Increasing Productivity by Networking Instruments

TECHNICAL BRIEF

KEITHLEY
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Introduction

Oftentimes, test setups will require monitoring signals over long periods of time without the constant presence of an operator. When these tests reside in a lab area that is not nearby one's typical working area, it can be inconvenient to make repetitive trips between the two stations several times a day, and increases the potential to miss when tests begin to return unexpected results.

Furthermore, it can be time consuming to operate older instruments that lack a fluid user interface like more modern equipment uses. Because no direct upgrade of these older instruments is possible, the user must look for other options that will streamline and ease their daily interactions.

Users of LAN-enabled equipment stand to benefit from their connectivity potential. Overcoming these obstacles and increasing productivity is easy with any Ethernet-capable Keithley instrument. By connecting an instrument via LAN, the user gains access to a multitude of remote monitoring and bench control features including, the Virtual Front Panel and TSP-Net.

This technical note will provide some high-level setup steps to connect to Keithley instruments with web enabled services (automatic and manual networking configuration). Web tools such as the informative home and administration screens, send and receive command windows, and the Virtual Front Panel will be introduced. We conclude with an example of how a script, code written by the user that is executed on the Keithley touch instrument, can be generated to manage routine operations of a remote piece of test equipment from a single user interface.

Setup Your Instrument for Remote Communications

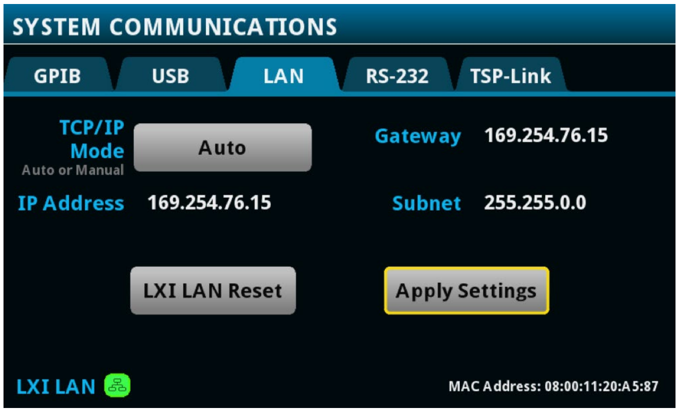
Automatic Networking

The automatic TCP/IP mode automatically generates an IP address for the instrument to utilize for LAN communications. When set to automatic, the instrument will identify and match its Subnet and Gateway addresses to those of the connected network or adapter (per the local DHCP server), and obtain a valid IP address. Plug an ethernet cable into the LAN port on the back of the instrument and connect it to a PC or additional instrument to employ a multitude of remote programming options.

Note that LAN communications cannot be utilized if the instrument is a DMM6500 or DAQ6510 and currently using a USB connection. To swap communication methods from USB to LAN, simply unplug the USB cable from the port on the back of the instrument.

To set up an automatically generated IP address:

1. Press the **Menu** Key.
2. Under System, select **Communication**.
3. Go to the **LAN** tab.
4. Hit the button next to TCP/IP Mode.
5. Select **Auto**. (Note: It may take several minutes for an IP address to be generated when using **Auto** mode.)
6. Press **Apply Settings**.


SYSTEM COMMUNICATIONS

TCP/IP Mode: Auto (Auto or Manual)

Gateway 169.254.76.15

IP Address 169.254.76.15

Subnet 255.255.0.0

MAC Address: 08:00:11:20:A5:87

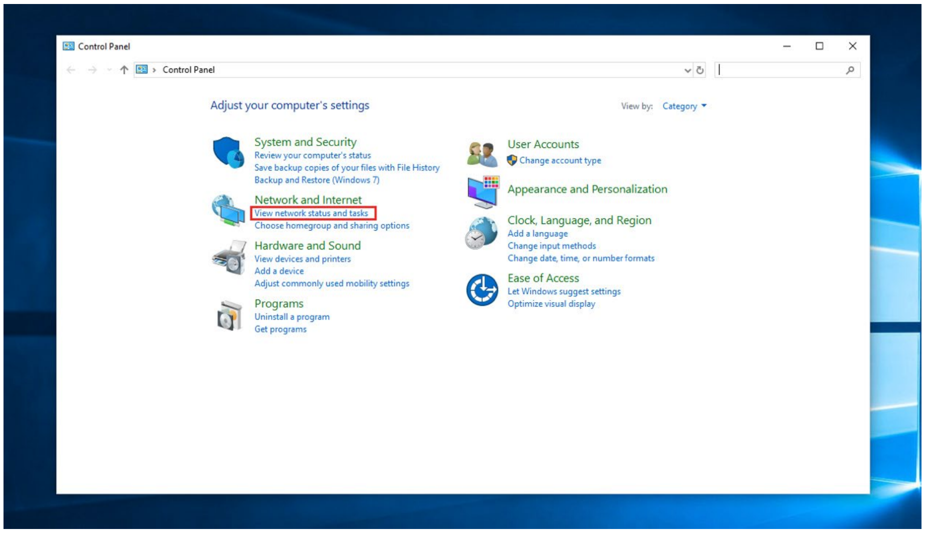
Manual Networking

The manual TCP/IP mode allows the user to specify a usable IP address of his or her choice for the instrument to utilize for LAN communications. Plug an ethernet cable into the LAN port on the back of the instrument and connect it to a PC or additional instrument to employ a multitude of remote programming options.

