

Design Tutorial: E5061B ENA Custom Multiport Switch Solution using L4491A

Application Note



ENA Series E5061B Network Analyzer

Table of Contents

1. Introduction	3
2. Resource Requirements	3
3. Hardware Configurations	4
3.1. L4491A front panel.....	4
3.2. System setup	5
3.3. E5061B network analyzer	5
3.4. L4491A switch platform.....	5
3.4.1. <i>Switch configuration</i>	5
3.4.2. <i>34945EXT module and distribution board</i>	6
4. Software Installation and Configurations	7
4.1. Connection configuration through Agilent connection expert using the USB/GPIB interface.....	7
4.2. Connection configuration through Agilent connection expert using LAN interface	7
4.3. How to change the GPIB address or IP address.....	8
5. Switch Box Control Programming Basic.....	9
5.1. Configuration file.....	9
5.2. Channel assignment and switch control command	10
5.3. VBA sample code.....	11
5.4. Operational example with the VBA program	13

1. Introduction

This document describes how to configure a 12-port custom switch box with the Agilent Technologies L4491A RF/Microwave switch platform. It also outlines the basic procedure for operating the custom switch box using the E5061B ENA Series network analyzer.

For a switch box using SP6T switches, the box is designed using an Agilent 50-Ω network analyzer

such as the E5061B with Option 235. However, because a 75-Ω multiport switch box solution has wider application, such as for CATV passive component measurements, this document describes how to configure a custom 75-Ω multiport switch box. The custom switch box uses mechanical coaxial switches and can be operated by the E5061B network analyzer via GPIB or LAN.

The custom switch box provides the ability to make a single connection and obtain multiple measurements

of multiport devices. This increases throughput by reducing the number of device reconnects that operators need to perform.

Please note that this document provides basic information for designing a custom multiport switch box. For detailed information, refer to the reference resources provided throughout the document.

2. Resource Requirements

Product	Qty
E5061B ENA Series network analyzer with Option 235	1
L4491A RF Switch Platform	1
34945EXT module (included in the L4491A chassis)	1
Terminated SPDT switch (N1810TL-004 or 8762A (low cost))	14
Terminated SP6T switch (87106A or L7106A (low cost))	4
Distribution board for SPDT switches (Y1150A)	2
Distribution board for SP6T switches (Y1151A)	2
Type N 50-Ω cables (connects the L4491A to the E5061B)	2
50-Ω N(m) to 75-Ω N(f) minimum loss pad, (Agilent 11852B Option 004), Maximum input power = 250 mW or + 24 dBm	12

3. Hardware Configurations

3.1. L4491A front panel

Figure 1 shows an example of the front panel for the 12-port custom switch box. The standard L4491A front panel does not have ports for the reflection, transmission, and test port connectors. These openings must be made by the user to create the custom switch box.

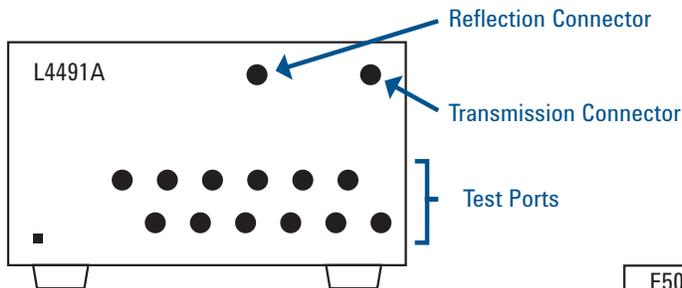


Figure 1. Front panel features

Reflection connector

The reflection connector is a female type-N 50-Ω connector and connects directly to Port 1 of the E5061B using a type-N(m)-to-type-N(m) cable.

Transmission connector

The transmission connector is a female type-N 50-Ω connector and connects directly to Port 2 of the E5061B using a type-N(m)-to-type-N(m) cable.

Test ports (ports 1 to 12)

Ports 1 thru 12 are female type-N 50-Ω connectors and connect to the device under test (DUT). To configure a 75-Ω multiport test set, connect a 50-Ω N(m) to 75-Ω N(f) minimum loss pad to the test port connectors. (If desired, a 50-Ω multiport switch box can be configured by removing the 50-Ω to 75-Ω minimum loss pads in front of test ports on the custom switch box.)

3.2. System setup

Place the L4491A switch platform under the E5061B ENA Series network analyzer. As shown in Figure 2, connect the E5061B and the rear panel of the L4491A using a USB/GPIB or LAN cable.

