

1 Introduction

Originally Omega interfaced instrument through GPIB, but rare new instruments in 2023 offer GPIB interface by default or and very few as an option for surcharge.

Instrument manufacturers generally provide interfacing software, but those are proprietary and often limited in functionality, thus preventing use of the instrument in unison with other instrument types and brands.

The types and levels of documentation for ways to interface the device vary greatly.

TCPIP over LAN is one of the interface methods that is relatively easy and non-restricted. It is increasingly possible to use with Omega. It is however impossible to perform auto search (too large address space to seek from) or auto configure, so the user must setup things manually.

Like anything, LAN has good and bad sides to it. It is easy and fast to program, but as said, it is impossible for the instruments to be automatically discovered. Furthermore, the IP addresses are dynamic, so they may change often (even during operation). Networks are also complicated, regulated, and ports get blocked by firewalls and such security measures. These are things the Omega software has no control over, but it upto the end user, or their IT department.

Another interface available, only for Zurich Instruments Impedance analyser, is the ZAPI. See relevant chapter at the end of this manual.

2 TCPIP and LAN

2.1 Supported types

	LAN	Role	Notes
Keithley 6500	Full	Multimeter	Entry level instrument -suitable for simple tasks only
Keithley 2260B	Work in progress 2023.11.09	Multimeter 2-wire operations only. Voltage and current measurements nodes only (.MV and .MC accordingly)	<p>Programmable power supply, use in DMM role.</p> <p>Initialization plays a tune, turns the beeper off, and unlocks the physical keys. This allows user to set up device to their preferences (but also allows for problems when setup is unsuitable for use with Omega)</p> <p>Applied voltage, current, safety levels are handled either from keyboard before measurement, or by sending custom GPIB code in appropriate places (static levels only).</p> <p>AU node type is possible once the static or manual levels and MV and MC nodes work nicely.</p>

2.2 Nomenclature

2.2.1 IP address

Four-part string of numbers like X.X.X.X where X is a number 0 to 255

2.2.2 Ports

Port is a number (from 1 to 65535) usually preceded by the IP address. X.X.X.X:Y where Y is the port.

2.3 Devices

The support for TCPIP is relatively easy to add for any device that internally uses SCPI command language, do inquire.

As of 2023.04.19, Omega supports the following devices:

Keithley 6500.

2.4 Preparatory steps

Connect the instrument directly to a computer or LAN network, turn it on and verify from the menu/communication/lan, that the device has acquired (it asks for an address from the network if it has access to the network) an IP address and a port. Write down this info, such as 169.254.7.0:5025

2.5 Manually entering the device

Since auto search is out of the question, the software must be told manually where to find the instrument to be used (each time it has new IP address, and in worst case that may change often, unfortunately)

Create a new .txt file and open it for editing.

Each device entry is three lines where second line is indented with tab once and third line is indented with tab twice.

Example:

```
LAN
    KEITHLEY
        Multimeter DMM6500 169.254.94.232 5025 LAN
```

First line informs Omega that there is device, with interface type LAN. Second is used for other things and here we just fill it with the device brand. The third line is very important and has five pieces of info, each separated by empty space. First is instrument **role** followed by **model**, then **IP address**, then the **port**, and last again the text **LAN**. Once this info is entered into the file, save the file under the 'Device Setups' folder, as "K6500 LAN.odc" or use "default.odc" if the Keithley 6500 is the only device configuration you plan to use (if a file called default.odc exists, it is opened by default on each startup, reducing the amount of clicking required).

Open Omega, and open the aforementioned device configuration file.

Click validate button to see if instrument is found.

2.6 Devices setup vs Measurement setup

Each measurement records the fingerprint of the device setup the measurement was performed with, as the measurements highly rely on the information what instruments are available and where they can be found. If anything at all changes in the devices configuration file, the device setup fingerprint is different and old measurements will complain when the setup fingerprint does not anymore match what the measurement remembers.

If the user is certain that nothing else than the IP changed, it is safe to override & update the memorized fingerprint and continue with the old measurement file(s).

