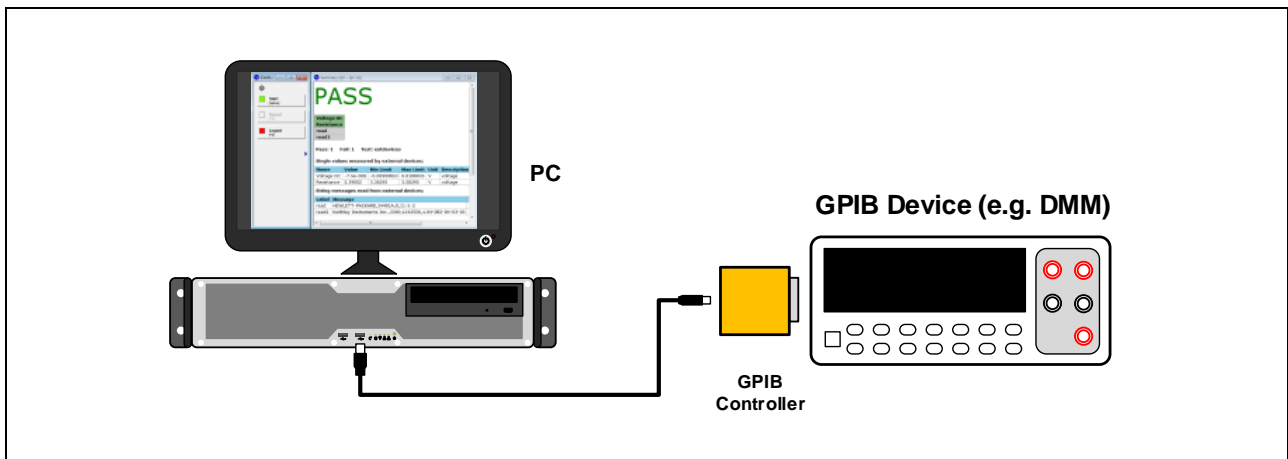


## Features

- GPIB compliant protocols (IEEE 488 & 488.2)
- Communicates with any GPIB device for control, measurement and data acquisition
- Device status handling (IEEE 488.2)
- Results included in Pass/Fail verdict
- Automatic limit generation
- Flexible user definable sequences
- Shell execution and message box generation
- IO monitor communication
- Control Digital I/O port of Klippel Production Analyzer
- Versatile stimulus generator
- Read measurement data from text file
- Simple script syntax

## Benefits

- High flexibility through multiple action steps in one task
- Integration of existing hardware
- Extension of inputs and physical domains
- Control a variety of GPIB compliant peripheral devices (e.g. power supply)
- Start applications or scripts via command line access
- Control custom IO monitor applications
- Instruct operator with message boxes
- Control devices connected to Digital I/O port of Production Analyzer (e.g. switch multiplexer)



The QC External Devices task is a versatile add-on for the QC framework of the KLIPPEL Analyzer System dedicated to interfacing with arbitrary GPIB (IEEE 488) compliant measurement equipment, such as multimeters or power supplies. Simple programmable step sequences enable the user to control external devices and to include the measured data in the QC System. Full limit handling is provided to generate PASS/FAIL verdicts.

## APPLICATIONS:

- Testing of complex DUTs (e.g. handsets)
- Electronics testing
- Automatize complex tests

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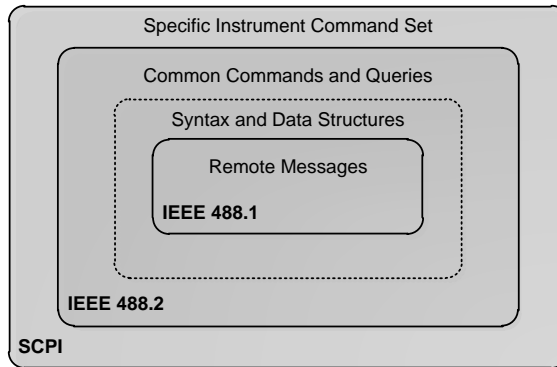
**CONTENTS:**

