

VTC user guide

Quality assurance tests for VMM hybrids

VMM Test System project

Table of Contents

1 Introduction.....	2
2 Setup.....	2
2.1 All things needed.....	2
2.2 VTC USB drivers.....	4
2.3 Software.....	4
2.4 Setting the label printing.....	4
2.5 Connecting everything.....	4
3 Usage.....	5
3.1 First look at the program.....	5
3.2 Setting the serial port.....	6
3.3 Running the test.....	7
3.4 Interpreting the results.....	7
3.5 Operations with database.....	8
3.6 Label printing.....	9
3.7 Turning hybrid on/off.....	10
3.8 Measuring the temperature.....	10
3.9 Changing the FPGA firmware.....	10
4 Diagnostics of test errors.....	11
4.1 HDMI pins.....	11
4.2 No I2C.....	11
4.3 Zero baselines.....	11
4.4 Programming firmware failing.....	11

1 Introduction

This document is a basic user guide describing how to use a VTC system for testing VMM3a hybrid readout boards.

The VTC system is intended for an *initial* assessment of the functionality of the hybrids. It determines whether the hybrids are working as expected. In case of a malfunctioning, the VTC is helpful in locating the problem. The test was designed to be quick and easy to do. The VTC is not supposed to replace a more detailed qualification of the VMM3a ASICs, that can be carried out with the help of the slow control software and the whole SRS setup.

Tested parameters:

- Resistances of HDMI pins: verifies proper soldering of HDMI connector and FPGA pins connected to it

- Power consumption: hybrid with both VMMs working has supply voltage and current in known range
- I2C devices: FPGA, EEPROM (contains register with fixed unique ID number), ADCs (one for each VMM)
- VMM reconfiguration: for measuring baselines and temperature, VMMs must react to new configuration data sent from VTC through FPGA
- Baseline values of all channels (analogue output)

The VTC **cannot test the digital part** of VMM3a ASICs like the ADC and time measurements (BCID and TDC), the serialization of data and the high-speed connection between VMMs and FPGA.

As accompanying software for the VTC a python GUI has been developed to carry out the tests and to administer the SQLite3 database, in which the results are stored. Database records can also be retrieved from the database, and viewed in the GUI. The test results can be printed to labels (38×21 mm), which fit onto the hybrid coolers.

Additionally, the software can also help in programming the FPGA on the hybrid. The firmware on the FPGA can be changed – either temporary (until the hybrid is turned off) or permanently by writing to configuration flash memory.

2 Setup

2.1 All things needed

Essential items:

- Computer (Windows, Linux or Mac OS) with one USB port (two USB ports if using reprogramming feature)
- VTC box: comes with attached power cable for the hybrid (AUX connector)
- Micro USB cable: if VTC box is not visible to the computer, try higher quality cable
- Power supply with USB-C connector (5 V) : should be decent quality with enough power
 - Recommended: <https://uk.rs-online.com/web/p/ac-dc-adapters/1871369/>
- HDMI-micro HDMI cable 2 m
 - Recommended: MOLEX 68786-0003, available from CERN Store



Figure 1: HDMI cable with connectors type D and A

The updating of the firmware is only possible on Windows or Linux, since the Xilinx Impact software is not supported on MacOS. To update the firmware one needs:

- Programmer: Digilent JTAG-HS2, Xilinx Platform Cable USB (II)
 - if buying new one, Digilent is recommended as it is cheaper and faster
- special adapters