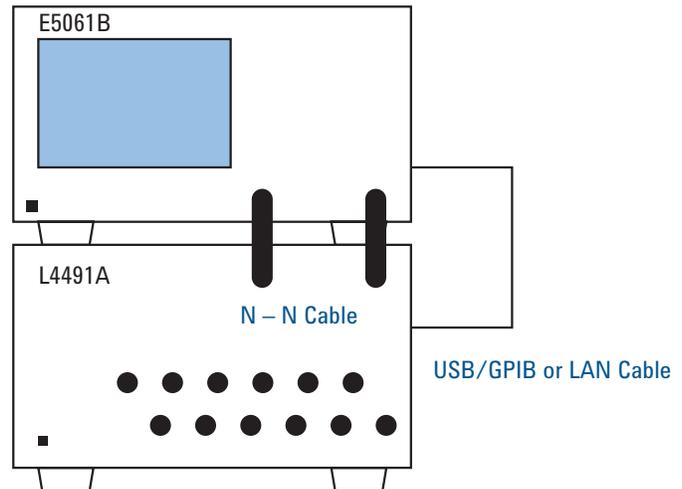


Figure 2. System setup

3.3. E5061B network analyzer

Additional resources

E5061B network analyzer:
 E5061B Network Analyzer Online Help.
<http://ena.tm.agilent.com/e5061b/manuals/webhelp/eng/>
 Agilent E5061B Network Analyzer, installation guide, document number E5061-90008
 - Agilent E5061B Network Analyzer, data sheet, literature number 5990-4392EN

3.4. L4491A switch platform

3.4.1. Switch configuration

The 12-port custom switch box consists of fourteen 1 x 2 SPDT switches and four 1 x 6 SP6T switches. Their configuration in the L4491A RF switch platform is shown in Figure 3.

Table 1 shows the connection diagram for the reflection and transmission ports, and test ports 1 thru 12. This configuration supports 12-port full crossbar measurement (12x12 port matrix).

Connect the minimum loss pad (11852B Option 004) to all test ports of the switch box if you are configuring a 75-Ω multiport test set.

The switch and port numbers of RF coaxial switches are shown in Figure 4. These numbers are necessary for the distribution board settings.

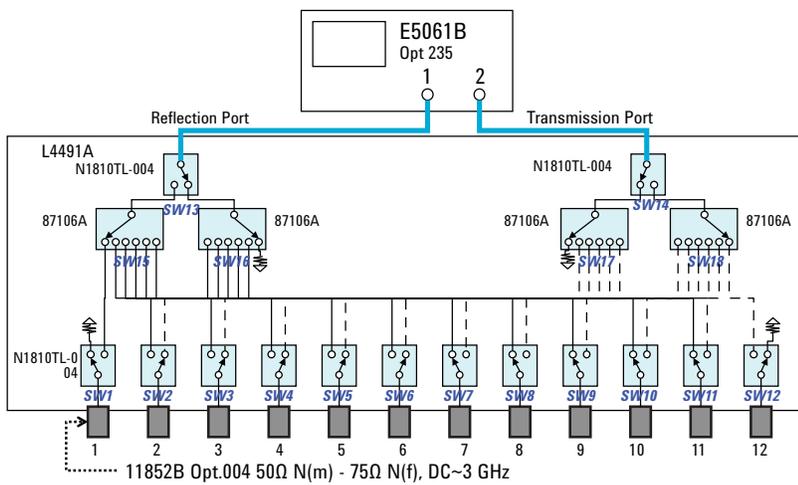


Figure 3. Switch configuration

Table 1. Interconnection between E5061B and Test Ports on L4491A

E5061B Port	Test Port on L4491A
Port 1 (Reflection port)	Port 1 to Port 11
Port 2 (Transmission port)	Port 2 to Port 12

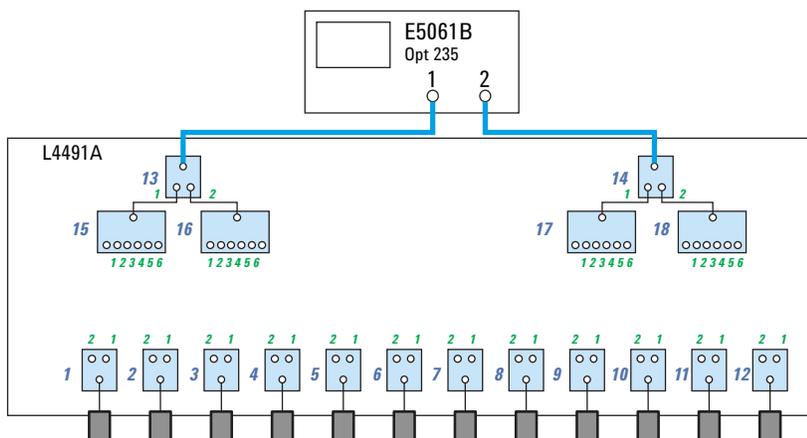


Figure 4. Switch number and switch channel

An example of an L4491A switch assembly is shown in Figure 5 .

