
Keysight - N5244/5A Add 4-Port Capability For Version 6 Synthesizers (For Models With Version 6 Synthesizers Only) - Installation Guide

To Upgrade N5244/5A Series Option
219 to Option 419 -

(900 Hz/10 MHz - 43.5 GHz)

(900 Hz/10 MHz - 50 GHz)

Upgrade Kit Order Numbers:

N5244AU- 942 and N5245AU- 942

Keysight Kit Number: N5245-60106

This is the Installation Guide for the N5244/5A Series Microwave Network Analyzers.

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Keysight Add 4-Port Capability Upgrade Kit
Upgrade Kit Number: N5245-60106
Installation Note

Description of the Upgrade

This upgrade converts your N5244A or N5245A Option 219 2-port analyzer to a N5244A or N5245A Option 419 4-port analyzer by adding:

- an additional source
- an additional source synthesizer
- two additional doublers
- an additional mixer brick
- two additional reference couplers
- two additional test port couplers
- two additional bias tees
- two additional source attenuators
- two additional receiver attenuators
- a splitter
- a modified front panel
- many new cables

Refer to **“Overview of the Installation Procedure” on page 13.**

CAUTION

This repair must be done at a service center or a self-maintainer service center! Refer to **“Getting Assistance from Keysight” on page 4.**

Getting Assistance from Keysight

Installing this upgrade kit requires special skills and experience. If you think you may not be qualified to do the work, or need advice, contact Keysight.

Contacting Keysight

Assistance with test and measurements needs and information on finding a local Keysight office are available on the Web at:

<http://www.keysight.com/find/assist>

If you do not have access to the Internet, please contact your Keysight field engineer.

NOTE

In any correspondence or telephone conversation, refer to the Keysight product by its model number and full serial number. With this information, the Keysight representative can determine whether your product is still within its warranty period.

If You Have Problems With the Upgrade Kit Contents

Keysight stands behind the quality of the upgrade kit contents. If you have problems with any item in the kit, please contact Keysight at

<http://www.keysight.com/us/en/contact.html>.

Getting Prepared

CAUTION

The PNA contains extremely sensitive components that can be ruined if mishandled. Follow instructions carefully when making cable connections, especially wire harness connections.

The person performing the work accepts responsibility for the full cost of the repair or replacement of damaged components.

To successfully install this upgrade kit, you will need the following:

- A license key - refer to **“License Key Redemption”** below.
- A PDF copy or a paper copy of the PNA Service Guide - refer to **“Downloading the Online PNA Service Guide”** below.
- An ESD-safe work area - refer to **“Protecting Your Workspace from Electrostatic Discharge”** below.
- Correct tools - refer to **“Tools Required for the Installation”** on page 8.
- Enough time - refer to **“About Installing the Upgrade”** on page 8
- Test equipment for the post-upgrade adjustments and full instrument calibration. To view the equipment list, click the Chapter 3 bookmark “Tests and Adjustments” in the PDF Service Guide¹

License Key Redemption

NOTE

The enclosed Option Entitlement Certificate is a receipt, verifying that you have purchased a licensed option for the PNA of your choice. You must now use a Keysight Web page to request a license key for the instrument that will receive the option.

To enable the option product, you must request a license key from: <http://www.keysight.com/find/softwaremanager>. To complete the request, you will need to gather the following information:

- From the certificate
 - Order number
 - Certificate number
- From your instrument
 - Model number
 - Serial number

1. See **“Downloading the Online PNA Service Guide”** on page 7.

Getting Prepared

– From the online Keysight HostID utility

Part of the OEC procedure to obtain the 12-digit license key online requires you to provide the HostID number of the PNA. This HostID number is NOT the one currently shown on the PNA. To determine your new HostID, Keysight personnel should use the new model number with the utility at go to

<http://mktwww.srs.is.keysight.com/field/service/network/pna/upgrades.html>.

Non-Keysight personnel should contact Keysight at <http://www.keysight.com/us/en/contact.html>.

– Host ID

Using the information just gathered, you must request license key(s) for your A model or for your B models, a license key file(s) from the Keysight Software Manager: <http://www.keysight.com/find/softwaremanager>.

You will need to provide an email address, Keysight will promptly email your A model license key(s) or a for a B model, license key file(s) attachment message. Refer to **“License Key Redemption” on page 5**.

Verify the License Contents

Refer to the license message you received from Keysight:

If the model number, serial number, or option number do not match those on the license message you received from Keysight, you will not be able to install the license key file. If this is the case, contact Keysight for assistance. Refer to **“Getting Assistance from Keysight” on page 4**.

Downloading the Online PNA Service Guide

To view the online Service Guide for your PNA model number, use the following steps:

1. Go to www.keysight.com.
2. In the Search box, enter the model number of the analyzer (e.g., N5225B) and click **Search**.
3. Click **Support** > **Keysight Product Support**.
4. In the **Search Support** area type your instrument's model number (e.g., N2225B).
5. Press **Enter**.
6. Scroll down to the **PRINT DOCUMENTATION** section and click to select **Service Manual**.

The **Service Manual** for your instrument will be displayed near the top of the right column.

7. Click the hyperlink of the Service Guide title to download the PDF file.
8. When the PDF of the Service Guide is displayed, scroll through the Contents section bookmarks to locate the information needed.

Protecting Your Workspace from Electrostatic Discharge

For information, click on the Chapter 1 bookmark, "Electrostatic Discharge Protection" in the PDF Service Guide¹.

ESD Equipment Required for the Installation

Description	Keysight Part Number
ESD grounding wrist strap	9300-1367
5-ft grounding cord for wrist strap	9300-0980
2 x 4 ft conductive table mat and 15-ft grounding wire	9300-0797
ESD heel strap (for use with conductive floors)	9300-1308

Tools Required for the Installation

Description	Qty	Part Number
T-6 TORX driver - set to 4 in-lbs (0.45 N.m)	1	N/A
T-10 TORX driver - set to 9 in-lbs (1.02 N.m)	1	N/A
T-20 TORX driver - set to 21 in-lbs (2.38 N.m)	1	N/A
5/16-in (8 mm) nutsetter or open end torque wrench - set to 10 in-lbs (1.13 N.m)	1	N/A
5/16-in (8 mm) nutsetter or open end torque wrench - set to 21 in-lbs (2.38 N.m)	1	N/A
3/16-in (5 mm) nutsetter or open end torque wrench - set to 6 in-lbs (0.68 N.m)	1	N/A
5/8-in (16 mm) nutsetter or open end torque wrench - set to 21 in-lbs (2.38 N.m)	1	N/A
9 mm nutsetter or open end torque wrench - set to 21 in-lbs (2.38 N.m)	1	N/A
1-in (25.4 mm) torque wrench - set to 72 in-lbs (8.15 N.m)	1	N/A
1/4-in (6 mm) open end wrench	1	N/A

CAUTION

Use a 5/16-in torque wrench set to 10 in-lbs on all cable connections except the front and rear panel bulkhead connectors and the bias tees. The bias tees should be torqued to 9 in-lbs. And, on the front and rear bulkhead connectors, use a 5/16 inch nutsetter or open end torque wrench set to 21 in-lb.

About Installing the Upgrade

Products affected	N5244A and N5245A Option 219
Installation to be performed by	Keysight service center or personnel qualified by Keysight
Estimated installation time	5 hours
Estimated adjustment time	0.5 hours
Estimated full instrument calibration time	4.5 hours

Items Included in the Upgrade Kit

Check the contents of your kit against the following list. If any part is missing or damaged, contact Keysight Technologies. Refer to **“Getting Assistance from Keysight” on page 4.**

Table 1 **Contents of Upgrade Kit N5245-60106**

Ref Desig.	Description	Qty	Part Number
-	Installation note (this document)	1	N5245-90012
A10	26.5 GHz source (2) assembly	1	5087-7780
A12	Doubler assembly, port 3	2	5087-7349
A13	Doubler assembly, port 4		
A17	13.5 GHz source 2 synthesizer board ^a	3	N5240-60076
A28	Mixer brick (2)	1	5087-7417
A30	Test port 3 reference coupler	2	5087-7760
A31	Test port 4 reference coupler		
A34	Test port 3 coupler	2	5087-7793
A35	Test port 4 coupler		
A39	Test port 3 source attenuator	2	33325-60022
A40	Test port 4 source attenuator		
A43	Test port 3 bias tee (includes wire harness)	2	5087-7855
A44	Test port 4 bias tee (includes wire harness)		
A47	Test port 3 receiver attenuator	2	33325-60023
A48	Test port 4 receiver attenuator		
A26	Splitter	1	5067-4086
-	Front frame, diecast, 4-port	1	N5247-20141
-	Test set front plate, 4-port	1	N5224-00005
-	Machine screw, M3.0 x 6, flat head (to attach lower front dress panel to the test set front plate)	4	0515-1227
-	Machine screw, M2.0 x 6, flat head (to attach 2 reference couplers to brackets)	8	0515-1602
-	Machine screw, M3.0 x 25, pan head (to attach mixer brick A28 to mounting block)	3	0515-0667
-	Machine screw, M4.0 x 10, pan head (2 to attach source 2 to chassis; 2 to attach A12 doubler 3 to chassis; 2 to attach A13 doubler 4 to chassis)	6	0515-0380

Items Included in the Upgrade Kit

Table 1 **Contents of Upgrade Kit N5245-60106**

Ref Desig.	Description	Qty	Part Number
-	Machine screw, M3.0 x 8, pan head (3 to attach shield to mixer brick; 8 to attach 2 src attn and 2 rcvr attn to brackets; 4 to attach 2 bias tee brackets to chassis; 1 to attach cable bracket to deck)	16	0515-0372
-	Machine screw, M2.5 x 16, pan head (to attach splitter to mixer brick)	2	0515-2007
-	Machine screw, M3.0 x 6, pan head (4 to attach 2 reference coupler/bracket assemblies to deck)	4	0515-0374
-	Machine screw, M3.0 x 6, pan head (4 to attach 2 receiver attenuator/bracket assy. to deck; 4 to attach 2 source attenuator/bracket assy to deck; 4 to attach 2 reference coupler/bracket assemblies to deck)	8	0515-0430
-	Machine screw, M3.0 x 14, pan head (to attach 2 bias tees to brackets)	4	0515-2994
-	Front panel overlay (label), 4-port	1	N5242-80003
-	Nameplate, N5245A	1	N5245-80003
-	Nameplate, N5244A	1	N5244-80001
-	Gap pad (between each coupler and test set front sub panel)	4	E4403-20033
-	Gap pad (between mixer brick A28 and shield)	4	N5245-20125
-	Power button overlay (label)	1	N5242-80007
-	50 ohm load, attached to W58 (N5245-20095)	1	1250-4261
-	Vibration mount (between couplers 1 & 3, and 2 & 4)	2	0460-2725
-	Mounting nuts (for port 3 & 4 test port couplers)	2	5022-1087
-	Cable guard, center jumper cables	1	N5242-00030
-	Cable tie wrap, 1 to secure W21 (N5245-20008) to side of deck	5	1400-0249
-	Cable clamp, 1 to secure W25 (N5245-20116) to deck	5	1400-1334
-	Bracket for bias tee	2	N5245-00011
-	Bracket for reference coupler	2	N5245-00017
-	Bracket for cables	1	N5245-00022
-	Bracket for source attenuator and receiver attenuator	4	N5245-00015
-	Dust caps for test ports	4	1401-0214
W2	A10 (source 2) P1 to A17 13.5 GHz source (2) synthesizer J1207	1	N5245-20100
W7	A10 (source 2) P5 to A12 port 3 doubler	1	N5245-20034
W8	A10 (source 2) P3 to A13 port 4 doubler	1	N5245-20035
W9	A10 (source 2) P4 to A12 port 3 doubler	1	N5245-20032