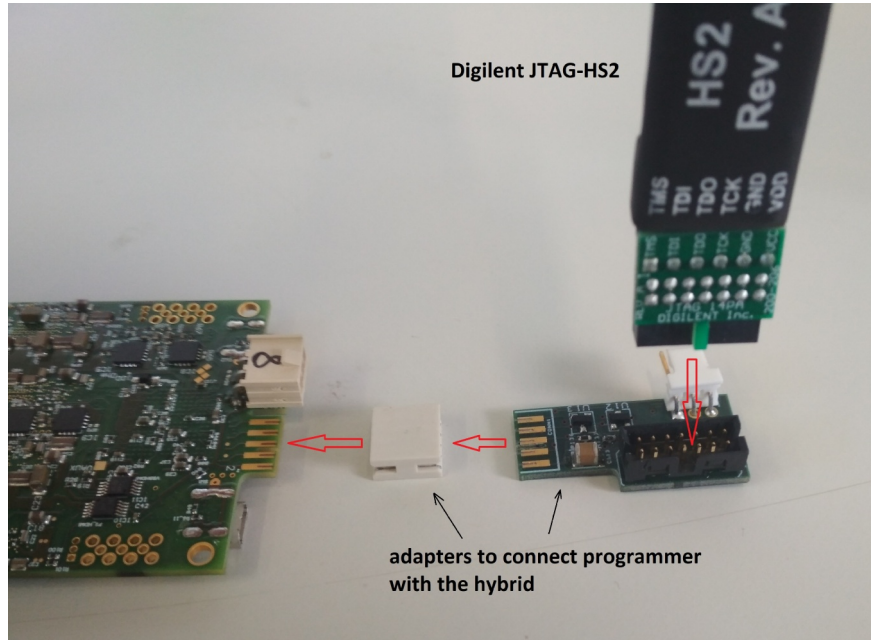


Figure 2: Connecting the Digilent JTAG to the Hybrid

Warning: During the test, the programming adapter should not be connected to the hybrid, otherwise the test, especially the I2C part, can fail.

For label printing:

- labels 38×21.2 mm from Avery: <https://www.avery.co.uk/product/multipurpose-labels-3666>
- standard printer for A4 paper

2.2 VTC USB drivers

Linux and Mac OS: VTC should work out of the box. In case of connection issues between the Micropython pyboard on the VTC and the PC, try looking for possible solutions in the Micropython documentation: <https://wiki.micropython.org/Installation>

Windows: To use the VTC, one has to install pyboard driver. After connecting the VTC with USB cable to PC, its internal storage should appear as a storage device, similar to flash drive. On this drive you can find file *pyboard.inf*. On Windows 7 and older you can directly install it. On newer Windows versions, please follow the directions here (<https://www.makeuseof.com/tag/how-can-i-install-hardware-with-unsigned-drivers-in-windows-8/>) to switch the system to special mode, then install the driver as described here: <https://wiki.micropython.org/Installation>.

2.3 Software

To install the VTC software just unzip the provided *vtc-sw.zip*. Inside the extracted folder you'll find the *vtc-sw* binary (e.g. on Windows *vtc-sw.exe*) that directly launches the program, no other installation necessary.

For changing the firmware on the hybrid (reprogramming the FPGA or flash), install the Xilinx Lab Tools 14.7 from here:

https://www.xilinx.com/member/forms/download/xef-ise.html?filename=Xilinx_LabTools_14.7_1015_1.tar

(Xilinx account needed – free to set up). Optionally add the *Impact* binary (programming software itself, part of Lab Tools) to the PATH variable of your operating system, so that the VTC gui can call *Impact*.

2.4 Setting the label printing

If you want to print labels with the VTC system, configure the printer that you intend to use for label printing as the system default printer. On Linux, to use the label preview feature, make sure that the program *xdg-open* (part of *xdg-utils* collection) is installed.