Warning: Do not connect a DUT that has DC bias is applied. Use a blocking capacitor to prevent damaging the minimum loss pad.

Additional resources

L4491A switch platform: Agilent L4490A/91A RF Switch Platform, data sheet, literature number 5989-7857EN

8710x Series SP6T switches: Agilent 8710x Series Coaxial Multiport Switches operating and service manual, page 17, document number 87104-90001

Agilent RF and Microwave Switch Selection Guide, literature number 5989-6031EN

N1810 SPDT switches: N1810/1/2 Coaxial Switches, technical overview, literature number 5968-9653E

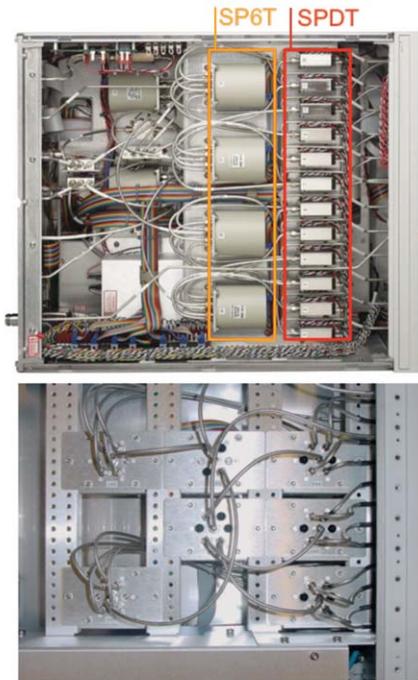


Figure 5. Example of multiport switch assemblies

3.4.2. 34945EXT module and distribution board

Two types of distribution boards are installed on the 34945EXT switch driver module. The SPDT switch is controlled via the Y1150A distribution board and the SP6T switch is controlled via the Y1151A distribution board.

The 34945EXT switch driver module is divided into four banks organized by channel number. (Refer to Section 5.2 “Channel assignment and switch control command.”) Any distribution board may be installed in any bank, and multiple distribution boards of the same type may be installed in the same 34945EXT module.

Additional resources

Agilent 34945A Microwave Switch / Attenuator Driver Module User’s Guide, page 20, document number 34980-90045

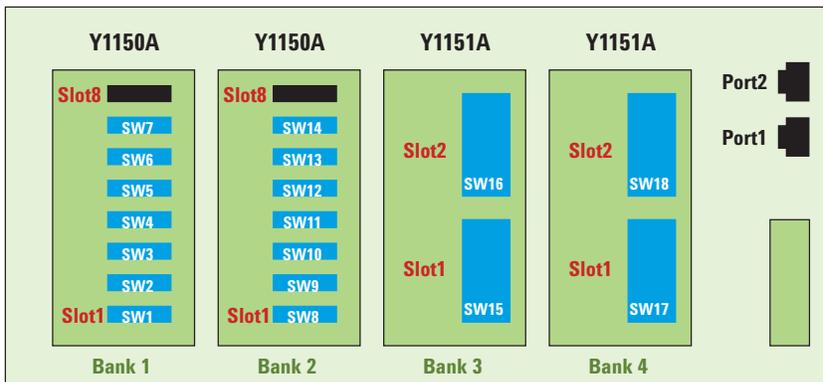


Figure 6. Configuration of distribution boards on the 34945EXT

4. Software Installation and Configurations

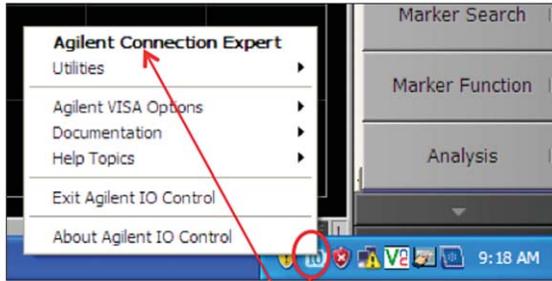
The L4491A is a slave instrument controlled by the E5061B network analyzer. The E5061B has a built-in macro function, allowing a single instruction to substitute for multiple instructions. The E5061B can automatically execute a macro-program containing a series of Visual Basic® for Application (VBA) statements.