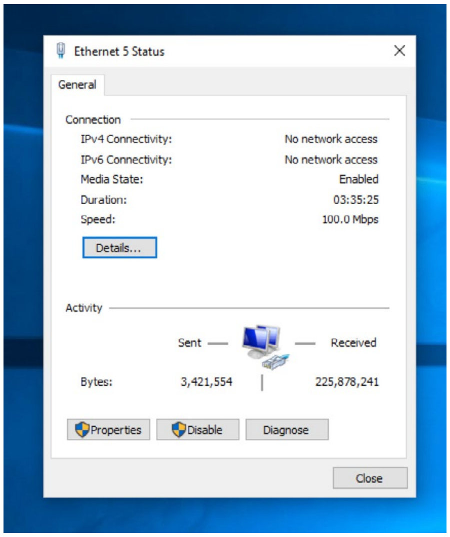
Note that LAN communications cannot be utilized if the instrument is a DMM6500 or DAQ6510 and currently using a USB connection. To swap communication methods from USB to LAN, simply unplug the USB cable from the port on the back of the instrument.

To determine the IP, Subnet, and Gateway addresses used by the computer or ethernet adapter running with a Windows operating system:

1. Open the **Control Panel**.
   a. For Windows 7 users, the Control Panel can be found from the start menu.
   b. For Windows 10 users, the Control Panel can be found by using the Cortana search bar next to the start menu.


Control Panel
Control Panel
Adjust your computer's settings
View by: Category
System and Security
Review your computer's status
Save backup copies of your files with File History
Backup and Restore (Windows 7)
Network and Internet
View network status and tasks
Choose homegroup and sharing options
Hardware and Sound
View devices and printers
Add a device
Adjust commonly used mobility settings
Programs
Uninstall a program
Get programs
User Accounts
Change account type
Appearance and Personalization
Clock, Language, and Region
Add a language
Change input methods
Change date, time, or number formats
Ease of Access
Let Windows suggest settings
Optimize visual display

2. From the Control Panel, under Network and Internet, select **View Network Status and Tasks**. This will open the **Network and Sharing Center**.
3. From the Network and Sharing Center, the user can select the networks and adapters currently connected to the computer.
4. After selecting a network connection, click **Details**. The Details window will display the IP address, Subnet, and Gateway for that network connection.


Ethernet 5 Status

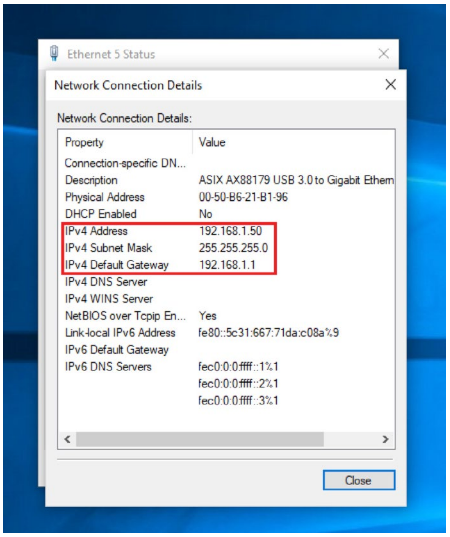
General

Connection

IPv4 Connectivity:	No network access
IPv6 Connectivity:	No network access
Media State:	Enabled
Duration:	03:35:25
Speed:	100.0 Mbps

Activity

	Sent	Received
Bytes:	3,421,554	225,878,241


Ethernet 5 Status

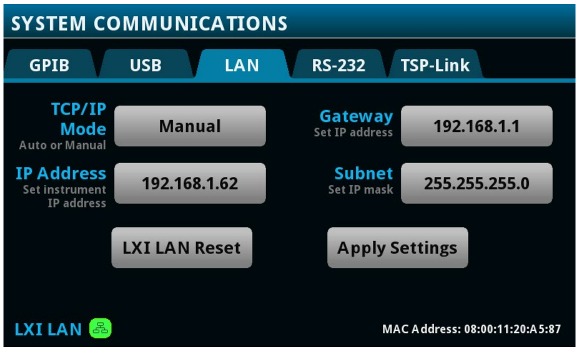
Network Connection Details

Network Connection Details:

Property	Value
Connection-specific DN...	
Description	ASIX AX88179 USB 3.0 to Gigabit Ethern
Physical Address	00-50-B6-21-B1-96
DHCP Enabled	No
IPv4 Address	192.168.1.50
IPv4 Subnet Mask	255.255.255.0
IPv4 Default Gateway	192.168.1.1
IPv4 DNS Server	
IPv4 WINS Server	
NetBIOS over Tcpip En...	Yes
Link-local IPv6 Address	fe80::5c31:667:71da:c08a%9
IPv6 Default Gateway	
IPv6 DNS Servers	fec0:0:0:ffff::1%1 fec0:0:0:ffff::2%1 fec0:0:0:ffff::3%1

To manually set up an IP address on the DMM6500 or DAQ6510:

1. Press the **Menu** Key.
2. Under System, select **Communication**.
3. Go to the **LAN** tab.
4. Hit the button next to TCP/IP Mode.
5. Select **Manual**.
6. Type in the preferred IP Address, Gateway Address, and Subnet Address in the appropriate fields using the displayed number pad.
   a. Be sure to match the Subnet and Gateway addresses to those of the preferred network, but DO NOT match the IP addresses. Be sure to use a unique IP address for the instrument.
7. Press **Apply Settings**.


SYSTEM COMMUNICATIONS

TCP/IP Mode (Auto or Manual): Manual

Gateway (Set IP address): 192.168.1.1

IP Address (Set instrument IP address): 192.168.1.62

Subnet (Set IP mask): 255.255.255.0

MAC Address: 08:00:11:20:A5:87

Several instruments have a convenient indicator that displays the LAN connection status, (see the green "LXI LAN" icon in the above image) however if the instrument is in a remote location or does not have an indicator, the user can confirm the network connection using the Keithley instrument web interface.

To learn more about networking setups including connections, IP addressing, and Ethernet adapters, see the Network Primer and Programming Tutorial for Ethernet-based DMM/Data Acquisition Systems.

Using the Embedded Web Tools

Through the web interface, the user can abort tests should unexpected results occur, check the instrument event log for errors and warnings, access and extract data from the instrument buffers, and issue remote programming strings to the instrument.