2.5 Connecting everything

Some schematics probably, from Hans presentation

Testing setup:

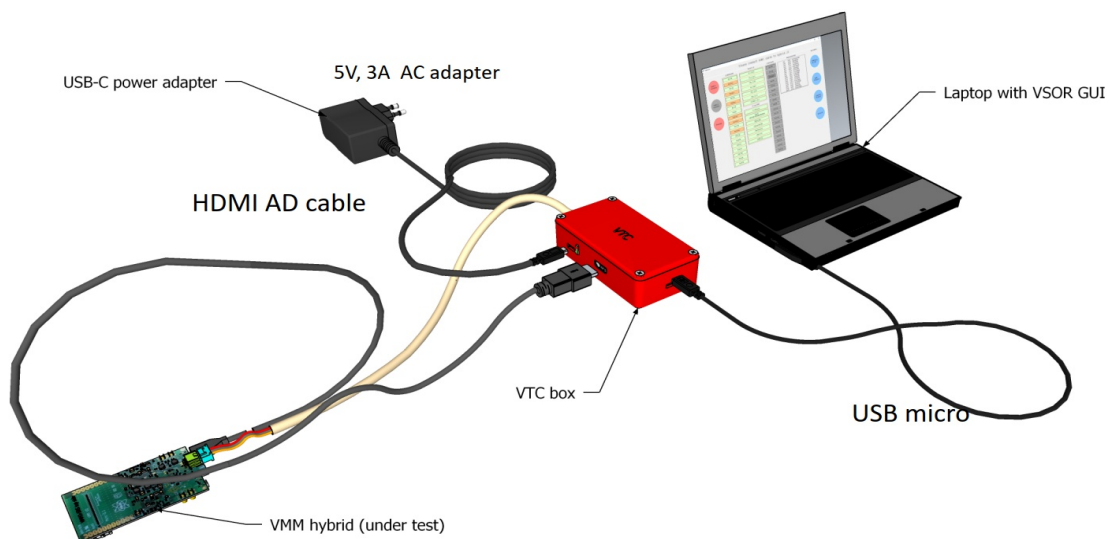


Figure 3: Schematic drawing of the test setup with hybrid, VTC and computer

HDMI cable is plugged into hybrid through J2 connector:

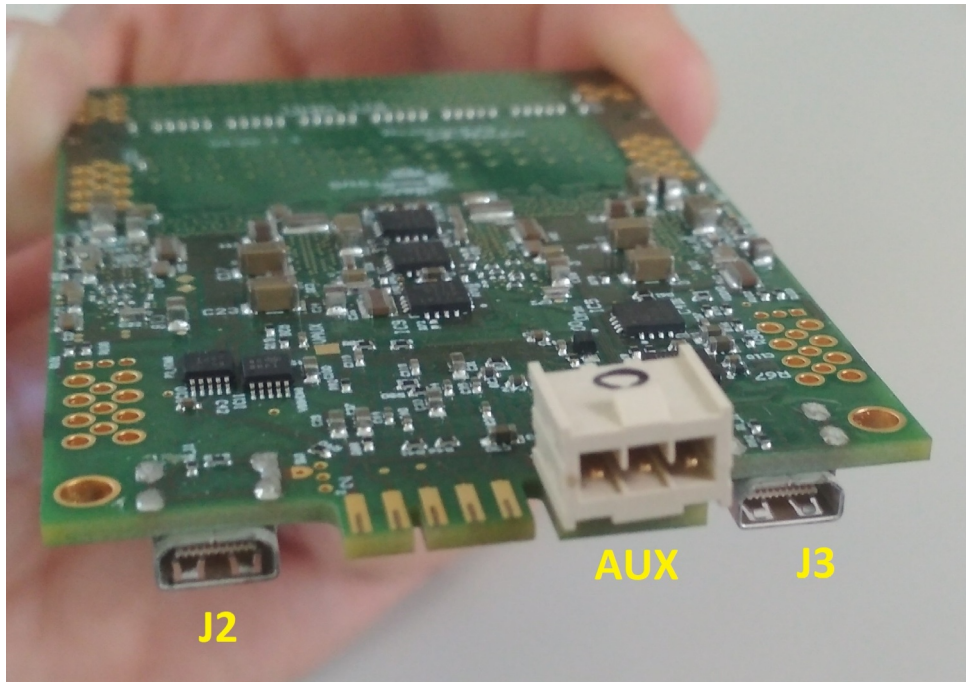


Figure 4: Connectors on the hybrid. The J2 connector of the hybrid is connected via the HDMI cable to the VTC. The sense/ground cable of the VTC is connected to the AUX connector.