If anything else than the IP changed, and the user updates the fingerprint, and tries to measure, the old measurement files will try to measure, but will produce unexpected results and errors.

More information about this can be found in the Omega manual.

3 Instrument specific information – LAN

Device configuration file data format:

Three lines, indentations for 2nd line =1 tab, 3rd line=2 tabs, five items space separated. Keywords cannot have spaces in them. See specific keywords in device specific subchapters below.

LAN

Brandname

Role Model IP 5025 LAN

Where **LAN** is always LAN

Brandname is manufacturer keyword

Role is a keyword for device role

Model is a model-specific keyword

IP is 4 part IP such as 1.2.3.4

Port is Port when needed and an integer number placeholder otherwise

3.1 Keithley 6500 - LAN

Connect LAN cable from instrument to computer or usable network. Turn on instrument and go to Menu->LAN to view IP address and port. IP address is written with large letters, but port information is with small letters at bottom right corner.

Device configuration file data format:

LAN

KEITHLEY

Multimeter DMM6500 169.254.94.232 5025 LAN

3.2 Keithley 2260B

Device configuration file data format:

LAN

KEITHLEY

Multimeter 2260B 169.254.94.232 5025 LAN

3.3 Zurich Instruments MFIA – LAN

Not fully implemented yet -> Use ZAPI instead

~~Install LabOne package. Connect LAN cable from instrument to computer or usable network. Turn on instrument and start LabOne web interface. Take note of data server IP address and port. The IP address on the user interface may be cut off, make sure to retrieve all 4 segments.~~

~~Device configuration file data format:~~

~~**LAN**~~

~~**ZHINST**~~

~~**Imp.Spectrometer mf dev5677 169.254.112.8004 LAN**~~

The device name (for example mf-dev5677) is important also. The software only works with devices with pre-approved serial numbers, and in case it is not added in the source code of the software, the spectrometer will not work with Omega. In such case send the device name/serial to Norecs, so that we can update the software to work with that device serial. This is normally done prior shipping the instrument, but not always.

4 LAN programming considerations

4.1 User

There is no serial poll for instruments using GPIB and SCPI via LAN. Readiness of commanded task can not be easily evaluated, is not normally documented in the manuals i.e. the Omega software has no way of knowing if commanded measurement result is ready to be read back to the software.

For nodes making slow measurements with long integration times etc., a timeout may happen and the node may proceed with NAN (Not a number) result, 0-result or completely skip the whole measurement loop.

4.2 Developer

Internal notes for myself – end users need not read this.

4.2.1 No autosearch

Instead Instrument details entered by hand to configuration file.

4.2.2 Validation

LANTest instead of **SIDNGPIBDevice** (both in units/instruments.pas)

Followed by **InitializeGPIBDevices** (in UnitOmega2.pas ca. line 2400) This does call **InstrumentInitializeLAN** (in units/instruments.pas) for LAN type devices.

4.2.3 Measuring

Multimeter nodes in units/MeasuringEngine.pas line 360 onwards. Just executes device specific GPIB, which is defined in units/InstrumentGPIB2.pas line 1090 onwards

4.2.4 Result reading

Multimeter nodes in units/MeasuringEngine.pas line 1400 onwards.

Has root GPIB commands (only from wrong registers)

Has SCPI for reading registers (will builtin GPIB features work via TCPIP?)

MAV is bit 4 in service request register and status byte register (so 16)

Try:

*STB? (read result)

*CLS (no result)

:MEAS:VOLT? (read result)

*STB? (read result)