Overview..... 2  
 Hardware ..... 4  
 Limits, Settings and Results ..... 5  
 Appendix..... 10  
 References: ..... 10

**Overview**

**Summary**

The  *GPIB (General Purpose Interface Bus)* according to  *IEEE 488* industry standard is a versatile and very common communication bus for all kinds of instrumentation equipment. It specifies the mechanical and electrical bus structure and a selection of hardware level communication protocols. Additionally, the extended  *IEEE 488.2* standard specified controller functionality, common commands and functionality as well as a device status reporting system for status information and device error handling. Built on the  *IEEE 488.2* standard the  *SCPI (Standard Commands for Programmable Instruments)* recommendation introduced a simple and versatile device independent programming syntax to minimize manufacturer specific differences and to support portability.



The QC External Devices module combined with the  *Prologix GPIB-USB* controller provides a high-level interface for GPIB communication. Compliant devices can be set up and queried to generate QC measures. Only the specific commands and the device address have to be specified by the user. All device initialization and status handling is performed automatically according to the task settings. The application of the SCPI status handling is explained in section  *Status Handling*.

Additionally, this module offers communication with the  *GPIO* port of the  *Production Analyzer* hardware and custom  *IO Monitor* applications extending the communication channels. Furthermore, any shell command can be executed. Operator interaction is provided using message boxes.

**Requirements**

**Software**

- QC framework: Klippel QC Standard or Programmable version or
- R&D framework: dB-Lab min. version 210
- EXD license

**Hardware**

- Production Analyzer, KLIPPEL Analyzer 3 or 3<sup>rd</sup> party audio interface
- USB license dongle (or KA3 as license device)

**GPIB (if required):**

- GPIB compatible device (DMM, generator...)
- GPIB – USB controller interface (see below)

**Principle**

This EXD module can be added to any existing Klippel QC sequence. 3<sup>rd</sup> party devices can be set up and queried using a simple scripted step sequence that can be saved and modified in any text editor.

**Available Step Types**

- GPIB: Configure and query arbitrary GPIB devices
- Digital I/O (GPIO): Write and poll the state of the Digital I/O port pins of *the Production Analyzer*
- IO Monitor: communicate with external custom IO monitor applications
- Command line: execute command line entries e.g. to start external programs
- Message box: Communicate with operator using message boxes that interrupt the execution sequence and import external test data.
- File: read data from text file
- Stimulus: Generate and configure stimulus signals for Production Analyzer outputs using the internal signal generators or imported wave files