Items Included in the Upgrade Kit

Table 1 **Contents of Upgrade Kit N5245-60106**

Ref Desig.	Description	Qty	Part Number
W10	A12 port 3 doubler to A13 port 4 doubler	1	N5245-20033
W13	A12 port 3 doubler to W14	1	N5245-20036
W14	A30 port 3 reference coupler to W13	1	N5245-20043
W15	A13 port 4 doubler to W16	1	N5245-20036
W16	A31 port 4 reference coupler to W15	1	N5245-20044
W21	A29 port 1 reference coupler to A37 reference mixer switch	1	N5245-20008
W22	A33 port 1 coupler to front-panel Port 1 CPLR ARM	1	N5245-20014
W25	A30 port 3 ref coupler to front-panel REF 3 SOURCE OUT	1	N5245-20116
W26	A34 port 3 coupler to front-panel Port 3 CPLR ARM	1	N5245-20015
W29	A31 port 4 ref coupler to front-panel REF 4 SOURCE OUT	1	N5245-20117
W30	A35 port 4 coupler to front-panel Port 4 CPLR ARM	1	N5245-20018
W34	A36 port 2 coupler to front-panel Port 2 CPLR ARM	1	N5245-20019
W36	Front panel jumper	6	N5245-20155
W44	REF 3 RCVR R3 IN to A28 mixer brick (R3)	1	N5245-20020
W45	REF 4 RCVR R4 IN on A28 mixer brick (R4)	1	N5245-20191
W46	REF 2 RCVR R2 IN to A27 mixer brick (R2)	1	N5245-20115
W52	A25 HMA26.5 to A26 splitter	1	N5245-20013
W53	A26 splitter to A27 mixer brick	1	N5245-20023
W54	A26 splitter to A28 mixer brick	1	N5245-20022
W58	A28 mixer brick to 50 ohm load (1250-4261)	1	N5245-20095
W62	A27 mixer brick (R1) to A24 IF multiplexer (P411)	1	N5242-60021
W63	A27 mixer brick (R2) to A24 IF multiplexer (P412)	1	N5242-60022
W65	A28 mixer brick (D) to A24 IF multiplexer (P801)	1	N5242-60024
W66	A28 mixer brick (R4) to A24 IF multiplexer (P414)	1	N5242-60019
W67	A28 mixer brick (R3) to A24 IF multiplexer (P413)	1	N5242-60020
W68	A28 mixer brick (C) to A24 IF multiplexer (P601)	1	N5242-60023
W70	A20 IF multiplexer (P203) to A12 SPAM (J2)	1	N5242-60013
W72	A20 IF multiplexer (P603) to A12 SPAM (J5)	1	N5242-60015
W77	A14 frequency reference (J7) to A17 13.5 GHz (source 2) synth (J5)	1	N5242-60030

Items Included in the Upgrade Kit

Table 1 **Contents of Upgrade Kit N5245-60106**

Ref Desig.	Description	Qty	Part Number
W84	A42 port 1 bias tee to front panel port 1 CPLR THRU	1	N5245-20085
W85	A30 port 3 reference coupler to A39 port 3 source attenuator	1	N5245-20026
W86	A39 port 3 source attenuator to front-panel Port 3 SOURCE OUT	1	N5245-20027
W87	Port 3 CPLR THRU to A43 port 3 bias tee	1	N5245-20089
W88	A43 port 3 bias tee to A34 port 3 coupler	1	N5245-20086
W89	A31 port 4 reference coupler to A40 port 4 source attenuator	1	N5245-20026
W90	A40 port 4 source attenuator to front-panel Port 4 SOURCE OUT	1	N5245-20028
W91	Port 4 CPLR THRU to A44 port 4 bias tee	1	N5245-20090
W92	A44 port 4 bias tee to A35 port 4 coupler	1	N5245-20088
W96	A45 port 2 bias tee to front panel port 2 CPLR THRU	1	N5245-20087
W99	Port 3 RCVR C IN to A47 port 3 receiver attenuator	1	N5245-20073
W100	A47 port 3 receiver attenuator to A28 mixer brick (C)	1	N5245-20066
W101	Port 4 RCVR D IN to A48 port 4 receiver attenuator	1	N5245-20074
W102	A48 port 4 receiver attenuator to A28 mixer brick (D)	1	N5245-20075
-	Ribbon cable, A23 test set motherboard J547 to A39 port 3 source attenuator	2	N5245-60006
-	Ribbon cable, A23 test set motherboard J548 to A40 port 4 source attenuator		
-	Ribbon cable, A23 test set motherboard J206 to A47 port 3 receiver attenuator	2	N5245-60026
-	Ribbon cable, A23 test set motherboard J207 to A48 port 4 receiver attenuator		
-	Ribbon cable, A23 test set motherboard J552 to A28 mixer brick (2) J52	1	N5247-60015
-	Wire assembly, A23 test set motherboard J221 to ports 1/3 LED board J1	2	N5225-60001
-	Wire assembly, A23 test set motherboard J222 to ports 2/4 LED board J1		

- a. The three 13.5 GHz Synthesizer boards included in this kit are the RoHS compliant N5240-60076 boards. These new boards are not compatible with the old N5230-60002 13.5 GHz Synthesizer boards. If the boards installed in your PNA are the old N5230-60002, you must replace ALL of them with the N5240-60076 boards included in this kit - refer to your PNA Service Guide's chapter 7 for instructions. If your PNA already contains the new boards, scrap the two extra N5240-60076 boards included in this kit.

For the new N5240-60076 boards to function properly in your PNA, you must upgrade your PNA firmware to rev A09.33xx or above. Download PNA firmware at: <http://na.support.keysight.com/pna/firmware/firmware.html>.

NOTE

Extra quantities of items such as protective plastic caps, screws, cable ties, and cable clamps may be included in this upgrade kit. It is normal for some of these items to remain unused after the upgrade is completed

Installation Procedure for the Upgrade

The network analyzer must be in proper working condition prior to installing this option. Any necessary repairs must be made before proceeding with this installation.

WARNING

This installation requires the removal of the analyzer's protective outer covers. The analyzer must be powered down and disconnected from the mains supply before performing this procedure.

NOTE

Some of the following figures provided in this procedure contain bias tees. Bias tees are included in the Option 219/419 upgrade kits and can be ignored for Options 217/417 and 222/422.

Overview of the Installation Procedure

- “Step 1. Obtain a Keyword and Verify the Information.”
- “Step 2. Remove the Outer Cover.”
- “Step 3. Remove the Inner Cover.”
- “Step 4. Remove the Front Panel Assembly.”
- “Step 5. Remove the A23 Test Set Motherboard.”
- “Step 6. Remove Some Cables.”
- “Step 7. Remove the A27 Mixer Brick Assembly.”
- “Step 8. Assemble the A28 Mixer Brick Assembly.”
- “Step 9. Install the A27/A28 Mixer Bricks Assembly.”
- “Step 10. Assemble the A30 and A31 Reference Coupler Assemblies.”
- “Step 11. Install the A30 and A31 Reference Coupler Assemblies.”
- “Step 12. Assemble the A47 and A48 Receiver Attenuator Assemblies.”
- “Step 13. Install the A47 and A48 Receiver Attenuator Assemblies.”
- “Step 14. Assemble the A39 and A40 Source Attenuator Assemblies.”
- “Step 15. Install the A39 and A40 Source Attenuator Assemblies.”
- “Step 16. Install the Bias Tee Brackets.”
- “Step 17. Install the A43 and A44 Bias Tees.”
- “Step 18. Assemble the A33 - A36 Test Port Coupler Assemblies.”
- “Step 19. Install the LED Boards and Test Port Coupler Assemblies to the Test Set Front Plate.”

- “Step 20. Install the Coupler Plate Assembly to the Deck.”
- “Step 21. Assemble the A10 26.5 GHz Source 2 Assembly.”
- “Step 22. Assemble and Install the A12 and A13 Doubler Assemblies.”
- “Step 23. Install the A10 26.5 GHz Source 2 Assembly and Cables.”
- “Step 24. Install the A17 13.5 GHz (Source 2) Synthesizer Board and Cables.”
- “Step 25. Install the Test Set Cables.”
- “Step 26. Secure the Front Panel Bulkhead Connectors.”
- “Step 27. Reinstall the A23 Test Set Motherboard.”
- “Step 28. Disassemble the 2-Port Front Panel and Assemble the 4-Port Front Panel.”
- “Step 29. Reinstall Front Panel Assembly.”
- “Step 30. Install the Overlays.”
- “Step 31. Install the Front Panel Jumper Cables.”
- “Step 32. Position the Cables and Wires to Prevent Pinching.”
- “Step 33. Reinstall the Inner Cover.”
- “Step 34. Reinstall the Outer Cover.”
- “Step 35. Remove Option 219 License.”
- “Step 36. Enable Options P04 (400) and 419.”
- “Step 37. Perform Post-Upgrade Adjustments and Calibration.”
- “Step 38. Prepare the PNA for the User.”

Step 1. Obtain a Keyword and Verify the Information

Follow the instructions on the Option Entitlement Certificate supplied to obtain a license key for installation of this upgrade. Refer to **“License Key Redemption” on page 5**.

Verify that the model number, serial number, and option number information on the license key match those of the instrument on which this upgrade will be installed.

Once the license key has been received and the information verified, you can proceed with the installation at step 2.

NOTE

If the model number, serial number, or option number do not match those on your license key, you will not be able to install the option. If this is the case, contact Keysight for assistance before beginning the installation of this upgrade. Refer to **“Contacting Keysight” on page 4**.

Step 2. Remove the Outer Cover

For instructions, click the Chapter 7 bookmark “Removing the Covers” in the PDF Service Guide¹.

Step 3. Remove the Inner Cover

For instructions, click the Chapter 7 bookmark “Removing the Covers” in the PDF Service Guide¹.

Step 4. Remove the Front Panel Assembly

For instructions, click the Chapter 7 bookmark “Removing and Replacing the Front Panel Assembly” in the PDF Service Guide¹.

Step 5. Remove the A23 Test Set Motherboard

For instructions, click the Chapter 7 bookmark “Removing and Replacing the A23 test set motherboard” in the PDF Service Guide¹.

Step 6. Remove Some Cables

NOTE

Be careful not to damage the center pins of the semirigid cables. Some flexing of the cables may be necessary but do not over-bend them.

NOTE

Leave the gray flexible cables, the wire harnesses, and the ribbon cables connected where possible. **Any that are removed should be labeled for reconnection later.**

NOTE

When removing a cable, also remove the plastic cable clamp, if present. It is normal for some of the cable clamp’s adhesive to remain.

1. Place the analyzer bottom-side up on a flat surface.
2. Remove and discard the following gray flexible cables:
 - W130 A20 IF multiplexer (P203) to A12 SPAM (J5)
 - W129 A20 IF multiplexer (P603) to A12 SPAM (J2)

1. See [“Downloading the Online PNA Service Guide” on page 7](#).

3. Remove all bottom-side (test set) semirigid cables except for those in the following table. Do not discard the cables that are removed because some will be reused later in the procedure.

To see an image showing the location of cables W11, W17, and W51 click the Chapter 6 bookmark “Top Cables, All Cables - All Options” in the PDF Service Guide¹. To see an image showing the location of cables W55, W56, and W57, click the Chapter 6 bookmark “Bottom RF Cables, 2-Port, Option 219, S/N Prefixes <6021” in the PDF Service Guide¹.

Reference Designator	Type ^a	Part Number	Qty	Description
W11	SR	N5245-20036	1	A7 port 1 doubler to W12
W17	SR	N5245-20036	1	A8 port 2 doubler to W18
W51	SR	N5245-20101	1	A15 13.5 GHz (LO) synthesizer board J1207 to A25
W55	SR	N5245-20102	1	A7 port 1 doubler to W56
W56	SR	N5245-20103	1	W55 to rear-panel EXT TSET DRIVE RF OUT (J6)
W57	SR	N5245-20012	1	A27 mixer brick to EXT TSET DRIVE LO OUT (J5)

a. SR = semirigid coaxial cable.