Additional resources

Configuring LAN and GPIB interface: Agilent 34945A Microwave Switch / Attenuator Driver Module User's Guide, page 43, document number 34980-90045

4.1. Connection configuration through Agilent connection expert using the USB/GPIB interface

1. Run Agilent connection expert on the E5061B by selecting the icon in the task tray. If you cannot see the task tray, resize the E5061B graphical user interface (GUI) by selecting "Minimize" from the "Resize" menu on the top right corner on the screen.
2. Connect the E5061B and the L4491A using a USB/GPIB interface such as the 82357B. When configured properly the connection is detected automatically and the L4491A appears on "Instrument I/O on this PC" panel of Agilent connection expert as shown in Figure 8.



Clicking the icon opens the pop-up menu

Figure 7. Accessing the Agilent connection expert

4.2. Connection configuration through Agilent connection expert using LAN interface

1. Run Agilent connection expert on the E5061B by selecting the icon on the task tray.
2. Connect the E5061B to the L4491A using a LAN cable. When connecting the E5061B directly to the L4491A, use the LAN cross-over cable (p/n 5061-0701) provided with the L4491A instrument. For network configurations that include a LAN switch or router between the E5061B and the L4491A, a standard LAN cable can be used.

3. Set the IP address, gateway, and subnet mask of the L4491A. For the local connection:
 - IP address
Set the L4491A's IP address one unit higher than the E5061B's IP address. For example, if the IP address of the E5061B is 192.168.0.1 set the L4491A's IP address to 192.168.0.2.
 - Gateway address
Enter the same value as the E5061B's gateway.
 - Subnet mask
Enter the same value as the E5061B's gateway.
4. For the network connection
Use the IP address, gateway, and subnet mask assigned by your IT department.

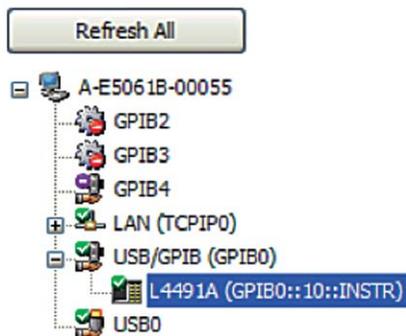


Figure 8. L4491A is added to the Instrument I/O list once connected

4.3. How to change the GPIB address or IP address

1. Run Agilent connection expert.
2. Select "Agilent L4491A" then right click "Access Instrument Web Interface" on the Agilent connection expert drop-down window.
3. When the L4491A LXI menu appears, select "View & Modify Configuration".
4. When the "Current Configuration of L4491A RF Switch Platform" menu appears, select "Modify Configuration".
5. When the "Configuring your L4491A RF Switch Platform" menu appears, input the IP address or GPIB address.
6. To store the new address information, select "Save".

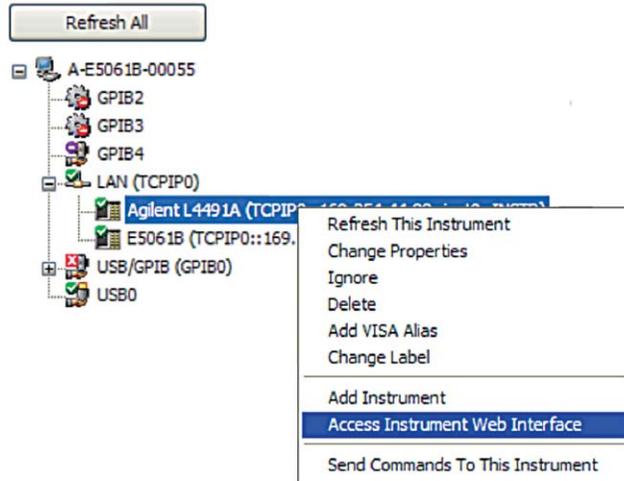


Figure 9. Path to "Access Instrument Web Interface"

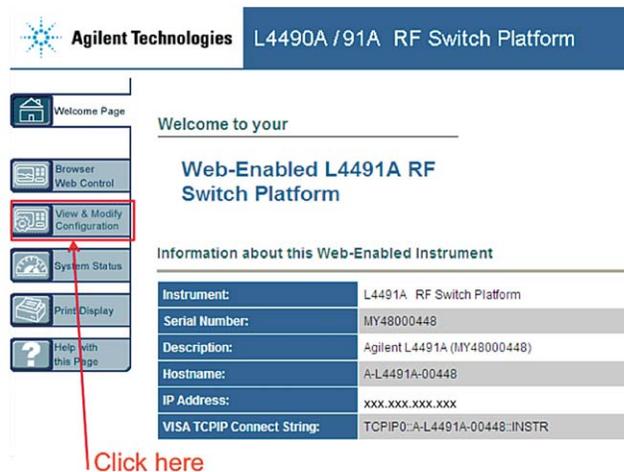


Figure 10. Access to "View & Modify Configuration"