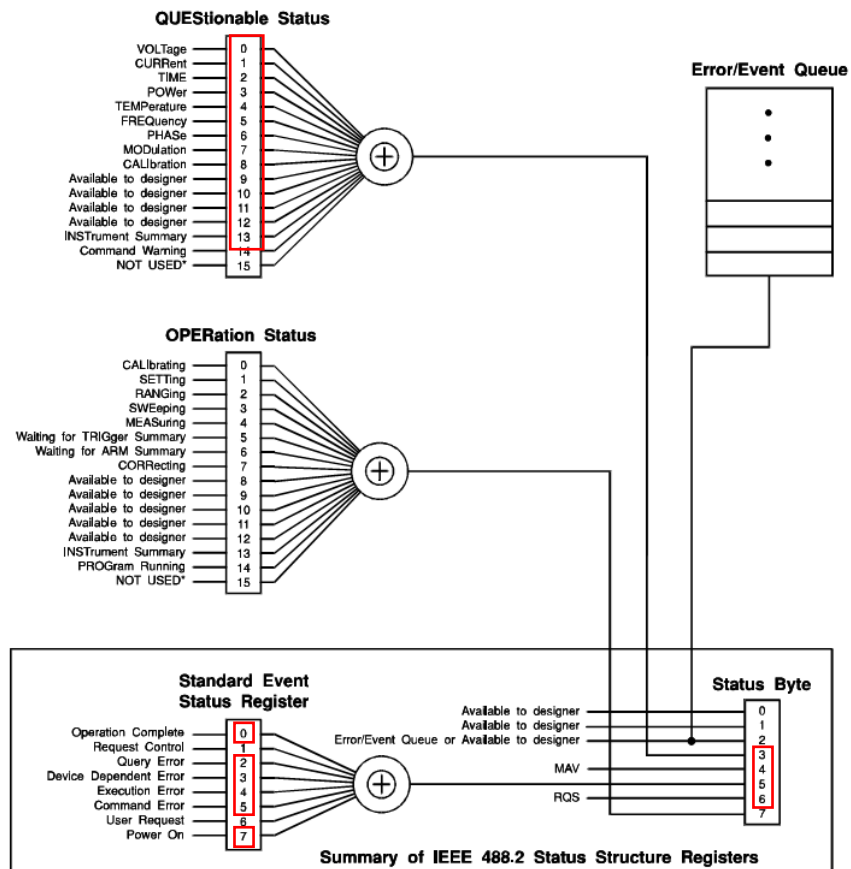
**Status Handling (IEE 488.2)**

With the extended IEEE 488.2 standard, a general GPIB device status handling system was introduced to monitor the device status in terms of service request and synchronization as well as communication and device errors.

The standard comprises four *status registers* according to the figure below. Each register mirrors the current device status according to the information represented by the concerning bit. There are device independent common states as well as device specific states defined by the manufacturer. All status register can be queried independently.

Additionally, every status register is followed by an *enable register* (not displayed). It acts as a mask controlling which entries in the register are used to build up a sum status bit (logical OR) which is forwarded to the *status byte register*. The *status byte* is summing up the information given in the state registers' or the state of the device's output buffers.

The status byte can be read any time by the controller even parallel to pending operations with a *serial poll* to synchronize GPIB communication. Setting the *status byte enable register* mask can be used to generate a *service request (SRQ)* interrupt on the bus any time.



*Status register structure according to IEEE 488.2[1]*

The External Devices module supports automatic status handling. The operation status register is excluded. During device initialization all standard (device independent) *enable registers* are set for *service request*. The relevant bits are marked in the picture above. The *standard event register* may generate step errors while the *questionable status register* only causes warnings.

The status of every device is monitored during communication and the user is informed, if any errors or warnings occurred. Synchronization is given at any time referring to *MAV (message available)* and *\*OPC? (operation complete)*. The device status is reset at the beginning of the task's sequence.

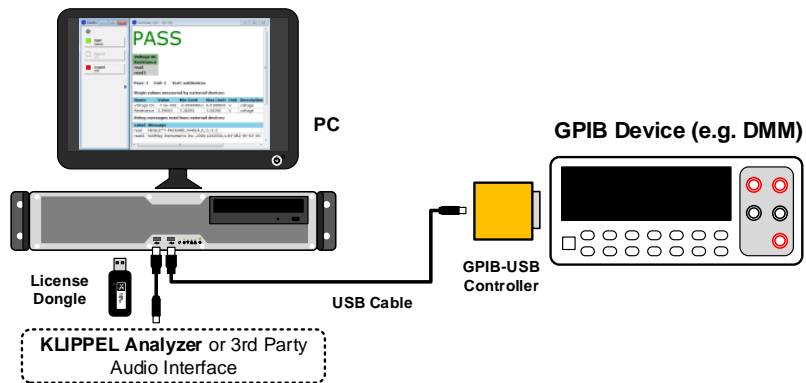
For the purpose of customization and additional feedback all enable registers can be set and all status registers can be queried by the user anytime in the control sequence. For further information please refer to the user manual of the External Devices Task and to the programmer manual of your GPIB device.

**Limitations**

- Data acquisition and result processing is limited to single values in plain, standard scientific exponential or hexadecimal notation or as string parameters without numerical processing
- Parallel GPIB event handling is not supported generally, except bus wide triggering and service request
- No internal analyzer is provided by the EXD Task. Therefore, no measurement can be performed using the signal in- and outputs of the analyzer (PA or KA3) hardware while the EXD Task is running.