4. Remove and discard the following gray flexible cables:
- W62 (N5242-60025) A27 mixer brick (R1) to A24 IF multiplexer (P601)
 - W63 (N5242-60026) A27 mixer brick (R2) to A24 IF multiplexer (P801)
5. Leave the remaining gray flexible cables, the wire harnesses, and the ribbon cables connected where possible. Any that are removed should be labeled for reconnection later.

Step 7. Remove the A27 Mixer Brick Assembly

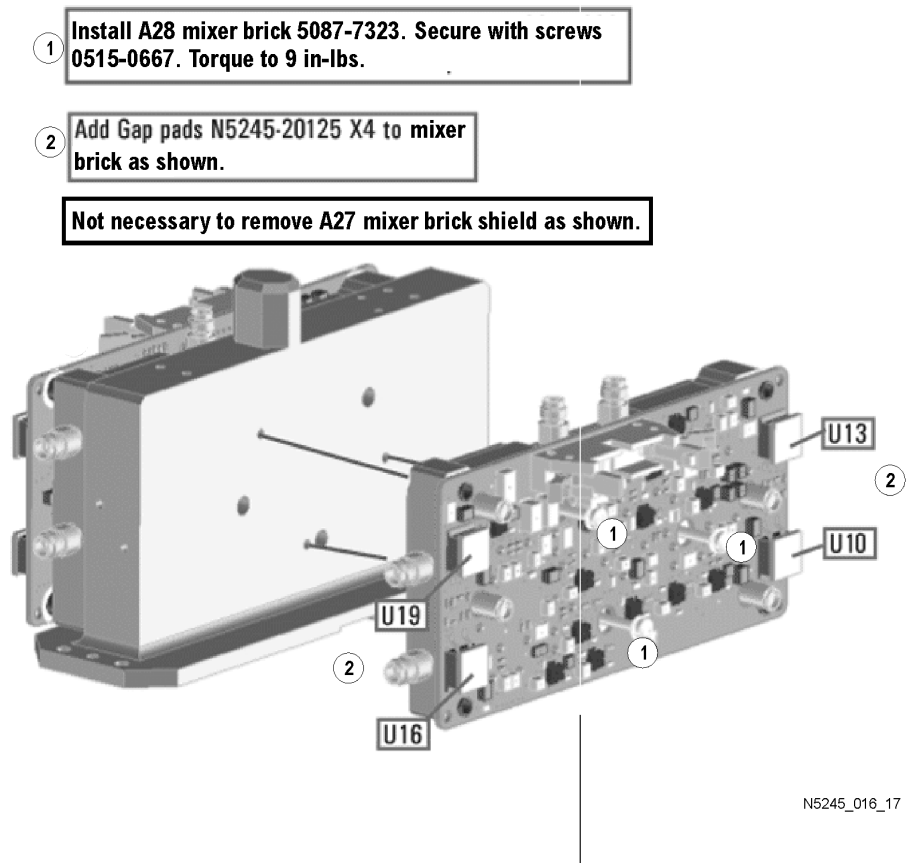
Remove the A27 mixer brick assembly from the PNA. For instructions, click the Chapter 7 bookmark, “Removing and Replacing the A27 and A28 Mixer Bricks” in the PDF Service Guide¹.

1. See “[Downloading the Online PNA Service Guide](#)” on page 7.

Step 8. Assemble the A28 Mixer Brick Assembly

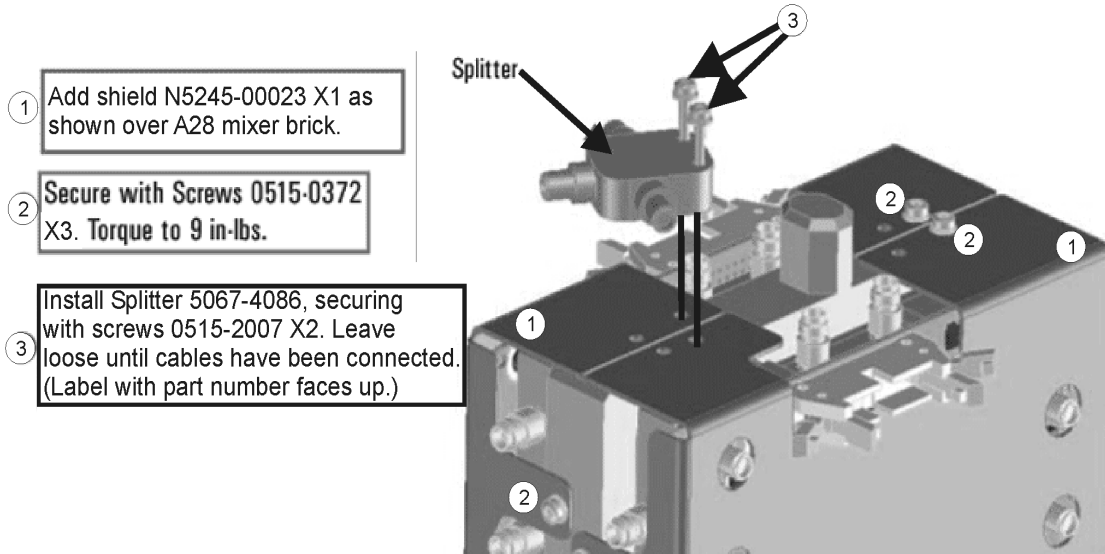
1. Follow the two instructions shown in **Figure 1**. New parts are listed in **Table 1 on page 9** of this document.

Figure 1 A28 Mixer Brick Assembly (0515-0667, 5087-7323, N5245-20125)



2. Follow the four instructions shown in **Figure 2**.

Figure 2 Shields, and Splitter Installation (0515-0372, 0515-2007, 5067-4086, N5245-00023)

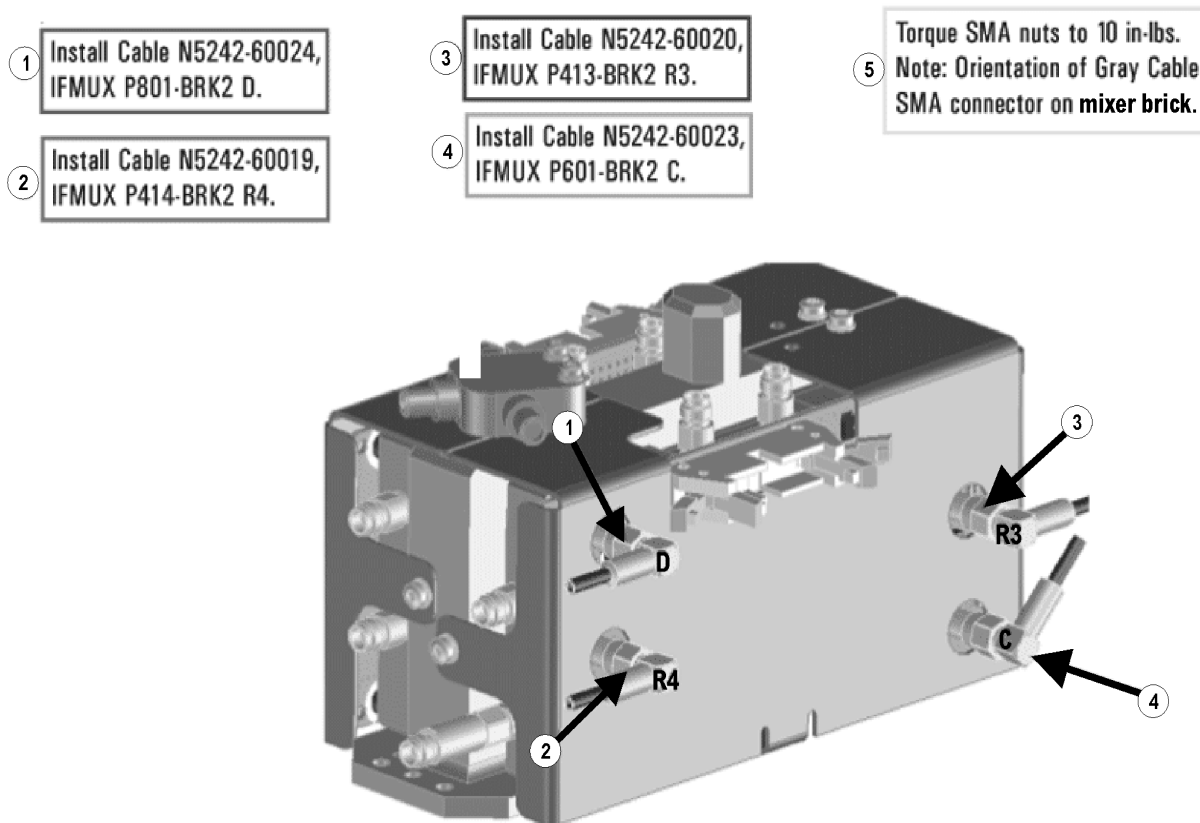


3. Connect the gray flexible cables in the order shown in **Figure 3**.

NOTE

Graphics in this document such as **Figure 3** use very brief text to instruct where to connect a cable. For example, text that reads “N5242-60018 IFMUX P201 - BRK1 B” means to connect the N5242-60018 gray flexible cable at the A24 IF MUX board connector P201 and at A27 Mixer Brick 1 connector B.

Figure 3 A28 Mixer Brick Cable Installation (N5242-60019, N5242-60020, N5242-60023, N5242-60024)¹



Step 9. Install the A27/A28 Mixer Bricks Assembly

Install the A27/A28 mixer brick assembly, reusing the 4 existing screws. For instructions, click the Chapter 7 bookmark, “Removing and Replacing the A27 and A28 Mixer Bricks” in the PDF Service Guide². New parts are listed in **Table 1 on page 9** of this document

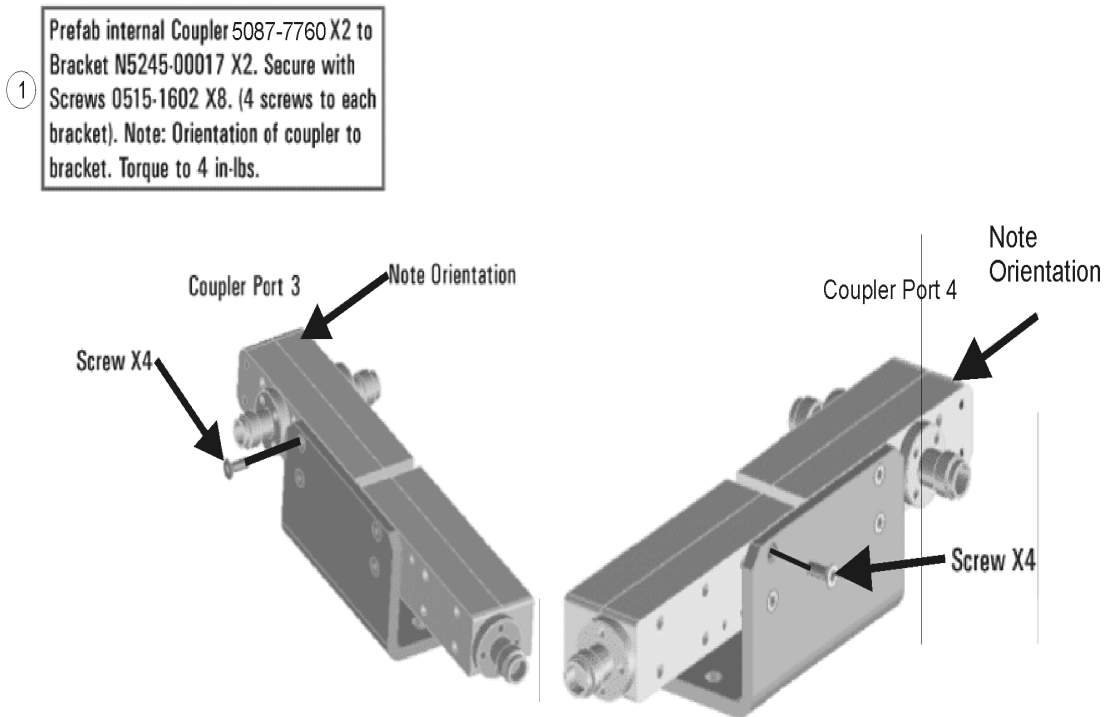
1. This drawing shows a 3 dB connected to the mixer block near R4. This pad is internal on all 5087-7417 mixer blocks and does **not** apply to the 5087-7417 assembly.