GPIB tool does not work with TCPIP

4.2.5 Always compile and build

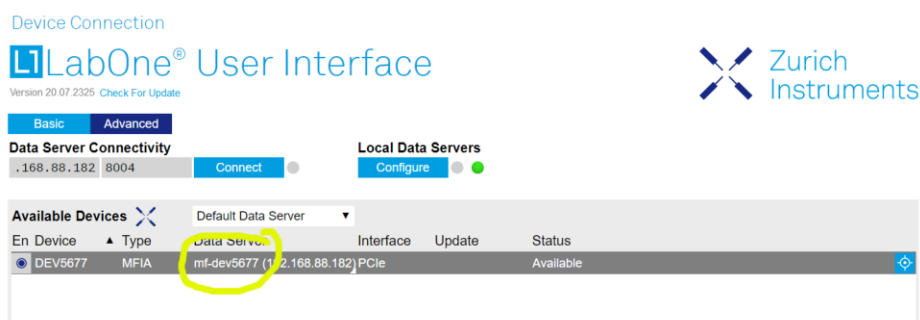
Anything else break ZAPI

5 ZAPI – Zurich Instruments Application Programming Interface

- Uninstall any previous versions of LabOne.
- Download and install the 20.07 version of LabOne software from https://www.zhinst.com/europe/en/support/download-center/release/20_07
Uncheck the checkbox to automatically check and install updates, Omega may not work with future versions of the API.
- Connect the instrument to a computer using the USB cable. After connecting, the device shows up as storage device on Windows Explorer, named 'MF-DRIVER'. Navigate there and go to the 'drivers'-folder, right click zi_mf.inf and select install.
- Open LabOne. The system may suggest an upgrade to device firmware. Don't do that. Hovering over the link shows installed version, it should be 20.07.2325.

Alternatively open "MF device finder" same information is visible on that app.

- Take note of the serial, and write it down.
Sometimes the ID is shown as MFIA-DEVXXXX Regardless of what is displayed, the correct format is mf-devXXXX



- Navigate to Omega/Utility/ folder and place the ziAPI-win32.dll there. The file can be downloaded from http://norecs.com/work/files/PUBLIC_FILES/software/Omega/ZHInst/
- Create or open a device configuration file, for example default.odc in Device setups folder.
- Add the data in the correct format:

API

ZHINST

Imp.Spectrometer mf-devXXXX 1.2.3.4 8004 API

The IP and Port info does not really matter, but we need to fill in something to those in any case. How the software finds the instrument is based on the keyword 'API' and the instrument serial mf-devXXXX where XXXX matches the information in the LabOne software.

Note (to self): Due to some memory management differences between C and Delphi, the project needs to be compiled and then built (Shift+F9), for a released version. Handing out the debug-exe will not have Z-API working properly.

Another note to self: Change .dll linking from static to dynamic.

6 ZHINST MFIA notes

This instrument has lot of speed and advanced settings to tweak its performance. There is no single shot measurement that gives one unambiguous result, instead the instrument streams all results in rapid fashion and leaves it up to the user to decide when the data is good, or at least which filters to turn on.

The instrument offers range of filters called ‘confidence indicators’ to judge the data quality.

6.1 Confidence indicators

Each measurement datapoint from the instrument can have a set of ‘flags’ associated with it. These flags are conditions that the result is tested against. All the flags are off unless a) the corresponding confidence indicator feature is turned on, b) the measurement datapoint failed to satisfy the relevant condition. Some confidence indicators can have user defined parameters, some do not.

Omega can utilize these flags to reject a datapoint in case a read result has any of these flags associated with it. In such case Omega will wait for a datapoint without any flags, or until a timeout happens.

See table for which flags can be enabled in Omega and the relevant instrument commands to use.

6.2 Omega results ratio (per node setting)

Another way to judge the data quality is to compare two results to each other and see how much they vary.

Looking at the stream of results, and by taking two non-adjacent readings from the data stream and comparing their real to real and imaginary to imaginary parts accordingly. If the “results ratio” of real parts is below a set threshold, one may deem that the measurement process has reached an equilibrium, and the result is accepted. Likewise, if the ratio between the imaginary parts is below the threshold, the result is accepted. So the result is accepted if either real ratio or imaginary ratio (or both) is below the threshold. This ratio can be set individually for every node on the “IC and IS node parameters” tab. The default 1.001 so 0.1%. To turn off the results ratio functionality, set the value to 0.

If the results ratio is larger than the threshold, the result is ignored and Omega will wait for a datapoint that fulfils the criteria, or until a timeout takes place.