**Hardware**

**Minimal Setup**



The figure above shows the minimal equipment required to use the EXD module:

- Klippel Production Analyzer, Klippel Analyzer 3 or 3rd party audio interface
- Personal computer (see separate PC requirements)
- USB license dongle
- GPIB compatible device
- GPIB-USB interface for host computer (see below)
- GPIB cable, if multiple devices shall be connected

<b>GPIB Interface for Host PC</b>	<p>The EXD is dedicated to be operated with <i>Prologix GPIB-USB Controller</i> [1], a cost-effective and versatile GPIB-Bus interface. In contrast to other proprietary devices it does not need any additional host software and can be addressed as a virtual serial port. The interface handles the low-level GPIB communication to send high-level GPIB commands and receive data transmitted by GPIB devices. Thus, it can be used with any kind of software platform. The interface configuration and port communication are handled by the EXD.</p> <p>Interface versions 6.91 or higher are supported. Older versions may be used as long as the standard instruction set to setup and communicate with the controller is supported.</p> <p>The abstraction level of the External Devices Task is high to provide high usability and fast setup. Thus, the user is not required to setup the bus communication. For this reason, currently only the recommended Prologix GPIB interface is supported.</p>
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<b>Limits, Settings and Results</b>	
<b>INPUT PARAMETERS (SETUP)</b>	
<b>Measurement Sequence</b>	<p>A simple text input is used to provide a flexible interface to defined a step sequence. The complete measurement and control sequence is set up with plain ASCII strings following simple format conventions:</p> <ul style="list-style-type: none"> <li>• Each line stands for one test step using a defined communication channel (step type: GPIB, Digital IO etc.) and a corresponding action (read, write, value). For multiple steps simply enter more lines.</li> <li>• Each line has the following fixed format: `&lt;Label of test step or measure&gt;   &lt;Step type&gt;   &lt;Step action&gt;   &lt;Step parameter 1&gt;   &lt;opt:Step parameter 2&gt;   &lt;opt: unit&gt;   &lt;opt: comment&gt;`</li> <li>• Each line has to start and to end with a quotation mark</li> <li>• The delimiter character is the vertical dash “ ”.</li> <li>• Optional entries are not required and do not have to be specified. If any optional entry within the line shall not be specified, only the delimiters “   ” have to be entered.</li> <li>• Each line must not have more than 1024 characters.</li> <li>• One step can be defined over multiple lines using line break</li> <li>• Line breaks can be achieved by adding “...” at the end of one line and continuing in the next line Example: ` instruct operator   MsgBox   write   This is the...` ` instruction text which is too long for one line. `</li> <li>• Lines with “//” are ignored, this may be used for comments or to deactivate entries Example: `// This is a comment`</li> </ul> <p>The setup may be prepared in a simple text editor and copied via clipboard.</p> <p>Find a table of all available step types and parameters in the appendix.</p>
Label	String label /measure name to be shown in verdict list and result table on Summary Page. The step labels must be unique within one sequence.
Step type	<p>Step type specifies communication channel or mode:</p> <ul style="list-style-type: none"> <li>• GPIB: GPIB device communication</li> <li>• DigitalIO: Digital I/O (GPIO) port communication (Production Analyzer)</li> <li>• IOmonitor: IO monitor communication</li> <li>• Wait: wait specified time</li> <li>• MsgBox: message box for operator communication</li> <li>• Execute: execute any command line (shell command)</li> <li>• Stimulus: generate stimulus signal using the output of the analyzer</li> <li>• File: read data from text file</li> </ul>
Step action	<p>This parameter specifies the action performed in the step:</p> <ul style="list-style-type: none"> <li>• write: write to device or perform action without returning data</li> <li>• read: read character string (message/data)</li> <li>• value: read numerical string data to create a QC measure</li> </ul>