2. See “[Downloading the Online PNA Service Guide](#)” on page 7.

Step 10. Assemble the A30 and A31 Reference Coupler Assemblies

Follow the instruction shown in **Figure 4**. New parts are listed in **Table 1** on **page 9** of this document.

Figure 4 A30 and A31 Reference Coupler Assembly (0515-1602, 5087-7760, N5245-00017)



N5245_015_20

Step 11. Install the A30 and A31 Reference Coupler Assemblies

Install the A30 and A31 reference coupler assemblies. For instructions, click the Chapter 7 bookmark, “Removing and Replacing the A29-A32 Reference Couplers and Reference Coupler Mounting Brackets” in the PDF Service Guide¹. New parts are listed in **Table 1 on page 9** of this document.

Step 12. Assemble the A47 and A48 Receiver Attenuator Assemblies

Assemble the A47 and A48 receiver attenuator assemblies. For instructions, click the Chapter 7 bookmark, “Removing and Replacing the A38-A41 Source Attenuators and the A46-A49 Receiver Attenuators” in the PDF Service Guide¹. New parts are listed in **Table 1 on page 9** of this document.

Step 13. Install the A47 and A48 Receiver Attenuator Assemblies

Install the A47 and A48 receiver attenuator assemblies. For instructions, click the Chapter 7 bookmark, “Removing and Replacing the A38-A41 Source Attenuators and the A46-A49 Receiver Attenuators” in the PDF Service Guide¹. New parts are listed in **Table 1 on page 9** of this document.

Step 14. Assemble the A39 and A40 Source Attenuator Assemblies

Assemble the A39 and A40 source attenuator assemblies. For instructions, click the Chapter 7 bookmark, “Removing and Replacing the A38-A41 Source Attenuators and the A46-A49 Receiver Attenuators” in the PDF Service Guide¹. New parts are listed in **Table 1 on page 9** of this document.

Step 15. Install the A39 and A40 Source Attenuator Assemblies

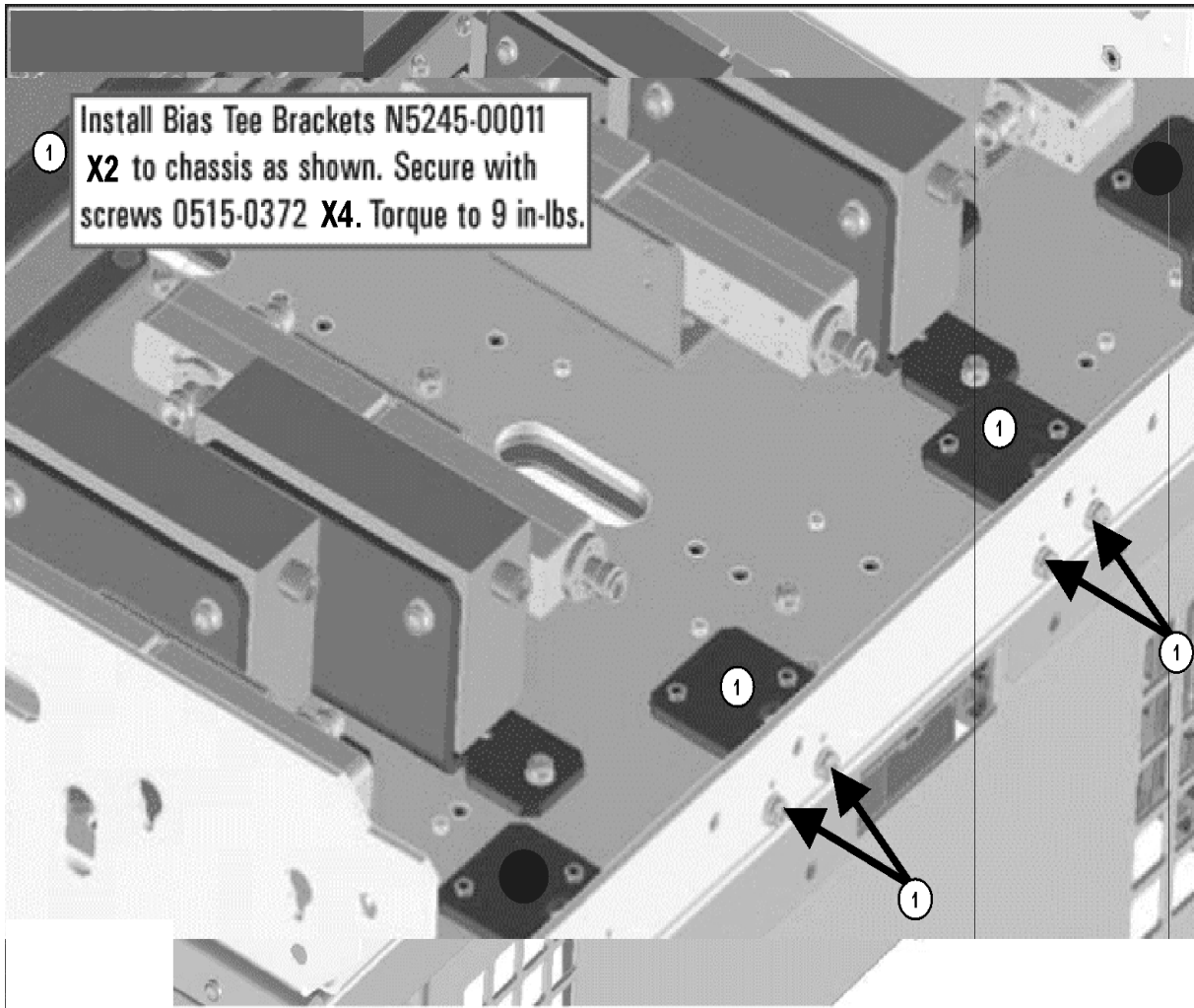
Install the A39 and A40 source attenuator assemblies. For instructions, click the Chapter 7 bookmark, “Removing and Replacing the A38-A41 Source Attenuators and the A46-A49 Receiver Attenuators” in the PDF Service Guide¹.

1. See **“Downloading the Online PNA Service Guide” on page 7.**

Step 16. Install the Bias Tee Brackets

Refer to **Figure 5** for this step of the procedure. New parts are listed in **Table 1** on **page 9**.

Figure 5 Bias Tee Brackets (0515-0372, N5245-00011)



N5245_016_21

Step 17. Install the A43 and A44 Bias Tees

Install the A43 and A44 bias tees. For instructions, click the Chapter 7 bookmark, “Removing and Replacing the A42-A45 Bias Tees” in the PDF Service Guide¹. New parts are listed in **Table 1 on page 9** of this document.

NOTE

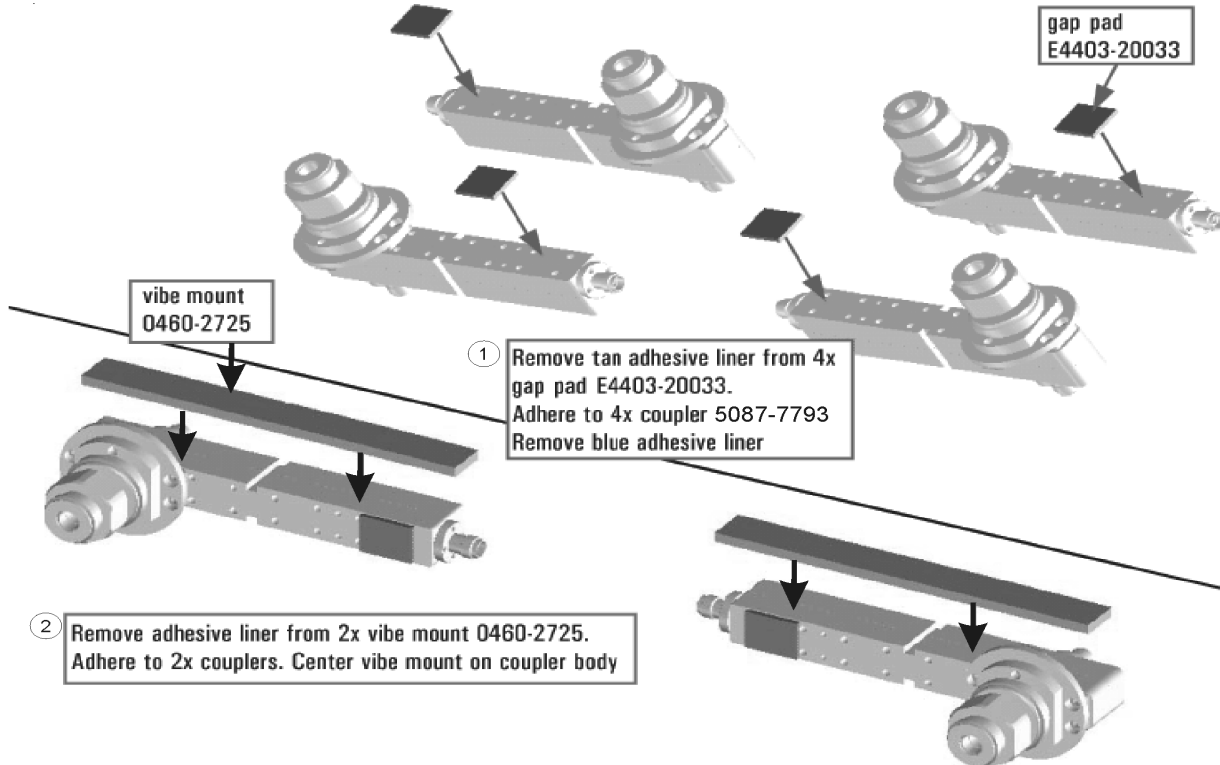
Orient the port 3 bias tee so that the capacitor faces the capacitor on the port 1 bias tee. Likewise, port 2 and port 4 bias tee capacitors should face each other. Also, fasten each bias tee’s red wire lug nut using the screw on the side of the bias tee without a capacitor.

Step 18. Assemble the A33 - A36 Test Port Coupler Assemblies

1. Remove the A33 test port 1 coupler and A36 test port 2 coupler from the PNA. For instructions, click the Chapter 7 bookmark, “Removing and Replacing the A33 - A36 Test Port Couplers” in the PDF Service Guide¹.
2. Using pliers, remove the adhesive bumper on the A33 test port 1 coupler and on the A36 test port 2 coupler.
3. Follow the two instructions shown in **Figure 6**. New parts are listed in **Table 1 on page 9** of this document.

