforms and Measurement Events set by Programming Example 9**

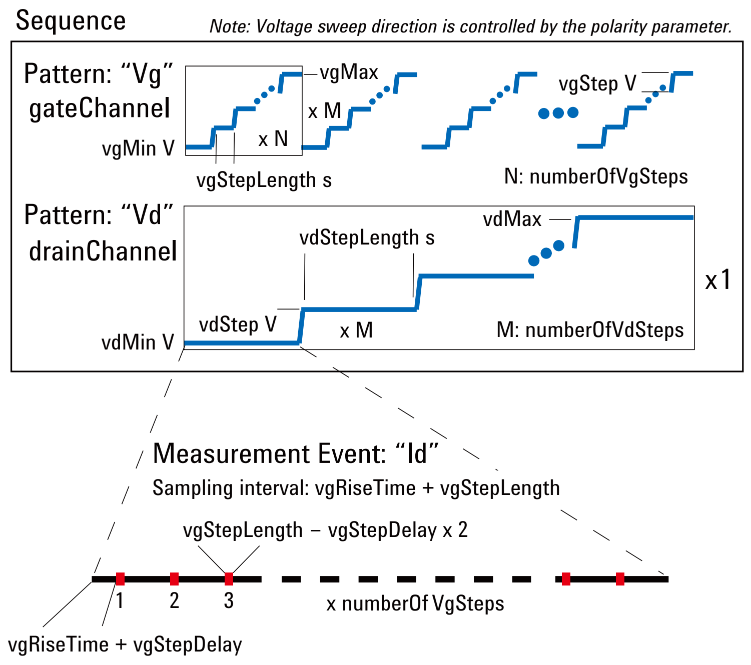


Table 3-16 Programming Example 9

```
int main()                                                                  // 1
{
  int polarity = -1;
  double vgRiseTime = 100e-9;
  double vgStepLength = 500e-9;
  double vgMin = 2;
  double vgMax = 3;
  double vgStep = 0.01;
  double vgStepDelay = 200e-9;
  int gateChannel = 101;
  int numberOfVgSteps = (int)((vgMax - vgMin) / vgStep) + 1;
  double vdRiseTime = 100e-9;
  double vdStepLength = (vgRiseTime + vgStepLength) * numberOfVgSteps;
  double vdMin = 0;
  double vdMax = 10;
  double vdStep = 2;
  //double vdStepDelay = 100e-9;
  int drainChannel = 102;
  int numberOfVdSteps = (int)((vdMax - vdMin) / vdStep) + 1;

  WGFMU_openLogFile("C:/temp/B1530A/log/ex09.log");                         //21
  // OFFLINE
  WGFMU_clear();

  // Gate Channel Pattern and Sequence
  double vg = vgMin;                                                        //26
  WGFMU_createPattern("Vg", vg * polarity);

  for(int i = 0; i < numberOfVgSteps; i++) {
    vg = vgMin + vgStep * i;
    WGFMU_addVector("Vg", vgRiseTime, vg * polarity);
    WGFMU_addVector("Vg", vgStepLength, vg * polarity);
  }
  WGFMU_addSequence(gateChannel, "Vg", numberOfVdSteps);
```

Line	Description
3 to 19	Declares variables used in this program and defines value.
20 to 23	Opens the B1530A instrument library log file and clears the instrument library.
26 to 34	Creates the pattern data “Vg” and the sequence data for gateChannel.

```
  // Drain Channel Pattern and Sequence
  double vd = vdMin;                                                          //37
  WGFMU_createPattern("Vd", vd);
  for(int i = 0; i < numberOfVdSteps; i++) {
    vd = vdMin + vdStep * i;
    WGFMU_addVector("Vd", vdRiseTime, vd * polarity);
    WGFMU_addVector("Vd", vdStepLength, vd * polarity);
    WGFMU_setMeasureEvent("Vd", "Id", (vdRiseTime + vdStepLength) * i + vgRiseTime
 + vgStepDelay, numberOfVgSteps, vgRiseTime + vgStepLength, vgStepLength - vgStepD
elay * 2, WGFMU_MEASURE_EVENT_DATA_AVERAGED);
  }
  WGFMU_addSequence(drainChannel, "Vd", 1);

  WGFMU_exportAscii("C:/temp/B1530A/waveform/ex09.csv");                      //47

  // ONLINE
  WGFMU_openSession("GPIB0::17::INSTR");
  WGFMU_initialize();
  WGFMU_setOperationMode(gateChannel, WGFMU_OPERATION_MODE_FASTIV);
  WGFMU_setOperationMode(drainChannel, WGFMU_OPERATION_MODE_FASTIV);
  WGFMU_setMeasureMode(drainChannel, WGFMU_MEASURE_MODE_CURRENT);
  WGFMU_connect(gateChannel);
  WGFMU_connect(drainChannel);
  WGFMU_execute();
  WGFMU_waitUntilCompleted();

  for(int i = 0; i < numberOfVdSteps; i++) {                                  //60
    vd = vdMin + vdStep * i;
    char fileName[1024];
    sprintf(fileName, "C:/temp/B1530A/data/ex09_Id-Vg@Vd=%dV.csv", (int)vd);
    writeResults3(gateChannel, drainChannel, numberOfVgSteps * i, numberOfVgSteps,
fileName);
  }

  WGFMU_initialize();                                                         //67
  WGFMU_closeSession();
  WGFMU_closeLogFile();
)
```

Line	Description
37 to 45	Creates the pattern data “Vd”, defines the Id measurement events, and creates the sequence data for drainChannel.
47	Creates the sequence data to the specified file.
50 to 58	Opens the session, initializes the all WGFMU channels, sets the operation mode and measurement mode, enables the channels, and performs the Id-Vg measurement.
60 to 65	Calls the writeResults3 subprogram in the project template. Saves the measurement result data to the specified file.
67 to 69	Initializes the all WGFMU channels, closes the session, and closes the log file.

Example 10

This program applies DC bias by using a SMU during the measurement almost same as Example 3. The error check is performed by the checkError3 subprogram in the project template shown in Table 3-7. If an error is detected, this program displays the error message. This program requires visa32.lib.

Table 3-17 **Programming Example 10**

```
int main()                                                                    // 1
{
  try {
    // OFFLINE
    checkError3(WGFMU_clear());
    checkError3(WGFMU_createPattern("pulse", 0));
    checkError3(WGFMU_addVector("pulse", 0.0001, 1));
    checkError3(WGFMU_addVector("pulse", 0.0004, 1));
    checkError3(WGFMU_addVector("pulse", 0.0001, 0));
    checkError3(WGFMU_addVector("pulse", 0.0004, 0));
    checkError3(WGFMU_setMeasureEvent("pulse", "evt", 0, 1000, 1e-6, 0, WGFMU_MEAS
URE_EVENT_DATA_AVERAGED));
    checkError3(WGFMU_addSequence(101, "pulse", 10));

    // ONLINE
    ViSession defaultRM;                                                      //15
    ViSession vi;
    checkError3(viOpenDefaultRM(&defaultRM) + VISA_ERROR_OFFSET);
    checkError3(viOpen(defaultRM, "GPIB0::17::INSTR", VI_NULL, VI_NULL, &vi) +
VISA_ERROR_OFFSET);
    checkError3(WGFMU_openSession("GPIB0::17::INSTR"));
    checkError3(WGFMU_initialize());
    checkError3(WGFMU_setOperationMode(101, WGFMU_OPERATION_MODE_FASTIV));
    checkError3(viPrintf(vi, "CN 201\n") + VISA_ERROR_OFFSET);                //22
    checkError3(WGFMU_connect(101));
    checkError3(viPrintf(vi, "DV 201,0,3\n") + VISA_ERROR_OFFSET);            //24
    checkError3(WGFMU_execute());
    checkError3(WGFMU_waitUntilCompleted());
    checkError3(WGFMU_initialize());
    checkError3(viPrintf(vi, "CL 201\n") + VISA_ERROR_OFFSET);                //28
    checkError3(WGFMU_closeSession());
    checkError3(viClose(vi) + VISA_ERROR_OFFSET);                             //30
    checkError3(viClose(defaultRM) + VISA_ERROR_OFFSET);
  }
```

Line	Description
1 to 48	Almost same as Example 3.
15 to 18	Open the session for the SMU installed in the B1500A with the WGFMU.
22 and 24	Enables the SMU of the channel number 201 and applies DC bias from the channel.
28, 30, 31	Disables the SMU and closes the session for the SMU.

```
  catch(int e) {
    if(e < VISA_ERROR_OFFSET) {                                             //34
      char error[1024];
      sprintf(error, "ViStatus = %d\n", e - VISA_ERROR_OFFSET);
      fprintf(stderr, "%s", error);
    }
    else {                                                                  //39
      int size;
      WGFMU_getErrorSize(&size);
      char* error = new char[size + 1];
      WGFMU_getError(error, &size);
      fprintf(stderr, "%s", error);
      delete[] error;
    }
  }
}
```

Line	Description
34 to 38	Creates a VISA error message and displays it.
39 to 46	Reads and displays the B1530A instrument library error message.

Example 11

This program performs sampling measurement by using a SMU, after that performs the measurement almost same as Example 3. The error check is performed by the checkError3 subprogram in the project template shown in Table 3-7. If an error is detected, this program displays the error message. This program requires visa32.lib.

Table 3-18 **Programming Example 11**

```
int main()                                                             // 1
{
  try {
    // OFFLINE
    checkError3(WGFMU_clear());
    checkError3(WGFMU_createPattern("pulse", 0));
    checkError3(WGFMU_addVector("pulse", 0.0001, 1));
    checkError3(WGFMU_addVector("pulse", 0.0004, 1));
    checkError3(WGFMU_addVector("pulse", 0.0001, 0));
    checkError3(WGFMU_addVector("pulse", 0.0004, 0));
    checkError3(WGFMU_setMeasureEvent("pulse", "evt", 0, 1000, 1e-6, 0, WGFMU_MEAS
URE_EVENT_DATA_AVERAGED));
    checkError3(WGFMU_addSequence(101, "pulse", 10));

    // ONLINE
    ViSession defaultRM;                                               //15
    ViSession vi;
    checkError3(viOpenDefaultRM(&defaultRM) + VISA_ERROR_OFFSET);
    checkError3(viOpen(defaultRM, "GPIB0::17::INSTR", VI_NULL, VI_NULL, &vi) +
VISA_ERROR_OFFSET);
    checkError3(WGFMU_openSession("GPIB0::17::INSTR"));
    checkError3(WGFMU_setTimeout(120));
    checkError3(viPrintf(vi, "*RST\n") + VISA_ERROR_OFFSET);           //21
    checkError3(WGFMU_initialize());
    checkError3(WGFMU_setOperationMode(101, WGFMU_OPERATION_MODE_FASTIV));
    checkError3(viPrintf(vi, "CN 201\n") + VISA_ERROR_OFFSET);         //24
    checkError3(WGFMU_connect(101));
    checkError3(viPrintf(vi, "MV 201,0,0,5\n") + VISA_ERROR_OFFSET);   //26
    checkError3(viPrintf(vi, "MT 0,1,110,5\n") + VISA_ERROR_OFFSET);
    checkError3(viPrintf(vi, "MM 10,201\n") + VISA_ERROR_OFFSET);
```

Line	Description
1 to 64	Almost same as Example 3.
15 to 18	Open the session for the SMU installed in the B1500A with the WGFMU.
21	Resets the B1500A.
24	Enables the SMU of the channel number 201.
26 to 28	Sets the sampling measurement condition to the SMU.

```
    char buffer[2048];                                                      //29
    checkError3(viPrintf(vi, "ERRX?\n") + VISA_ERROR_OFFSET);
    checkError3(viScanf(vi, "%t", buffer) + VISA_ERROR_OFFSET);
    fprintf(stderr, "%s", buffer);
    checkError3(viPrintf(vi, "XE\n") + VISA_ERROR_OFFSET);
    checkError3(WGFMU_execute());
    checkError3(WGFMU_waitUntilCompleted());

    int nub;                                                                //37
    checkError3(viPrintf(vi, "NUB?\n") + VISA_ERROR_OFFSET);
    checkError3(viScanf(vi, "%d%t", &nub, buffer) + VISA_ERROR_OFFSET);
    fprintf(stderr, "%d\n", nub);
    checkError3(viScanf(vi, "%t", buffer));
    fprintf(stderr, "%s", buffer);
    checkError3(WGFMU_initialize());
    checkError3(viPrintf(vi, "CL 201\n") + VISA_ERROR_OFFSET);              //44
    checkError3(WGFMU_closeSession());
    checkError3(viClose(vi) + VISA_ERROR_OFFSET);                           //46
    checkError3(viClose(defaultRM) + VISA_ERROR_OFFSET);
  }
  catch(int e) {
    if(e < VISA_ERROR_OFFSET) {                                             //50
      char error[1024];
      sprintf(error, "ViStatus = %d\n", e - VISA_ERROR_OFFSET);
      fprintf(stderr, "%s", error);
    }
    else {                                                                  //55
      int size;
      WGFMU_getErrorSize(&size);
      char* error = new char[size + 1];
      WGFMU_getError(error, &size);
      fprintf(stderr, "%s", error);
      delete[] error;
    }
  }
}
```

Line	Description
29 to 33	Performs error check and execute the sampling measurement.
37 to 42	Confirms the number of measurement data.
44, 46, 47	Disables the SMU and closes the session for the SMU.
50 to 54	Creates a VISA error message and displays it.
55 to 62	Reads and displays the B1530A instrument library error message.

If You Perform DC Measurement

WGFMU also provides DC voltage output and voltage or current measurement capability. To perform the DC measurement, use the functions listed in Table 3-19.

Table 3-19 **To Perform DC Measurement**

Step	Action	Function
	Starts error and warning logging [a]	WGFMU_openLogFile
1	Opens session	WGFMU_openSession
	Initializes WGFMU channels [a]	WGFMU_initialize
2	Sets operation mode to DC mode	WGFMU_setOperationMode
	Sets voltage output range [b]	WGFMU_setForceVoltageRange
	Sets measurement mode [b]	WGFMU_setMeasureMode
	Sets measurement range [b]	WGFMU_setMeasureCurrentRange
		WGFMU_setMeasureVoltageRange
3	Enables WGFMU channels	WGFMU_connect
	Starts DC voltage output [b]	WGFMU_dcforceVoltage
4	Starts voltage or current measurement and returns result	WGFMU_dcmeasureValue
	Starts sampling measurement and returns results	WGFMU_dcmeasureAveragedValue
5	Disables WGFMU channels	WGFMU_disconnect
6	Closes session	WGFMU_closeSession
	Stops error and warning logging [a]	WGFMU_closeLogFile

a. Optional.
b. Optional for changing setup to a new value.

4 Instrument Library Reference

This chapter is the complete reference of the Keysight B1530A WGFMU Instrument Library and consists of the following sections.

- “Function Reference”
- “Parameters”
- “Channel Execution Status”
- “WGFMU Setup Functions”
- “Return Codes”
- “Error Messages”

For the summary of the WGFMU instrument library functions, see Table 4-1. The functions are classified by applications.

NOTE

About function name

Function name depends on the programming environment as shown below.

- For Microsoft Visual C++ .NET, Visual Basic .NET, Visual Basic 6.0, or VBA:

  WGFMU_*functionName* (ex. `WGFMU_abortChannel`)

  See “Syntax” in “Function Reference”.

- For Microsoft Visual C# .NET:

  WGFMU.*functionName* (ex. `WGFMU.abortChannel`)

  Change the prefix shown in “Syntax” from “`WGFMU_`” to “`WGFMU.`”.

- For HTBasic:

  Wm_*fctnName* (ex. `Wm_abortch`)

  See “Using HTBasic” in “Function Reference”.

  For receiving the return code of the function, change the prefix from `Wm_` to `Fnwm_` and execute the function as shown in the following example.

Example:

```
LONG Ret
LONG Chid
Chid = 101
Ret = Fnwm_abortch(Chid)
```

Table 4-1 WGFMU Instrument Library Function Summary

Group	Function	Description
Common - Initialize	WGFMU_openSession	Opens or closes the communication session with the B1500A by using the WGFMU instrument library.
	WGFMU_closeSession	
	WGFMU_initialize	Resets all WGFMU channels.
	WGFMU_setTimeout	Sets timeout of the present session.
	WGFMU_doSelfCalibration	Performs the self-calibration for the mainframe and all modules.
	WGFMU_doSelfTest	Performs the self-test for the mainframe and all modules.
	WGFMU_getChannelIdSize	Reads the channel id of the WGFMU channels installed in the B1500A connected to the session.
	WGFMU_getChannelIds	
Common - Error and Warning	WGFMU_getErrorSize	Reads the next one error string.
	WGFMU_getError	
	WGFMU_getErrorSummarySize	Reads the all error string.
	WGFMU_getErrorSummary	
	WGFMU_treatWarningsAsErrors	Sets the threshold between warning and error.
	WGFMU_setWarningLevel	Sets or reads the warning level.
	WGFMU_getWarningLevel	
	WGFMU_getWarningSummarySize	Reads the all warning string.
	WGFMU_getWarningSummary	
	WGFMU_openLogFile	Opens or closes a file used to log errors and warnings.
	WGFMU_closeLogFile	

Group	Function	Description
Common - Setup	WGFMU_setOperationMode	Sets or reads the operation mode of the specified WGFMU channel, Fast IV, PG, DC, or SMU operation mode.
	WGFMU_getOperationMode	
	WGFMU_setForceVoltageRange	Sets or reads the voltage output range of the specified source channel.
	WGFMU_getForceVoltageRange	
	WGFMU_setMeasureMode	Sets or reads the measurement mode, voltage or current measurement mode.
	WGFMU_getMeasureMode	
	WGFMU_setMeasureCurrentRange	Sets or reads the current measurement range of the specified measurement channel.
	WGFMU_getMeasureCurrentRange	
	WGFMU_setMeasureVoltageRange	Sets or reads the voltage measurement range of the specified measurement channel.
	WGFMU_getMeasureVoltageRange	
	WGFMU_setForceDelay	Sets or reads the device delay time of the specified source channel.
	WGFMU_getForceDelay	
	WGFMU_setMeasureDelay	Sets or reads the device delay time of the specified measurement channel.
	WGFMU_getMeasureDelay	
	WGFMU_setMeasureEnabled	Enables/disables or confirms the measurement ability of the specified WGFMU channel.
	WGFMU_isMeasureEnabled	
	WGFMU_setTriggerOutMode	Sets or reads the trigger output mode of the specified WGFMU channel.
	WGFMU_getTriggerOutMode	
Common - Measurement	WGFMU_connect	Enables or disables the specified WGFMU channel and the RSU connected to the WGFMU.
	WGFMU_disconnect	
WGFMU - Initialize	WGFMU_clear	Clears the instrument library's software setup information such as all pattern and sequence information.