LXI Home Page

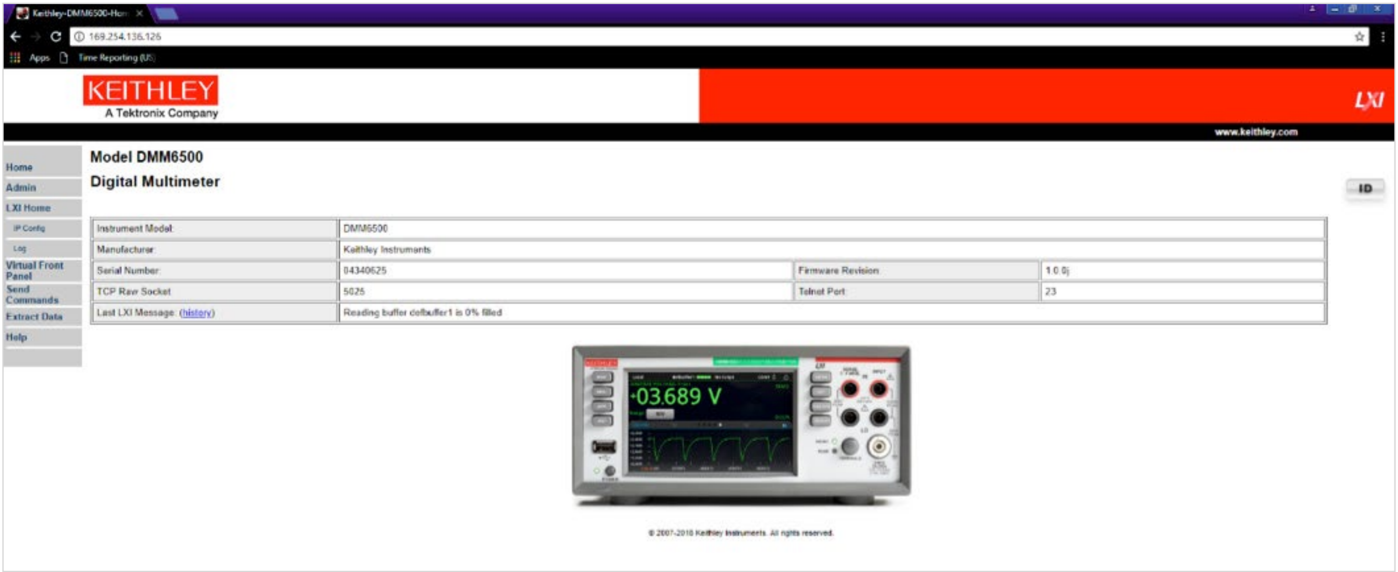
The LXI Home page provides the user with an ID button, which when selected, pulls up the LAN tab in the Communications menu on the connected instrument to help the user identify which instrument is currently being accessed. The IP Configuration page allows the user to change or modify the hostname, TCP/IP configuration mode, IP address, Subnet mask, gateway, DNS server, and domain without having to be in the same room as the instrument. The Event Log records all event messages that the instrument generates and receives, along with identifiers, timestamps, and message text.

To access these features:

1. Begin by connecting the instrument to the same local area network (LAN) that the chosen computer is using via the LAN port on the rear panel with an ethernet cable.
2. Depending on the user's needs, refer to either the Automatic Networking or Manual Networking sections above to create the proper system communications setup.
3. Open a web browser on the host computer, enter the instrument's IP address in the address box.
4. If prompted, enter a user name and password. The default is admin for both.

Virtual Front Panel

The Virtual Front Panel allows the user to monitor and control the DMM6500 or DAQ6510 remotely from their personal computer over a private network. Note that the DMM6500 and DAQ6510 allow fewer than three clients to open the virtual front panel web page at the same time. Only the first successfully connected client can operate the instrument. Other clients can view the virtual front panel. The Virtual



Model DMM6500

Digital Multimeter

Instrument Model:	DMM6500		
Manufacturer:	Keithley Instruments		
Serial Number:	04340625	Firmware Revision:	1.0.0j
TCP Raw Socket:	5025	Telnet Port:	23
Last LXI Message: (history)	Reading buffer defbuffer1 is 0% filled		

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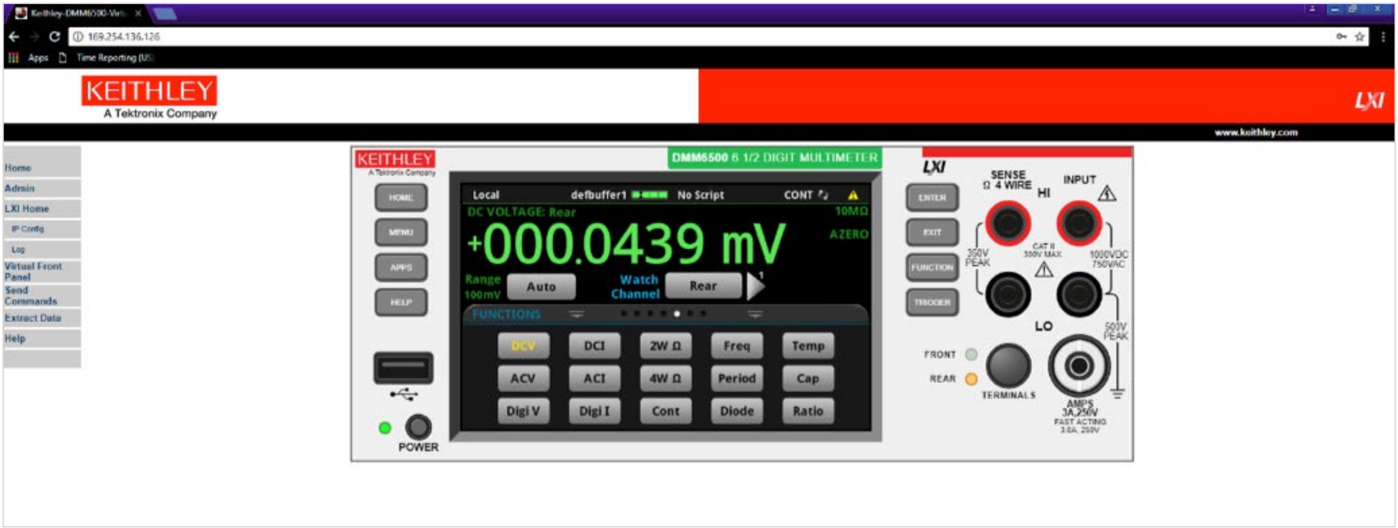
Front Panel can be operated in a similar fashion to the front panel of the DMM6500 and DAQ6510, supporting most swipes and behaviors. Any test, setup, scan, or instrument setting that can be created or changed using the instrument's front panel can also be done using the Virtual Front Panel.