<p>Parameter 1</p>	<p>The interpretation of step parameter 1 depends on the specified type and action.</p> <ul style="list-style-type: none"> <li>• <b>GPIB: command sequence</b> Device (SCPI or other GPIB protocol) or bus controller command sequence for device setup, query and measurement.</li> <li>• <b>DigitalIO: bit sequence</b> (only "write") A 9 bit sequence (e.g. "001010011") can be specified to be written to the Digital I/O (GPIO) port of the <i>Production Analyzer</i>. The bits correspond to specific pins of the port. The corresponding mask in <i>Parameter 2</i> specifies which bits shall be set. Alternatively, the value "x" keeps the previous state of the pin (e.g. "00xx10x11"). Please see the manual of the QC System for further information.</li> <li>• <b>IOmonitor: control matrix</b> (only "write") Format: &lt;channel value mask aux&gt; Used for communication with your IO monitor application. See IO monitor API documentation for more information.</li> <li>• <b>Execute: command line</b> Command line (incl. parameters) to be executed in the windows shell. The task waits until the action is terminated. Use quotation marks in case the path or filename contains white spaces.</li> <li>• <b>MsgBox: message string</b> Opens a message box with the specified message string. The task waits until the message box is terminated.</li> <li>• <b>Wait: time in s</b> (only "write") The task execution is interrupted for the specified time.</li> <li>• <b>Stimulus: file path</b> <ul style="list-style-type: none"> <li>○ [ GenMode fstart, fstop, res, voltage, time, loop ] for internal or</li> <li>○ [ GenMode filePath, voltage, loop ] for GenMode="wave"</li> <li>○ only "write"</li> </ul> <p>Configure the built-in stimulus generator or specify wave file input.</p> </li> <li>• <b>File</b> File path (absolute or relative) of file to be read.</li> </ul> <p>See section <i>Examples</i> for practical examples. Please also see the overview table in the appendix.</p>
<p>Parameter 2</p>	<p>The interpretation of step parameter 2 depends on the specified type and action.</p> <ul style="list-style-type: none"> <li>• <b>GPIB: device address</b> The GPIB address (1-30) of the used device in this step is to be specified here. This entry is compulsory for GPIB communication steps. The device address has to be unique within the bus and can be set or determined manually at the particular device.</li> <li>• <b>DigitalIO: bit mask</b> (only "write") A bit mask of 9 bits (e.g. "111000011") is specified here to set which bits of the Digital Output shall be set according to <i>Parameter 1</i>. Only pins with the mask "1" are set, while "0" keeps the previous state.</li> <li>• <b>Stimulus: output routing</b> (only "write") Set the output of the Production Analyzer to use for stimulus playback (Speaker1/2, Out1/2)</li> <li>• <b>MsgBox: message string</b> initial value or character string of the data input field</li> <li>• <b>File: parameter name</b> Name of the parameter in the source file to be read:</li> </ul>
<p>Unit (optional)</p>	<p>Specifies the unit of the measured quantity for display purpose in the result table. This entry is obsolete for "write" steps.</p>
<p>Comment (optional)</p>	<p>Optionally a comment can be provided which is used for the result table only. This entry is obsolete for "write" steps.</p>

<b>Bus Mode</b>	Select bus mode used for communication with GPIB devices <ul style="list-style-type: none"> <li>• none</li> <li>• GBIP (IEEE 488.1) - use GPIB via virtual COM interface provided by Prologix GPIB-USB controller</li> <li>• GBIP (IEEE 488.2) - use GPIB via virtual COM interface provided by Prologix GPIB-USB controller, full IEEE 488.2 common command set and status handling is used</li> </ul>
<b>Termination Character</b>	Specify GPIB command termination characters. These characters are appended to any command sent to a GPIB device. <ul style="list-style-type: none"> <li>• None</li> <li>• CR + LF</li> <li>• CR (carriage return)</li> <li>• LF (line feed)</li> </ul>
<b>EOI Termination (enable/disable)</b>	Enable assertion of EOI (end of instruction) signal with last character of any command sent over GPIB bus. Some instruments require EOI signal to be asserted in order to properly detect the end of a command.
<b>Status Handling (enable/disable)</b>	Enable internal IEEE 488.2 compliant status register handling to identify state of GPIB device and communication errors. includes: SRQ, Message available, Standard Events Register, Questionable data flag All enable registers are initialized automatically for all standard status bits.
<b>Init Controller</b>	Select the initialization mode of the GPIB bus controller <ul style="list-style-type: none"> <li>• automatic: automatically detect controller (virtual COM port)</li> <li>• manual: set the virtual COM port number manually</li> </ul>
<b>COM Port</b>	Specify virtual COM port number of GPIB bus controller. (according to settings in “ <i>Bus mode</i> ”)  Only available if <i>Init controller – manual</i> is selected.
<b>Read Timeout</b>	The <i>Read timeout</i> specifies the global time span for serial port or GPIB communication timeouts (read access) in seconds.
<b>Error Mode</b>	In case of a step error the final result may be <ul style="list-style-type: none"> <li>• force FAIL: All measures are marked as FAIL (red color)</li> <li>• Ignore: All measures are marked as VOID (grey color)</li> <li>• Warning: All measures are marked as Warning (Yellow color)</li> </ul> <p>In any case, errors are indicated in the verdict table.</p>
<b>Error Handling</b>	In case of a step error <ul style="list-style-type: none"> <li>• Abort</li> <li>• Continue</li> </ul> the step sequence. All error messages are logged and displayed in case of “continue”.
<b>Digital Out (amp check)</b>	GPIO setting applied during amplifier check (if <i>Stimulus</i> step and <i>Speaker</i> routing step are used).
<b>Import Parameters</b>	Activates task and limit parameter import from external parameter file
<b>Parameter File</b>	File path of parameter file for import of settings and limits