Group	Function	Description
WGFMU - Setup - Pattern	WGFMU_createPattern	Creates a waveform pattern.
	WGFMU_addVector	Specifies scalar data (time and voltage) and adds it to the specified waveform pattern at the end of pattern.
	WGFMU_addVectors	
	WGFMU_setVector	Specifies scalar data (time and voltage) and adds it to the specified waveform pattern or replaces the scalar previously defined in the specified waveform pattern with the scalar specified by this function.
	WGFMU_setVectors	
WGFMU - Setup - Pattern operation	WGFMU_createMergedPattern	Creates a waveform pattern by copying a waveform and adding another waveform.
	WGFMU_createMultipliedPattern	Creates a waveform pattern by copying a waveform and multiplying the waveform by the specified factor.
	WGFMU_createOffsetPattern	Creates a waveform pattern by copying a waveform and adding the specified offset.
WGFMU - Setup - Event	WGFMU_setMeasureEvent	Defines a measurement event which is a sampling measurement performed by the WGFMU channel while it outputs a waveform pattern.
	WGFMU_setRangeEvent	Defines a range event which is the range change operation for the current measurement performed by the WGFMU channel while it outputs a waveform pattern.
	WGFMU_setTriggerOutEvent	Defines a trigger output event which is the trigger output operation performed by the WGFMU channel while it outputs a waveform pattern.
WGFMU - Setup - Sequence	WGFMU_addSequence	Adds sequence data (pattern and count) to the source output sequence defined in the specified WGFMU channel.
	WGFMU_addSequences	

Group	Function	Description
WGFMU - Setup check - Pattern	WGFMU_getPatternForceValueSize	Reads the scalar data (time and voltage) for the source output point defined in the specified pattern.
	WGFMU_getPatternForceValues	
	WGFMU_getPatternForceValue	
	WGFMU_getPatternInterpolatedForceValue	Reads the voltage output value of the specified pattern at the specified time.
	WGFMU_getPatternMeasureTimeSize	Reads the measurement start time (time) for the measurement point defined in the specified pattern.
	WGFMU_getPatternMeasureTimes	
	WGFMU_getPatternMeasureTime	
WGFMU - Setup check - Sequence	WGFMU_getForceValueSize	Reads the scalar data (time and voltage) for the source output point defined in the sequences set to the specified WGFMU channel.
	WGFMU_getForceValues	
	WGFMU_getForceValue	
	WGFMU_getInterpolatedForceValue	Reads the voltage value applied by the specified WGFMU channel at the specified time.
	WGFMU_getMeasureTimeSize	Reads the measurement start time (time) for the measurement point defined in the sequences set to the specified WGFMU channel.
	WGFMU_getMeasureTimes	
	WGFMU_getMeasureTime	
WGFMU - Setup check - Event	WGFMU_getMeasureEventSize	Reads the setup (pattern, event, cycle, loop, count, index, and length) for the measurement event defined in the sequences set to the specified WGFMU channel.
	WGFMU_getMeasureEvents	
	WGFMU_getMeasureEvent	
	WGFMU_getMeasureEventAttribute	Reads the setup parameters (time, points, interval, average, and rdata) of WGFMU_setMeasureEvent.

Group	Function	Description
WGFMU - Measurement	WGFMU_update	Updates the setting of all WGFMU channels.
	WGFMU_updateChannel	Updates the setting of the specified WGFMU channel.
	WGFMU_execute	Runs the sequencer of all enabled WGFMU channels.
	WGFMU_abort	Stops the sequencer of all WGFMU channels.
	WGFMU_abortChannel	Stops the sequencer of the specified WGFMU channel.
	WGFMU_getStatus	Reads the status of the WGFMU channels.
	WGFMU_getChannelStatus	Reads the status of the specified WGFMU channel.
	WGFMU_waitUntilCompleted	Waits until all connected WGFMU channels are in the ready to read data status.
WGFMU - Data retrieve - Measurement value	WGFMU_getMeasureValueSize	Reads the measurement data (time and voltage or current) for the measurement point defined in the sequences set to the specified WGFMU channel.
	WGFMU_getMeasureValues	
	WGFMU_getMeasueValue	
WGFMU - Data retrieve - Event	WGFMU_getCompletedMeasureEventSize	Reads the number of the measurement events already completed and the total number of the measurement events.
	WGFMU_isMeasureEventCompleted	Reads the execution status (complete, measId, index, and length) of the specified measurement event setup.
WGFMU - Export setup data	WGFMU_exportAscii	Creates a setup summary report and saves it as a csv (comma separated values) file.

Group	Function	Description
DC - Measurement	WGFMU_dcforceVoltage	Starts DC voltage output immediately by using the specified WGFMU channel.
	WGFMU_dcmeasureValue	Starts a voltage or current measurement immediately by using the specified WGFMU channel and returns the measurement value (voltage or current).
	WGFMU_dcmeasureAveragedValue	Starts a sampling measurement immediately by using the specified WGFMU channel and returns the averaged measurement value (voltage or current).

Function Reference

This section describes the functions of the WGFMU instrument library. “Syntax” shows the function syntax and “Example” shows an example program code for using the Visual C++ language. “Using HTBasic” shows the function expression for using the HTBasic language. In “Parameters”, the parameters are put in italics such as *chanId*. The functions are appeared in alphabetical order.

WGFMU_abort

This function stops the sequencer of all WGFMU channels. After this command, the channels keep the output voltage when this command is executed.

Syntax

```
int WGFMU_abort();
```

Using HTBasic

```
Wm_abort()
```

Example

```
int ret;
ret = WGFMU_abort();
```

WGFMU_abortChannel

This function stops the sequencer of the specified channel. After this command, the channel keeps the output voltage when this command is executed.

Syntax

```
int WGFMU_abortChannel(int chanId);
```

Using HTBasic

```
Wm_abortch(chanId)
```

Parameters

***chanId* :** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

Example

```
int ret;
int chId = 101;
ret = WGFMU_abortChannel(chId);
```

WGFMU_addSequence

This function specifies a sequence by using *pattern* and *count*, and connects it to the last point of the sequence data set to the specified channel. See “WGFMU Setup Functions” on page 4-77 for the error check of parameters.

Execution Conditions

Waveform pattern specified by *pattern* must be created before this function is executed. See WGFMU_createPattern and WGFMU_create*Xxx*Pattern to create a pattern data.

Syntax

```
int WGFMU_addSequence(int chanId, const char* pattern,
double count);
```

Using HTBasic

```
Wm_addsequence(chanId, pattern, count)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
pattern **:**	Name of waveform pattern. String.
count **:**	Repeat count of the waveform pattern. 1 to 1,099,511,627,776. If the specified value is out of this range, the sequence is not added. Numeric. If the value is not integer, the value is rounded to the nearest integer. For example, if the value is 7.2, the value is rounded to 7.

Example

```
int ret;
int chId = 101;
const char* ptn = "Pattern1";
double cnt = 10;
ret = WGFMU_createPattern(ptn, 0);         /*  0 ms, 0 V */
ret = WGFMU_addVector(ptn, 0.04, 0);       /* 40 ms, 0 V */
ret = WGFMU_addVector(ptn, 0.01, 5);       /* 50 ms, 5 V */
ret = WGFMU_addVector(ptn, 0.04, 5);       /* 90 ms, 5 V */
ret = WGFMU_addVector(ptn, 0.01, 0);       /*100 ms, 0 V */
ret = WGFMU_addSequence(chId, ptn, cnt);
```

Remarks

If a channel repeats a sequence output, no delay time occurs between the repeats. If a channel outputs sequences in series, 50 ns delay time occurs between the sequences. In the delay time, the channel outputs the last voltage of the last vector for the beginning 10 ns and the start voltage of the next vector for the rest 40 ns.

WGFMU_addSequences

This function specifies sequences by using *pattern* and *count*, and connects them to the last point of the sequence data set to the specified channel in the array element order. See “WGFMU Setup Functions” on page 4-77 for the error check of parameters.

Execution Conditions

Waveform pattern specified by *pattern* must be created before this function is executed. See WGFMU_createPattern and WGFMU_create*Xxx*Pattern to create a pattern data.

Syntax

```
int WGFMU_addSequences(int chanId, const char** pattern,
double* count, int size);
```

Using HTBasic

```
Wm_addsequences(chanId, pattern, count, size, slength)
```

Parameters

***chanId* :** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

***pattern* :** Name of waveform pattern. String array. Array elements must be corresponding to the *count* array elements together in the element order.

***count* :** Repeat count of the waveform pattern. Numeric array. Array elements must be corresponding to the *pattern* array elements together in the element order. The value must be 1 to 1,099,511,627,776. If the specified value is out of this range, the sequences are not added.

If the value is not integer, the value is rounded to the nearest integer. For example, if the value is 7.2, the value is rounded to 7.

***size* :** Array size. Number of array elements for both *pattern* and *count*. Integer.

***slength* :** Only for the HTBasic programming environment. Length of string. Integer.

Example

```
int ret;
int chId = 101;
int size = 3;
const char* pts[] = { "Initial", "Pattern1", "Pattern2" };
double cts[] = { 1, 5, 5 };
ret = WGFMU_addSequences(chId, pts, cts, size);
```

Remarks

If a channel repeats a sequence output, no delay time occurs between the repeats. If a channel outputs sequences in series, 50 ns delay time occurs between the sequences. In the delay time, the channel outputs the last voltage of the last vector for the beginning 10 ns and the start voltage of the next vector for the rest 40 ns.

Notices

The following notices are required to use the *pattern* string array for the HTBasic programming environment and the Visual Basic 6.0 programming environment.

- For the HTBasic programming environment:

  Define and use the string array variable as shown below.

  ```
  LONG Size = 3
  LONG Slength = 10
  ALLOCATE Pattern$(Size)[Slength]
  Pattern$(0)="Initial"
  Pattern$(1)="Pattern1"
  Pattern$(2)="Pattern2"
  ```

```
   :
Wm_addsequences( ... , Pattern$(0), ... , (size), (Slength))
```

- For the Visual Basic 6.0 programming environment:

  Define and use the string array variable as shown below. Then the VarPtrStringArray function is required. For creating the VarPtrStringArray function, visit http://support.microsoft.com/kb/199824.

```
Dim size As Long
size = 3
ReDim pattern(size) As String
pattern(0)="Initial"
pattern(1)="Pattern1"
pattern(2)="Pattern2"
   :
WGFMU_addSequences( ... , VarPtrStringArray(pattern()), ... ,
size)
```

WGFMU_addVector

This function specifies a scalar data by using *dTime* and *voltage*, and connects it to the last point of the specified waveform pattern. This adds a vector to the pattern. See "WGFMU Setup Functions" on page 4-77 for the error check of parameters.

Execution Conditions

Waveform pattern specified by *pattern* must be created before this function is executed. See WGFMU_createPattern and WGFMU_create*Xxx*Pattern to create a pattern data.

Syntax

```
int WGFMU_addVector(const char* pattern, double dTime,
double voltage);
```

Using HTBasic

```
Wm_addvector(pattern, dTime, voltage)
```

Parameters

pattern **:** Name of waveform pattern to add a vector. String.

dTime **:** Incremental time value, in second. Numeric.

10^{-8} (10 ns) to 10995.11627775 seconds, in 10^{-8} second resolution. If the specified value is out of this range, the vector is not added.

If the value is not multiple number of 10 ns, the value is rounded to the nearest multiple number. For example, if the value is 72 ns, the value is rounded to 70 ns.

voltage **:** Output voltage, in V. Numeric. See Table 4-2 on page 4-66.

Example

```
int ret;
const char* ptn = "Pattern2";
ret = WGFMU_createPattern(ptn, 0);          /*  0 ms, 0 V */
ret = WGFMU_addVector(ptn, 0.01, 0);        /* 10 ms, 0 V */
ret = WGFMU_addVector(ptn, 0.01, -5);       /* 20 ms,-5 V */
ret = WGFMU_addVector(ptn, 0.03, -5);       /* 50 ms,-5 V */
ret = WGFMU_addVector(ptn, 0.01, 5);        /* 60 ms, 5 V */
ret = WGFMU_addVector(ptn, 0.03, 5);        /* 90 ms, 5 V */
ret = WGFMU_addVector(ptn, 0.01, 0);        /*100 ms, 0 V */
```

WGFMU_addVectors

This function specifies multiple scalar data by using *dTime* and *voltage*, and connects them to the last point of the specified waveform pattern in the array element order. This adds vectors to the pattern. See “WGFMU Setup Functions” on page 4-77 for the error check of parameters.

Execution Conditions

Waveform pattern specified by *pattern* must be created before this function is executed. See WGFMU_createPattern and WGFMU_create*Xxx*Pattern to create a pattern data.

Syntax

```
int WGFMU_addVectors(const char* pattern, double* dTime,
double* voltage, int size);
```

Using HTBasic

```
Wm_addvectors(pattern, dTime, voltage, size)
```

Parameters

pattern : Name of waveform pattern to add vectors. String.

dTime : Incremental time value, in second. Numeric array. Array elements must be corresponding to the *voltage* array elements together in the element order.

The value must be 10^{-8} (10 ns) to 10995.11627775 seconds, in 10^{-8} second resolution. If the specified value is out of this range, the vectors are not added.

If the value is not multiple number of 10 ns, the value is rounded to the nearest multiple number. For example, if the value is 72 ns, the value is rounded to 70 ns.

voltage : Output voltage, in V. See Table 4-2 on page 4-66. Numeric array. Array elements must be corresponding to the *dTime* array elements together in the element order.

size : Array size. Number of array elements for both *dTime* and *voltage*. Integer.

Example

```
int ret;
int size = 4;
const char* ptn = "Pattern3";
double* dts = new double[size];
double* vts = new double[size];
dts[0] = dts[1] = dts[2] = dts[3] = 0.1;
vts[0] = vts[3] = 0;
vts[1] = vts[2] = 5;
ret = WGFMU_createPattern(ptn, 0);
ret = WGFMU_addVectors(ptn, dts, vts, size);
delete [] dts;
delete [] vts;
```

WGFMU_clear

This function clears the instrument library's software setup information such as all pattern and sequence information, error, error summary, warning, warning summary, warning level, warning level for the WGFMU_treatWarningsAsErrors function.

This function does not change the hardware status.

Syntax

```
int WGFMU_clear();
```

Using HTBasic

```
Wm_clear()
```

Example

```
int ret;
ret = WGFMU_clear();
```

WGFMU_closeLogFile

This function closes the log file opened by the WGFMU_openLogFile function.

Syntax

```
int WGFMU_closeLogFile();
```

Using HTBasic

```
Wm_closelogfile()
```

Example

```
int ret;
const char* fname = "C:¥¥Keysight¥¥B1530A¥¥log¥¥20080901.log";
ret = WGFMU_openLogFile(fname);
// :
ret = WGFMU_closeLogFile();
```

WGFMU_closeSession

This function closes the session (communication with B1500A) opened by the WGFMU_openSession function.

Syntax

```
int WGFMU_closeSession();
```

Using HTBasic

```
Wm_closesession()
```

Example

```
int ret;
const char* addr1 = "GPIB0::17::INSTR";
ret = WGFMU_openSession(addr1);
// :
ret = WGFMU_closeSession();
```

WGFMU_connect

This function enables the specified WGFMU channel and the RSU connected to the WGFMU.

Syntax

```
int WGFMU_connect(int chanId);
```

Using HTBasic

```
Wm_connect(chanId)
```

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

Example

```
int ret;
int chId = 101;
ret = WGFMU_connect(chId);
```

WGFMU_createMergedPattern

This function creates a waveform pattern by copying the waveform specified by *pattern1* and adding the waveform specified by *pattern2*. See "WGFMU Setup Functions" on page 4-77 for the error check of parameters.

Execution Conditions

Waveform patterns specified by *pattern1* and *pattern2* must be created before this function is executed. See WGFMU_createPattern and WGFMU_create*Xxx*Pattern to create a pattern data.

Syntax

```
int WGFMU_createMergedPattern(const char* pattern, const
char* pattern1, const char* pattern2, int direction);
```

Using HTBasic

```
Wm_createmgdpt(pattern, pattern1, pattern2, direction)
```

Parameters

pattern **:** Name of waveform pattern to create. String. Name must be unique. However, the same value as *pattern1* or *pattern2* is allowed.

pattern1 **:** Name of waveform pattern to be copied. String. Same value as *pattern* or *pattern2* is allowed.

pattern2 **:** Name of waveform pattern to be added. String. Same value as *pattern* or *pattern1* is allowed.

***direction* :** Direction to add waveform pattern. Integer. See Table 4-12 on page 4-74.

Example

```
int ret;
const char* ptn = "Pattern5";
const char* ptn0 = "Pattern1";
const char* ptn1 = "Pattern2";
ret = WGFMU_createMergedPattern(ptn, ptn0, ptn1, WGFMU_AXIS_TIME);
```

NOTE

Event settings by this function with direction=WGFMU_AXIS_VOLTAGE

The *pattern2* event settings delete and overwrite the *pattern1* event settings of the same event type in the same time frame. For example, the *pattern2* measurement event settings delete and overwrite the *pattern1* measurement event settings in the same time frame, but do not delete the *pattern1* range change event settings and the *pattern1* trigger output event settings.

WGFMU_createMultipliedPattern

This function creates a waveform pattern by copying the waveform specified by *pattern1* and multiplying the waveform by the specified factor for each direction; time and voltage. See “WGFMU Setup Functions” on page 4-77 for the error check of parameters.

Execution Conditions

Waveform pattern specified by *pattern1* must be created before this function is executed. See WGFMU_createPattern and WGFMU_create*Xxx*Pattern to create a pattern data.

Syntax

```
int WGFMU_createMultipliedPattern(const char* pattern,
const char* pattern1, double factorT, double factorV);
```

Using HTBasic

```
Wm_creatempdpt(pattern, pattern1, factorT, factorV)
```

Parameters

***pattern* :** Name of waveform pattern to be created. String. Name must be unique. However, the same value as *pattern1* is allowed.

***pattern1* :** Name of waveform pattern to be copied. String. Same value as *pattern* is allowed.

***factorT* :** Multiplier factor in the time direction. Numeric. Non zero value. Event attributes are changed by *factorT*. See following NOTE.

***factorV* :** Multiplier factor in the voltage direction. Numeric. Non zero value. Event attributes are not changed by *factorV*.

Example