Exceptions to typical front panel behavior include:

- The instrument cannot be powered off from the Virtual Front Panel.
- The Front/Rear Terminals switch acts only as an indicator and cannot be interacted with remotely.
- The user cannot pinch nor zoom on the graph screen.
- To scroll up, down, left, or right hold the left mouse button and swipe up, down, left, or right.
- To navigate the HOME swipe menus more easily, click the dots at the top of the screen to maneuver through the swipe menus.

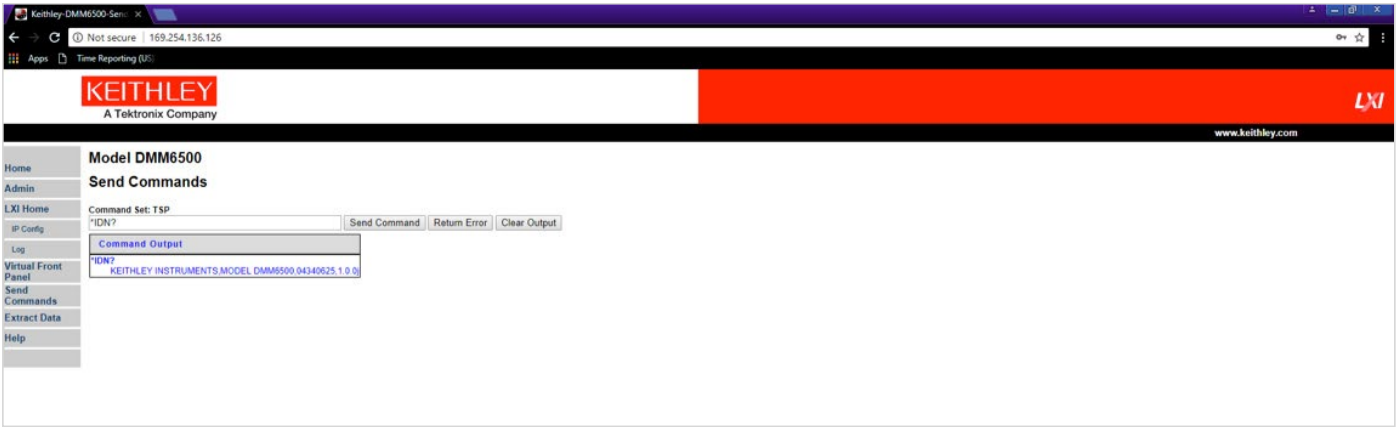


Some additional options to be aware of when using the Virtual Front Panel are as follows:

- Right click on the Virtual Front Panel to reveal a pop-up presenting the option to enable/disable the **High Resolution** option. When enabled, the High Resolution mode will give you a clearer image of the instrument front panel; however, the update rate will have some additional delay. When disabled, the front panel image will not be as finely detailed but the update rate is faster.
- Right click on the Virtual Front Panel to reveal a pop-up presenting the Screen Only option. By default, the Virtual Front Panel provides a full instrument view. When the Screen Only option is selected, the user will only see the instrument display.

Sending Commands and Extracting Buffer Data

The Send Commands page automatically senses the command set currently being used by the instrument and allows the user to send commands directly to the instrument. To send a command, type the command into the command box and click **Send Command**. The command is then displayed in the Command Output box and responses to the command are displayed after. To view errors, click **Return Error**, and to clear the output list, click **Clear Output**.



Model DMM6500

Send Commands

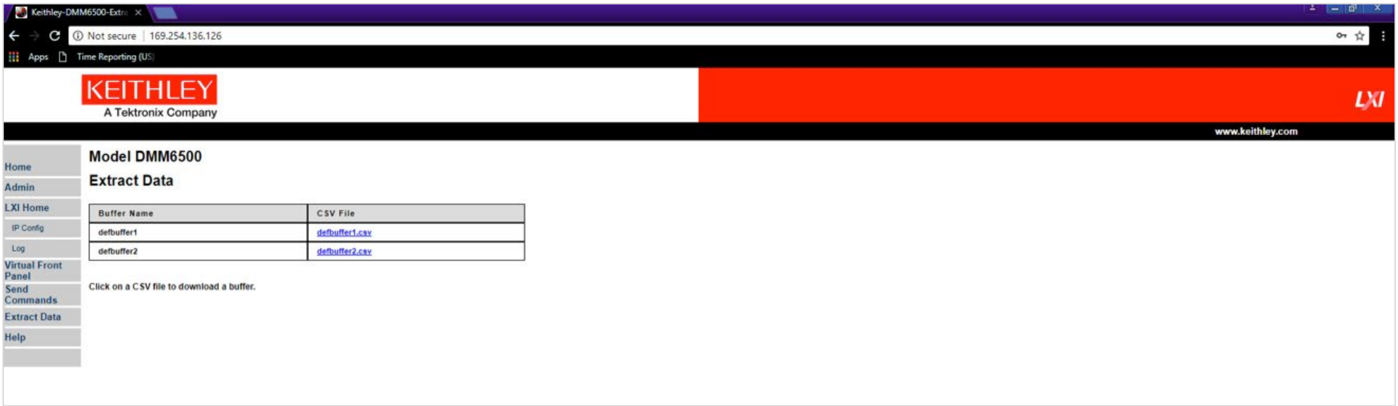
Command Set: TSP

*IDN?