Figure 6

A33 - A36 Test Port Coupler Assembly (0460-2725, 5087-7793, E4403-20033)



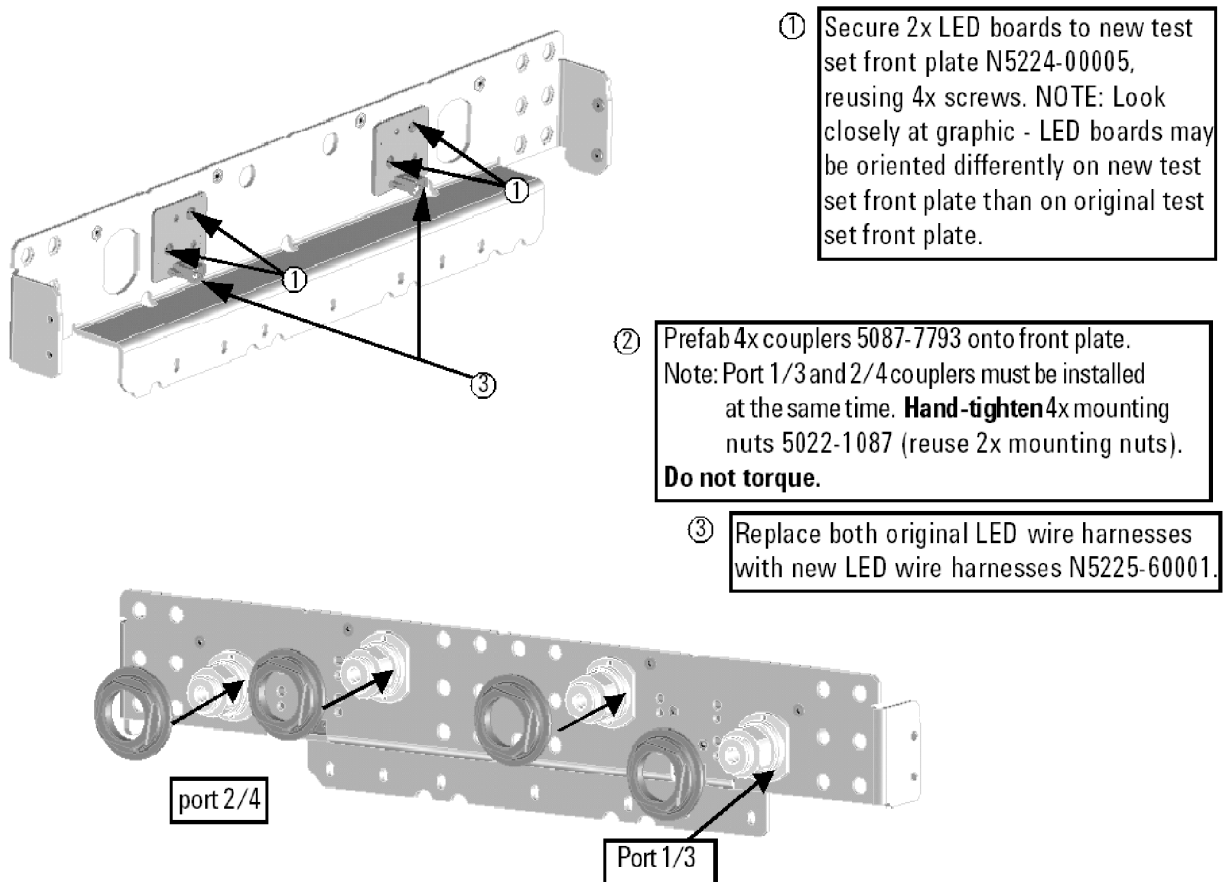
1. See [“Downloading the Online PNA Service Guide” on page 7](#).

Step 19. Install the LED Boards and Test Port Coupler Assemblies to the Test Set Front Plate

1. Remove two screws from each LED board and remove the boards from the 2-port test set front plate of the PNA.
2. Remove the 2-port test set front plate from the test set deck.
3. Follow the instructions shown in **Figure 7**.

Figure 7

LED Board Assemblies and Test Port Coupler Assemblies Installation
(5022-1087, 5087-7793, N5224-00005, N5225-60001)

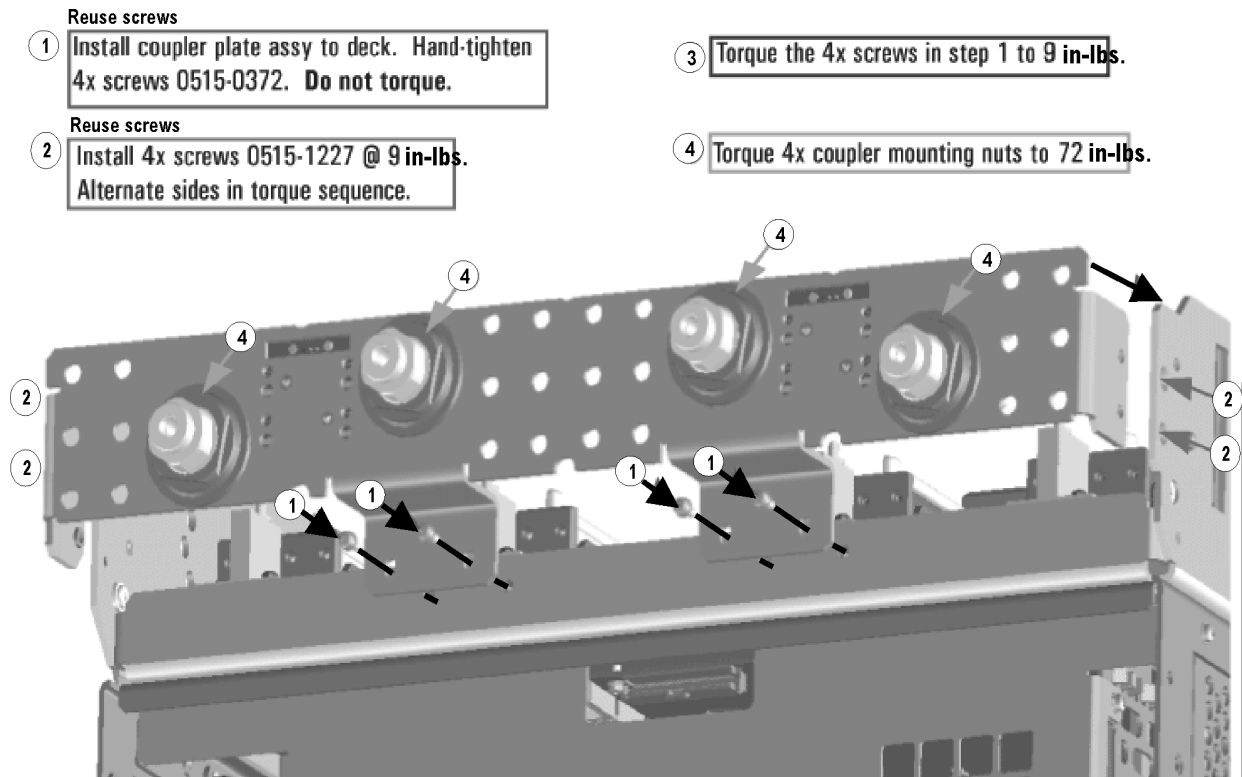


N5245_016_12

Step 20. Install the Coupler Plate Assembly to the Deck

Follow the four instructions shown in **Figure 8**.

Figure 8 Coupler Plate Assembly Installation (0515-0372, 0515-1227)

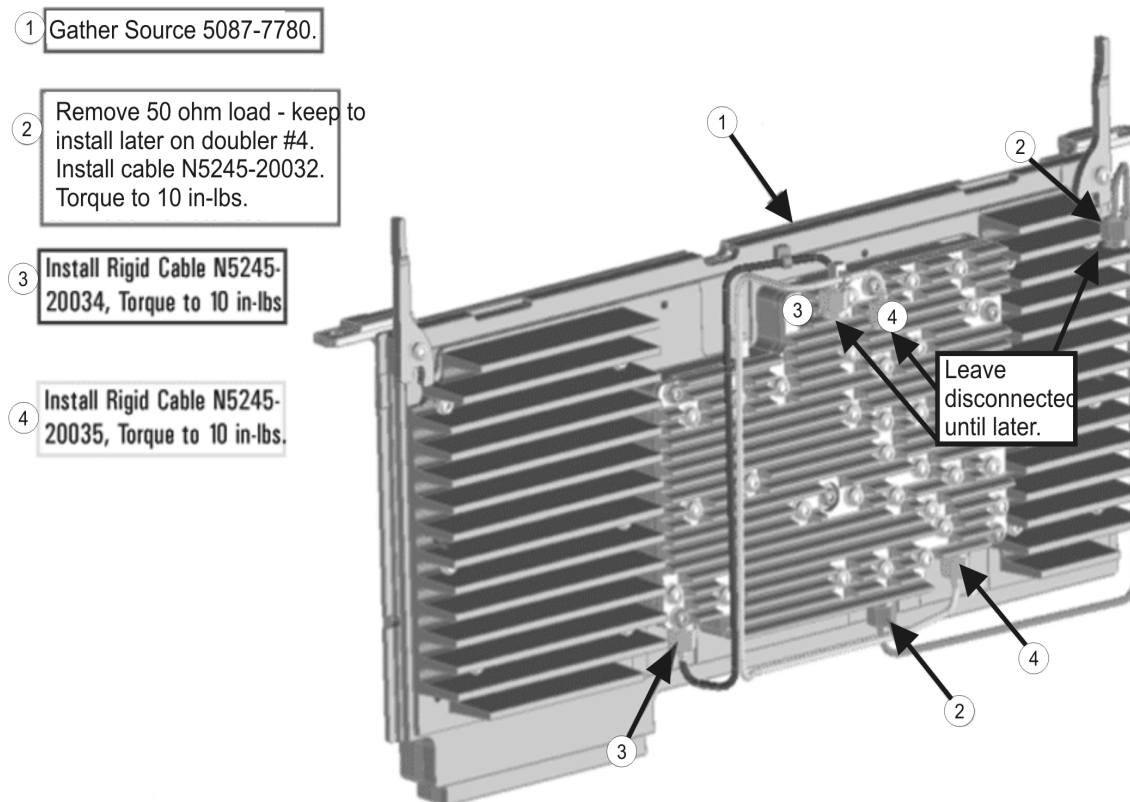


N5245_016_13

Step 21. Assemble the A10 26.5 GHz Source 2 Assembly

Follow the four instructions shown in **Figure 9**.

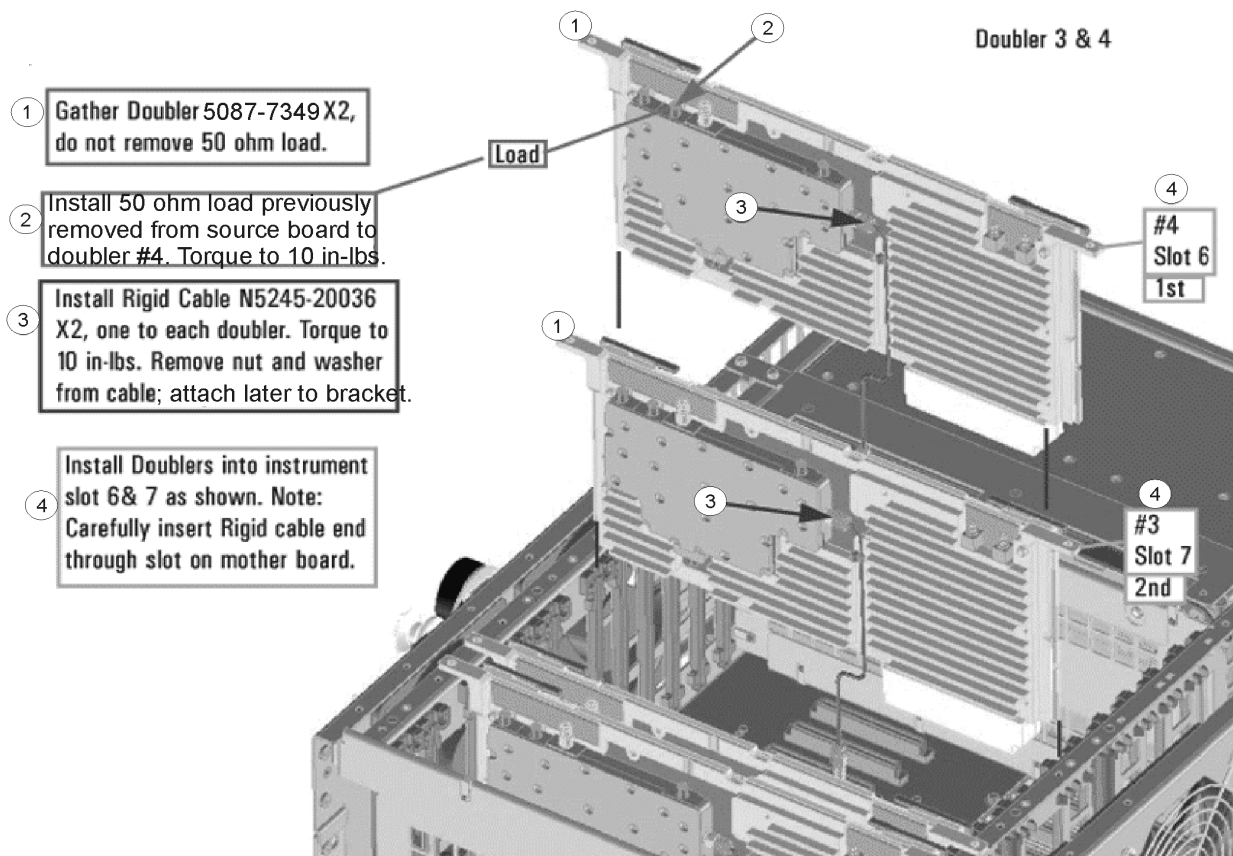
Figure 9 A10 Source 2 Assembly (5087-7780, N5245-20032, N5245-20034, N5245-20035)



Step 22. Assemble and Install the A12 and A13 Doubler Assemblies

Follow the four instructions shown in **Figure 10**.