```
int ret;
const char* ptn = "Pattern6";
const char* ptn0 = "Pattern1";
double ftime = 2;
double fvolt = 2;
ret = WGFMU_createMultipliedPattern(ptn, ptn0, ftime, fvolt);
```

NOTE

Measurement event attributes changed by factorT

Event attributes *time*, *interval*, and *avgTime* are multiplied by *factorT*. The *measPts* attribute is not changed.

NOTE

Range change event attributes changed by factorT

Event attribute *time* is multiplied by *factorT*. The *rngIndex* attribute is not changed.

NOTE

Trigger output event attributes changed by factorT

Event attributes *time* and *duration* are multiplied by *factorT*.

NOTE

For the negative factorT

If $factorT < 0$, this function creates a new pattern by calculating the line symmetry of the copied pattern and multiplying it by $|factorT|$. Then the axis of symmetry is the voltage axis placed on the center of the copied pattern.

The time value *newTime* of the measurement event for the new pattern is calculated by the following formula.

$newTime = pattern1\ period - time - interval \times (measPts - 1) - avgTime$

For example, if *time*=100 ns, *measPts*=4, *interval*=50 ns, *avgTime*=30 ns, and *pattern1 period*=500 ns, the inverted time value *newTime* is 220 ns.

By the line symmetry, the first point of a pattern will become the last point of the new pattern. Also, the averaging end of a measurement point will become the averaging start of the point on the new pattern. So the measurement start time of the new pattern will be the inversion of the averaging end of the last measurement point. The start time of each measurement point will be automatically adjusted.

WGFMU_createOffsetPattern

This function creates a waveform pattern by copying the waveform specified by *pattern1* and adding the specified offset for each direction; time and voltage. See "WGFMU Setup Functions" on page 4-77 for the error check of parameters.

Execution Conditions

Waveform pattern specified by *pattern1* must be created before this function is executed. See WGFMU_createPattern and WGFMU_create*Xxx*Pattern to create a pattern data.

Syntax

```
int WGFMU_createOffsetPattern(const char* pattern,
const char* pattern1, double offsetT, double offsetV);
```

Using HTBasic

```
Wm_createostpt(pattern, pattern1, offsetT, offsetV)
```

Parameters

pattern **:**	Name of waveform pattern to be created. String. Name must be unique. However, the same value as *pattern1* is allowed.
pattern1 **:**	Name of waveform pattern to be copied. String. Same value as *pattern* is allowed.
offsetT **:**	Offset value in the time direction, in second. Numeric. Event attribute *time* is changed by *offsetT*. The value will be *time* + *offsetT*.
offsetV **:**	Offset value in the voltage direction, in V. Numeric. See Table 4-2 on page 4-66. Event attributes are not changed by *offsetV*.

For the positive *offsetT*, the copied pattern will be shifted to the positive direction, and a vector with the initial voltage will be inserted at the beginning of the pattern.

For the negative *offsetT*, the copied pattern will be shifted to the negative direction. Then the vectors before *offsetT* will be deleted and the time *offsetT* will become the time origin. At the end of the pattern, no vector is added.

Example

```
int ret;
const char* ptn = "Pattern7";
const char* ptn0 = "Pattern1";
double otime = 1;
double ovolt = -2;
ret = WGFMU_createOffsetPattern(ptn, ptn0, otime, ovolt);
```

WGFMU_createPattern

This function creates a waveform pattern. See “WGFMU Setup Functions” on page 4-77 for the error check of parameters.

Syntax

```
int WGFMU_createPattern(const char* pattern,
double initV);
```

Using HTBasic

```
Wm_creatept(pattern, initV)
```

Parameters

pattern **:**	Name of waveform pattern. String. Name must be unique.

***initV* :** Voltage value for the start point of the pattern, in V. Numeric. See Table 4-2 on page 4-66. This value is voltage for the time origin (0 s) of the pattern.

Example

```
int ret;
ret = WGFMU_createPattern("Pattern0", 0);
```

WGFMU_dcforceVoltage

This function starts DC voltage output immediately by using the specified channel.

Error occurs if the specified channel is not in the DC mode. The operation mode is set by the WGFMU_setOperationMode function.

Syntax

```
int WGFMU_dcforceVoltage(int chanId, double voltage);
```

Using HTBasic

```
Wm_dcforcevol(chanId, voltage)
```

Parameters

***chanId* :** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

***voltage* :** Voltage value, in V. Numeric. See Table 4-2 on page 4-66.

Example

```
int ret;
int chId = 101;
double dcvol = 5;
ret = WGFMU_dcforceVoltage(chId, dcvol);
```

Remarks

The WGFMU_dcforceVoltage, WGFMU_dcmeasureAveragedValue, and WGFMU_dcmeasureValue functions apply the setup of the following function to the channel.

- WGFMU_setOperationMode
- WGFMU_setForceVoltageRange
- WGFMU_setMeasureCurrentRange
- WGFMU_setMeasureVoltageRange
- WGFMU_setMeasureMode

WGFMU_dcmeasureAveragedValue

This function starts a sampling measurement immediately by using the specified channel and returns the averaged measurement voltage or current. The measurement mode is set by the WGFMU_setMeasureMode function.

Error occurs if the specified channel is not in the DC mode. The operation mode is set by the WGFMU_setOperationMode function.

Syntax

```
int WGFMU_dcmeasureAveragedValue(int chanId, int points,
int interval, double* value);
```

Using HTBasic

```
Wm_dcmeasureave(chanId, points, interval, value)
```

Parameters

***chanId* :** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

***points* :** Number of sampling points. Integer. 1 to 65535.

***interval* :** Sampling interval. Integer. 1 to 65535. The channel sets the sampling interval given by the following formula.

sampling interval = *interval* × 5 ns

***value* :** Numeric pointer to receive the measured value, in V or A.

Example

```
int ret;
int chId = 101;
int count = 5;
int interval = 2;
double mVal;
ret = WGFMU_dcmeasureAveragedValue(chId, count, interval, &mVal);
```

WGFMU_dcmeasureValue

This function starts a voltage or current measurement immediately by using the specified channel and returns the measurement value.

Error occurs if the specified channel is not in the DC mode. The operation mode is set by the WGFMU_setOperationMode function.

Syntax

```
int WGFMU_dcmeasureValue(int chanId, double* value);
```

Using HTBasic

```
Wm_dcmeasureval(chanId, value)
```

Parameters

***chanId* :** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

***value* :** Numeric pointer to receive the measured value, in V or A.

Example

```
int ret;
int chId = 101;
double mVal;
ret = WGFMU_dcmeasureValue(chId, &mVal);
```

WGFMU_disconnect

This function disables the specified WGFMU channel and the RSU.

Syntax

```
int WGFMU_disconnect(int chanId);
```

Using HTBasic

```
Wm_disconnect(chanId)
```

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

Example

```
int ret;
int chId = 101;
ret = WGFMU_disconnect(chId);
```

WGFMU_doSelfCalibration

This function performs the self-calibration for the mainframe and all modules.

Syntax

```
int WGFMU_doSelfCalibration(int* result, char* detail,
int* size);
```

Using HTBasic

```
Wm_doselfcal(result, detail, size)
```

Parameters

result **:** Integer pointer to receive the self-calibration result. The following response will be returned. If multiple failures are detected, the returned value will be sum of responses. For example, if failures are detected in the slot 2 and 3 modules, 6 (2^1+2^2) is returned.

0: Mainframe and all modules passed self-calibration.

2^{N-1}: Slot N module failed self-calibration.

2^{10} (1024): Mainframe failed self-calibration.

detail **:** String pointer to receive the self-calibration result detail string. The string size must be longer than the length of the detail string.

size **:** Integer pointer to specify the number of characters to read as the self-calibration result detail string. Error occurs if the specified *size* value is negative or 0.

If the specified *size* value is greater than or equal to the length of the detail string, all of the detail string is stored in *detail*. And this pointer returns the length of the detail string.

If the specified *size* value is less than the length of the detail string, a part of the detail string is stored in *detail* and a warning occurs. Then the number of characters stored in *detail* is *size*.

Example

```
int ret;
int result;
char* detail;
int size = 256;
detail = new char[size + 1];
ret = WGFMU_doSelfCalibration(&result, detail, &size);
// delete [] after required process is completed
```

WGFMU_doSelfTest

This function performs the self-test for the mainframe and all modules.

Syntax

```
int WGFMU_doSelfTest(int* result, char* detail,
int* size);
```

Using HTBasic

```
Wm_doselftest(result, detail, size)
```

Parameters

result **:** Integer pointer to receive the self-test result. The following response will be returned. If multiple failures are detected, the returned value will be sum of responses. For example, if failures are detected in the slot 1 and 2 modules, 3 (2^0+2^1) is returned.

0: Mainframe and all modules passed self-test.

2^{N-1}: Slot N module failed self-test.

2^{10} (1024): Mainframe failed self-test.

detail **:** String pointer to receive the self-test result detail string. The string size must be longer than the length of the detail string.

size **:** Integer pointer to specify the number of characters to read as the self-test result detail string. Error occurs if the specified *size* value is negative or 0.

If the specified *size* value is greater than or equal to the length of the detail string, all of the detail string is stored in *detail*. And this pointer returns the length of the detail string.

If the specified *size* value is less than the length of the detail string, a part of the detail string is stored in *detail* and a warning occurs. Then the number of characters stored in *detail* is *size*.

Example

```
int ret;
int result;
char* detail;
int size = 256;
detail = new char[size + 1];
ret = WGFMU_doSelfTest(&result, detail, &size);
// delete [] after required process is completed
```

WGFMU_execute

This function runs the sequencer of all enabled WGFMU channels in the Fast IV mode or the PG mode. The channels start the predefined operation. If there are channels in the run status, this function stops the sequencers and runs the sequencer of all enabled WGFMU channels. After the execution, the channels keep the last output voltage.

This function applies the setup of the following function to the channel.

- WGFMU_setOperationMode
- WGFMU_setForceVoltageRange
- WGFMU_setMeasureCurrentRange
- WGFMU_setMeasureVoltageRange
- WGFMU_setMeasureMode

Syntax

```
int WGFMU_execute();
```

Using HTBasic

```
Wm_execute()
```

Example

```
int ret;
ret = WGFMU_execute();
```

WGFMU_exportAscii

This function creates a setup summary report and saves it as a csv (comma separated values) file. The summary report contains the pattern data, event data, and sequence data for the channels configured by the instrument library. The file can be read by using a spreadsheet software. This is effective for quick debugging. See Figure 4-1 for example data.

If the specified file does not exist, this function creates new file. If the specified file exists, this function overwrites the file. Error occurs if an invalid path is specified, a file is not created, or a setup summary is not written.

Syntax

```
int WGFMU_exportAscii(const char* file);
```

Using HTBasic `Wm_exportascii(file)`

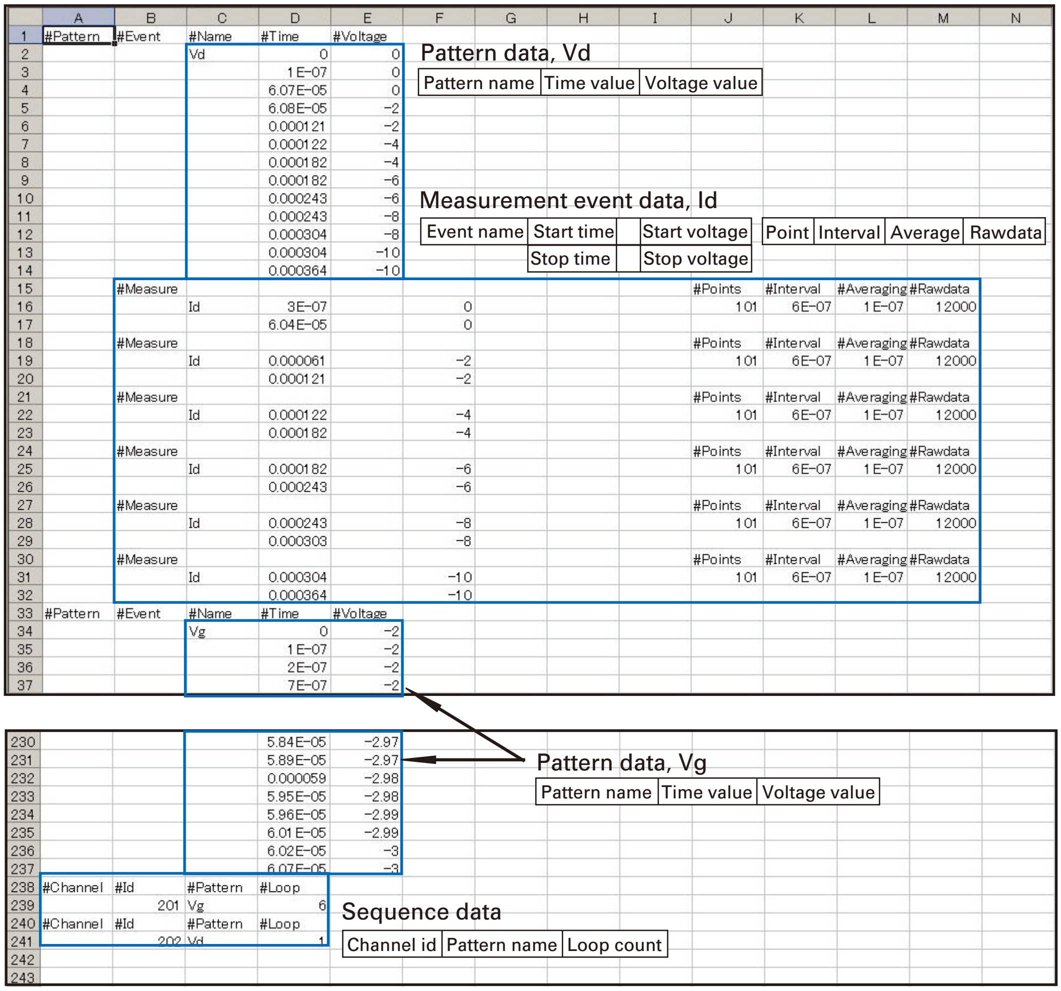
Parameters

file : Name of the summary report file. The file extension will be *csv* if you do not specify it.

Example

```
int ret;
const char* fname = "C:¥¥Keysight¥¥B1530A¥¥setup¥¥summary1.csv";
ret = WGFMU_exportAscii(fname);
```

Figure 4-1 **WGFMU_exportAscii Output Example**


Pattern data, Vd
Pattern name | Time value | Voltage value
Measurement event data, Id
Event name | Start time | Start voltage | Point | Interval | Average | Rawdata
Stop time | Stop voltage
Pattern data, Vg
Pattern name | Time value | Voltage value
Sequence data
Channel id | Pattern name | Loop count

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	#Pattern	#Event	#Name	#Time	#Voltage									
2			Vd	0	0									
3				1E-07	0									
4				6.07E-05	0									
5				6.08E-05	-2									
6				0.000121	-2									
7				0.000122	-4									
8				0.000182	-4									
9				0.000182	-6									
10				0.000243	-6									
11				0.000243	-8									
12				0.000304	-8									
13				0.000304	-10									
14				0.000364	-10									
15		#Measure								#Points	#Interval	#Averaging	#Rawdata	
16			Id	3E-07		0				101	6E-07	1E-07	12000	
17				6.04E-05		0								
18		#Measure								#Points	#Interval	#Averaging	#Rawdata	
19			Id	0.000061		-2				101	6E-07	1E-07	12000	
20				0.000121		-2								
21		#Measure								#Points	#Interval	#Averaging	#Rawdata	
22			Id	0.000122		-4				101	6E-07	1E-07	12000	
23				0.000182		-4								
24		#Measure								#Points	#Interval	#Averaging	#Rawdata	
25			Id	0.000182		-6				101	6E-07	1E-07	12000	
26				0.000243		-6								
27		#Measure								#Points	#Interval	#Averaging	#Rawdata	
28			Id	0.000243		-8				101	6E-07	1E-07	12000	
29				0.000303		-8								
30		#Measure								#Points	#Interval	#Averaging	#Rawdata	
31			Id	0.000304		-10				101	6E-07	1E-07	12000	
32				0.000364		-10								
33	#Pattern	#Event	#Name	#Time	#Voltage									
34			Vg	0	-2									
35				1E-07	-2									
36				2E-07	-2									
37				7E-07	-2									
230				5.84E-05	-2.97									
231				5.89E-05	-2.97									
232				0.000059	-2.98									
233				5.95E-05	-2.98									
234				5.96E-05	-2.99									
235				6.01E-05	-2.99									
236				6.02E-05	-3									
237				6.07E-05	-3									
238	#Channel	#Id	#Pattern	#Loop										
239		201	Vg	6										
240	#Channel	#Id	#Pattern	#Loop										
241		202	Vd	1										
242														
243														

WGFMU_getChannelIds

This function reads the channel id of the WGFMU channels installed in the B1500A connected to this session. To know the number of WGFMU channels, execute the WGFMU_getChannelIdSize function.

Syntax

```
int WGFMU_getChannelIds(int* result, int* size);
```

Using HTBasic

```
Wm_getchids(result, size)
```

Parameters

***result* :** Integer array pointer to receive the channel id. Array size must be greater than or equal to the actual number of WGFMU channels.

***size* :** Integer pointer to specify the number of WGFMU channel id to read. Error occurs if the specified *size* value is negative or 0.

If the specified *size* value is greater than or equal to the actual number of WGFMU channels, all of the channel id is stored in *result*. And this pointer returns the actual number of WGFMU channels.

If the specified *size* value is less than the actual number of WGFMU channels, some of channel id is stored in *result* and a warning occurs. Then the number of channel id stored in *result* is *size*.

WGFMU_getChannelIdSize

This function returns the number of WGFMU channels installed in the B1500A connected to this session.

Syntax

```
int WGFMU_getChannelIdSize(int* size);
```

Using HTBasic

```
Wm_getchidsz(size)
```

Parameters

***size* :** Integer pointer to receive the number of WGFMU channels.

Example

```
int ret;
int size = 1;
ret = WGFMU_getChannelIdSize(&size);
int* rId = new int[size];
ret = WGFMU_getChannelIds(rId, &size);
// delete [] after required process is completed
```

WGFMU_getChannelStatus

This function returns the status of the specified channel in the Fast IV mode or the PG mode. See “Channel Execution Status” on page 4-76 for the returned time data.

Syntax

```
int WGFMU_getChannelStatus(int chanId, int* status,
double* elapsT, double* totalT);
```

Using HTBasic

```
Wm_getchstatus(chanId, status, elapsT, totalT)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
status **:**	Integer pointer to receive the status shown in Table 4-17 on page 4-79.
elapsT **:**	Numeric pointer to receive the estimated elapsed time, in second.
totalT **:**	Numeric pointer to receive the estimated total time until all sequences are completed, in second.