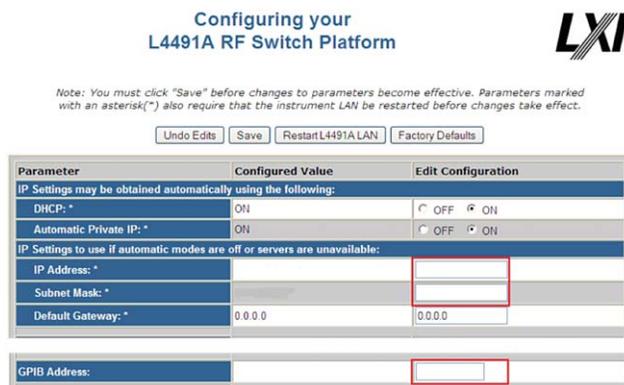


Figure 11. Entry screen for new IP or GPIB address

5. Switch Box Control Programming Basic

5.1. Configuration file

The configuration of the L4491A custom switch box is defined in a .csv-format configuration file similar to the one shown in Figure 12.

1. Enter the GPIB or IP address of the L4491A unit. For a LAN cable connection, use the LAN VISA address of the L4491A such as "TCPIP0::192.168.0.2::inst0::INSTR". Refer to Section 4 for details on how to verify the L4491A's instrument address.

2. Enter switch types, and bank and slot numbers for each switch. The L4491A and 34945EXT number is always "1". (Refer to Agilent 34945A Microwave Switch / Attenuator Driver Module, user's guide, document number 34980-90045 for bank, slot, and channel numbering rules.)
3. Enter the port number definition of the RF switches appropriate for each switch type.
4. Enter switch configurations for Port 1 (reflection port) and Port 2 (transmission port).

#Demo Unit									
IBox Info									
Box#	No of SWs Addr								
1	18 GPIB0::10::INSTR								
ISW Assignment									
SW#	Type	Box	34945EXT	Bank	Slot				
1	SPDT	1	1	1	1	1			
2	SPDT	1	1	1	1	2			
3	SPDT	1	1	1	1	3			
4	SPDT	1	1	1	1	4			
5	SPDT	1	1	1	1	5			
6	SPDT	1	1	1	1	6			
7	SPDT	1	1	1	1	7			
8	SPDT	1	1	2	1				
9	SPDT	1	1	2	2				
10	SPDT	1	1	2	3				
11	SPDT	1	1	2	4				
12	SPDT	1	1	2	5				
13	SPDT	1	1	2	6				
14	SPDT	1	1	2	7				
15	SP6T	1	1	3	1				
16	SP6T	1	1	3	2				
17	SP6T	1	1	4	1				
18	SP6T	1	1	4	2				
IPin Assignment									
Type	Pt1	Pt2	Pt3	Pt4	Pt5	Pt6			
SPDT		0	1						
SP4T		2	3	5	6				
SP6T		1	2	3	4	5	6		
IState									
State	Port1	SW-Top	SW-Mid	SW-Btm	Port2	SW-Top	SW-Mid	SW-Btm	
1	Pt1	SW13-1	SW15-1	SW1-1	Pt2	SW14-1	SW17-2	SW2-1	
2	Pt2	SW13-1	SW15-2	SW2-2	Pt3	SW14-1	SW17-3	SW3-1	
3	Pt3	SW13-1	SW15-3	SW3-2	Pt4	SW14-1	SW17-4	SW4-1	
4	Pt4	SW13-1	SW15-4	SW4-2	Pt5	SW14-1	SW17-5	SW5-1	
5	Pt5	SW13-1	SW15-5	SW5-2	Pt6	SW14-1	SW17-6	SW6-1	
6	Pt6	SW13-1	SW15-6	SW6-2	Pt7	SW14-1	SW18-1	SW7-1	
7	Pt7	SW13-2	SW16-1	SW7-2	Pt8	SW14-2	SW18-2	SW8-1	
8	Pt8	SW13-2	SW16-2	SW8-2	Pt9	SW14-2	SW18-3	SW9-1	
9	Pt9	SW13-2	SW16-3	SW9-2	Pt10	SW14-2	SW18-4	SW10-1	
10	Pt10	SW13-2	SW16-4	SW10-2	Pt11	SW14-2	SW18-5	SW11-1	
11	Pt11	SW13-2	SW16-5	SW11-2	Pt12	SW14-2	SW18-6	SW12-2	

Figure 12. Example of a .csv-format configuration file

5.2. Channel assignment and switch control command

RF switches are controlled by channel syntax as shown in Figure 13.