<b>LIMIT PARAMETERS (SETUP)</b>	
<b>Limit Setup (“value”)</b>	<p>The limits settings for single value measures are defined similar to the <i>Measurement sequence</i>:</p> <ul style="list-style-type: none"> <li>• Each line defines limit for one “value” step. For multiple steps simply enter more lines.</li> <li>• Each line has the following fixed format: '&lt;Measure name (step label)&gt;   &lt;Limit calculation mode&gt;   &lt;opt1:Limit parameter min&gt;   &lt;opt2:Limit parameter max&gt;   &lt;opt3:Cpk-PoolSize&gt;}   &lt;opt3:Cpk-Limit&gt;   &lt;opt3:Ppk-Limit&gt;   &lt;opt3:Cpk/Ppk-PassedOnly&gt;'</li> <li>• The number and order of line entries may be chosen arbitrary</li> <li>• Missing entries will deactivate the limits for the corresponding measure (passive – void verdict)</li> <li>• The measure names/labels must correspond to the unique step labels in the <i>Measurement sequence</i> setup matrix</li> <li>• Lines with “//” are ignored, this may be used for comments or to deactivate entries Example: '// This is a comment'</li> </ul> <p>The delimiter character is the vertical dash “ ”. Each line must not have more than 1024 characters. The setup may be prepared in a simple text editor and copied via clipboard.</p>
<b>Limit Calculation Mode</b>	<ul style="list-style-type: none"> <li>• Shift: Values are added to the mean of reference results</li> <li>• Relative: Values are multiplied: <math>limit = refValue * (1 +/- relative\ tolerance)</math>. Relative tolerance is specified in percent.</li> <li>• Statistics: Values are multiples of the standard deviation of the reference results. At least 2 reference DUTs must be used.</li> <li>• Absolute: Values are directly compared to the measured results. Reference DUTs are not used for limit calculation.</li> </ul> <p>No limits are calculated if left empty. For more details on limit calculation, refer to the <i>QC User Manual</i>.</p>
<b>Limit Parameter Min</b>	<p>For each Limit calculation mode the upper limit parameter is specified here.</p> <ul style="list-style-type: none"> <li>• Shift: Shift Min</li> <li>• Relative: Tolerance Min</li> <li>• Statistics: Factor of sigma for Min</li> <li>• Absolute: Min Limit</li> </ul> <p>No upper limit is applied if empty.</p>
<b>Limit Parameter Max</b>	<p>For each Limit calculation mode the lower limit parameter is specified here:</p> <ul style="list-style-type: none"> <li>• Shift: Shift Max</li> <li>• Relative: Tolerance Max</li> <li>• Statistics: Factor of sigma for Max</li> <li>• Absolute: Max Limit</li> </ul> <p>No lower limit is applied if field is left empty.</p>
<b>Imported Measured Data</b>	Import external reference data (reference DUTs or mean values)
<b>Imported Standard Deviation</b>	Import external standard deviation (related to mean values of <i>Imported Measured Data</i> )
<b>Cpk / Ppk</b>	<p>The Cpk/Ppk process analysis is activated if all four parameters for the corresponding single value measure is specified in in the <i>Limit setup</i></p> <ul style="list-style-type: none"> <li>• Cpk-Poolsize:</li> <li>• Cpk-Limit:</li> <li>• Ppk-Limit:</li> <li>• PassedOnly</li> </ul>