Example

```
int ret;
int chId = 101;
int stat;
double elapsT;
double totalT;
ret = WGFMU_getChannelStatus(chId, &stat, &elapsT, &totalT);
```

WGFMU_getCompletedMeasureEventSize

This function returns the number of completed measurement events and the total number of measurement events set to the specified channel. See "Channel Execution Status" on page 4-76.

Syntax

```
int WGFMU_getCompletedMeasureEventSize(int chanId,
int* complete, int* total);
```

Using HTBasic

```
Wm_getcdmeevtsz(chanId, complete, total)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
complete **:**	Integer pointer to receive the number of the measurement events which have been already completed.
total **:**	Integer pointer to receive the total number of the measurement events.

Example

```
int ret;
int chId = 101;
int comp = 1;
int ttl = 1;
do {
  ret = WGFMU_getCompletedMeasureEventSize(chId, &comp, &ttl);
} while ( comp < ttl );
```

WGFMU_getError

This function reads one error string. To know the length of the next error string, execute the WGFMU_getErrorSize function. The error string is cleared by the WGFMU_clear function.

Syntax `int WGFMU_getError(char* result, int* size);`

Using HTBasic `Wm_geterr(result, size)`

Parameters

***result* :** String pointer to receive one error string. The string size must be longer than the length of the next error string.

***size* :** Integer pointer to specify the number of characters to read as the error string. Error occurs if the specified *size* value is 0 or negative.

If the specified *size* value is greater than or equal to the length of the error string, all of the error string is stored in *result*. And this pointer returns the length of the error string.

If the specified *size* value is less than the length of the error string, a part of the error string is stored in *result* and a warning occurs. Then the number of characters stored in *result* is *size*.

WGFMU_getErrorSize

This function returns the length of the next error string.

Syntax `int WGFMU_getErrorSize(int* size);`

Using HTBasic `Wm_geterrsz(size)`

Parameters

***size* :** Integer pointer to receive the length of the next error string.

Example

```
int checkErrorFlag = 1;
void checkError(int ret) {
  if(checkErrorFlag != 0) {
    if(ret != WGFMU_NO_ERROR) {
      int size = 1;
      WGFMU_getErrorSize(&size);
      char* msg = new char[size + 1];
      WGFMU_getError(msg, &size);
      // do something with msg
      // delete [] after required process is completed
    }
  }
}
int main()
```

```
{
int ret;
const char* fname = "C:¥¥Keysight¥¥B1530A¥¥setup¥¥summary1.csv";
ret = WGFMU_exportAscii(fname);
checkError(ret);
}
```

WGFMU_getErrorSummary

This function reads the error summary string which contains all errors. To know the length of the error summary string, execute the WGFMU_getErrorSummarySize function. The error summary string is cleared by the WGFMU_clear function.

Syntax

```
int WGFMU_getErrorSummary(char* result, int* size);
```

Using HTBasic

```
Wm_geterrsum(result, size)
```

Parameters

result **:** String pointer to receive the error summary string. The string size must be longer than the length of the error summary string.

size **:** Integer pointer to specify the number of characters to read as the error summary string. Error occurs if the specified *size* value is 0 or negative.

If the specified *size* value is greater than or equal to the length of the error summary string, all of the error summary string is stored in *result*. And this pointer returns the length of the error summary string.

If the specified *size* value is less than the length of the error summary string, a part of the error summary string is stored in *result* and a warning occurs. Then the number of characters stored in *result* is *size*.

WGFMU_getErrorSummarySize

This function returns the length of the error summary string which contains all errors.

Syntax

```
int WGFMU_getErrorSummarySize(int* size);
```

Using HTBasic

```
Wm_geterrsumsz(size)
```

Parameters

size **:** Integer pointer to receive the length of the error summary string.

Example

```
int size = 1;
WGFMU_getErrorSummarySize(&size);
if (size != 0) {
  char* msg = new char[size + 1];
  WGFMU_getErrorSummary(msg, &size);
  // do something with msg
  // delete [] after required process is completed
}
```

WGFMU_getForceDelay

This function returns the device delay time of the specified source channel in the Fast IV mode or the PG mode.

Syntax

```
int WGFMU_getForceDelay(int chanId, double* delay);
```

Using HTBasic

```
Wm_getfodelay(chanId, delay)
```

Parameters

***chanId* :** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

***delay* :** Numeric pointer to receive the device delay time, in second.

delay must be -50×10^{-9} (−50 ns) to 50×10^{-9} (50 ns), in 625×10^{-12} (625 ps) resolution.

If the value is not multiple number of 625 ps, the value is rounded to the nearest multiple number. For example, if the value is 1.5 ns, the value is rounded to 1.25 ns.

Example

```
int ret;
int chId = 101;
double fDelay;
ret = WGFMU_getForceDelay(chId, &fDelay);
```

WGFMU_getForceValue

This function specifies a channel and an index of sequence data, and returns the corresponding setup data (*time* and *voltage*).

Syntax

```
int WGFMU_getForceValue(int chanId, double index,
double* time, double* voltage);
```

Using HTBasic

```
Wm_getfoval(chanId, index, time, voltage)
```

Parameters

***chanId* :** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

***index* :** Index of the sequence data to read setup. Numeric. *index* must be 0 to the total number of setup data −1. Error occurs if the value is out of this range.

***time* :** Numeric pointer to receive the time data, in second.

***voltage* :** Numeric pointer to receive the voltage data, in V.

Example

```
int ret;
int chId = 101;
double dsize = 1;
ret = WGFMU_getForceValueSize(chId, &dsize);
int size = int(dsize);
double* dTime = new double[size];
double* volt = new double[size];
for (int i = 0; i < size; i++){
  ret = WGFMU_getForceValue(chId, i, &dTime[i], &volt[i]);
}
```

WGFMU_getForceValues

This function specifies a channel and a range of sequence data, and returns the corresponding setup data (*time* and *voltage*). To know the total number of setup data, execute the WGFMU_getForceValueSize function.

Syntax

```
int WGFMU_getForceValues(int chanId, double index,
int* length, double* time, double* voltage);
```

Using HTBasic

```
Wm_getfovals(chanId, index, length, time, voltage)
```

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

index **:** First index of the sequence data to read setup. Numeric. *index* must be 0 to the total number of setup data −1. Error occurs if the value is out of this range.

length **:** Integer pointer to specify the number of setup data to read and receive the number of data returned. *length* must be 1 to the total number of setup data − *index*. If *length* is greater than this value, all of the returned data is stored in *time* and *voltage* and a warning occurs. Error occurs if *length* is less than 1.

time **:** Numeric array pointer to receive the time data, in second.

voltage **:** Numeric array pointer to receive the voltage data, in V.

For the array pointers, the array size must be ≥ *length*.

Example

```
int ret;
int chId = 101;
double dsize = 1;
ret = WGFMU_getForceValueSize(chId, &dsize);
int size = int(dsize);
double* dTime = new double[size];
double* volt = new double[size];
ret = WGFMU_getForceValues(chId, 0, &size, dTime, volt);
```

WGFMU_getForceValueSize

This function returns the total number of setup data (*time* and *voltage*) defined in the source output sequence set to the specified channel.

Syntax

```
int WGFMU_getForceValueSize(int chanId, double* size);
```

Using HTBasic

```
Wm_getfovalsz(chanId, size)
```

Parameters

chanId :	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
size :	Numeric pointer to receive the total number of setup data.

Example

```
int ret;
int chId = 101;
double dsize = 1;
ret = WGFMU_getForceValueSize(chId, &dsize);
```

WGFMU_getForceVoltageRange

This function returns the voltage output range set to the specified channel. The value is set by the WGFMU_setForceVoltageRange function. The setting is applied to the channel by the WGFMU_update, WGFMU_updateChannel, WGFMU_execute, or the functions of the DC measurement group.

Syntax

```
int WGFMU_getForceVoltageRange(int chanId, int* range);
```

Using HTBasic

```
Wm_getfovolrng(chanId, range)
```

Parameters

chanId :	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
range :	Integer pointer to receive the voltage output range. See Table 4-6 on page 4-70.

Example

```
int ret;
int chId = 101;
int fRange;
ret = WGFMU_getForceVoltageRange(chId, &fRange);
```

WGFMU_getInterpolatedForceValue

This function specifies a channel and a time value (*time*), and returns the voltage value (*voltage*) applied by the specified WGFMU channel at the specified *time*. The returned value may be the value given by the interpolation.

Syntax

```
int WGFMU_getInterpolatedForceValue(int chanId,
double time, double* voltage);
```

Using HTBasic

```
Wm_getidfoval(chanId, time, voltage)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
time **:**	Time to read the voltage output value, in second. Numeric. *time* must be 0 to the length of the waveform set to the specified channel. Error occurs if the value is out of this range.
voltage **:**	Numeric pointer to receive the voltage output value, in V.

Example

```
int ret;
int chId = 101;
double reTm = 1E-6;
double volt;
ret = WGFMU_getInterpolatedForceValue(chId, reTm, &volt);
```

WGFMU_getMeasureCurrentRange

This function returns the current measurement range set to the specified channel. The value is set by the WGFMU_setMeasureCurrentRange function. The setting is applied to the channel by the WGFMU_update, WGFMU_updateChannel, WGFMU_execute, or the functions of the DC measurement group. The setting is not effective for the voltage measurement mode.

Syntax

```
int WGFMU_getMeasureCurrentRange(int chanId, int*
range);
```

Using HTBasic

```
Wm_getmecurrng(chanId, range)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
range **:**	Integer pointer to receive the current measurement range. See Table 4-9 on page 4-72.

Example

```
int ret;
int chId = 101;
int mRange;
ret = WGFMU_getMeasureCurrentRange(chId, &mRange);
```

WGFMU_getMeasureDelay

This function returns the device delay time of the specified measurement channel in the Fast IV mode or the PG mode.

Syntax

```
int WGFMU_getMeasureDelay(int chanId, double* delay);
```

Using HTBasic

```
Wm_getmedelay(chanId, delay)
```

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

delay **:** Numeric pointer to receive the device delay time, in second.

delay must be -50×10^{-9} (−50 ns) to 50×10^{-9} (50 ns), in 625×10^{-12} (625 ps) resolution.

If the value is not multiple number of 625 ps, the value is rounded to the nearest multiple number. For example, if the value is 1.5 ns, the value is rounded to 1.25 ns.

Example

```
int ret;
int chId = 101;
double mDelay;
ret = WGFMU_getMeasureDelay(chId, &mDelay);
```

WGFMU_getMeasureEvent

This function specifies a channel and an index of measurement event, and returns the corresponding setup (*pattern*, *event*, *cycle*, *loop*, *count*, *index*, and *length*).

Syntax

```
int WGFMU_getMeasureEvent(int chanId, int measId,
const char* pattern, const char* event, int* cycle,
double* loop, int* count, int* index, int* length);
```

Using HTBasic

```
Wm_getmeevt(chanId, measId, pattern, event, cycle, loop,
count, index, length)
```

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

measId **:** Index of the measurement event to read setup. Integer. *measId* must be 0 to the total number of measurement events −1. Error occurs if the value is out of this range.

pattern **:** String pointer to receive the waveform pattern name.

event **:** String pointer to receive the event name.

cycle **:** Integer pointer to receive the usage count. This parameter means how many times the pattern is used in the sequence of the specified channel.

loop **:** Numeric pointer to receive the loop count. This parameter means how many times the pattern is looped in the sequence of the specified channel.

count **:** Integer pointer to receive the event count. This parameter means how many times the event is used in the pattern.

index **:** Integer pointer to receive the first data index assigned to the specified measurement event.

length **:** Integer pointer to receive the number of sampling points for the specified measurement event.

Example

```
int ret;
int chId = 101;
int measId = 0;
int size = 1;
ret = WGFMU_getMeasureEventSize(chId, &size);
int stringSize = 512;
char** ptn = new char*[size];
char** evt = new char*[size];
for (int i = 0; i < size; i++){
  ptn[i] = new char[stringSize];
  evt[i] = new char[stringSize];
}
int* cycle = new int[size];
double* loop = new double[size];
int* count = new int[size];
int* idx = new int[size];
int* len = new int[size];
for (int i = measId; i < measId + size; i++){
  ret = WGFMU_getMeasureEvent(chId, i, ptn[i], evt[i], &cycle[i],
&loop[i], &count[i], &idx[i], &len[i]);
}
// delete [] after required process is completed
```

WGFMU_getMeasureEventAttribute

This function specifies a channel and a measurement event index, and returns the corresponding measurement event attribute (*time*, *points*, *interval*, *average*, and *rdata*) which have been set by the WGFMU_setMeasureEvent function.

Syntax

```
int WGFMU_getMeasureEventAttribute(int chanId,
int measId, double* time, int* points, double* interval,
double* average, int* rdata);
```

Using HTBasic

```
Wm_getmeevtattr(chanId, measId, time, points, interval,
average, rdata)
```

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

measId **:** Measurement event index. Integer. For instance, the index can be read by WGFMU_isMeasureEventCompleted.

time **:** Numeric pointer to receive the measurement start time in the pattern, in second.

points **:** Integer pointer to receive the number of sampling points.

interval **:** Numeric pointer to receive the sampling interval, in second.

average **:** Numeric pointer to receive the averaging time, in second.

rdata **:** Integer pointer to receive *rdata* value of WGFMU_setMeasureEvent.

Example

```
int ret;
int chId = 101;
const char* ptn = "Pattern1";
const char* evt = "Event1";
int cycle = 0;
double loop = 0;
int count = 0;
int cmp;
int measId;
int idx;
int len;
ret = WGFMU_isMeasureEventCompleted(chId, ptn, evt, cycle, loop,
count, &cmp, &measId, &idx, &len);
double sTime;
int pts;
double tInt;
double tAve;
int rdat;
ret = WGFMU_getMeasureEventAttribute(chId, measId, &sTime, &pts,
&tInt, &tAve, &rdat);
```

WGFMU_getMeasureEvents

This function specifies a channel and a range of measurement events, and returns the corresponding setup (*pattern*, *event*, *cycle*, *loop*, *count*, *index*, and *length*). To know the total number of events, execute the WGFMU_getMeasureEventSize function.

Syntax

```
int WGFMU_getMeasureEvents(int chanId, int measId,
int* eventsNo, const char** pattern, const char** event,
int* cycle, double* loop, int* count, int* index,
int* length);
```

Using HTBasic

```
Wm_getmeevts(chanId, measId, eventsNo, pattern, event,
cycle, loop, count, index, length, slength)
```

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

measId **:** First index of the measurement events to read setup. Integer. *measId* must be 0 to the total number of measurement events −1. Error occurs if the value is out of this range.

eventsNo **:** Integer pointer to specify the number of measurement events to read setup and receive the number of events returned. *eventsNo* must be 1 to the total number of measurement events − *measId*. If *eventsNo* is greater than this value, all of the returned data is stored in *pattern*, *event*, *cycle*, *loop*, *count*, *index*, and *length* and a warning occurs. Error occurs if *eventsNo* is less than 1.

pattern **:** String array pointer to receive the waveform pattern name.

event **:** String array pointer to receive the event name.

cycle **:** Integer array pointer to receive the usage count. This parameter means how many times the pattern is used in the sequence of the specified channel.

loop **:** Numeric array pointer to receive the loop count. This parameter means how many times the pattern is looped in the sequence of the specified channel.

count **:** Integer array pointer to receive the event count. This parameter means how many times the event is used in the pattern.

index **:** Integer array pointer to receive the first data index assigned to the specified measurement event.

length **:** Integer array pointer to receive the number of sampling points for the specified measurement event.

slength **:** Only for the HTBasic programming environment. Length of string. Integer.

For the array pointers, the array size must be ≥ *eventsNo*.

Example

```
int ret;
int chId = 101;
int measId = 0;
int size = 1;
ret = WGFMU_getMeasureEventSize(chId, &size);
int stringSize = 512;
char** ptn = new char*[size];
char** evt = new char*[size];
for (int i = 0; i < size; i++){
  ptn[i] = new char[stringSize];
  evt[i] = new char[stringSize];
}
int* cycle = new int[size];
double* loop = new double[size];
int* count = new int[size];
int* idx = new int[size];
int* len = new int[size];
```

```
ret = WGFMU_getMeasureEvents(chId, measId, &size, ptn, evt, cycle,
loop, count, idx, len);
// delete [] after required process is completed
```

Remarks

The following notices are required to use the *pattern* and *event* string arrays for the HTBasic environment and the Visual Basic 6.0 environment.

- For the HTBasic programming environment:

  Define and use the string array variables as shown below.

```
LONG Size = 3
LONG Slength = 10
ALLOCATE Pattern$(Size)[Slength]
ALLOCATE Event$(Size)[Slength]
Pattern$(0)="Initial"
Pattern$(1)="Pattern1"
Pattern$(2)="Pattern2"
Event$(0)="Event0"
Event$(1)="Event1"
Event$(2)="Event2"
  :
Wm_getmeevts( ... , 0, Size, Pattern$(0), Event$(0), ... ,
(Slength))
```

- For the Visual Basic 6.0 programming environment:

  Define and use the string array variables as shown below. Then the VarPtrStringArray function is required. For creating the VarPtrStringArray function, visit http://support.microsoft.com/kb/199824.

```
Dim size As Long
size = 3
ReDim pattern(size) As String
ReDim event(size) As String
pattern(0)="Initial"
pattern(1)="Pattern1"
pattern(2)="Pattern2"
event(0)="Event0"
event(1)="Event1"
event(2)="Event2"
  :
WGFMU_getMeasureEvents( ... , 0, size, VarPtrStringArray(
pattern()), VarPtrStringArray(event()), ... )
```

WGFMU_getMeasureEventSize

This function returns the total number of measurement events defined in the source output and measurement sequence set to the specified channel.

Syntax

```
int WGFMU_getMeasureEventSize(int chanId, int* size);
```

Using HTBasic

```
Wm_getmeevtsz(chanId, size)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
size **:**	Integer pointer to receive the total number of measurement events.

Example

```
int ret;
int chId = 101;
int size = 1;
ret = WGFMU_getMeasureEventSize(chId, &size);
```

WGFMU_getMeasureMode

This function returns the measurement mode set to the specified channel. The value is set by the WGFMU_setMeasureMode function. The setting is applied to the channel by the WGFMU_update, WGFMU_updateChannel, WGFMU_execute, or the functions of the DC measurement group.