The channel syntax is defined by a four digit number and decides the contact path of the RF switches.

Channel Syntax = <Slot #>
 <Ext #><Ch #>
 Slot #: always 1.
 Ext #: always 1.
 Ch #: see Table 2.

The lower two digits of the channel syntax are associated with each bank on the 34945EXT. Refer to Table 2.

The Table 3 describes the default settings for the channel syntax of the 18 RF switches. The channel syntax values are set in the initialization process of the switch control program.

For example, if you assign Test Port 3 as the reflection port (E5061B Port 1), send the following commands:
 "ROUT:CLOS(@1126)"
 "ROUT:CLOS(@1143)"
 "ROUT:CLOS(@1113)"

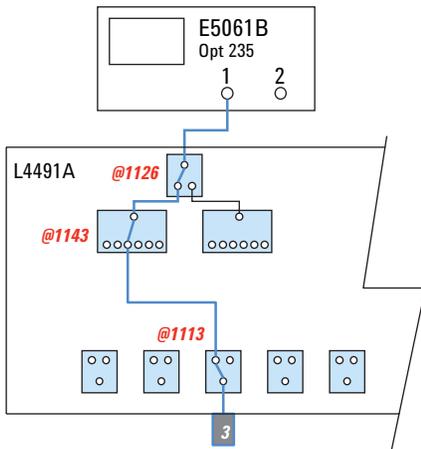


Figure 14. Example commands

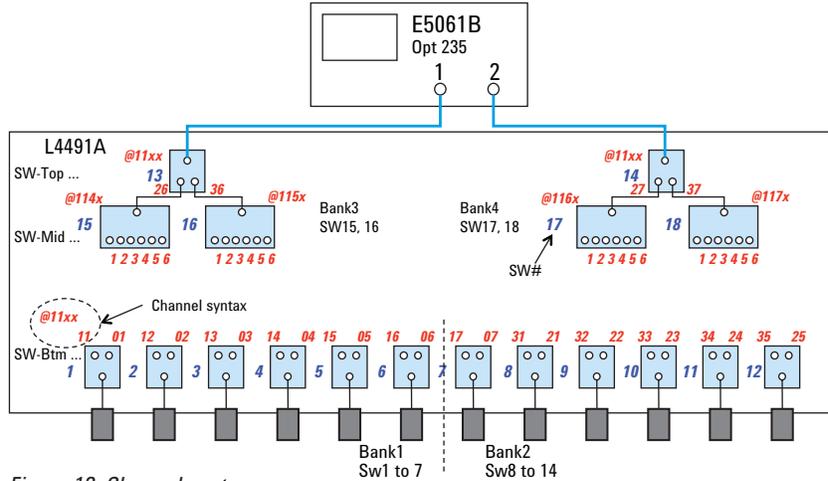


Figure 13. Channel syntax

Table 2. Lower two digits of the channel syntax

Bank	Channels (lower)	Channels (upper)
Bank 1	01 - 08	11 - 18
Bank 2	21 - 28	31 - 38
Bank 3	41 - 48	51 - 58
Bank 4	61 - 68	71 - 78

Table 3. Default channel syntax settings

SW#	Channel syntax	Command
1	@1111	"ROUT:CLOS (@1111)"
2	@1102	"ROUT:CLOS (@1102)"
3	@1103	"ROUT:CLOS (@1103)"
4	@1104	"ROUT:CLOS (@1104)"
5	@1105	"ROUT:CLOS (@1105)"
6	@1106	"ROUT:CLOS (@1106)"
7	@1117	"ROUT:CLOS (@1117)"
8	@1131	"ROUT:CLOS (@1131)"
9	@1132	"ROUT:CLOS (@1132)"
10	@1133	"ROUT:CLOS (@1133)"
11	@1134	"ROUT:CLOS (@1134)"
12	@1125	"ROUT:CLOS (@1125)"
13	@1136	"ROUT:CLOS (@1136)"
14	@1127	"ROUT:CLOS (@1127)"
15	@1141	"ROUT:CLOS (@1141)"
16	@1156	"ROUT:CLOS (@1156)"
17	@1161	"ROUT:CLOS (@1161)"
18	@1176	"ROUT:CLOS (@1176)"

5.3. VBA sample code

Refer to the sample program named "MultiportControl_E5061B_0100.vba", and the switch configuration file named "SW_Config_E5061B.csv" on the Agilent Web site, http://www.home.agilent.com/agilent/redirector.jspx?action=ref&cname=AGILENT_EDITORIAL&ckey=2102183&cc=US&lc=eng, or search them by "MultiportControl_E5061B" keyword on Agilent web site.

```
frmMain ->  
    UserForm_Initialize()
```