Figure 10 A12 and A13 Doubler Assemblies Installation (5087-7349, N5245-20036)

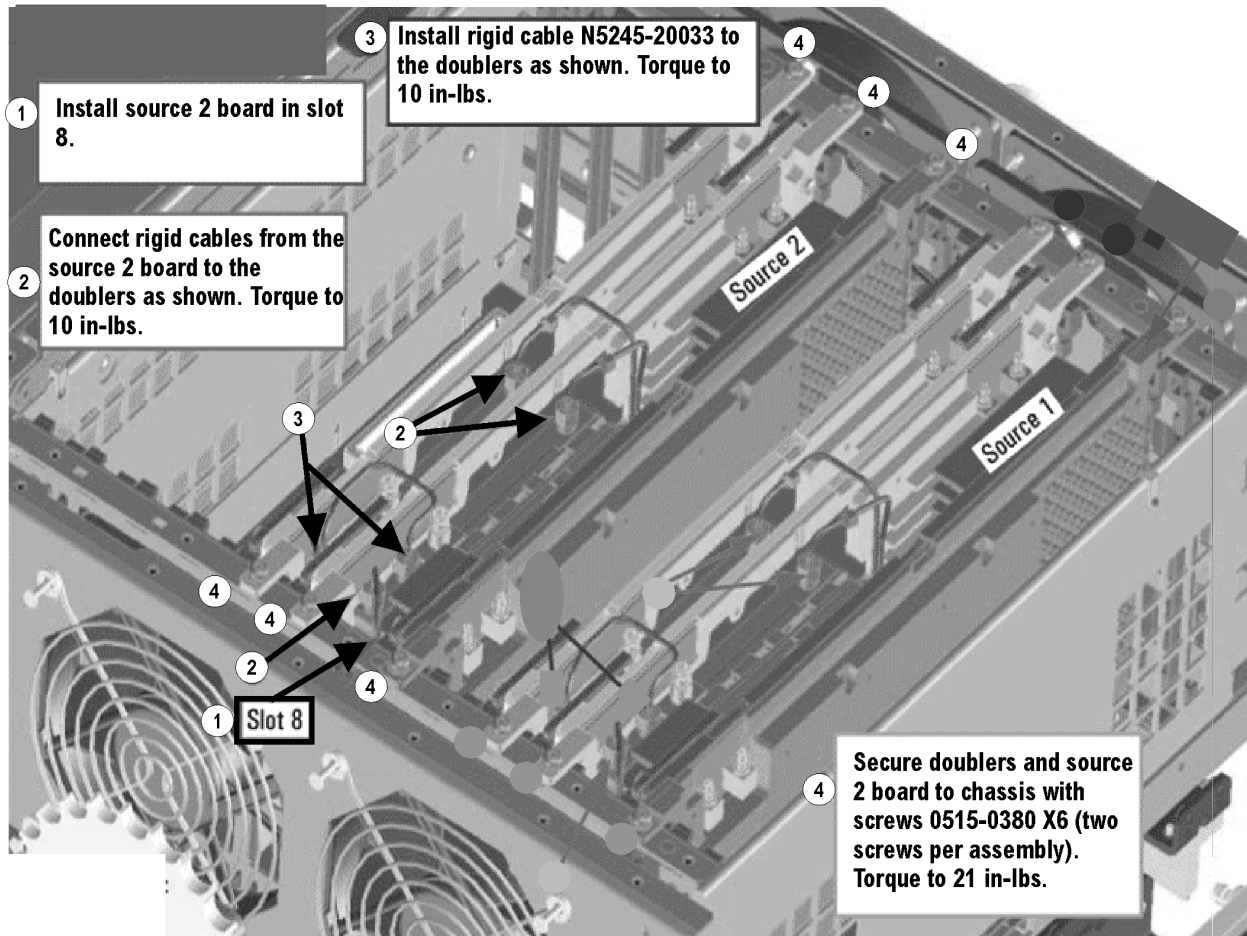


N5245-018-07

Step 23. Install the A10 26.5 GHz Source 2 Assembly and Cables

Follow the four instructions shown in **Figure 11**.

Figure 11 A10 Source 2 Assembly Installation (0515-0380, N5245-20033)



Step 24. Install the A17 13.5 GHz (Source 2) Synthesizer Board and Cables

1. Install gray cable W77 (N5242-60030) to connector J5 of the A17 (source 2) synthesizer board (N5230-60002). The loose end of the cable will be connected on the A14 frequency reference board (J7) after the A17 board has been installed in the analyzer.
2. Install the A17 board into slot 2 in the motherboard. To see an image showing the location of the A17 board in the motherboard, click the Chapter 6 bookmark "Top Assemblies, All Options" in the PDF Service Guide¹.

1. See **"Downloading the Online PNA Service Guide" on page 7**.

3. Connect cable W2 (N5245-20100) between the A10 source 2 board and the A17 (source 2) synthesizer board, positioning the cable in the wire looms. Tighten the cable connectors to 10 in-lbs using a 5/16-in torque wrench.
4. Connect the loose end of new gray flex cable W77 (N5242-60030) on the A14 frequency reference board (J7). (The other end of this cable was previously connected to J5 of the source 2 synthesizer board.)

NOTE

The three 13.5 GHz Synthesizer boards included in this kit are the RoHS compliant N5240-60076 boards. These new boards are not compatible with the old N5230-60002 13.5 GHz Synthesizer boards. If the boards installed in your PNA are the old N5230-60002, you must replace ALL of them with the N5240-60076 boards included in this kit - refer to your PNA Service Guide's chapter 7 for instructions. If your PNA already contains the new boards, scrap the two extra N5240-60076 boards included in this kit.

For the new N5240-60076 boards to function properly in your PNA, you must upgrade your PNA firmware to rev A09.33xx or above. Download PNA firmware at:

<http://na.support.keysight.com/pna/firmware/firmware.html>.

Step 25. Install the Test Set Cables

CAUTION

Follow instructions carefully when making cable connections, especially wire harness connections. Incorrect connections can destroy components, resulting in additional customer costs.

CAUTION

Be careful not to damage the center pins of the semirigid cables. Some flexing of the cables may be necessary but do not over-bend them.

CAUTION

Use a 5/16-in torque wrench set to 10 in-lbs on all cable connections except the front and rear panel bulkhead connectors. On these, use a 9 mm nutsetter or open end torque wrench set to 21 in-lb.

Flexible Cables Required for Upgrading to an Option 419 PNA

Install the following flexible cables in the order listed. To see images showing the location of these cables, click either of the Chapter 6 bookmarks "Bottom RF Cables, 4-Port, Option 419, S/N Prefixes <6021" in the PDF Service Guide¹. New parts are listed in **Table 1 on page 9**.

- W62 (N5242-60021)A27 mixer brick (R1) to A24 IF multiplexer (P411)
- W63 (N5242-60022)A27 mixer brick (R2) to A24 IF multiplexer (P412)

Semirigid Cables Required for Upgrading to an Option 419 PNA

To see images showing the location of these cables, click the Chapter 6 bookmark “Bottom RF Cables, 4-Port, Option 419” in the PDF Service Guide¹. New parts are listed in [Table 1 on page 9](#).

- Follow the two instructions shown in [Figure 12](#) in this document.

Figure 12 Semirigid Cables Installation (0515-0372, N5245-20022, N5245-20036)



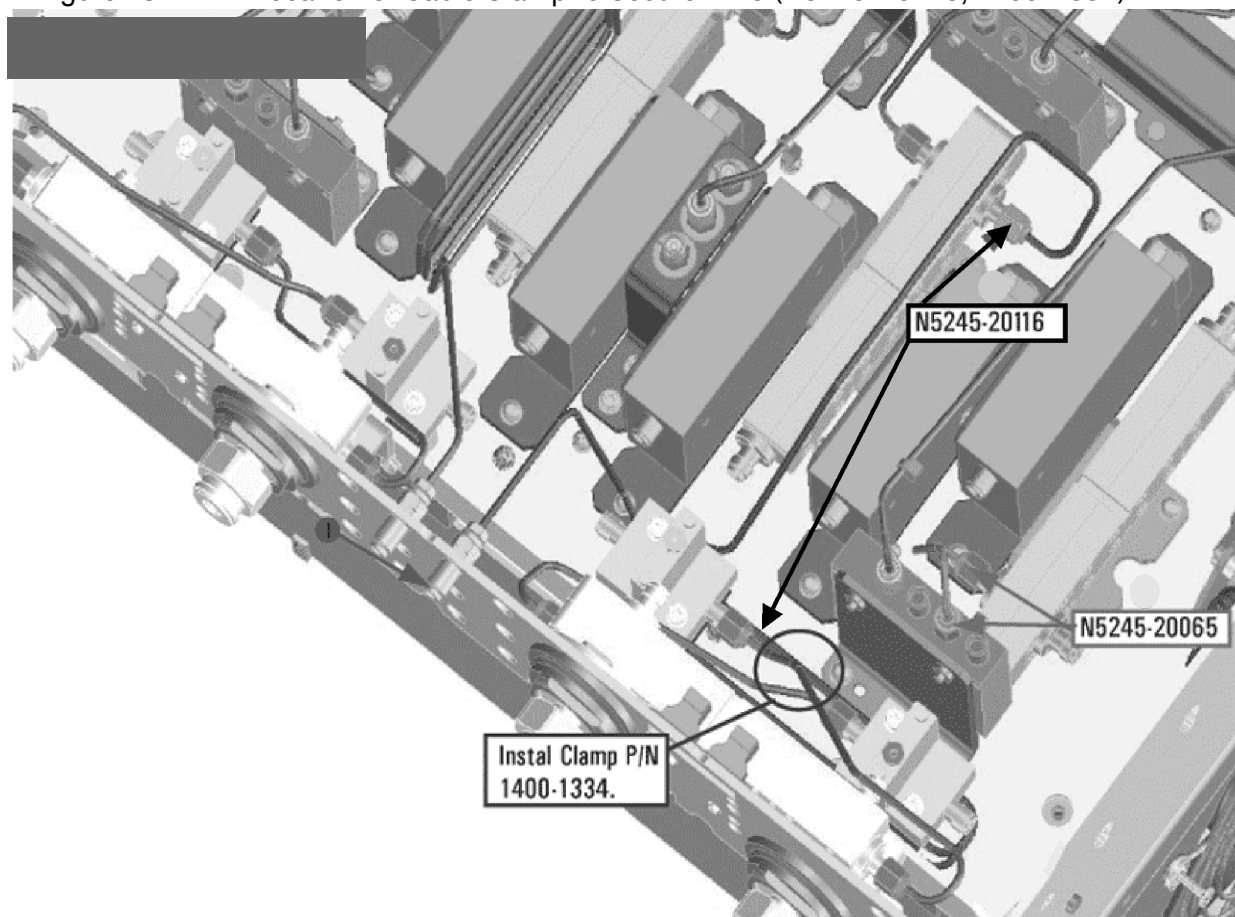
N5245_016_32

- W96 (N5245-20087)A45 port 2 bias tee to port 2 CPLR THRU
- W92 (N5245-20088)A44 port 4 bias tee to A35 port 4 coupler
- W84 (N5245-20085)A42 port 1 bias tee to A33 port 1 coupler
- W88 (N5245-20086)A43 port 3 bias tee to A34 port 3 coupler
- W25 (N5245-20116)A30 port 3 ref coupler to front-panel REF 3 SOURCE OUT

* As shown in [Figure 13](#), install clamp part number 1400-1334 to secure W25.