Syntax

```
int WGFMU_getMeasureMode(int chanId, int* mode);
```

Using HTBasic

```
Wm_getmemod(chanId, mode)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
mode **:**	Integer pointer to receive the measurement mode of the specified channel. See Table 4-7 on page 4-71.

Example

```
int ret;
int chId = 101;
int mMode;
ret = WGFMU_getMeasureMode(chId, &mMode);
```

WGFMU_getMeasureTime

This function specifies a channel and an index of measurement point, and returns the measurement start time for the point. For the averaging measurement which takes multiple data for one point measurement, the returned value will be (*start time* + *stop time*)/2.

Syntax

```
int WGFMU_getMeasureTime(int chanId, int index,
double* time);
```

Using HTBasic

```
Wm_getmetim(chanId, index, time)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

index **:** Index of the measurement point to read the measurement start time. Integer. *index* must be 0 to the total number of measurement points −1. Error occurs if the value is out of this range.

time **:** Numeric pointer to receive the measurement start time, in second.

Example

```
int ret;
int chId = 101;
int size = 1;
ret = WGFMU_getMeasureTimeSize(chId, &size);
double* sTime = new double[size];
for (int i = 0; i < size; i++){
  ret = WGFMU_getMeasureTime(chId, i, &sTime[i]);
}
// delete [] after required process is completed
```

WGFMU_getMeasureTimes

This function specifies a channel and a range of measurement points, and returns the measurement start time for the points. For the averaging measurement which takes multiple data for one point measurement, the returned value will be (*start time* + *stop time*)/2. To know the total number of measurement points, execute the WGFMU_getMeasureTimeSize function.

Syntax

```
int WGFMU_getMeasureTimes(int chanId, int index,
int* length, double* time);
```

Using HTBasic

```
Wm_getmetims(chanId, index, length, time)
```

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

index **:** First index of the measurement points to read the measurement start time. Integer. *index* must be 0 to the total number of measurement points −1. Error occurs if the value is out of this range.

length **:** Number of measurement points to read the measurement start time. Integer. *length* must be 1 to the total number of measurement points − *index*. If *length* is greater than this value, all of the returned data is stored in *time* and a warning occurs. Error occurs if *length* is less than 1.

time **:** Numeric array pointer to receive the measurement start time, in second. Array size must be ≥ *length*.

Example

```
int ret;
int chId = 101;
int size = 1;
ret = WGFMU_getMeasureTimeSize(chId, &size);
```

```
double* sTime = new double[size];
ret = WGFMU_getMeasureTimes(chId, 0, &size, sTime);
// delete [] after required process is completed
```

WGFMU_getMeasureTimeSize

This function returns the total number of measurement points defined in the source output and measurement sequence set to the specified channel.

Syntax

```
int WGFMU_getMeasureTimeSize(int chanId, int* size);
```

Using HTBasic

```
Wm_getmetimsz(chanId, size)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
size **:**	Integer pointer to receive the total number of measurement points.

Example

```
int ret;
int chId = 101;
int size = 1;
ret = WGFMU_getMeasureTimeSize(chId, &size);
```

WGFMU_getMeasueValue

This function specifies a channel and an index of measurement point, and returns the measurement data (*time* and *value*) for the point. For the averaging measurement which takes multiple data for one point measurement, the returned value is the value given by averaging the multiple measured values.

Syntax

```
int WGFMU_getMeasureValue(int chanId, int index,
double* time, double* value);
```

Using HTBasic

```
Wm_getmeval(chanId, index, time, value)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
index **:**	Index of the measurement point to read the measured value. Integer. *index* must be 0 to the total number of measurement points −1. Error occurs if the value is out of this range.
time **:**	Numeric pointer to receive the measurement start time, in second.
value **:**	Numeric pointer to receive the measured value, in V or A.

Example

```
int ret;
int chId = 101;
int i = 1;
int size = 1;
```

```
do {
  ret = WGFMU_getMeasureValueSize(chId, &i, &size);
} while ( i < size );
double* mTm = new double[size];
double* rVal = new double[size];
for (int i = 0; i < size; i++){
  ret = WGFMU_getMeasureValue(chId, i, &mTm[i], &rVal[i]);
}
// delete [] after required process is completed
```

WGFMU_getMeasureValues

This function specifies a channel and a range of measurement points, and returns the measurement data (*time* and *value*) for the points. For the averaging measurement which takes multiple data for one point measurement, the returned value is the value given by averaging the multiple measured values.

Syntax

```
int WGFMU_getMeasureValues(int chanId, int index,
int* length, double* time, double* value);
```

Using HTBasic

```
Wm_getmevals(chanId, index, length, time, value)
```

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

index **:** First index of the measurement points to read the measured value. Integer. *index* must be 0 to the total number of measurement points −1. Error occurs if the value is out of this range.

length **:** Number of measurement points to read the measured value. Integer. *length* must be 1 to the total number of measurement points − *index*. If *length* is greater than this value, all of the returned data is stored in *time* and *voltage* and a warning occurs. Error occurs if *length* is less than 1.

time **:** Numeric array pointer to receive the measurement start time, in second.

value **:** Numeric array pointer to receive the measured values, in V or A.

For the array pointers, the array size must be ≥ *length*.

Example

```
int ret;
int chId = 101;
int i = 1;
int size = 1;
do {
  ret = WGFMU_getMeasureValueSize(chId, &i, &size);
} while ( i < size );
double* mTm = new double[size];
double* rVal = new double[size];
ret = WGFMU_getMeasureValues(chId, 0, &size, mTm, rVal);
// delete [] after required process is completed
```

WGFMU_getMeasureValueSize

This function returns the number of completed measurement points and the total number of measurement points set to the specified channel. See "Channel Execution Status" on page 4-76.

Syntax

```
int WGFMU_getMeasureValueSize(int chanId, int* complete,
int* total);
```

Using HTBasic

```
Wm_getmevalsz(chanId, complete, total)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
complete **:**	Integer pointer to receive the number of the measurement events which have been already completed.
total **:**	Integer pointer to receive the total number of the measurement events.

Example

```
int ret;
int chId = 101;
int i = 1;
int j = 1;
do {
  ret = WGFMU_getMeasureValueSize(chId, &i, &j);
} while ( i < j );
```

WGFMU_getMeasureVoltageRange

This function returns the voltage measurement range set to the specified channel. The value is set by the WGFMU_setMeasureVoltageRange function. The setting is applied to the channel by the WGFMU_update, WGFMU_updateChannel, WGFMU_execute, or the functions of the DC measurement group. The setting is not effective for the current measurement mode.

Syntax

```
int WGFMU_getMeasureVoltageRange(int chanId,
int* range);
```

Using HTBasic

```
Wm_getmevolrng(chanId, range)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
range **:**	Integer pointer to receive the voltage measurement range. See Table 4-8 on page 4-71.

Example

```
int ret;
int chId = 101;
int mRange;
ret = WGFMU_getMeasureVoltagefRange(chId, &mRange);
```

WGFMU_getOperationMode

This function returns the operation mode set to the specified channel. The value is set by the WGFMU_setOperationMode function. The setting is applied to the channel by the WGFMU_update, WGFMU_updateChannel, WGFMU_execute, or the functions of the DC measurement group.

Syntax

```
int WGFMU_getOperationMode(int chanId, int* mode);
```

Using HTBasic

```
Wm_getopemod(chanId, mode)
```

Parameters

***chanId* :** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

***mode* :** Integer pointer to receive the operation mode. See Table 4-5 on page 4-69.

Example

```
int ret;
int chId = 101;
int omode;
ret = WGFMU_getOperationMode(chId, &omode);
```

WGFMU_getPatternForceValue

This function specifies a pattern and an index of scalar, and returns the corresponding scalar data (*time* and *voltage*).

Syntax

```
int WGFMU_getPatternForceValue(const char* pattern,
int index, double* time, double* voltage);
```

Using HTBasic

```
Wm_getptfoval(pattern, index, time, voltage)
```

Parameters

***pattern* :** Name of waveform pattern to read the scalar data. String.

***index* :** Index of the scalar to read data. Integer. *index* must be 0 to the total number of scalar −1. Error occurs if the value is out of this range.

***time* :** Numeric pointer to receive the time value of the scalar, in second.

***voltage* :** Numeric pointer to receive the voltage value of the scalar, in V.

Example

```
int ret;
const char* ptn = "Pattern1";
int dsize = 1;
ret = WGFMU_getPatternForceValueSize(ptn, &dsize);
double* dTime = new double[dsize];
double* volt = new double[dsize];
```

```
for (int i = 0; i < dsize; i++){
  ret = WGFMU_getPatternForceValue(ptn, i, &dTime[i], &volt[i]);
}
```

WGFMU_getPatternForceValues

This function specifies a pattern and a range of scalar, and returns the corresponding scalar data (*time* and *voltage*). To know the total number of scalar, execute the WGFMU_getPatternForceValueSize function.

Syntax

```
int WGFMU_getPatternForceValues(const char* pattern,
int index, int* length, double* time, double* voltage);
```

Using HTBasic

```
Wm_getptfovals(pattern, index, length, time, voltage)
```

Parameters

***pattern* :** Name of waveform pattern to read the scalar data. String.

***index* :** First index of the scalar to read data. Integer. *index* must be 0 to the total number of scalar −1. Error occurs if the value is out of this range.

***length* :** Integer pointer to specify the number of scalar to read and receive the number of scalar returned. *length* must be 1 to the total number of scalar − *index*. If *length* is greater than this value, all of the returned data is stored in *time* and *voltage* and a warning occurs. Error occurs if *length* is less than 1.

***time* :** Numeric array pointer to receive the time value of the scalar, in second.

***voltage* :** Numeric array pointer to receive the voltage value of the scalar, in V.

For the array pointers, the array size must be ≥ *length*.

Example

```
int ret;
const char* ptn = "Pattern1";
int dsize = 1;
ret = WGFMU_getPatternForceValueSize(ptn, &dsize);
double* dTime = new double[dsize];
double* volt = new double[dsize];
ret = WGFMU_getPatternForceValues(ptn, 0, &dsize, dTime, volt);
```

WGFMU_getPatternForceValueSize

This function returns the total number of scalar defined in the specified waveform pattern.

Syntax

```
int WGFMU_getPatternForceValueSize(const char* pattern,
int* size);
```

Using HTBasic `Wm_getptfovalsz(pattern, size)`

Parameters

pattern **:** Name of waveform pattern to read the scalar data. String.

size **:** Integer pointer to receive the total number of scalar.

Example

```
int ret;
const char* ptn = "Pattern1";
int dsize = 1;
ret = WGFMU_getPatternForceValueSize(ptn, &dsize);
```

WGFMU_getPatternInterpolatedForceValue

This function specifies a pattern and a time value (*time*), and returns the voltage output value (*voltage*) of the specified pattern at the specified *time*. The returned value may be the value given by the interpolation.

Syntax

```
int WGFMU_getPatternInterpolatedForceValue(const char*
pattern, double time, double* voltage);
```

Using HTBasic `Wm_getptidfoval(pattern, time, voltage)`

Parameters

pattern **:** Name of waveform pattern to read the voltage output value. String.

time **:** Time to read the voltage output value, in second. Numeric. *time* must be 0 to the length of the waveform specified by *pattern*. Error occurs if the value is out of this range.

voltage **:** Numeric pointer to receive the voltage output value, in V.

Example

```
int ret;
const char* ptn = "Pattern1";
int nStp = 3;
double dT1 = 100E-9;
double dT2 = 1E-6;
double* reTm = new double[nStp];
double* volt = new double[nStp];
for (int i = 0; i < nStp; i++){
  reTm[i] = ( dT1 + dT2 ) * ( i + .5 );
  ret = WGFMU_getPatternInterpolatedForceValue(ptn, reTm[i],
&volt[i]);
}
```

WGFMU_getPatternMeasureTime

This function specifies a pattern and an index of measurement point, and returns the measurement start time for the point. For the averaging measurement which takes multiple data for one point measurement, the returned value will be (*start time* + *stop time*)/2.

Syntax

```
int WGFMU_getPatternMeasureTime(const char* pattern,
int index, double* time);
```

Using HTBasic

```
Wm_getptmetim(pattern, index, time)
```

Parameters

pattern **:** Name of waveform pattern to read the measurement start time. String.

index **:** Index of the measurement point to read the measurement start time. Integer. *index* must be 0 to the total number of measurement points −1. Error occurs if the value is out of this range.

time **:** Numeric pointer to receive the measurement start time, in second.

Example

```
int ret;
const char* ptn = "Pattern1";
int dsize = 1;
ret = WGFMU_getPatternMeasureTimeSize(ptn, &dsize);
double* sTime = new double[dsize];
for (int i = 0; i < dsize; i++){
  ret = WGFMU_getPatternMeasureTime(ptn, i, &sTime[i]);
}
```

WGFMU_getPatternMeasureTimes

This function specifies a pattern and a range of measurement points, and returns the measurement start time for the points. For the averaging measurement which takes multiple data for one point measurement, the returned value will be (*start time* + *stop time*)/2. To know the total number of measurement points, execute the WGFMU_getPatternMeasureTimeSize function.

Syntax

```
int WGFMU_getPatternMeasureTimes(const char* pattern,
int index, int* length, double* time);
```

Using HTBasic

```
Wm_getptmetims(pattern, index, length, time)
```

Parameters

pattern **:** Name of waveform pattern to read the measurement start time. String.

index **:** First index of the measurement points to read the measurement start time. Integer. *index* must be 0 to the total number of measurement points −1. Error occurs if the value is out of this range.

length **:** Integer pointer to specify the number of measurement points to read the measurement start time and receive the number of measurement points returned. *length* must be 1 to the total number of measurement points − *index*. If *length* is greater than this value, all of the returned data is stored in *time* and a warning occurs. Error occurs is *length* is less than 1.

***time* :** Numeric array pointer to receive the measurement start time, in second. Array size must be ≥ *length*.

Example

```
int ret;
const char* ptn = "Pattern1";
int dsize = 1;
ret = WGFMU_getPatternMeasureTimeSize(ptn, &dsize);
double* sTime = new double[dsize];
ret = WGFMU_getPatternMeasureTimes(ptn, 0, &dsize, sTime);
```

WGFMU_getPatternMeasureTimeSize

This function returns the total number of measurement points in the specified waveform pattern.

Syntax

```
int WGFMU_getPatternMeasureTimeSize(const char* pattern,
int* size);
```

Using HTBasic

```
Wm_getptmetimsz(pattern, size)
```

Parameters

***pattern* :** Name of waveform pattern to read the measurement start time. String.

***size* :** Integer pointer to receive the total number of measurement points.

Example

```
int ret;
const char* ptn = "Pattern1";
int dsize = 1;
ret = WGFMU_getPatternMeasureTimeSize(ptn, &dsize);
```

WGFMU_getStatus

This function reads the status of the WGFMU channels in the Fast IV mode or the PG mode. The returned values are the maximum of the values presented by all active channels.

Syntax

```
int WGFMU_getStatus(int* status, double* elapsT,
double* totalT);
```

Using HTBasic

```
Wm_getstatus(status, elapsT, totalT)
```

Parameters

***status* :** Integer pointer to receive the status shown in Table 4-17 on page 4-79.

***elapsT* :** Numeric pointer to receive the estimated elapsed time, in second.

***totalT* :** Numeric pointer to receive the estimated total time until all sequences are completed, in second.

Example

```
int ret;
int stat;
double elapsT;
double totalT;
ret = WGFMU_getStatus(&stat, &elapsT, &totalT);
```

WGFMU_getTriggerOutMode

This function returns the trigger output mode of the specified channel.

Syntax

```
int WGFMU_getTriggerOutMode(int chanId, int* mode,
int* polarity);
```

Using HTBasic

```
Wm_gettrgoutmod(chanId, mode, polarity)
```

Parameters

***chanId* :** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

***mode* :** Integer pointer to receive the trigger output mode. See Table 4-11 on page 4-73.

***polarity* :** Integer pointer to receive the trigger polarity. See Table 4-11 on page 4-73.

Example

```
int ret;
int chId = 101;
int tMode;
int tPol;
ret = WGFMU_getTriggerOutMode(chId, &tMode, &tPol);
```

WGFMU_getWarningLevel

This function reads the warning level setting. The warning level affects to the WGFMU_getWarningSummary, WGFMU_getWarningSummarySize, and WGFMU_openLogFile functions.

Syntax

```
int WGFMU_getWarningLevel(int* level);
```

Using HTBasic

```
Wm_getwarlevel(level)
```

Parameters

***level* :** Integer pointer to receive the warning level setting. See Table 4-4 on page 4-68.

Example

```
int ret;
int level;
ret = WGFMU_getWarningLevel(&level);
```

WGFMU_getWarningSummary

This function reads the warning summary string which contains all warnings. To know the length of the warning summary string, execute the WGFMU_getWarningSummarySize function. The warning summary string is cleared by the WGFMU_clear function.

Syntax

```
int WGFMU_getWarningSummary(char* result, int* size);
```

Using HTBasic

```
Wm_getwarsum(result, size)
```

Parameters

result **:** String pointer to receive the warning summary string. The string size must be longer than the length of the warning summary string.

size **:** Integer pointer to specify the number of characters to read as the warning summary string. Error occurs if the specified *size* value is 0 or negative.

If the specified *size* value is greater than or equal to the length of the warning summary string, all of the warning summary string is stored in *result*. And this pointer returns the length of the warning summary string.

If the specified *size* value is less than the length of the warning summary string, a part of the warning summary string is stored in *result* and a warning occurs. Then the number of characters stored in *result* is *size*.

WGFMU_getWarningSummarySize

This function returns the length of the warning summary string which contains all warnings.

Syntax

```
int WGFMU_getWarningSummarySize(int* size);
```

Using HTBasic

```
Wm_getwarsumsz(size)
```

Parameters

size **:** Integer pointer to receive the length of the warning summary string.

Example

```
int size = 1;
WGFMU_getWarningSummarySize(&size);
if (size != 0) {
  char* msg = new char[size + 1];
  WGFMU_getWarningSummary(msg, &size);
  // do something with msg and delete []
}
```

WGFMU_initialize

This function resets all WGFMU channels. This function does not clear the software setup information of the instrument library.

Syntax

```
int WGFMU_initialize();
```

Using HTBasic

```
Wm_initialize()
```

Example

```
int ret;
ret = WGFMU_initialize();
```

WGFMU_isMeasureEnabled

This function returns if the specified channel is enabled or disabled for the measurement. This function is not available for the channels in the DC mode.