This sub-routine initializes the VBA UI (refer to Figure 15). The VBA macro loads the switch port names which are displayed in the list box from the configuration file.

```
SwitchControl -> Set IO
```

This subroutine initializes the VISA COM I/O.

```
Option Explicit  
  
Private Sub UserForm_Initialize()  
  
On Error GoTo ErrHandle  
  
    'Read configuration file.  
    Call ReadSWConfig("D:\VBA\SW_Config_E5061B.csv")  
    'Initialize VISA COM ID.  
    Call SetIO(SWBoxInfo.BoxAddr)  
    'Initialize switch settings  
    Call InitSWSetting  
    'Initialize list box settings.  
    SetListBox  
  
Exit Sub  
  
ErrHandle:  
    MsgBox Err.Description, , "Error@UserFormInitialize"  
    Err.Clear  
  
End Sub
```

```
Public Sub SetIO(IOaddress1)  
  
On Error GoTo ErrHandle  
    'initialize the VISA COM IO for communication  
    Dim io_mgr As VisaComLib.ResourceManager  
  
    If IOaddress1 <> "None" Then  
        'Instantiate the Global Resource Manager  
        Set io_mgr = New VisaComLib.ResourceManager  
        Set SWBox1 = New VisaComLib.FormattedIO488  
        Set SWBox1.IO = io_mgr.Open(IOaddress1)  
        '-----  
        'Set the drive current source to internal.  
        SWBox1.WriteString ("ROUT:RMOD:DRIV:SOUR INT,(@1100)")  
    End If  
Exit Sub  
  
ErrHandle:  
    MsgBox Err.Description, vbExclamation, "Error@SetIO"  
  
End Sub
```

SwitchControl -> SetSwitch

This subroutine sends switch setting SCPI commands (ROUT:CLOS) by reading the connection test port number from the VBA UI (refer to Figure 15).

```
Public Sub SetSwitch(iSWState() As Integer)

    Dim iPt As Integer, iSW_No1 As Integer, iSW_No2 As Integer, iSW_No3 As Integer
    Dim i As Integer, iState As Integer
    Dim sSWChT As String, sSWChM As String, sSWChB As String "T:top, M: middle, B: bottom
    Dim sTmp(5) As String, sTmp1 As String
    Dim vTmp As Variant

    On Error GoTo ErrHandle

    For iPt = 1 To 2
        '--Top Switches-----
        sTmp1 = SWState(iSWState(iPt)).SW_Top(iPt)
        If sTmp1 <> "None" Then
            vTmp = Split(sTmp1, "-")
            iSW_No1 = Cint(Mid(vTmp(0), 3, Len(vTmp(0)) - 2))
            iState = vTmp(1)
            'Get channel syntax.
            sSWChT = SW_addr(iSW_No1, iState)
        End If

        '--Middle Switches-----
        sTmp1 = SWState(iSWState(iPt)).SW_Mid(iPt)
        If sTmp1 <> "None" Then
            vTmp = Split(sTmp1, "-")
            iSW_No2 = Cint(Mid(vTmp(0), 3, Len(vTmp(0)) - 2))
            iState = vTmp(1)
            'Get channel syntax.
            sSWChM = SW_addr(iSW_No2, iState)
        End If

        '--Bottom Switches-----
        sTmp1 = SWState(iSWState(iPt)).SW_Btm(iPt)
        If sTmp1 <> "None" Then
            vTmp = Split(sTmp1, "-")
            iSW_No3 = Cint(Mid(vTmp(0), 3, Len(vTmp(0)) - 2))
            iState = vTmp(1)
            'Get channel syntax.
            sSWChB = SW_addr(iSW_No3, iState)
        End If

        '--SW Switching-----
        If sSWChT <> "" Then
            'Switching control for top switches.
            SWBox1.WriteString ("ROUT:CLOS (@" + sSWChT + ")")
        End If
        If sSWChM <> "" Then
            'Switching control for middle switches.
            SWBox1.WriteString ("ROUT:CLOS (@" + sSWChM + ")")
        End If

        If sSWChB <> "" Then
            'Switching control for bottom switches.
            SWBox1.WriteString ("ROUT:CLOS (@" + sSWChB + ")")
        End If

    Next iPt
    Exit Sub
End Sub
```