<p><b>Limit Setup (“read”)</b></p>	<p>The limits settings for character string messages are defined similar to the <i>Measurement sequence</i>:</p> <ul style="list-style-type: none"> <li>• Each line defines target string for one “read” step. For multiple steps simply enter more lines.</li> <li>• Each line has the following fixed format: `&lt;Label (step label)&gt;   &lt;Mode&gt;   &lt;Target string&gt;`</li> <li>• The number and order of line entries may be chosen arbitrary</li> <li>• Missing entries will deactivate the limits for the corresponding measure (passive – void verdict)</li> <li>• The labels must correspond to the unique step labels in the <i>Measurement sequence</i> setup matrix</li> <li>• Lines with “//” are ignored, this may be used for comments or to deactivate entries Example: `// This is a comment`</li> </ul> <p>The delimiter character is the vertical dash “ ”. Each line must not have more than 1024 characters. The setup may be prepared in a simple text editor and copied via clipboard.</p>
<p>Mode</p>	<ul style="list-style-type: none"> <li>• equal: Pass if input string equals target string.</li> <li>• notEqual: True if input string differs from target string</li> </ul> <p>No limit is set if left empty.</p>
<p>Target String</p>	<p>Here the target string is defined which is to be compared with the input string.</p> <p>Target check is deactivated if left empty.</p>
<p><b>RESULTS</b></p>	
<p>Single value measures</p>	<p>For “value” steps the input data is interpreted as numerical data. The results are shown in a measure table on the <i>Summary Page</i>. Limits are applied and shown, if specified.</p>
<p>Cpk / Ppk</p>	<p>If Cpk / Ppk values are enabled and can be calculated, they will be displayed in separate columns within the result table in the <i>Summary</i> window. The standard processes are applied, please refer to the user manual for more details on Cpk/Ppk.</p>
<p>String messages</p>	<p>For “read” steps the input string data is not interpreted as numerical data. The message is displayed in a results table on the <i>Summary window</i>. Limits can be applied in terms of a target string comparison.</p>
<p>Log File</p>	<p>All results are logged in the summary.log – file, if enabled.</p>
<p>Database</p>	<p>All results are stored in the result database, if enabled. Using the <i>Automation</i> interface all results and limits can be accessed.</p>

# Appendix

## Overview over Available Step Types and Parameters

Label/measure name	Step type	Step action	Parameter 1	Parameter 2	Unit (opt)	Comment (opt)
<label >	GPIB	write	<command>	<GPIB address>	-	-
<name>	GPIB	read	<command>	<GPIB address>	<unit>	<comment>
<measure name>	GPIB	value	<command>	<GPIB address>	<unit>	<comment>
<label >	Execute	write	<Cmd line entry>	-	-	-
<label >	MsgBox	write	<message>	-	-	-
<label >	MsgBox	read	<message>	<init input>	<unit>	<comment>
<label >	MsgBox	value	<message>	<init input>	<unit>	<comment>
<label >	IOmonitor	write	<chan val mask aux>	-	-	-
<label >	DigitalIO	write	<bit sequence>	<bit mask>	-	-
<name >	DigitalIO	read	-	-	-	<comment>
<label >	Wait	write	<Time>	-	-	-
<label >	Stimulus	write	<config>	<routing>	-	-
<measure name>	File	value	<file path>	<var name>	<unit>	<comment>
<name>	File	read	<file path>	<var name>	<unit>	<comment>

### References:

1. **Prologix, LLC.** Features of GPIB-USB Controller. [Online] [Cited: August 23, 2010.] <http://store.prologix.biz/gpco.html>.
2. **SCPI Consortium.** SCPI Specifications. [Online] 1999. [Cited: August 23, 1010.] <http://www.ivifoundation.org/docs/SCPI-99.PDF>.



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