Syntax

```
int WGFMU_isMeasureEnabled(int chanId, int* status);
```

HTBasic Syntax

```
Wm_ismeenabled(chanId, status)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
status **:**	Integer pointer to receive the measurement status of channel. See Table 4-10 on page 4-73.

If *status*=7000 (WGFMU_MEASURE_ENABLED_DISABLE), the channel cannot perform measurement even if the channel is either Fast IV or PG mode and the running sequence pattern tries measurement.

Example

```
int ret;
int chId = 101;
int stats;
ret = WGFMU_isMeasureEnabled(chId, &stats);
```

WGFMU_isMeasureEventCompleted

This function specifies a measurement event setup (*chanId*, *pattern*, *event*, *cycle*, *loop*, and *count*), and returns the corresponding execution status (*complete*, *measId*, *index*, and *length*).

Syntax

```
int WGFMU_isMeasureEventCompleted(int chanId,
const char* pattern, const char* event, int cycle,
double loop, int count, int* complete, int* measId,
int* index, int* length);
```

Using HTBasic

```
Wm_ismeevtcd(chanId, pattern, event, cycle, loop,
count, complete, measId, index, length)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
pattern **:**	Name of waveform pattern to get the event address. String.
event **:**	Name of event to get the event address. String.
cycle **:**	Usage count. Integer. The value starts from 0. This parameter means how many times the specified pattern is used in the sequence of the specified channel.
loop **:**	Loop count. Numeric. The value starts from 0. This parameter means how many times the specified pattern is looped in the sequence of the specified channel.
count **:**	Event count. Integer. The value starts from 0. This parameter means how many times the specified event is used in the specified pattern.
complete **:**	Integer pointer to receive the execution status of the specified measurement event. See Table 4-13 on page 4-75.
measId **:**	Integer pointer to receive the measurement event index used for WGFMU_getMeasureEventAttribute.
index **:**	Integer pointer to receive the first data index assigned to the specified measurement event.
length **:**	Integer pointer to receive the number of sampling points for the specified measurement event.

Example

```
int ret;
int chId = 101;
const char* ptn = "Pattern1";
const char* evt = "Event1";
int cycle = 0;
double loop = 0;
int count = 0;
int cmp;
int measId;
int idx;
int len;
ret = WGFMU_isMeasureEventCompleted(chId, ptn, evt, cycle, loop,
count, &cmp, &measId, &idx, &len);
```

WGFMU_openLogFile

This function opens a file used to log errors and warnings.

If the specified file does not exist, this function creates new file. If the specified file exists, this function appends the log information to the file. Error occurs if an invalid path is specified, a file is not created, or a log information is not written.

Syntax

```
int WGFMU_openLogFile(const char* fname);
```

Using HTBasic

```
Wm_openlogfile(fname)
```

Parameters

fname :	Name of log file to store errors and warnings information. String.

Example

```
int ret;
const char* fname = "C:¥¥Keysight¥¥B1530A¥¥log¥¥20080901.log";
ret = WGFMU_openLogFile(fname);
```

WGFMU_openSession

This function opens the communication session with the B1500A by using the WGFMU instrument library.

Syntax

```
int WGFMU_openSession(const char* address);
```

Using HTBasic

```
Wm_opensession(address)
```

Parameters

address :	VISA address of the B1500A. String.

Example

```
int ret;
const char* addr1 = "GPIB0::17::INSTR";
ret = WGFMU_openSession(addr1);
```

WGFMU_setForceDelay

This function sets the device delay time of the specified source channel in the Fast IV mode or the PG mode.

Syntax

```
int WGFMU_setForceDelay(int chanId, double delay);
```

Using HTBasic

```
Wm_setfodelay(chanId, delay)
```

Parameters

chanId :	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
delay :	Device delay time, in second. Numeric. -50×10^{-9} (−50 ns) to 50×10^{-9} (50 ns), in 625×10^{-12} (625 ps) resolution.

If the value is not multiple number of 625 ps, the value is rounded to the nearest multiple number. For example, if the value is 1.5 ns, the value is rounded to 1.25 ns.

Example

```
int ret;
int chId = 101;
double fDelay = 1E-8;
ret = WGFMU_setForceDelay(chId, fDelay);
```

WGFMU_setForceVoltageRange

This function sets the voltage output range of the specified source channel. The setting is applied to the channel by the WGFMU_update, WGFMU_updateChannel, WGFMU_execute, or the functions of the DC measurement group.

Syntax `int WGFMU_setForceVoltageRange(int chanId, int range);`

Using HTBasic `Wm_setfovolrng(chanId, range)`

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

range **:** Voltage output range. Integer. See Table 4-6 on page 4-70.

Example

```
int ret;
int chId = 101;
ret = WGFMU_setForceVoltageRange(chId, WGFMU_FORCE_VOLTAGE_RANGE_
10V_POSITIVE);
```

WGFMU_setMeasureCurrentRange

This function sets the current measurement range of the specified measurement channel. The setting is applied to the channel by the WGFMU_update, WGFMU_updateChannel, WGFMU_execute, or the functions of the DC measurement group. The setting is not effective for the voltage measurement mode.

Syntax `int WGFMU_setMeasureCurrentRange(int chanId, int range);`

Using HTBasic `Wm_setmecurrng(chanId, range)`

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

range **:** Current measurement range. Integer. See Table 4-9 on page 4-72.

Example

```
int ret;
int chId = 101;
ret = WGFMU_setMeasureCurrentRange(chId, WGFMU_MEASURE_CURRENT_RA
NGE_1MA);
```

WGFMU_setMeasureDelay

This function sets the device delay time of the specified measurement channel in the Fast IV mode or the PG mode.

Syntax

```
int WGFMU_setMeasureDelay(int chanId, double delay);
```

Using HTBasic

```
Wm_setmedelay(chanId, delay)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
delay **:**	Device delay time, in second. Numeric. -50×10^{-9} (-50 ns) to 50×10^{-9} (50 ns), in 625×10^{-12} (625 ps) resolution. If the value is not multiple number of 625 ps, the value is rounded to the nearest multiple number. For example, if the value is 1.5 ns, the value is rounded to 1.25 ns.

Example

```
int ret;
int chId = 101;
double mDelay = -1E-8;
ret = WGFMU_setMeasureDelay(chId, mDelay);
```

WGFMU_setMeasureEnabled

This function enables or disables the measurement ability of the specified channel. This function is not available for the channels in the DC mode.

Syntax

```
int WGFMU_setMeasureEnabled(int chanId, int status);
```

HTBasic Syntax

```
Wm_setmeenabled(chanId, status)
```

Parameters

chanId **:**	Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.
status **:**	Enables or disables the measurement ability of the channel. Integer. See Table 4-10 on page 4-73.

If *status*=7000 (WGFMU_MEASURE_ENABLED_DISABLE), the channel cannot perform measurement even if the channel is either Fast IV or PG mode and the running sequence pattern tries measurement.

Example

```
int ret;
int chId = 101;
ret = WGFMU_setMeasureEnabled(chId, WGFMU_MEASURE_ENABLED_ENABLE);
```

WGFMU_setMeasureEvent

This function defines a measurement event which is a sampling measurement performed by the WGFMU channel while it outputs a waveform pattern. See "WGFMU Setup Functions" on page 4-77 for the error check of parameters.

Execution Conditions

Waveform pattern specified by *pattern* must be created before this function is executed. See WGFMU_createPattern and WGFMU_create*Xxx*Pattern to create a pattern data.

Syntax

```
int WGFMU_setMeasureEvent(const char* pattern,
const char* event, double time, int points,
double interval, double average, int rdata);
```

Using HTBasic

```
Wm_setmeevt(pattern, event, time, points, interval,
average, rdata)
```

Parameters

***pattern* :** Waveform pattern name. String. The measurement event is performed while the WGFMU channel outputs this waveform pattern.

***event* :** Measurement event name. String. The event name is not unique. The name can be used for another measurement event, such as an event to set a different sampling condition within the same waveform pattern, an event for the other waveform pattern, and so on.

***time* :** Measurement start time, in second. Numeric. Sampling measurement is started at this time. Time origin is the origin of the specified pattern. The sampling measurement will be stopped at the following eventEndTime. If you set *average*=0, add 10^{-8} (10 ns) to the formula.

eventEndTime = $time + interval \times (points - 1) + average$

The *time* and eventEndTime must be 0 to the total time of pattern in 10^{-8} (10 ns) resolution.

***points* :** Number of sampling points. Integer. Positive value.

Note that the measurement data must be read before the total number of data stored in the channel exceeds about 4,000,000. The number of data which can be stored in the hardware memory depends on the *average* value.

***interval* :** Sampling interval, in second. Numeric. 10^{-8} (10 ns) to 1.34217728, in 10^{-8} (10 ns) resolution.

***average* :** Averaging time, in second. Numeric. 0 (no averaging), or 10^{-8} (10 ns) to 0.020971512 (approximately 20 ms), in 10^{-8} (10 ns) resolution. Do not have to exceed the *interval* value.

If nonzero value is specified, the channel repeats measurement in 5 ns interval while the *average* period, and returns the averaging result data. For example, if a measurement starts at 0 ns and *average*=20 ns, measurement is performed at 0, 5, 10, and 15 ns. And time data for the averaging result data is 10 ns = (0+20)/2.

***rdata* :** Averaging data output mode or raw data output mode. Integer. See Table 4-14 on page 4-75.

If *time*, *interval*, or *average* value is not multiple number of 10 ns, the value is rounded to the nearest multiple number. For example, if the value is 32 ns, the value is rounded to 30 ns.

NOTE

If a pattern contains the multiple events which change the averaging conditions, the interval between the measurement start times (*time*) of the adjacent events must be ≥ 100 ns. Improper interval causes a runtime error.

Example

```
int ret;
const char* ptn = "Pattern1";
const char* evt = "ev1";
double sTime = 0.001;
int pts = 5;
double tInt = 0.0001;
double tAve = 0;
ret = WGFMU_setMeasureEvent(ptn, evt, sTime, pts, tInt, tAve,
WGFMU_MEASURE_EVENT_DATA_RAW);
```

WGFMU_setMeasureMode

This function sets the measurement mode. The setting is applied to the channel by the WGFMU_update, WGFMU_updateChannel, WGFMU_execute, or the functions of the DC measurement group.

Syntax

```
int WGFMU_setMeasureMode(int chanId, int mode);
```

Using HTBasic

```
Wm_setmemod(chanId, mode)
```

Parameters

***chanId* :** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

***mode* :** Measurement mode of the specified channel. Integer. See Table 4-7 on page 4-71.

Example

```
int ret;
int chId = 101;
ret = WGFMU_setMeasureMode(chId, WGFMU_MEASURE_MODE_VOLTAGE);
```

WGFMU_setMeasureVoltageRange

This function sets the voltage measurement range of the specified measurement channel. The setting is applied to the channel by the WGFMU_update, WGFMU_updateChannel, WGFMU_execute, or the functions of the DC measurement group. The setting is not effective for the current measurement mode.

Syntax `int WGFMU_setMeasureVoltageRange(int chanId, int range);`

Using HTBasic `Wm_setmevolrng(chanId, range)`

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

range **:** Voltage measurement range. Integer. See Table 4-8 on page 4-71.

Example

```
int ret;
int chId = 101;
ret = WGFMU_setMeasureVoltageRange(chId, WGFMU_MEASURE_VOLTAGE_RA
NGE_10V);
```

WGFMU_setOperationMode

This function sets the operation mode of the specified channel. The setting is applied to the channel by the WGFMU_update, WGFMU_updateChannel, WGFMU_execute, or the functions of the DC measurement group.

Syntax `int WGFMU_setOperationMode(int chanId, int mode);`

Using HTBasic `Wm_setopemod(chanId, mode)`

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

mode **:** Operation mode. Integer. See Table 4-5 on page 4-69.

In the Fast IV mode, the channel can perform the voltage force and current measurement (VFIM) or the voltage force and voltage measurement (VFVM).

In the PG mode, the channel can perform the voltage force and voltage measurement (VFVM). The output voltage will be divided by the internal 50 Ω resistor and the load impedance.

Example

```
int ret;
int chId = 101;
ret = WGFMU_setOperationMode(chId, WGFMU_OPERATION_MODE_FASTIV);
```

WGFMU_setRangeEvent

This function defines a range event which is the range change operation for the current measurement performed by the WGFMU channel while it outputs a waveform pattern. This function is available only for the current measurements in the Fast IV mode. See "WGFMU Setup Functions" on page 4-77 for the error check of parameters.

Execution Conditions

Waveform pattern specified by *pattern* must be created before this function is executed. See WGFMU_createPattern and WGFMU_create*Xxx*Pattern to create a pattern data.

Syntax

```
int WGFMU_setRangeEvent(const char* pattern,
const char* event, double time, int range);
```

Using HTBasic

```
Wm_setrngevt(pattern, event, time, range)
```

Parameters

pattern :	Waveform pattern name. String. The range event is performed while the WGFMU channel outputs this waveform pattern.
event :	Range event name. String.
time :	Range change time, in second. Numeric. Range change is performed at this time. Time origin is the origin of the specified pattern. 0 to the total time of pattern in 10^{-8} (10 ns) resolution. The event end time will be *time*+10 ns. If the value is not multiple number of 10 ns, the value is rounded to the nearest multiple number. For example, if the value is 32 ns, the value is rounded to 30 ns.
range :	Current measurement range. Integer. See Table 4-9 on page 4-72.

NOTE

To set a pattern with the multiple events which change the range setup three times or more continuously, the time difference between the measurement start time (*time*) of the adjacent events must be > 2 μs.

To set a pattern with both of the range event and the measurement event, the range event must be set to a term out of *average* defined in the measurement event.

Example

```
int ret;
const char* ptn = "Pattern1";
const char* evt = "ev1";
double rTime = 0.001;
ret = WGFMU_setRangeEvent(ptn, evt, rTime, WGFMU_MEASURE_CURRENT_
RANGE_100UA);
```

WGFMU_setTimeout

This function sets timeout of the present session.

Syntax

```
int WGFMU_setTimeout(double timeout);
```

Using HTBasic

```
Wm_settimeout(timeout)
```

Parameters

timeout **:** Timeout value, in second. Numeric. 1 or more, 1 μs resolution. Error occurs if the timeout value is less than 1. Default value is 100 s.

If the WGFMU_doSelfCalibration or WGFMU_doSelfTest function is executed when the timeout setting is less than 600 s, the timeout is automatically changed to 600 s and returned to the previous value after the function is completed.

Example

```
int ret;
double timeout = 10;
ret = WGFMU_setTimeout(timeout);
```

Remarks

The instrument library checks the set ready bit (bit 4) of the status byte when a function is executed. If the set ready bit is not raised, the instrument library continues checking the status byte until the set ready bit is raised or timeout occurs.

Timeout will be caused by the following reason.

- Improper GPIB address is specified by the WGFMU_openSession function.
- The timeout value is too short to complete the function.

Appropriate timeout value will be the maximum time required to complete the function.

WGFMU_setTriggerOutEvent

This function defines a trigger output event which is the trigger output operation performed by the WGFMU channel while it outputs a waveform pattern. See "WGFMU Setup Functions" on page 4-77 for the error check of parameters.

Execution Conditions

Event trigger output mode must be set by WGFMU_setTriggerOutMode.

Waveform pattern specified by *pattern* must be created before this function is executed. See WGFMU_createPattern and WGFMU_create*Xxx*Pattern to create a pattern data.

Syntax

```
int WGFMU_setTriggerOutEvent(const char* pattern,
const char* event, double time, double duration);
```

Using HTBasic

```
Wm_settrgoutevt(pattern, event, time, duration)
```

Parameters

pattern **:** Waveform pattern name. String. The trigger output event is performed while the WGFMU channel outputs this waveform pattern.

event **:** Trigger output event name. String.

time **:** Trigger output time, in second. Numeric. Trigger is output at this time. Time origin is the origin of the specified pattern. 0 to the total time of pattern in 10^{-8} (10 ns) resolution. The event end time will be *time*+*duration*.

If the value is not multiple number of 10 ns, the value is rounded to the nearest multiple number. For example, if the value is 32 ns, the value is rounded to 30 ns.

duration **:** Duration time of output trigger, in second. Numeric.

NOTE

If *time* = *duration* = 0 is set, the channel outputs the trigger when it starts to apply the initial voltage of the specified pattern.

Example

```
int ret;
int chId = 101;
const char* ptn = "Pattern1";
const char* evt = "ev1";
double sTime = 0.001;
double tWidth = 1E-8;
ret = WGFMU_setTriggerOutMode(chId, WGFMU_TRIGGER_OUT_MODE_EVENT,
WGFMU_TRIGGER_OUT_POLARITY_POSITIVE);
ret = WGFMU_setTriggerOutEvent(ptn, evt, sTime, tWidth);
```

WGFMU_setTriggerOutMode

This function sets the trigger output mode of the specified channel.

Syntax

```
int WGFMU_setTriggerOutMode(int chanId, int mode,
int polarity);
```

Using HTBasic

```
Wm_settrgoutmod(chanId, mode, polarity)
```

Parameters

chanId **:** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

mode **:** Trigger output mode. Integer. See Table 4-11 on page 4-73.

polarity **:** Trigger polarity. Integer. See Table 4-11 on page 4-73.

Example

```
int ret;
int chId = 101;
ret = WGFMU_setTriggerOutMode(chId, WGFMU_TRIGGER_OUT_MODE_START_
SEQUENCE,WGFMU_TRIGGER_OUT_POLARITY_NEGATIVE);
```

WGFMU_setVector

This function specifies a scalar data by using *time* and *voltage*, and adds it to the specified waveform pattern or replaces the scalar previously defined in the specified waveform pattern with the scalar specified by this function. The latest execution is always effective. See “WGFMU Setup Functions” on page 4-77 for the error check of parameters.

Execution Conditions

Waveform pattern specified by *pattern* must be created before this function is executed. See WGFMU_createPattern and WGFMU_create*Xxx*Pattern to create a pattern data.

Syntax

```
int WGFMU_setVector(const char* pattern, double time,
double voltage);
```

Using HTBasic

```
Wm_setvector(pattern, time, voltage)
```

Parameters

pattern **:** Name of waveform pattern to add a vector. String.

time **:** Absolute time value, not incremental time value, in second. Numeric. The value must be *time* ≥ 0 in 10^{-8} second (10 ns) resolution. If the specified value does not satisfy this requirement, the vector is not added or replaced. For the error check, see “WGFMU Setup Functions” on page 4-77.

If *time*=0, the initial voltage of the pattern is replaced. If *time* is not multiple number of 10 ns, the value is rounded to the nearest multiple number. For example, if the value is 72 ns, it is rounded to 70 ns.

voltage **:** Output voltage, in V. Numeric. See Table 4-2 on page 4-66.

Example