SwitchControl -> SW_addr

This sub-routine calculates the channel syntax of the required switch setting. The routine is called from the SetSwitch() sub-routine.

```
Private Function SW_addr(iSW As Integer, iState As Integer) As String
'34945EXT @11**
'Bank1 1 - 8, 11 - 18
'Bank2 21 - 28, 31 - 38
'Bank3 41 - 48, 51 - 58
'Bank4 61 - 68, 71 - 78

Dim iTmp As Integer, iTmp0 As Integer, iTmp1 As Integer, iTmp2 As Integer

iTmp0 = SWProp(iSW).i34945EXT
iTmp = 2 * (SWProp(iSW).Bank - 1)

Select Case SWProp(iSW).SWtype
Case "SP4T"
iTmp1 = iTmp + SWProp(iSW).Slot - 1
iTmp2 = vSP4T(iState)

Case "SP6T"
iTmp1 = iTmp + SWProp(iSW).Slot
iTmp2 = vSP6T(iState)

Case "SPDT"
iTmp1 = 2 * (SWProp(iSW).Bank - 1) + vSPDT(iState)
iTmp2 = SWProp(iSW).Slot
End Select

SW_addr = "1" + CStr(iTmp0) + CStr(iTmp1) + CStr(iTmp2)

End Function
```

5.4. Operational example with the VBA program

When you load the VBA project and run the macro using the [Macro Run] hard key, a user-defined form appears (refer to Figure 15).

You can select the test ports for the reflection and transmission ports.

1. Select the test port for the reflection port.
2. Select the test port for the transmission port.
3. Click "Set" button to change the switch connection.

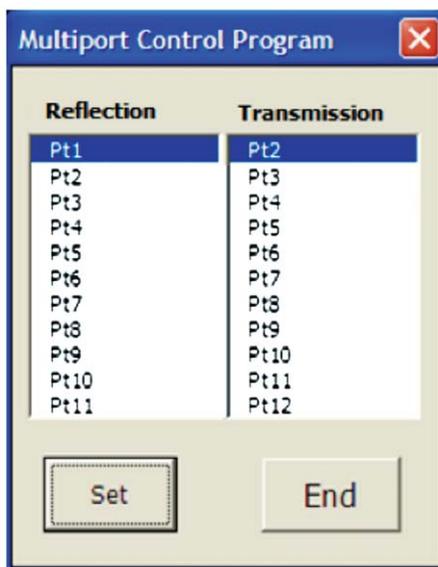


Figure 15. Multiport control program



Agilent Email Updates

www.agilent.com/find/emailupdates

Get the latest information on the products and applications you select.



www.axistandard.org

AdvancedTCA® Extensions for Instrumentation and Test (AXIe) is an open standard that extends the AdvancedTCA for general purpose and semiconductor test. Agilent is a founding member of the AXIe consortium.



www.lxistandard.org

LAN eXtensions for Instruments puts the power of Ethernet and the Web inside your test systems. Agilent is a founding member of the LXI consortium.



www.pxisa.org

PCI eXtensions for Instrumentation (PXI) modular instrumentation delivers a rugged, PC-based high-performance measurement and automation system.

Agilent Channel Partners

www.agilent.com/find/channelpartners

Get the best of both worlds: Agilent's measurement expertise and product breadth, combined with channel partner convenience.



Agilent Advantage Services is committed to your success throughout your equipment's lifetime. To keep you competitive, we continually invest in tools and processes that speed up calibration and repair and reduce your cost of ownership. You can also use Infoline Web Services to manage equipment and services more effectively. By sharing our measurement and service expertise, we help you create the products that change our world.

www.agilent.com/find/advantageservices



The information contained in this document is subject to change without notice. Agilent shall not be liable for errors or for incidental or consequential damages in connection with the furnishing, use, or performance of this document or any information contained herein.

Microsoft, Windows, and Visual Basic and VBA are trademarks or registered trademarks of Microsoft Corporation in the United States and/or other countries.

www.agilent.com
www.agilent.com/find/e5061b

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus

Americas

Canada	(877) 894 4414
Brazil	(11) 4197 3500
Mexico	01800 5064 800
United States	(800) 829 4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 375 8100

Europe & Middle East

Belgium	32 (0) 2 404 93 40
Denmark	45 70 13 15 15
Finland	358 (0) 10 855 2100
France	0825 010 700*
	*0.125 €/minute
Germany	49 (0) 7031 464 6333
Ireland	1890 924 204
Israel	972-3-9288-504/544
Italy	39 02 92 60 8484
Netherlands	31 (0) 20 547 2111
Spain	34 (91) 631 3300
Sweden	0200-88 22 55
United Kingdom	44 (0) 131 452 0200

For other unlisted countries:

www.agilent.com/find/contactus

Revised: June 8, 2011

Product specifications and descriptions in this document subject to change without notice.

© Agilent Technologies, Inc. 2011
Published in USA, November 29, 2011
5990-9359EN



Agilent Technologies