6.3 Timeout

The user may turn on confidence indicators and/or the results ratio. Having too tight requirements, open circuit, difficult sample, etc., may result in timeout. **Imp. spectrometer timeout (s)** is per measurement setting, with a default of 15 seconds. If the result fail to fulfil the above conditions, and the timeout occurs, result is marked as NaN and the measurement continues to the next task.

Flags	Used in Omega since	Notes
ZI_IMP_FLAGS_NONE = \$00000000		
ZI_IMP_FLAGS_VALID_INTERNAL = \$00000001		
ZI_IMP_FLAGS_VALID_USER = \$00000002		
ZI_IMP_FLAGS_AUTORANGE_GATING = \$00000004		
ZI_IMP_FLAGS_OVERFLOW_VOLTAGE = \$00000010	2022-06-28	Manual page 327. "Enables the overload detection for current and voltage"
ZI_IMP_FLAGS_OVERFLOW_CURRENT = \$00000020	2022-06-28	Manual page 327. "Enables the overload detection for current and voltage"
ZI_IMP_FLAGS_UNDERFLOW_VOLTAGE = \$00000040	2022-06-28	Manual page 327. "Enables the underflow detection for current and voltage."
ZI_IMP_FLAGS_UNDERFLOW_CURRENT = \$00000080	2022-06-28	Manual page 328. "The underflow condition is met if the measured amplitude is lower than the specified ratio relative to full scale."
ZI_IMP_FLAGS_FREQ_EXACT = \$00000100		
ZI_IMP_FLAGS_FREQ_INTERPOLATION = \$00000200		
ZI_IMP_FLAGS_FREQ_EXTRAPOLATION = \$00000400		
ZI_IMP_FLAGS_LOWDUTYT = \$00000800		
ZI_IMP_FLAGS_SUPPRESSION_PARAM0 = \$00001000		
ZI_IMP_FLAGS_SUPPRESSION_PARAM1 = \$00002000		
ZI_IMP_FLAGS_FREQLIMIT_RANGE_VOLTAGE = \$00004000		
ZI_IMP_FLAGS_FREQLIMIT_RANGE_CURRENT = \$00008000		
ZI_IMP_FLAGS_STRONGCOMPENSATION_PARAM0 = \$00010000		
ZI_IMP_FLAGS_STRONGCOMPENSATION_PARAM1 = \$00020000		
ZI_IMP_FLAGS_NEGATIVE_QFACTOR = \$00040000		
ZI_IMP_FLAGS_BWC_BIT0 = \$00100000		
ZI_IMP_FLAGS_BWC_BIT1 = \$00200000		
ZI_IMP_FLAGS_BWC_BIT2 = \$00400000		
ZI_IMP_FLAGS_BWC_BIT3 = \$00800000		
ZI_IMP_FLAGS_BWC_MASK = \$00F00000		
ZI_IMP_FLAGS_OPEN_DETECTION = \$01000000		
ZI_IMP_FLAGS_OVERFLOW_SIGIN0 = \$04000000		
ZI_IMP_FLAGS_OVERFLOW_SIGIN1 = \$08000000		
ZI_IMP_FLAGS_MODEL_MASK = \$F0000000		

Other confidence indicator flags and relevant default instrument commands can be enabled in Omega on request.

6.4 Instrument commands

Quote from instrument manual

/DEV.../IMPS/n/CONFIDENCE/QFACTOR/ENABLE

Properties: Read, Write, Setting

Type: Integer (64 bit)

Unit: None

Enables the detection of negative Q or D factors. Negative Q or D factors mean the measured impedance does not correspond to the chosen Representation. This can be due to an erroneous compensation, a bad choice of the Representation, or noise.

This command can be sent to the instrument through Omega. The format is three pieces of information separated by | sign:

Setting path|<type of data, either Integer or Double>|Value to apply

So change the setting defined in above quote one would add to Omega Instrument commands before measurement:

/DEVxxxx/IMPS/0/CONFIDENCE/QFACTOR/ENABLE|<Integer>|1

Where xxxx is the numerical part of your instrument ID.

Different settings have different units. Typical integer value On=1 Off=0, Double values for example for frequency, where the format of the number would be 123.456