```
int ret;
const char* ptn = "Pattern8";
ret = WGFMU_createPattern(ptn, 0);        /*  0 ms, 0 V */
ret = WGFMU_setVector(ptn, 0.01, 0);      /* 10 ms, 0 V */
ret = WGFMU_setVector(ptn, 0.02, -5);     /* 20 ms,-5 V */
ret = WGFMU_setVector(ptn, 0.05, -5);     /* 50 ms,-5 V */
ret = WGFMU_setVector(ptn, 0.06, 5);      /* 60 ms, 5 V */
ret = WGFMU_setVector(ptn, 0.09, 5);      /* 90 ms, 5 V */
ret = WGFMU_setVector(ptn, 0.1, 0);       /*100 ms, 0 V */
```

WGFMU_setVectors

This function specifies multiple scalar data by using *time* and *voltage*, and adds them to the specified waveform pattern or replaces the scalar previously defined in the specified waveform pattern with the scalar specified by this function. The latest execution is always effective. See "WGFMU Setup Functions" on page 4-77 for the error check of parameters.

Execution Conditions

Waveform pattern specified by *pattern* must be created before this function is executed. See WGFMU_createPattern and WGFMU_create*Xxx*Pattern to create a pattern data.

Syntax

```
int WGFMU_setVectors(const char* pattern, double* time,
double* voltage, int size);
```

Using HTBasic

```
Wm_setvectors(pattern, time, voltage, size)
```

Parameters

***pattern* :** Name of waveform pattern to add vectors. String.

***time* :** Absolute time value, not incremental time value, in second. Numeric array. Array elements must be corresponding to the *voltage* array elements together in the element order.

The value must be *time* ≥ 0 in 10^{-8} second (10 ns) resolution. If the specified value does not satisfy this requirement, the vectors are not added or replaced. For the error check, see "WGFMU Setup Functions" on page 4-77.

If *time*=0, the initial voltage of the pattern is replaced. If *time* is not multiple number of 10 ns, the value is rounded to the nearest multiple number. For example, if the value is 72 ns, it is rounded to 70 ns.

***voltage* :** Output voltage, in V. See Table 4-2 on page 4-66. Numeric array. Array elements must be corresponding to the *time* array elements together in the element order.

***size* :** Array size. Number of array elements for both *time* and *voltage*. Integer.

Example

```
int ret;
int size = 4;
const char* ptn = "Pattern9";
```

```
double* tms = new double[size];
double* vts = new double[size];
tms[0] = 0.1; tms[1] = 0.2; tms[2] = 0.3; tms[3] = 0.4;
vts[0] = vts[3] = 0;
vts[1] = vts[2] = 5;
ret = WGFMU_createPattern(ptn, 0);
ret = WGFMU_setVectors(ptn, tms, vts, size);
```

WGFMU_setWarningLevel

This function sets the warning level. The warning level affects to the WGFMU_getWarningSummary, WGFMU_getWarningSummarySize, and WGFMU_openLogFile functions.

Syntax

```
int WGFMU_setWarningLevel(int level);
```

Using HTBasic

```
Wm_setwarlevel(level)
```

Parameters

level **:** Warning level. Integer. See Table 4-4 on page 4-68.

Example

```
int ret;
ret = WGFMU_setWarningLevel(WGFMU_WARNING_LEVEL_INFORMATION);
```

WGFMU_treatWarningsAsErrors

This function sets the threshold between warning and error by specifying the warning level.

Syntax

```
int WGFMU_treatWarningsAsErrors(int level);
```

Using HTBasic

```
Wm_treatwarserr(level)
```

Parameters

level **:** Warning level which will be the threshold between warning and error. Integer. See Table 4-4 on page 4-68.

Remarks

If *level* = WGFMU_WARNING_LEVEL_OFF, no warning is assumed as error.

If *level* = WGFMU_WARNING_LEVEL_SEVERE, the warning of this level will be assumed as error and the others will be warning.

If *level* = WGFMU_WARNING_LEVEL_NORMAL, the warning of this level and WGFMU_WARNING_LEVEL_SEVERE will be assumed as error and the others will be warning.

If *level* = WGFMU_WARNING_LEVEL_INFORMATION, all warning will be assumed as error.

Example

```
int ret;
ret = WGFMU_treatWarningsAsError(WGFMU_WARNING_LEVEL_SEVERE);
```

WGFMU_update

This function updates the setting of all WGFMU channels in the Fast IV mode or the PG mode. After this function, all WGFMU channels apply the initial voltage set by the WGFMU_createPattern function.

This function applies the setup of the following function to the channel.

- WGFMU_setOperationMode
- WGFMU_setForceVoltageRange
- WGFMU_setMeasureCurrentRange
- WGFMU_setMeasureVoltageRange
- WGFMU_setMeasureMode

Syntax

```
int WGFMU_update();
```

Using HTBasic

```
Wm_update()
```

Example

```
int ret;
ret = WGFMU_update();
```

WGFMU_updateChannel

This function updates the setting of the specified channel in the Fast IV mode or the PG mode. After this function, the channel applies the initial voltage set by the WGFMU_createPattern function.

This function applies the setup of the following function to the channel.

- WGFMU_setOperationMode
- WGFMU_setForceVoltageRange
- WGFMU_setMeasureCurrentRange
- WGFMU_setMeasureVoltageRange
- WGFMU_setMeasureMode

Syntax

```
int WGFMU_updateChannel(int chanId);
```

Using HTBasic

```
Wm_updatech(chanId)
```

Parameters

***chanId* :** Channel number. Integer. 101 to 1002. See Table 4-3 on page 4-67.

Example

```
int ret;
int chId = 101;
ret = WGFMU_updateChannel(chId);
```

WGFMU_waitUntilCompleted

This function waits until all connected WGFMU channels in the Fast IV mode or the PG mode are in the ready to read data status. Error occurs if a sequencer is not running or if no channel is in the Fast IV mode or the PG mode.

Syntax