3 Usage

In this chapter the complete usage of the system is described. Before proceeding, connect the system and run the control software as described in the chapter *Setup*.

3.1 First look at the program

Here you can see how the main screen of the VTC software looks like. Most things can be done from here, only database tasks use a different window. The screen is divided into several parts:

1. Serial port entry field
2. First set of control buttons
3. Status of HDMI pins
4. Status of power and I2C devices
5. Unused fields for other HDMI connector (maybe used in future versions)
6. Measured values for individual HDMI pins and baselines values
7. Second set of control buttons



Figure 5: VTC python GUI with seven different functional areas or sections.

These areas or sections of the GUI will be explained in more detail in the description of the VTC software below.

3.2 Setting the serial port

First thing to do after launching the program is to set the correct serial port used to communicate with the VTC. On Windows this can be found in Device Manager, in Ports category and generally has a form of COMx, where x is a number. On Linux and Mac OS the shell program *dmesg* can be used to find the name of the virtual serial port.

3.3 Running the test

The main feature of the SW is the running the automatic test of the hybrid. The test is run with a button in section 2 of GUI called *Execute complete test*. For this test the hybrid does not have to be powered, the test turns the power on and off automatically. At the beginning of the test, a clicking noise, caused by the switching of a relay, should be heard from VTC. The power state of the hybrid is also indicated by a coloured dot next to *VMM Power On/Off* button in section 7 (red – Off, green – On, without colour – unknown state after running the program).

After clicking the button, the test starts. During that time, the program freezes. After the test finishes, the GUI starts to be responsive again. The test takes about 10 seconds, exceptionally if some problems occur it can take longer.

At the end of the test, the VTC turns off the power, and the clicking noise should be audible again.

3.4 Interpreting the results

After the execution of the test, the sections 3, 4 and 6 should display the measured data.

Additionally, beneath the buttons in section 7, the measured temperature of both VMMs should appear.

For the HDMI connector in section 3, each pin has a colour indicator: green means the pin is OK, whereas orange indicates an ERROR. The exact measured values and their permitted ranges can be checked in the upper table in section 6.

Pin14/19 (1/2 P2b) OK		Measurement field			
Pin15 (SDA) OK		aux	1.14 V	528924.63 OHM	(> 1000)
Pin16 (GND-D) OK		pin1	3.11 V	16.21 MOHM	(> 1)
Pin17 (SCL) OK		pin2	0.00 V	0.00 KOHM	(< 0.004)
Pin18 (SDA) Error		pin3	3.22 V	16.78 MOHM	(> 1)
		pin4	3.21 V	34.61 MOHM	(> 1)
		pin5	0.00 V	0.00 KOHM	(< 0.004)
		pin6	3.21 V	34.00 MOHM	(> 1)
		pin7	3.19 V	29.11 MOHM	(> 1)
		pin9	3.21 V	34.61 MOHM	(> 1)
		pin10	3.19 V	28.05 KOHM	(> 1)
		pin11	0.00 V	0.00 KOHM	(< 0.004)
		pin12	3.21 V	34.61 KOHM	(> 1)
		pin13	0.20 V	64.45 KOHM	(> 5)
		pin14	0.63 V	238.21 KOHM	(> 100)
		pin17	0.00 V	0.00 OHM	(< 4)
		pin18	0.02 V	6.88 KOHM	(> 4)
		pin19	0.63 V	238.21 KOHM	(> 100)

Figure 6: Screenshot of the VTC GUI. On the left the colour coded pins are shown, and in the table on the right the measured values.