1. See [“Downloading the Online PNA Service Guide” on page 7](#).

Figure 13 Location of Cable Clamp to Secure W25 (N5245-20116, 1400-1334)



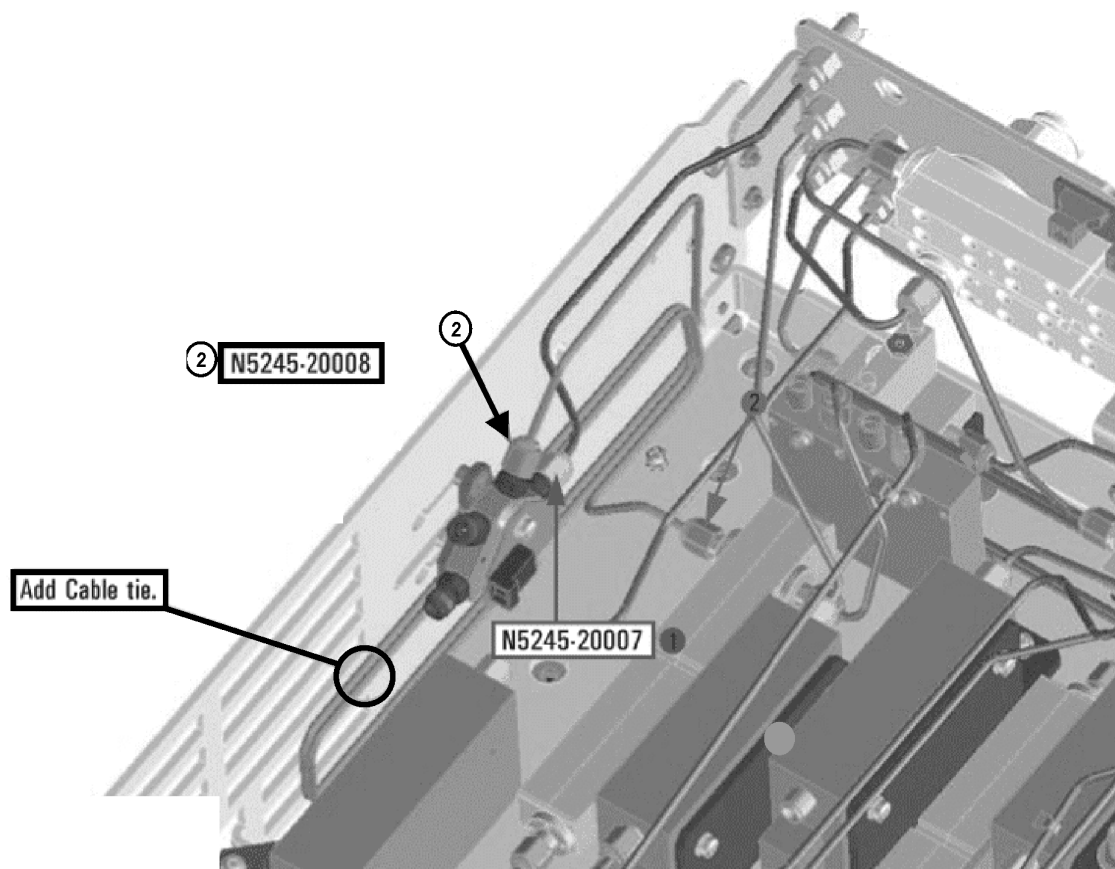
N5245_010_02

- W29 (N5245-20117)A31 port 4 ref coupler to front-panel REF 4 SOURCE OUT
- W89 (N5245-20026)A31 port 4 reference coupler to A40 port 4 source attenuator
- W85 (N5245-20026)A30 port 3 reference coupler to A39 port 3 source attenuator
- W93 (reuse) (N5245-20029)A32 port 2 reference coupler to A41 port 2 source attenuator
- W81 (reuse) (N5245-20029)A29 port 1 reference coupler to A38 port 1 source attenuator
- W103 (reuse) (N5245-20055)Port 2 RCVR B IN to A49 port 2 receiver attenuator
- W95 (reuse) (N5245-20030)Port 2 CPLR THRU to A45 port 2 bias tee
- W34 (N5245-20019)A36 port 2 coupler to front-panel Port 2 CPLR ARM

Installation Procedure for the Upgrade

- W94 (reuse) (N5245-20031)A41 port 2 source attenuator to front-panel Port 2 SOURCE OUT
- W46 (N5245-20115)REF 2 RCVR R2 IN to A27 mixer brick (R2)
 - * Connect W46 to top R2 connector on the mixer bricks.
- W33 (reuse) (N5245-20010)A32 port 2 ref coupler to front-panel REF 2 SOURCE OUT
- W30 (5245-20018)A35 port 4 coupler to front-panel Port 4 CPLR ARM
- W101 (N5245-20074)Port 4 RCVR D IN to A48 port 4 receiver attenuator
- W90 (N5245-20028)A40 port 4 source attenuator to front-panel Port 4 SOURCE OUT
- W91 (N5245-20090)Port 4 CPLR THRU to A44 port 4 bias tee
- W45 (N5245-20191)REF 4 RCVR R4 IN to A28 mixer brick (R4)
- W99 (N5245-20073)Port 3 RCVR C IN to A47 port 3 receiver attenuator
- W87 (N5245-20089)Port 3 CPLR THRU to A43 port 3 bias tee
- W26 (N5245-20015)A34 port 3 coupler to front-panel Port 3 CPLR AR
- W86 (N5245-20027)A39 port 3 source attenuator to front-panel Port 3 SOURCE OUT
- W44 (N5245-20020)REF 3 RCVR R3 IN to A28 mixer brick (R3)
 - * Connect W44 to top R3 connector on the mixer bricks.
- W22 (N5245-20014)A33 port 1 coupler to front-panel Port 1 CPLR ARM
- W97 (reuse) (N5245-20054)Front-panel Port 1 RCVR A IN to A46 port 1 receiver attenuator
- W82 (reuse) (N5245-20077)A38 port 1 source attenuator to front-panel Port 1 SOURCE OUT
- W83 (reuse) (N5245-20076)Front-panel Port 1 CPLR THRU to A42 port 1 bias tee
- W42 (reuse) (N5245-20007)REF 1 RCVR R1 IN to A37 reference mixer switch
- W21 (N5245-20008)A29 port 1 reference coupler to A37 reference mixer switch
 - * As shown in **Figure 14**, install cable tie part number 1400-0249 to secure W21.

Figure 14 Location of Cable Tie to Secure W21 (N5245-20008)



N5245_010_11

- W43 (reuse) (N5245-20009)A37 reference mixer switch to A27 mixer brick (R1)
 - * Connect W43 to bottom R1 connector on the mixer bricks.
- W41 (reuse) (N5245-20006)A37 reference mixer switch to front-panel REF 1 SOURCE OUT
- W102 (N5245-20075)A48 port 4 receiver attenuator to A28 mixer brick (D)
 - * Connect W102 to top D connector on the mixer bricks.
- W100 (N5245-20066)A47 port 3 receiver attenuator to A28 mixer brick (C)
 - * Connect W100 to bottom C connector on the mixer bricks.
- W104 (reuse) (N5245-20057)A49 port 2 receiver attenuator to A27 mixer brick (B)
 - * Connect W104 to bottom B connector on the mixer bricks
- W98 (reuse) (N5245-20056)A46 port 1 receiver attenuator to A27 mixer brick (A)

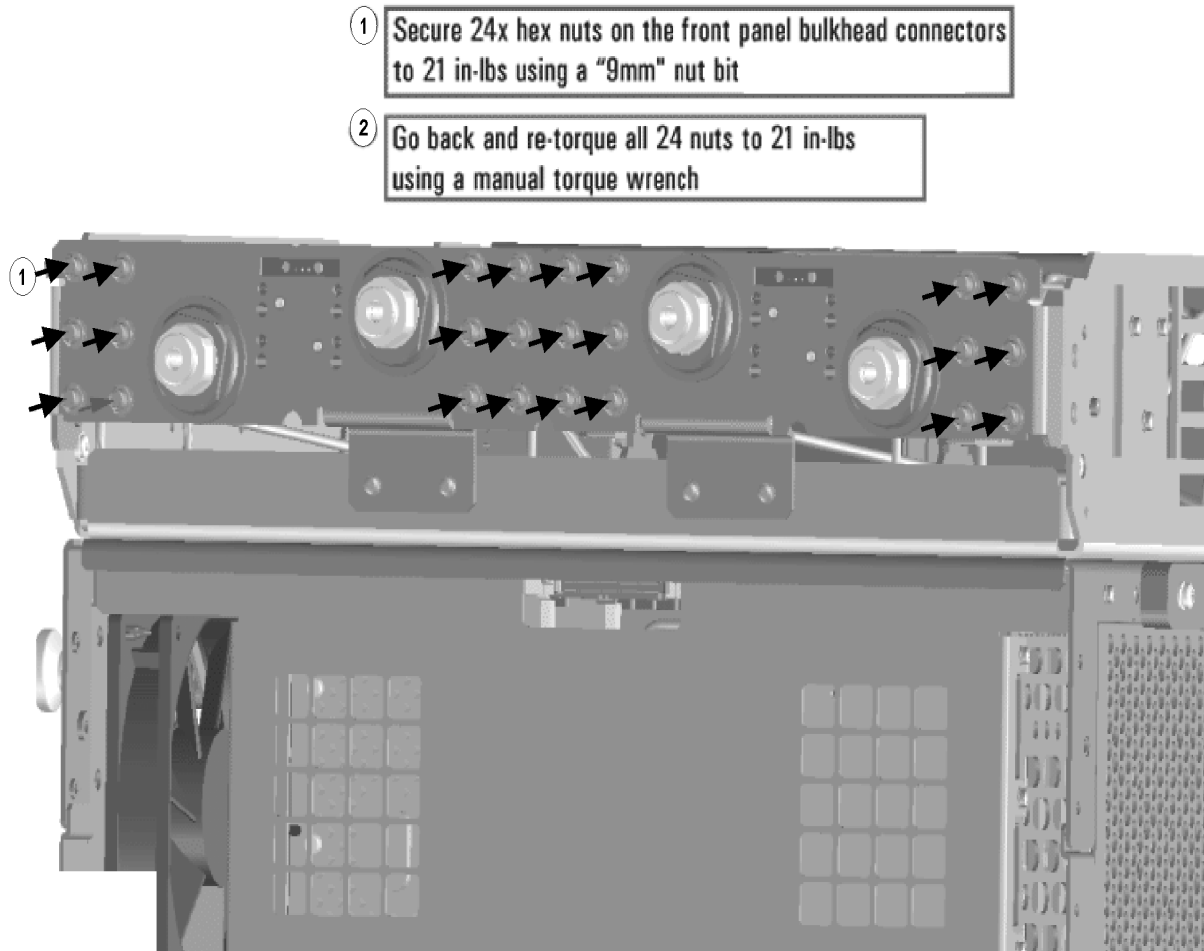
Installation Procedure for the Upgrade

- * Connect W98 to top A connector on the mixer bricks.
- W18 (reuse) (N5245-20049)A32 port 2 reference coupler to W17
- W12 (reuse) (N5245-20050)A29 port 1 reference coupler to W11
- W16 (N5245-20044)A31 port 4 reference coupler to W15
- W14 (N5245-20043)A30 port 3 reference coupler to W13
- W54 (N5245-20022)A26 splitter to A27 mixer brick
- W53 (N5245-20023)A26 splitter to A27 mixer brick
- W52 (N5245-20013)A25 HMA26.5 to A26 splitter
- W58 (N5245-20095)A28 mixer brick to 50 ohm load (1250-4261)
- * After installing W58 to the mixer brick, attach the new 50 ohm load (1250-4261) using a 1/4 inch open end wrench to hold cable W58 in place.
- * Torque A26 splitter screws to 6 in-lbs.
- W70 (N5242-60013) A20 IF multiplexer (P203) to A12 SPAM (J2)
- W72 (N5242-60015) A20 IF multiplexer (P603) to A12 SPAM (J5)

Step 26. Secure the Front Panel Bulkhead Connectors

Follow the instruction shown in **Figure 15** in this document.