Command Output

```
*IDN?
    KEITHLEY INSTRUMENTS,MODEL DMM6500,04340625,1.0.0
```

The Extract Buffer Data page allows the user to download reading buffer data from the instrument. To download the buffer data, click on the download link for the chosen buffer. Typically, the file will open in Microsoft Excel.



Model DMM6500

Extract Data

Buffer Name	CSV File
defbuffer1	defbuffer1.csv
defbuffer2	defbuffer2.csv

Click on a CSV file to download a buffer.

To learn more about the web interface, consult either the Keithley DMM6500 or Keithley DAQ6510 reference manuals.

Controlling Other LAN Connected Instruments

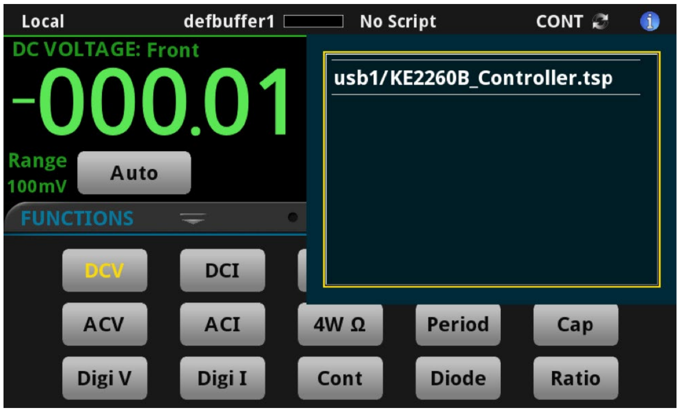
With the use of Keithley TSP-Net the user can use newer instruments, such as the DMM6500 and the DAQ6510, to control older ethernet compatible instruments. Using this feature, instruments can be controlled remotely by other instruments, without a PC. This type of setup is especially convenient for when an instrument lacks a front panel or requires navigating through settings with numerous buttons or knobs. Using TSP-Net, the user can use an instrument with a touch screen to act as a front panel for another instrument that is lacking one.

TSP-Net

TSP-Net allows any Keithley Test Script Processor enabled instrument to directly control up to 32 different ethernet enabled devices without the use of a controlling computer. Instead, the instruments are all connected to the same network. This allows one or more instruments that are not necessarily located in the same immediate area to control the others remotely and communicate with each other. The controlling instrument uses commands from the TSP-Net library to transfer string data to and from a remote instrument, and can then transfer and format data into Lua variables, so the user can send the appropriate commands to the target instrument even if it is not TSP compatible. To set up a TSP-Net connection, connect the desired instruments to the same network or to one another via ethernet cable and upload the TSP-Net script onto the controlling instrument. Scripts allow the user to customize their setup, including the ability to control other instruments through GUIs. Look to the appendix below to view an example TSP-Net script.

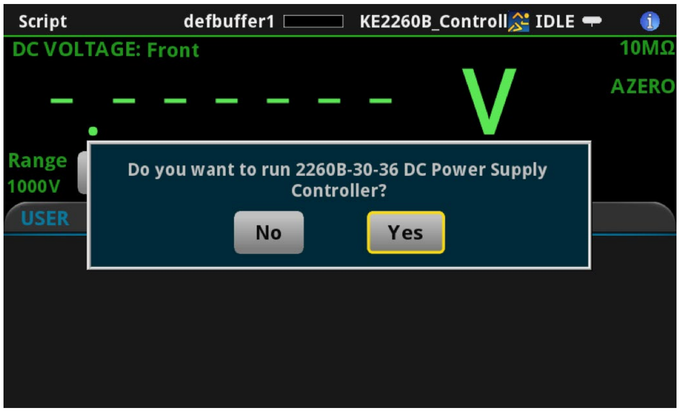
The provided custom script (See Appendix) allows the user to remotely control a Keithley Model 2260B-30-36 360W Multi-Range DC Power Supply via the front panel of a Keithley DMM6500 or Keithley DAQ6510. This setup uses the power of TSP-Net to apply the ease and intuitiveness of the DMM6500 and DAQ6510 touch interface to an older instrument. Essentially, the DMM6500 or DAQ6510 will act as a touch screen front panel for the 2260B.

1. Insert the USB flash drive containing the script into the front panel of the DMM6500 or DAQ6510. Towards the top of the **HOME** screen, press “No Script” and select the script in the resulting menu.

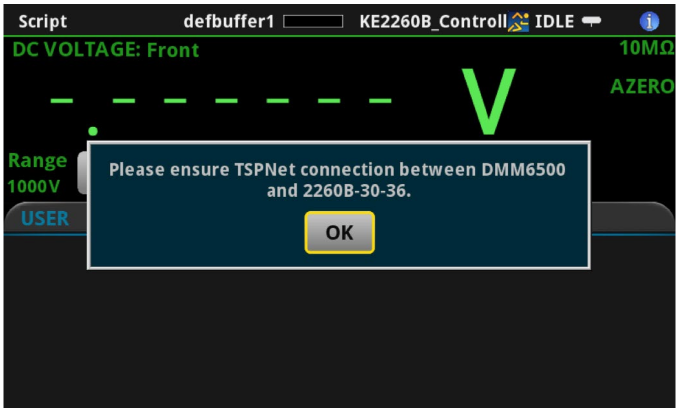


usb1/KE2260B_Controller.tsp

2. The script will open a dialog asking whether the user wants to run the program, followed by a prompt for the user to ensure that the physical setup is correct.