```
int WGFMU_waitUntilCompleted();
```

Using HTBasic

```
Wm_waituntilcd()
```

Example

```
int ret;
ret = WGFMU_waitUntilCompleted();
```

Parameters

Table 4-2 shows the WGFMU output voltage value set to the several functions. The available value depends on the operation mode, output range, and so on.

Table 4-3 lists the channel numbers available for the instrument library to specify the WGFMU to control.

Table 4-4 to Table 4-14 show the available parameter values (constants) for the specific functions. See the table title and header for the corresponding function name and parameter name. For each parameter value, see the top cell for Microsoft Visual C++ .NET, Visual Basic .NET, Visual Basic 6.0, or VBA programming environment, see the middle cell for Microsoft Visual C# .NET programming environment, and see the bottom cell for HTBasic programming environment.

In the table header, the parameters are put in italics such as *voltage*.

Table 4-2 **WGFMU Output Voltage**

Operation mode	**Voltage output range**	***voltage***	**Setting resolution**
PG	3 V fixed range	−3 V to +3 V	96 μV
	5 V fixed range	−5 V to +5 V	160 μV
Fast IV	3 V fixed range	−3 V to +3 V	96 μV
	5 V fixed range	−5 V to +5 V	160 μV
	−10 V fixed range	−10 V to 0 V	160 μV
	+10 V fixed range	0 V to +10 V	160 μV
DC	3 V fixed range	−3 V to +3 V	96 μV
	5 V fixed range	−5 V to +5 V	160 μV
	−10 V fixed range	−10 V to 0 V	160 μV
	+10 V fixed range	0 V to +10 V	160 μV

Table 4-3 **WGFMU Channel Number**

chanId	**Description**
101	Ch 1 of the WGFMU installed in the slot 1 (bottom slot)
102	Ch 2 of the WGFMU installed in the slot 1 (bottom slot)
201	Ch 1 of the WGFMU installed in the slot 2
202	Ch 2 of the WGFMU installed in the slot 2
301	Ch 1 of the WGFMU installed in the slot 3
302	Ch 2 of the WGFMU installed in the slot 3
401	Ch 1 of the WGFMU installed in the slot 4
402	Ch 2 of the WGFMU installed in the slot 4
501	Ch 1 of the WGFMU installed in the slot 5
502	Ch 2 of the WGFMU installed in the slot 5
601	Ch 1 of the WGFMU installed in the slot 6
602	Ch 2 of the WGFMU installed in the slot 6
701	Ch 1 of the WGFMU installed in the slot 7
702	Ch 2 of the WGFMU installed in the slot 7
801	Ch 1 of the WGFMU installed in the slot 8
802	Ch 2 of the WGFMU installed in the slot 8
901	Ch 1 of the WGFMU installed in the slot 9
902	Ch 2 of the WGFMU installed in the slot 9
1001	Ch 1 of the WGFMU installed in the slot 10 (top slot)
1002	Ch 2 of the WGFMU installed in the slot 10 (top slot)

Table 4-4 WGFMU_setWarningLevel, WGFMU_getWarningLevel, and WGFMU_treatWarningsAsError

level		**Description**
1000	WGFMU_WARNING_LEVEL_OFF	No warning is reported. Default setting for WGFMU_treatWarningsAsErrors.
	WGFMU.WARNING_LEVEL_OFF	
	Wm_warlvl_off	
1001	WGFMU_WARNING_LEVEL_SEVERE	Reports severe warning as follows. • When an event is tried to set on a pattern, if the event overlaps same type of events, the event overwrites the original events. • Channel specific WGFMU - Measurement API except for update is called to a non ALWG channel [a].
	WGFMU.WARNING_LEVEL_SEVERE	
	Wm_warlvl_svr	
1002	WGFMU_WARNING_LEVEL_NORMAL	Reports normal warning as follows. Default setting for WGFMU_setWarningLevel. • WGFMU - Measurement API except for update is called when there is no ALWG channel [a]. • Not all information is stored in an array because the given “size” is less than the required size. • All available information is stored in an array but the array is not fully filled because the given “offset + size” is greater than the total size. • The error queue on the instrument is not empty when opening or closing a session.
	WGFMU.WARNING_LEVEL_NORMAL	
	Wm_warlvl_norm	
1003	WGFMU_WARNING_LEVEL_INFORMATION	Reports information warning. A value is rounded.
	WGFMU.WARNING_LEVEL_INFORMATION	
	Wm_warlvl_info	

a. ALWG channel is a channel whose operation mode is either WGFMU_OPERATION_MODE_-FASTIV or WGFMU_OPERATION_MODE_PG.

Table 4-5 WGFMU_setOperationMode and WGFMU_getOperationMode

mode		**Description**
2000	WGFMU_OPERATION_MODE_DC WGFMU.OPERATION_MODE_DC Wm_opemod_dc	DC mode. DC voltage output and voltage or current measurement (VFVM or VFIM). The functions of the following group are available in this mode only. • DC - Measurement
2001	WGFMU_OPERATION_MODE_FASTIV WGFMU.OPERATION_MODE_FASTIV Wm_opemod_fast	Fast IV mode. ALWG voltage output and voltage or current measurement (VFVM or VFIM).
2002	WGFMU_OPERATION_MODE_PG WGFMU.OPERATION_MODE_PG Wm_opemod_pg	PG mode. ALWG voltage output and voltage measurement (VFVM). The output voltage will be divided by the internal 50 Ω resistor and the load impedance. Faster than the Fast IV mode.
2003	WGFMU_OPERATION_MODE_SMU WGFMU.OPERATION_MODE_SMU Wm_opemod_smu	SMU mode, default setting For using SMU connected to the RSU. The functions of the following groups are not available. • Common - Measurement • WGFMU - Measurement • WGFMU - Data retrieve • DC - Measurement

Table 4-6 WGFMU_setForceVoltageRange and WGFMU_getForceVoltageRange

range		Description
3000	WGFMU_FORCE_VOLTAGE_RANGE_AUTO	Auto range [a], default setting
	WGFMU.FORCE_VOLTAGE_RANGE_AUTO	
	Wm_fovolrng_aut	
3001	WGFMU_FORCE_VOLTAGE_RANGE_3V	3 V fixed range [a] (−3 V to +3 V)
	WGFMU.FORCE_VOLTAGE_RANGE_3V	
	Wm_fovolrng_3v	
3002	WGFMU_FORCE_VOLTAGE_RANGE_5V	5 V fixed range [a] (−5 V to +5 V)
	WGFMU.FORCE_VOLTAGE_RANGE_5V	
	Wm_fovolrng_5v	
3003	WGFMU_FORCE_VOLTAGE_RANGE_10V_NEGATIVE	−10 V fixed range [b] (−10 V to 0 V)
	WGFMU.FORCE_VOLTAGE_RANGE_10V_NEGATIVE	
	Wm_fovolrng_10n	
3004	WGFMU_FORCE_VOLTAGE_RANGE_10V_POSITIVE	+10 V fixed range [b] (0 V to +10 V)
	WGFMU.FORCE_VOLTAGE_RANGE_10V_POSITIVE	
	Wm_fovolrng_10p	

a. Available for the Fast IV, PG, and DC operation mode. Meaningless for the SMU mode.
b. Available for the Fast IV and DC operation mode. Meaningless for the SMU mode. Not available for the PG mode.

Table 4-7 WGFMU_setMeasureMode and WGFMU_getMeasureMode

mode		Description
4000	WGFMU_MEASURE_MODE_VOLTAGE	Voltage measurement mode [a], default setting Changing the mode to this mode does not change the current measurement range setting.
	WGFMU.MEASURE_MODE_VOLTAGE	
	Wm_memod_vol	
4001	WGFMU_MEASURE_MODE_CURRENT	Current measurement mode [b] Changing the mode to this mode changes the voltage measurement range to the 5 V range.
	WGFMU.MEASURE_MODE_CURRENT	
	Wm_memod_cur	

a. Available for the Fast IV, PG, and DC operation mode. Meaningless for the SMU mode.
b. Available for the Fast IV and DC operation mode. Meaningless for the SMU mode. Not available for the PG mode.

Table 4-8 WGFMU_setMeasureVoltageRange and WGFMU_getMeasureVoltageRange

range		Description
5001	WGFMU_MEASURE_VOLTAGE_RANGE_5V	5 V fixed range (±5 V)
	WGFMU.MEASURE_VOLTAGE_RANGE_5V	
	Wm_mevolrng_5v	
5002	WGFMU_MEASURE_VOLTAGE_RANGE_10V	10 V fixed range (±10 V), default setting
	WGFMU.MEASURE_VOLTAGE_RANGE_10V	
	Wm_mevolrng_10v	

Table 4-9 WGFMU_setMeasureCurrentRange, WGFMU_getMeasureCurrentRange, and WGFMU_setRangeEvent

range		Description
6001	WGFMU_MEASURE_CURRENT_RANGE_1UA	1 μA controlled range (±1 μA)
	WGFMU.MEASURE_CURRENT_RANGE_1UA	
	Wm_mecurrng_1u	
6002	WGFMU_MEASURE_CURRENT_RANGE_10UA	10 μA controlled range (±10 μA)
	WGFMU.MEASURE_CURRENT_RANGE_10UA	
	Wm_mecurrng_10u	
6003	WGFMU_MEASURE_CURRENT_RANGE_100UA	100 μA controlled range (±100 μA)
	WGFMU.MEASURE_CURRENT_RANGE_100UA	
	Wm_mecurrng_100	
6004	WGFMU_MEASURE_CURRENT_RANGE_1MA	1 mA controlled range (±1 mA)
	WGFMU.MEASURE_CURRENT_RANGE_1MA	
	Wm_mecurrng_1m	
6005	WGFMU_MEASURE_CURRENT_RANGE_10MA	10 mA controlled range (±10 mA), default setting
	WGFMU.MEASURE_CURRENT_RANGE_10MA	
	Wm_mecurrng_10m	

Table 4-10 WGFMU_setMeasureEnabled and WGFMU_isMeasureEnabled

status		Description
7000	WGFMU_MEASURE_ENABLED_DISABLE	Measurement cannot be performed.
	WGFMU.MEASURE_ENABLED_DISABLE	
	Wm_meenable_dis	
7001	WGFMU_MEASURE_ENABLED_ENABLE	Measurement can be performed. Default setting.
	WGFMU.MEASURE_ENABLED_ENABLE	
	Wm_meenable_ena	

Table 4-11 WGFMU_setTriggerOutMode and WGFMU_getTriggerOutMode

mode **(8000 to 8004) or** ***polarity*** **(8100/8101)**		Description
8000	WGFMU_TRIGGER_OUT_MODE_DISABLE	No trigger output, default setting Disables trigger output function.
	WGFMU.TRIGGER_OUT_MODE_DISABLE	
	Wm_tgoutmod_dis	
8001	WGFMU_TRIGGER_OUT_MODE_START_EXECUTION	Execution trigger output mode Channel outputs trigger only when starting the first sequence output.
	WGFMU.TRIGGER_OUT_MODE_START_EXECUTION	
	Wm_tgoutmod_exe	
8002	WGFMU_TRIGGER_OUT_MODE_START_SEQUENCE	Sequence trigger output mode Channel outputs trigger every start of the sequence output.
	WGFMU.TRIGGER_OUT_MODE_START_SEQUENCE	
	Wm_tgoutmod_seq	
8003	WGFMU_TRIGGER_OUT_MODE_START_PATTERN	Pattern trigger output mode Channel outputs trigger every start of the pattern output.
	WGFMU.TRIGGER_OUT_MODE_START_PATTERN	
	Wm_tgoutmod_pat	

mode (8000 to 8004) or *polarity* (8100/8101)		Description
8004	WGFMU_TRIGGER_OUT_MODE_EVENT	Event trigger output mode which enables the trigger output event. Channel outputs trigger at the timing set by WGFMU_setTriggerOutEvent.
	WGFMU.TRIGGER_OUT_MODE_EVENT	
	Wm_tgoutmod_evt	
8100	WGFMU_TRIGGER_OUT_POLARITY_POSITIVE	Polarity: positive, default setting. Channel usually outputs TTL low level and outputs TTL high level at the trigger timing.
	WGFMU.TRIGGER_OUT_POLARITY_POSITIVE	
	Wm_tgoutpol_pos	
8101	WGFMU_TRIGGER_OUT_POLARITY_NEGATIVE	Polarity: negative. Channel usually outputs TTL high level and outputs TTL low level at the trigger timing.
	WGFMU.TRIGGER_OUT_POLARITY_NEGATIVE	
	Wm_tgoutpol_neg	

Table 4-12 WGFMU_createMergedPattern

direction		Description
9000	WGFMU_AXIS_TIME	Time direction. The created pattern will be *pattern1* plus *pattern2* in this order (in the time direction). The *pattern1* last point will be connected to the *pattern2* second point. This deletes the *pattern2* first point defined by the WGFMU_createPattern function.
	WGFMU.AXIS_TIME	
	Wm_axis_tim	
9001	WGFMU_AXIS_VOLTAGE	Voltage direction. The created pattern will be *pattern1* plus *pattern2* in the voltage direction. This is made by adding voltage values together during the period of the longer pattern. For the period over the shorter pattern, the last value of the shorter pattern is used for calculation.
	WGFMU.AXIS_VOLTAGE	
	Wm_axis_vol	

Table 4-13 WGFMU_isMeasureEventCompleted

complete		Description
11000	WGFMU_MEASURE_EVENT_NOT_COMPLETED	Not completed.
	WGFMU.MEASURE_EVENT_NOT_COMPLETED	
	Wm_meevt_notcd	
11001	WGFMU_MEASURE_EVENT_COMPLETED	Completed. Ready to read result.
	WGFMU.MEASURE_EVENT_COMPLETED	
	Wm_meevt_cd	

Table 4-14 WGFMU_setMeasureEvent

rdata		Description
12000	WGFMU_MEASURE_EVENT_DATA_AVERAGED	Averaging data output mode Only the averaging result data will be returned and the number of returned data will be *points*.
	WGFMU.MEASURE_EVENT_DATA_AVERAGED	
	Wm_meevtdat_ave	
12001	WGFMU_MEASURE_EVENT_DATA_RAW	Raw data output mode All of the measurement data used for averaging will be returned and the number of returned data will be $points \times (1 + \mathrm{int}(average/(5 \times 10^{-9})))$.
	WGFMU.MEASURE_EVENT_DATA_RAW	
	Wm_meevtdat_raw	

Channel Execution Status

When sequencer of the WGFMU channel is running, channel execution status can be monitored by using the following functions.

- WGFMU_getChannelStatus

  This function returns the channel status, the elapsed time, and the total time.

- WGFMU_getCompletedMeasureEventSize

  This function returns the number of completed measurement events and the total number of measurement events.

- WGFMU_getMeasureValueSize

  This function returns the number of completed measurement points and the total number of measurement points.

For an example shown in Table 4-15, the total time, total number of measurement events, and total number of measurement points are calculated as follows.

Total time = 3 × 10 μs + 50 ns + 1 × 50 μs + 50 ns + 2 × 20 μs = 120.1 μs

Total number of measurement events = 3 × 7 + 1 × 6 + 2 × 5 = 37 events

Total number of measurement points = 3 × 7 × 5 + 1 × 6 × 4 + 2 × 5 × 3 = 159 points

Where, the required time between sequences is 50 ns.

For example, at the end of the first loop of the sequence 2, the elapsed time, number of completed events, and number of completed points will be as follows.

Elapsed time = 3 × 10 μs + 50 ns + 1 × 50 μs + 50 ns + 1 × 20 μs = 100.1 μs

Number of completed events = 3 × 7 + 1 × 6 + 1 × 5 = 32 events

Number of completed points = 3 × 7 × 5 + 1 × 6 × 4 + 1 × 5 × 3 = 144 points

Table 4-15 **Example Sequences**

	Pattern count	Pattern length	Number of events	Points/event for all events
Sequence 0	3	10 μs	7	5
Sequence 1	1	50 μs	6	4
Sequence 2	2	20 μs	5	3

WGFMU Setup Functions

Functions of WGFMU Setup group are used to define the WGFMU output voltage waveform and the voltage or current measurement condition and are classified by Pattern, Pattern operation, Event, and Sequence subgroup. See Table 4-1 for the group and the summary of functions.

Parameter values set to the WGFMU Setup functions will be checked as shown below when a function is executed.

- Setup check against the lowest limit

  The parameter setup values are checked when each function is executed.

- Setup check against the highest limit

  The parameter setup values are checked when one of the following functions is executed.

  - WGFMU_execute
  - WGFMU_exportAscii

    This function cannot check the measurement setup such as the voltage output range, measurement range, and so on.

  - WGFMU_update
  - WGFMU_updateChannel (effective only for the specified channel)

Return Codes

Status code of the instrument library is listed in Table 4-17. The code can be returned by the WGFMU_getChannelStatus or WGFMU_getStatus function.

Error code of the instrument library is listed in Table 4-18. The code will be returned by executing the functions. If no error occurs, WGFMU_NO_ERROR will be returned. See WGFMU_getError and WGFMU_getErrorSummary for more details.

Table 4-16 shows the return code of the WGFMU_doSelfCalibration or WGFMU_doSelfTest function.

For the predefined constant for each code in the tables, see the top cell for Microsoft Visual C++ .NET, Visual Basic .NET, Visual Basic 6.0, or VBA programming environment, see the middle cell for Microsoft Visual C# .NET programming environment, and see the bottom cell for HTBasic programming environment.

Table 4-16 Return Codes of WGFMU_doSelfCalibration and WGFMU_doSelfTest

Code	Predefined constant	Description
0	WGFMU_PASS	Self-test passed or self-calibration passed
	WGFMU.PASS	
	Wm_pass	
1	WGFMU_FAIL	Self-test failed or self-calibration failed
	WGFMU.FAIL	
	Wm_fail	

Table 4-17 Status Codes

Code [a]	Predefined constant	Description
10000	WGFMU_STATUS_COMPLETED	All sequences are completed and all data is ready to read
	WGFMU.STATUS_COMPLETED	
	Wm_status_cd	
10001	WGFMU_STATUS_DONE	All sequences are just completed
	WGFMU.STATUS_DONE	
	Wm_status_done	
10002	WGFMU_STATUS_RUNNING	Sequencer is running
	WGFMU.STATUS_RUNNING	
	Wm_status_run	
10003	WGFMU_STATUS_ABORT_COMPLETED	Sequencer is aborted and all data is ready to read.
	WGFMU.STATUS_ABORT_COMPLETED	
	Wm_status_abcd	
10004	WGFMU_STATUS_ABORTED	Sequencer is just aborted
	WGFMU.STATUS_ABORTED	
	Wm_status_ab	
10005	WGFMU_STATUS_RUNNING_ILLEGAL	Illegal state [b]
	WGFMU.STATUS_RUNNING_ILLEGAL	
	Wm_status_runil	
10006	WGFMU_STATUS_IDLE	Idle state
	WGFMU.STATUS_IDLE	
	Wm_status_idle	

a. Measurement data cannot be read when the channel status is 10005 or 10006.
b. The channel will enter the illegal state by receiving a function which changes a setup while the sequencer is running. In the illegal state, there is no consistency between the hardware setup and the software setup. However, the channel continues operation of the previous setup.

Table 4-18 **Error Codes**

Code [a]	Predefined constant	Description
0	WGFMU_NO_ERROR	No error.
	WGFMU.NO_ERROR	
	Wm_no_err	
−1	WGFMU_PARAMETER_OUT_OF_RANGE_ERROR	Invalid parameter value was found. It will be out of the range. Set the effective parameter value.
	WGFMU.PARAMETER_OUT_OF_RANGE_ERROR	
	Wm_param_err	
−2	WGFMU_ILLEGAL_STRING_ERROR	Invalid string value was found. It will be empty or illegal (pointer). Set the effective string value.
	WGFMU.ILLEGAL_STRING_ERROR	
	Wm_string_err	
−3	WGFMU_CONTEXT_ERROR	Context error was found between relative functions. Set the effective parameter value.
	WGFMU.CONTEXT_ERROR	
	Wm_context_err	
−4	WGFMU_FUNCTION_NOT_SUPPORTED_ERROR	Specified function is not supported by this channel. Set the channel id properly.
	WGFMU.FUNCTION_NOT_SUPPORTED_ERROR	
	Wm_function_err	
−5	WGFMU_COMMUNICATION_ERROR	IO library error was found.
	WGFMU.COMMUNICATION_ERROR	
	Wm_com_err	
−6	WGFMU_FW_ERROR	Firmware error was found.
	WGFMU.FW_ERROR	
	Wm_fw_err	
−7	WGFMU_LIBRARY_ERROR	WGFMU instrument library error was found.
	WGFMU.LIBRARY_ERROR	
	Wm_library_err	

Code [a]	Predefined constant	Description
−8	WGFMU_ERROR	Unidentified error was found.
	WGFMU.ERROR	
	Wm_err	
−9	WGFMU_CHANNEL_NOT_FOUND_ERROR	Specified channel id is not available for WGFMU. Set the channel id properly.
	WGFMU.CHANNEL_NOT_FOUND_ERROR	
	Wm_nchannel_err	
−10	WGFMU_PATTERN_NOT_FOUND_ERROR	Unexpected pattern name was specified. Specify the effective pattern name. Or create a new pattern.
	WGFMU.PATTERN_NOT_FOUND_ERROR	
	Wm_npattern_err	
−11	WGFMU_EVENT_NOT_FOUND_ERROR	Unexpected event name was specified. Specify the effective event name.
	WGFMU.EVENT_NOT_FOUND_ERROR	
	Wm_nevent_err	
−12	WGFMU_PATTERN_ALREADY_EXISTS_ERROR	Duplicate pattern name was specified. Specify the unique pattern name.
	WGFMU.PATTERN_ALREADY_EXISTS_ERROR	
	Wm_pattern_err	
−13	WGFMU_SEQUENCER_NOT_RUNNING_ERROR	Sequencer must be run to execute the specified function. Run the sequencer.
	WGFMU.SEQUENCER_NOT_RUNNING_ERROR	
	Wm_seqntrun_err	
−14	WGFMU_RESULT_NOT_READY_ERROR	Measurement is in progress. Read the result data after the measurement is completed.
	WGFMU.RESULT_NOT_READY_ERROR	
	Wm_resultnr_err	
−15	WGFMU_RESULT_OUT_OF_DATE_ERROR	Measurement result data was deleted by the setup change. The result data must be read before changing the waveform setup or the measurement setup.
	WGFMU.RESULT_OUT_OF_DATE_ERROR	
	Wm_resultod_err	

a. The B1530A WGFMU Instrument Library reserves the error code 0 to −9999.

Error Messages

When Keysight B1530A causes errors, the B1530A returns the following error code and error message.

Operation Error

3000	WGFMU module does not exist.
	Check the channel number of the WGFMU module and set the correct value.
3001	RSU is not connected.
	Check the channel number of the WGFMU module connected to the RSU and set the correct value.
3015	Measurement data corrupted.
	Cannot get the measurement data. Correct measurement result is not stored in the memory.
3050	Measurement data memory overflow error.
	ALWG sequencer run time error. WGFMU module memory overflow occurred. Data exceeds memory size could not be stored.
3051	Measurement data FIFO overflow error.
	ALWG sequencer run time error. WGFMU module FIFO overflow occurred because the averaging count was frequently changed.
3052	Measurement range change request error.
	ALWG sequencer run time error. Measurement range cannot be changed because the range change interval is too short.
3201	ALWG Sequence Data is not ready.
	Sequence data must be set to the specified WGFMU channel.
3202	ALWG Waveform Data is not ready.
	Waveform data must be set to the specified WGFMU channel.

3301	Specified output voltage is out of absolute limits. Check the output voltage and set the correct value. The value must be −3 V to +3 V for the 3 V range, −5 V to +5 V for the 5 V range, −10 V to 0 V for the −10 V range, or 0 V to +10 V for the + 10 V range.
3302	Specified voltage output range is invalid. Check the voltage output range and set the correct value.
3303	Invalid measurement mode for current operation mode. Operation mode must be Fast IV or DC to perform current measurement.
3304	Specified ALWG Vector Data size is out of absolute limits. ALWG data cannot be read because of too large data size.
3305	Specified ALWG Sequence Data size is out of absolute limits. ALWG data cannot be read because of too large sequence data size.
3306	ALWG Waveform Data is empty. ALWG data must not be empty.
3307	Specified ALWG Waveform Data size is out of absolute limits. ALWG data cannot be read because of too large waveform data size.
3308	Specified waveform index of ALWG Sequence Data is out of absolute limits. Check the index value of the sequence data and set the correct value.
3309	Specified loop number of ALWG Sequence Data is out of absolute limits. Check the loop value of the sequence data and set the correct value.
3310	Specified output voltage of ALWG Waveform Data is out of absolute limits. Check the output voltage and set the correct value. The value must be −3 V to +3 V for the 3 V range, −5 V to +5 V for the 5 V range, −10 V to 0 V for the −10 V range, or 0 V to +10 V for the + 10 V range.
3311	Specified interval time of ALWG Waveform is out of absolute limits. Check the incremental time (interval time) and set the correct value. The value must be 10 ns to 10995.11627775 s, in 10 ns resolution.

3312	Specified ALWG measurement interval time is out of absolute limits.
	Check the measurement interval time and set the correct value. The value must be 10 ns to 1.34217728 s, in 10 ns resolution.
3313	Specified ALWG measurement instruction code is invalid.
	Check the measurement event setting and set the correct values.
3314	Specified ALWG range change instruction code is invalid.
	Check the range event setting and set the correct values.
3315	Specified ALWG measurement count is out of absolute limits.
	Check the measurement averaging time and set the correct value. The value must be 0, or 10 ns to 0.020971512 s, in 10 ns resolution.
3316	Specified ALWG measurement count is greater than measurement interval.
	Check the measurement averaging time and set the correct value. The value must less than or equal to the measurement interval time.
3317	Specified slot is invalid.
	Check the slot number and set the correct value. The slot number must be 1 to 10.
3318	Specified module channel is invalid.
	Check the channel number and set the correct value.
3319	Output delay is out of absolute limits.
	Check the output delay and set the correct value. The value must be −50 ns to 50 ns, in 625 ps resolution.
3320	Measurement delay is out of absolute limits.
	Check the measurement delay and set the correct value. The value must be −50 ns to 50 ns, in 625 ps resolution.
3321	VM/IM measurement mode is invalid.
	Check the measurement mode and set the correct value.
3322	Voltage measurement range is invalid.
	Check the voltage measurement range and set the correct value.
3323	Current measurement range is invalid.
	Check the current measurement range and set the correct value.

3324	WGMA?,WGMB? command query size is out of absolute limits. Check the data size for WGMA? or WGMB? and set the correct value.
3325	Specified count for spot measurement is out of absolute limits. Check the count value for WGMS? and set the correct value.
3326	Specified interval for spot measurement is out of absolute limits. Check the interval value for WGMS? and set the correct value.
3327	Specified operation mode is invalid for spot measurement. Operation mode must be DC to perform spot measurement.

Self-test/Calibration Error

3002	WGFMU initialization failure.
3003	WGFMU FPGA is not configured.
3004	EEPROM CRC data of system timing data is invalid.
3005	EEPROM CRC data of DAC DCM PS data is invalid.
3006	EEPROM CRC data of ADC DCM PS data is invalid.
3007	EEPROM CRC data of DAC clock edge data is invalid.
3008	EEPROM CRC data of ADC clock edge data is invalid.
3009	EEPROM CRC data of DAC level calibration data is invalid.
3010	EEPROM CRC data of ADC level calibration data is invalid.
3011	EEPROM CRC data of DAC skew calibration data is invalid.
3012	EEPROM CRC data of ADC skew calibration data is invalid.
3013	EEPROM CRC data of RSU calibration data is invalid.
3014	Invalid EEPROM type.
3400	WGFMU module is in TEST FAIL state.
3401	Digital H/W function test failed.
3402	CPLD access function test failed.
3403	FPGA configuration test failed.
3404	FPGA1 access function test failed.

3405	FPGA2 access function test failed.
3406	FPGA1 System Clock DCM function test failed.
3407	FPGA1 DAC Clock DCM function test failed.
3408	FPGA1 ADC Clock DCM function test failed.
3409	FPGA1 Memory Clock DCM function test failed.
3410	FPGA2 System Clock DCM function test failed.
3411	FPGA2 DAC Clock DCM function test failed.
3412	FPGA2 ADC Clock DCM function test failed.
3413	FPGA2 Memory Clock DCM function test failed.
3414	FPGA1, 2 communication I/F test failed.
3415	CONVEND interrupt function test failed.
3416	10 MHz clock test failed.
3417	FPGA SYNC SEL pin control function test failed.
3418	FPGA SYNC FB pin control function test failed.
3419	FPGA SYNC IN pin control function test failed.
3420	IDELAY function test failed.
3421	Channel 1 SDRAM access function test failed.
3422	Channel 2 SDRAM access function test failed.
3423	WGFMU EEPROM access function test failed.
3424	Channel 1 RSU EEPROM access function test failed.
3425	Channel 2 RSU EEPROM access function test failed.
3426	WGFMU EEPROM CRC data is invalid.
3427	WGFMU EEPROM CRC data of format revision data is invalid.
3428	WGFMU EEPROM CRC data of serial number data is invalid.
3429	WGFMU EEPROM CRC data of system timing data is invalid.
3430	WGFMU EEPROM CRC data of DAC DCM PS data is invalid.
3431	WGFMU EEPROM CRC data of ADC DCM PS data is invalid.
3432	WGFMU EEPROM CRC data of DAC clock edge data is invalid.

3433	WGFMU EEPROM CRC data of ADC clock edge data is invalid.
3434	WGFMU EEPROM CRC data of DAC level calibration data is invalid.
3435	WGFMU EEPROM CRC data of ADC level calibration data is invalid.
3436	WGFMU EEPROM CRC data of DAC skew calibration data is invalid.
3437	WGFMU EEPROM CRC data of ADC skew calibration data is invalid.
3438	RSU EEPROM CRC data of format revision data is invalid.
3439	RSU EEPROM CRC data of serial number data is invalid.
3440	RSU EEPROM CRC data of type id data is invalid.
3441	RSU EEPROM CRC data of calibration data is invalid.
3450	WGFMU EEPROM data is invalid.
3451	WGFMU EEPROM data of RSU type is invalid.
3452	WGFMU EEPROM data of RSU cable type is invalid.
3460	Main DAC, Main ADC test failed.
3461	Bias DAC, Main ADC test failed.
3462	Main DAC, Reference ADC test failed.
3463	VM function test failed.
3464	IM offset test failed.
3465	IM short test failed.
3480	Invalid frame configuration.
3481	Invalid frame configuration.
3482	Frame has no modules.
3483	PLL not locked in secondary module.
3484	Reference line is not connected.
3485	Sync line is not connected.
3486	Sync Reserve line is not connected.
3487	Interrupt line is not available.
3488	Module service request assertion test failed.
3489	Module service request detection test failed.

3490	Emergency interrupt is not available.
3500	WGFMU calibration failed.
3501	ADC gain calibration failed.
3502	CMR calibration failed.
3503	IM offset calibration failed.
3504	VM offset calibration failed.
3505	VF gain calibration failed.
3506	VF offset calibration failed.
3507	Reference ADC does not exist. Cannot perform WGFMU calibration.
3508	WGFMU, RSU cable length calibration failed.

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