Figure 15 Bulkhead Connections, Front Panel



N5245_016_31

Step 27. Reinstall the A23 Test Set Motherboard

CAUTION

Follow instructions carefully when making cable connections, especially wire harness connections. Incorrect connections can destroy components, resulting in additional customer costs.

1. For instructions on reinstalling the board, click the Chapter 7 bookmark "Removing and Replacing the A23 test set motherboard" in the PDF Service Guide¹.

2. If not already done in a previous step, install the following new ribbon cables in the order listed. To see an image showing the location of these cables, click the Chapter 6 bookmark “Bottom Ribbon Cables and Wire Harnesses, 4-Port, Option 419, S/N Prefixes <6021” in the PDF Service Guide¹. New parts are listed in **Table 1 on page 9**.
 - Ribbon cable, N5247-60015 from A23 test set motherboard J552 to A28 mixer brick (2) J52
 - Ribbon cable (part of bias tee assembly), port 3 bias tee to A23 test set motherboard J543
 - Ribbon cable (part of bias tee assembly), port 4 bias tee to A23 test set motherboard J544
 - Ribbon cable (N5245-60026), A23 test set motherboard J206 to A47 port 3 receiver attenuator
 - Ribbon cable (N5245-60026), A23 test set motherboard J207 to A48 port 4 receiver attenuator
 - Ribbon cable (N5245-60006), A23 test set motherboard J547 to A39 port 3 source attenuator
 - Ribbon cable (N5245-60006), A23 test set motherboard J548 to A40 port 4 source attenuator
 - Wire harness (N5225-60001), A23 test set motherboard J221 to ports 1/3 LED board J1
 - Wire harness (N5225-60001), A23 test set motherboard J222 to ports 2/4 LED board J1

Step 28. Disassemble the 2-Port Front Panel and Assemble the 4-Port Front Panel

Before the front frame can be replaced, the items making up the back side of the front panel assembly must be removed. For instructions on removing these items, click the Chapter 7 bookmark “Removing and Replacing the A1-A3 and Other Front Panel Subassemblies” in the PDF Service Guide¹. New parts are listed in **Table 1 on page 9**.

1. In the section “Removing the A2 USB Board,” perform the only step.
2. In the section “Removing the A1 Front Panel Interface Board and Keypad Assembly,” perform steps 1 - 5.
3. In the section “Removing the Power Switch Board and Power Button Keypad,” perform only steps 1 and 2.
4. Remove the braided gasket from the backside edges of the 2-port front frame and install it in the 4-port front frame (N5247-20141).

1. See **“Downloading the Online PNA Service Guide” on page 7**.

5. **Rebuild the front panel assembly with the new 4-port front frame by reversing the order of the instructions previously followed.**

Step 29.Reinstall Front Panel Assembly

For instructions on reinstalling the front panel assembly, click the Chapter 7 bookmark “Removing and Replacing the Front Panel Assembly” in the PDF Service Guide¹.

In addition, attach the lower front dress panel to the test set front plate using 4x screws 0515-1227.

Step 30.Install the Overlays

To see an image of the front panel overlay (N5242-80003), keypad overlay (N5242-80005), and power button overlay (N5242-80007), click the Chapter 6 bookmark “Front Panel Assembly, Front Side, All Options” in the PDF Service Guide¹. New parts are listed in **Table 1 on page 9**.

1. **Remove the protective backing from the new front panel overlay (N5242-80003).**
2. **Loosely place the overlay in the recess on the lower front panel.**
3. **Placing two fingers at the middle, press the overlay firmly onto the frame while sliding your fingers in opposite directions towards the ends of the overlay. Repeat on all areas of the overlay.**
4. **Repeat steps 1-3 to install the keypad overlay (N5242-80005).**
5. **Repeat steps 1-3 to install the power button overlay (N5242-80007).**
6. **Install the new nameplate (N5245-80003).**

Step 31. Install the Front Panel Jumper Cables

Install twelve W36 front panel jumper cables (N5245-20155) - use 6 old jumpers and 6 new jumpers. To see an image of the front panel jumper cables, click the Chapter 7 bookmark “Removing and Replacing the Front Panel Assembly” in the PDF Service Guide¹.

Step 32. Position the Cables and Wires to Prevent Pinching

On the top side of the PNA, carefully position the gray flex cables so they can't be pinched between the covers and the rails.

On the bottom side of the PNA, carefully fold or push down the ribbon cables and wires so they can't be pinched between the hardware and the outer cover. Ribbon cables and wires must never be positioned on top of hardware.

Step 33. Reinstall the Inner Cover

For instructions, click the Chapter 7 bookmark “Removing the Covers” in the PDF Service Guide¹.

Step 34. Reinstall the Outer Cover

For instructions, click the Chapter 7 bookmark “Removing the Covers” in the PDF Service Guide¹.

Step 35. Remove Option 219 License

Procedure Requirements

- The analyzer must be powered up and operating to perform this procedure.
- The Network Analyzer program must **not** be running.
- A keyboard and mouse must be connected to the network analyzer.

Option 219 License Removal Procedure

1. To start the option enable utility, press UTILITY **System**, then **Service**, then **Option Enable**. An option enable dialog box will appear.
2. Click the arrow in the Select Desired Option box. A list of available options will appear.
3. In the Select Desired Option list, click 219.
4. Click Remove.

Step 36. Enable Options P04 (400) and 419

Procedure Requirements

- The analyzer must be powered up and operating to perform this procedure.
- The Network Analyzer program must be **not** running.
- A keyboard and mouse must be connected to the network analyzer.

Option Enable Procedure

1. To start the option enable utility, press UTILITY **System**, then **Service**, then **Option Enable**. An option enable dialog box will appear.
2. Click the arrow in the Select Desired Option box. A list of available options will appear.
3. In the Select Desired Option list, click P04 - 4-Ports.
4. Using the keyboard, enter the license key in the box provided. The license key is printed on the license message you received from Keysight. Enter

this key exactly as it is printed on the message.

5. Click Enable.
6. Click Yes in answer to the displayed question in the Restart Analyzer? box.
7. Repeat steps 3-6 to enable Option 419, clicking 419 - Src/Rcvr Atten & Bias Ts 4-Port in step 3.
8. When the installation is complete, click Exit.

Option Verification Procedure

Once the analyzer has restarted and the Network Analyzer program is again running:

1. On the analyzer's Help menu, click About Network Analyzer.
2. Verify that "P04" and "419" are listed, but "219" is not listed after "Options:" in the display. Click OK.

NOTE

If the options have not been enabled or if the option 219 license has not been removed, perform the prior steps again. If the options are still not correct, contact Keysight Technologies. Refer to ["Getting Assistance from Keysight" on page 4](#)

Step 37. Perform Post-Upgrade Adjustments and Calibration

Adjustments

The following adjustments must be made due to the hardware changes of the analyzer.

NOTE

IMPORTANT!

The 10 MHz reference crystal oscillator is the most accurate after running for three hours. The 10 MHz Frequency Reference Adjustment can be run after the PNA has warmed up for 90 minutes, and the other adjustments can be completed in the order presented, but then the 10 MHz Frequency Reference Adjustment should be repeated after the PNA has been able to warm up for three hours.

- 10 MHz frequency reference adjustment
- EE default adjustment
- synthesizer bandwidth adj. (only run when EE default adjust is not sufficient)
- source adjustment
- IF gain adjustment
- receiver characterization
- receiver adjustment

- IF Response Adjustment (Option 090 Only)
- Noise Adjustment (Option 029 Only)

These adjustments are described in the PNA Service Guide and in the PNA on-line HELP. A list of equipment required to perform these adjustments is also found in the service guide.

To view this Service Guide information, click the Chapter 3 bookmark “Tests and Adjustments” in the PDF Service Guide¹.

After the specified adjustments have been performed, the analyzer should operate and phase lock over its entire frequency range.

EEPROM Backup

The analyzer uses arrays of correction constants to enable the analyzer to produce accurate, leveled source signals and receive clean test signals. These constants are stored in non-volatile EEPROM memory and in flash memory files.

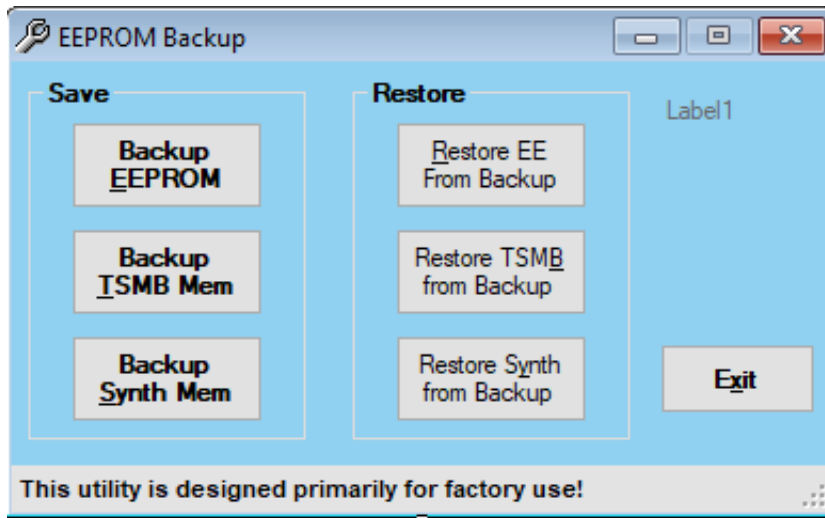
The adjustments listed here generate new correction constants. The analyzer must have a backup of this new data in case any of the data becomes corrupted.

To store the backup data, perform these steps:

- Navigate to the EEPROM Backup Utility, located at:
 - Windows 7 -- C:\Program Files (x86)\Keysight\Network Analyzer\Service\eebackup.exe
 - Windows 10 -- C:\Program Files\Keysight\Network Analyzer\Service\eebackup.exe
- Run the program.
- Click Backup EEPROM.
- Click Backup TSMB Mem.
- Click Backup Synth Mem. (Applies to Version 7 Synthesizers Only)
- Click Exit when the program has finished.

1. See [“Downloading the Online PNA Service Guide” on page 7](#).

Figure 16 EEPROM Backup Menu



Operator's Check

Perform the Operator's Check to check the basic functionality of the analyzer. For instructions, click the Chapter 3 bookmark "Tests and Adjustments" in the PDF Service Guide¹.

If you experience difficulty with the basic functioning of the analyzer, contact Keysight. Refer to **"Contacting Keysight" on page 4**.

Calibration

Although the analyzer functions, its performance relative to its specifications has not been verified. It is recommended that a full instrument calibration be performed using the analyzer's internal performance test software. To view information on the performance test software, click the Chapter 3 bookmark "Tests and Adjustments" in the PDF Service Guide¹.

Step 38. Prepare the PNA for the User

1. If necessary, reinstall front jumper cables.
2. Install the cable guards, pushing them over the front jumper cables until the cushioning material touches the front panel of the PNA.
3. Install the dust caps on the test ports.
4. Clean the analyzer, as needed, using a damp cloth.

Installation Procedure for the Upgrade