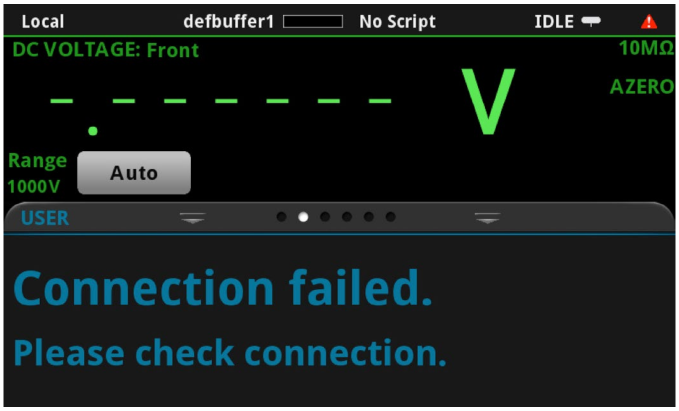


Do you want to run 2260B-30-36 DC Power Supply Controller?



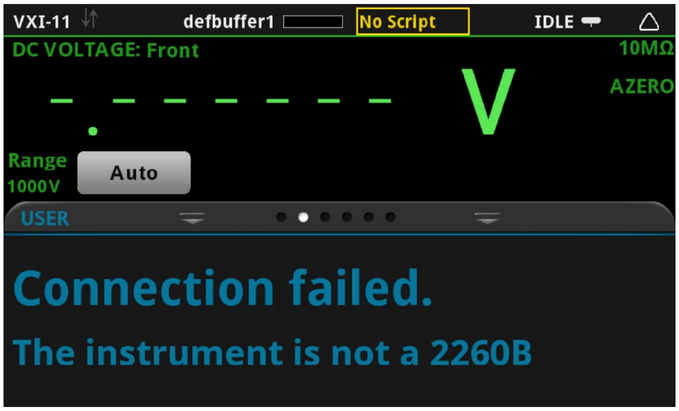
Please ensure TSPNet connection between DMM6500 and 2260B-30-36.

3. Next, the script establishes and tests the TSP-Net connection between the instruments. This step will fail if the connection is faulty or if the target instrument is not a Model 2260B-30-36, and a corresponding message will be displayed on the **USER** swipe screen.



Connection failed.

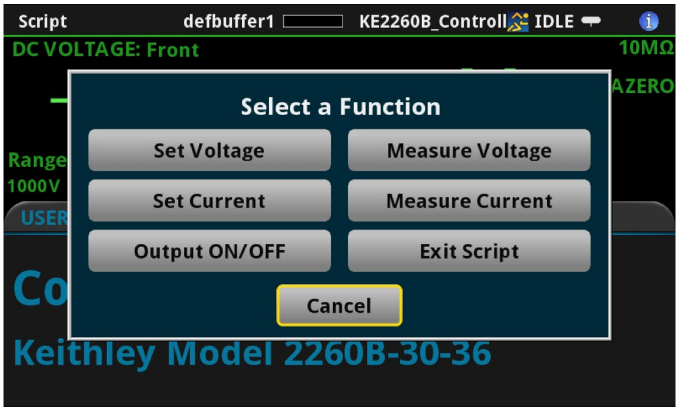
Please check connection.



Connection failed.

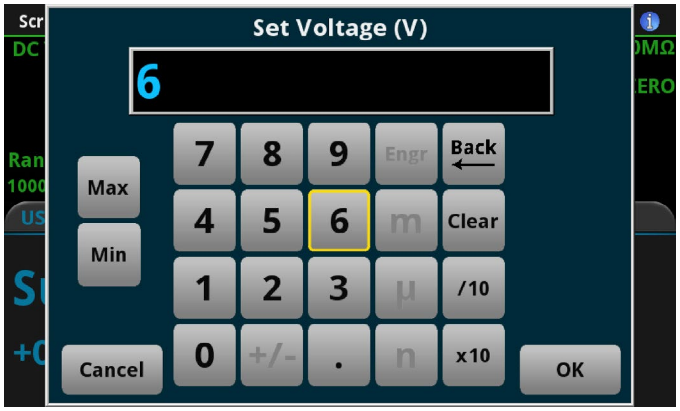
The instrument is not a 2260B

4. If the connection is successful, the script will display a menu of instrument control options, including: Set Source Voltage, Set Current Limit, Measure Supplied Voltage, Measure Supplied Current, Toggle Source Output, and Exit Script.

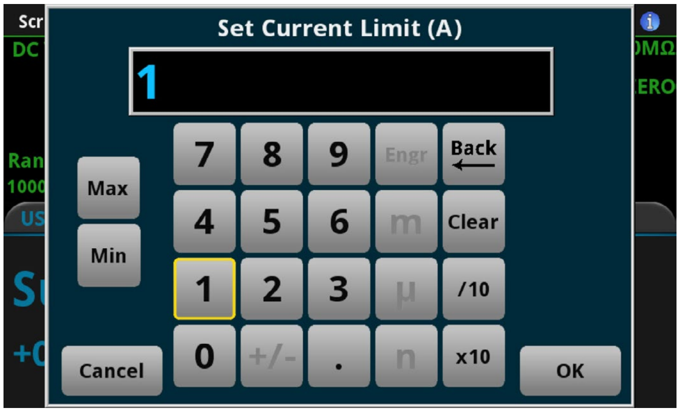


Keithley Model 2260B-30-36

5. Selecting **Set Voltage** or **Set Current** will cause a number pad to be displayed. For **Set Voltage**, the user can input any positive decimal between 0 and 30 volts. For **Set Current**, the user can input any positive decimal between 0 and 36 amperes.

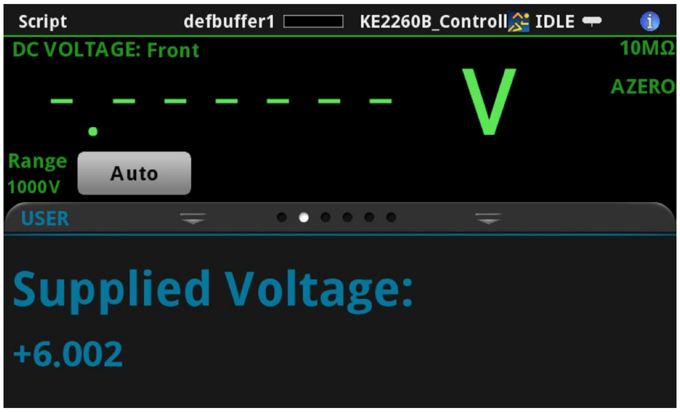

Set Voltage (V)

6


Set Current Limit (A)

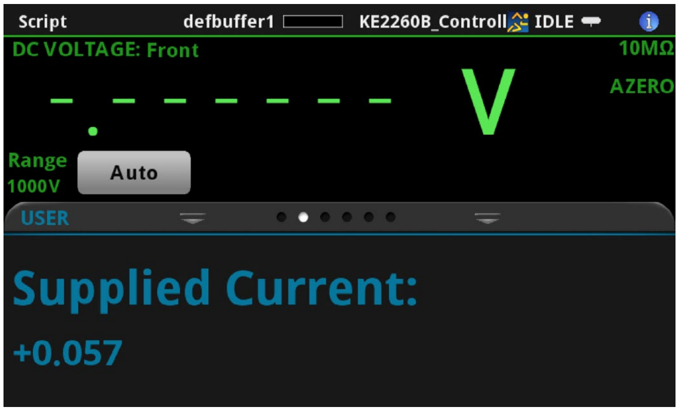
1

6. Selecting **Measure Voltage** or **Measure Current** will cause the value of the voltage or current being supplied by the instrument to be displayed on the **USER** swipe screen.



Supplied Voltage:

+6.002

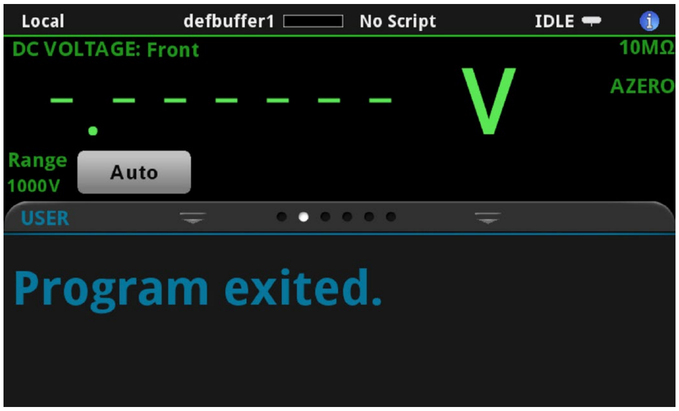


Supplied Current:

+0.057

7. Selecting **Output ON/OFF** will cause the state of the instrument's source output to change either ON or OFF depending on the current state.

8. Selecting **Exit Script** will close the TSP-Net connection, end the script, and display the corresponding message.



Program exited.

9. To learn more about TSP-Net, setup, and associated commands, consult either the Keithley DMM6500 or Keithley DAQ6510 reference manuals.

Conclusion

The host of web interface tools available along with the unique ability to control and manage less intuitive legacy instruments increases productivity and keeps testing on track. The embedded web tools give the user the ability to reference and edit communications settings and information, view and operate the front panel remotely, and send commands to the instrument. Keithley's unique TSP-Net functionality makes it possible to control up to 32 other LAN capable instruments at a time, new and old alike. Scripts allow the user to create custom test setups and controller applications, meanwhile remote networking allows the user to avoid frequent trips to the lab. These tools come together to create a remote and wholly customizable testing and communications environment.

Appendix – Script for Controlling Remote Instruments with TSP-Net

To use the script, copy and paste the code below into Keithley Test Script Builder, making sure to change the IP address assigned to the instAddr variable to the one assigned to the user's Model 2260B-30-36, and save it as KE2260B_Controller.tsp onto the root of a USB flash drive:

```
-- initialize constant values and global variables
local instPort = 2268                         -- Default ethernet port
local instAddr = "192.168.1.20"   -- Remote instrument IP address
local KE2260_idString = "Keithley Instruments Inc.,Model 2260B-30-36" -- 2260B ID String
local tspnet_instID = nil               -- Instrument connection object

- Initialize connection between DAQ and controlled instrument
function tspnet_init(remote_ip, remote_port)
   tspnet.timeout = 5.0
   tspnet.reset()
   tspnet_instID = tspnet.connect(remote_ip, remote_port, "*RST")
   if tspnet_instID == nil then return nil     end
   tspnet_ipaddress = remote_ip
   tspnet.termination(tspnet_instID, tspnet.TERM_LF)

   tspnet_send("*RST")
   return tspnet_instID
end

-- Send command to controlled remote instrument
function tspnet_send(command)
   tspnet.execute(tspnet_instID, command)
end

-- Query data from the controlled instrument and return as a string
function tspnet_query(command, timeout)
   timeout = timeout or 5.0 --Use default timeout of 5 secs if not specified
   tspnet.execute(tspnet_instID, command)
   timer.cleartime()


   while tspnet.readavailable(tspnet_instID) == 0 and timer.gettime() < timeout do
      delay(0.1)
   end
   return tspnet.read(tspnet_instID)
end

-- Terminate the connection between the master and subordinate instrument
function tspnet_destroy()
   if tspnet_instID ~= nil then
      tspnet.disconnect(tspnet_instID)
      tspnet_instID = nil
   end
end

--*** Setup Functions for 2260 **********************************************
-- Get 2260's instrument ID
function KE2260_GetIdString()
   myID = tspnet_query("*IDN?", 5)
   delay(0.1)
   return myID
end

-- Set 2260 Voltage
function KE2260_SetVoltage(volt)
   tspnet_send("DISP:MENU 3")
   delay(0.1)
   tspnet_send("VOLT " .. tostring(volt) .."\n")
   delay(0.1)
end

-- Set 2260 Current Limit
function KE2260_SetCurrent(curr)
   tspnet_send("DISP:MENU 3")
   delay(0.1)
   tspnet_send("CURR " .. tostring(curr) .."\n")
   delay(0.1)
end

-- Get 2260 Actual Voltage Output
function KE2260_GetVoltage()
   realVolt = tspnet_query("MEAS:VOLT?\n", timeout)
   display.changescreen(display.SCREEN_USER_SWIPE)
   display.settext(display.TEXT1, "Supplied Voltage:")
   display.settext(display.TEXT2, realVolt)
   delay(2)
end

-- Get 2260 Actual Current Output
function KE2260_GetCurrent()
   realCurr = tspnet_query("MEAS:CURR?\n", timeout)
   display.changescreen(display.SCREEN_USER_SWIPE)
   display.settext(display.TEXT1, "Supplied Current:")
   display.settext(display.TEXT2, realCurr)
   delay(2)
end

-- Set 2260 Output State ON
function KE2260_outputStateON()
   tspnet_send("OUTP ON\n")
   delay(0.1)
end

-- Set 2260 Output State OFF
function KE2260_outputStateOFF()
   tspnet_send("OUTP OFF\n")
   delay(0.1)
end

-- Check Output State
function KE2260_checkOutput()
   Ostate = tspnet_query("OUTP?\n", timeout)
   delay(0.1)
   return Ostate
end

-- *** Connection Status **************************************************
-- A function that tests the connection between DMM and 2260B
function test_connection()
   -- connect DMM to 2260B
   tspnet_init(instAddr, instPort)

   -- check for initial tsp connection
   if tspnet_instID == nil then
      display.changescreen(display.SCREEN_USER_SWIPE)
      display.settext(display.TEXT1, "Connection failed.")
      display.settext(display.TEXT2, "Please check connection.")
      return 0
   else
      -- query 2260B’s ID string
      KE2260_GetIdString()
      print (myID)

      -- change to user swipe screen
      display.changescreen(display.SCREEN_USER_SWIPE)

      -- check for query ID string nil value
      if myID == nil or myID == "" then
         display.settext(display.TEXT1, "Failed to query ID.")
         display.settext(display.TEXT2, "Please restart 2260B Controller.")

         -- terminate connection to controller
         tspnet_destroy()
         return 0
      else
         -- get manufacturer and model number from ID string
         -- instrument's name is formatted as follows: manufacturer, model number, serial
number, firmware level.
         -- each variable is separated by a comma ","
         -- the manufacturer_model variable is getting manufacturer and model number by
getting the index of
         -- the first 2 comma ","
         _, endPosition = string.find(myID, ",")
         _, endPosition = string.find(myID, ",", endPosition+1)
         manufacturer_model = string.sub(myID, 1, endPosition-1)

         -- if the manufacturer and model name are not matched
         if manufacturer_model != KE2260_idString then
            display.settext(display.TEXT1, "Connection failed.")
            display.settext(display.TEXT2, "The instrument is not a 2260B")

            -- terminate connection to controller
            tspnet_destroy()
            return 0
         else
            display.settext(display.TEXT1, "Connection Successful!")
            display.settext(display.TEXT2, "Keithley Model 2260B-30-36")
            return 1
         end
      end
   end
end

-- A function that displays exit text
function display_exit_text()
   -- change to user swipe screen
   display.changescreen(display.SCREEN_USER_SWIPE)
   display.settext(display.TEXT1, "Program exited.")
   display.settext(display.TEXT2, "")
end

--*** 2260 Control Code **********************************************
reset()

-- change to User Swipe Screen and clear all messages in this swipe screen
display.changescreen(display.SCREEN_USER_SWIPE)
display.settext(display.TEXT1, "")
display.settext(display.TEXT2, "")

run_choice, result = display.input.prompt(display.BUTTONS_YESNO, "Do you want to run 2260B-30-
36 DC Power Supply Controller?")
display.waitevent(1)

-- if user chose to test connection
if run_choice == display.BUTTON_YES then
```

```
   -- a reminder to ensure connection
   display.prompt(display.BUTTONS_OK, "Please ensure TSPNet connection between DMM6500 and 
2260B-30-36.")
   prompt_ID, result = display.waitevent()
   display.changescreen(display.SCREEN_USER_SWIPE)

   display.settext(display.TEXT1, "Please Wait ...")
   display.settext(display.TEXT2, "Checking Connection”)

   -- test/establish LAN connection
   test_status = test_connection()
end

--Loop that brings up the options menu which drives the 2260 from the 6500/6510
while tspnet_instID ~= nil do

   func_choice, result = display.input.option("Select a Function", "Set Voltage", "Set Current", 
"Output ON/OFF", "Measure Voltage", "Measure Current", "Exit Script")
   display.waitevent(1)

   if func_choice == display.BUTTON_OPTION1 then
      --ask user to specify supply voltage
      volt = display.input.number("Set Voltage (V)", display.NFORMAT_DECIMAL, 0, 0, 30)
      KE2260_SetVoltage(volt)
   end
   if func_choice == display.BUTTON_OPTION2 then
      --ask user to specify current limit
      curr = display.input.number("Set Current Limit (A)", display.NFORMAT_DECIMAL, 0, 0, 36)
      KE2260_SetCurrent(curr)
   end
   if (func_choice == display.BUTTON_OPTION3) then
      --Check if the output is ON or OFF
      KE2260_checkOutput()
      if Ostate == "1" then
         KE2260_outputStateOFF()
      elseif Ostate == "0" then
         KE2260_outputStateON()
      end
   end
   if func_choice == display.BUTTON_OPTION4 then
      --query the voltage being supplied
      KE2260_GetVoltage()
   end
   if func_choice == display.BUTTON_OPTION5 then
      --query the current being supplied
      KE2260_GetCurrent()
   end
   if func_choice == display.BUTTON_OPTION6 then
      --stop the script and disconnect the TSPNet connection
      display_exit_text()
      tspnet_destroy()
   end
end

tspnet_destroy()
```

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