A similar colour scheme is used for the power and I2C results in section 4. Note: The power values P1a, P1b, P2a and P2b are only displayed as additional information, they do not have a range of permitted values assigned to them. Relevant are currents P1 and P2 and the voltages P1 VMM and P2 VMM. The voltages are measured on the hybrid on the white AUX connector through the connected cable.

As a prerequisite for the I2C measurements, the FPGA target with the address 65 has to be present, since the FPGA serves as a connection between the VTC and the other I2C devices. The ID is the 128bit number that uniquely identifies the hybrid. It is stored in the ID chip (address 88), which is actually part of the same physical chip as the EEPROM memory (address 80). Therefore usually either all three I2C fields are OK, or all three show ERROR.

Baseline values are displayed in two forms, a plot and a table. By default the plot is shown as it is easier to see the variability of values between channels. In the table view all channels are displayed together with the exact measured values. If a channel values is out of bounds, it is highlighted red.

Plot	Table				
channel	VMM0	VMM1	channel	VMM0	VMM1
0	174.88	171.81	32	174.88	171.88
1	174.88	171.75	33	174.94	171.75
2	174.81	171.81	34	174.81	171.75
3	174.81	171.69	35	174.81	171.81
4	174.81	171.81	36	174.69	171.75
5	174.75	171.88	37	174.94	171.88
6	174.81	171.75	38	174.81	171.75
7	174.81	171.81	39	175.0	171.75
8	174.81	171.75	40	174.94	171.75
9	174.88	171.88	41	174.94	171.75
10	174.81	171.81	42	174.88	171.88
11	174.81	171.81	43	174.88	171.81
12	175.0	171.88	44	174.88	171.81
13	174.81	171.88	45	174.88	171.75
14	174.81	171.88	46	174.94	171.81
15	174.81	171.88	47	175.06	171.81
16	174.94	171.75	48	174.81	171.75
17	175.06	171.88	49	174.81	171.81
18	174.88	171.69	50	174.88	171.88
19	174.88	171.75	51	174.94	171.75
20	174.94	171.69	52	174.88	171.88
21	174.69	171.94	53	174.94	171.88
22	174.88	171.75	54	174.94	171.75
23	174.88	171.69	55	174.94	171.81
24	175.0	171.81	56	174.81	171.69
25	174.88	171.88	57	174.88	171.88
26	174.88	171.75	58	174.88	171.88
27	174.94	171.81	59	174.94	171.81
28	174.88	171.81	60	174.88	171.75
29	174.81	171.69	61	174.88	171.75
30	174.88	171.81	62	174.81	172.0
31	174.81	171.75	63	174.88	171.94

Figure 7: Tabular view of baseline values. If a baseline value is outside of the defined range, it is displayed in red.

3.5 Operations with database

It is useful to store the test results in a database to keep track of a large number of hybrids. The VTC software uses for this purpose an SQLite database (local database saved in one file). The VTC GUI can thus save the measurements to the database. The user can also search for records in the database, load previously stored records (e.g. for printing labels later), or delete records.

Before saving a record, as first step the user has to fill in the name of the hybrid or measurement in the text field beneath the button *Execute complete test* in section 2. This entry serves as additional identifier, in addition to the very long ID number in the EEPROM. Older hybrids that do not have an ID chip, can only be identified with the help of this user input.

The screenshot shows a 'Database management' window. At the top, there's a 'Search database' section with input fields for 'Measurement (user) description:', 'Chip id:', 'Measurement date:', 'Measurement no.:', and 'Search database:'. A 'Search' button is below these fields. To the right of the search fields is a green button labeled 'Save current record'. Below the search section, a table titled 'Records found' displays 19 records. Each record has columns for ID, CREATE_DATE, MEAS_DESCR, and CHIP_ID. To the right of each record are 'Load' and 'Delete' buttons.

ID	CREATE_DATE	MEAS_DESCR	CHIP_ID	Load	Delete
1	2020-09-07 09:05:22	Check	1e8071864100602ca4a00a000e1	Load	Delete
2	2020-09-07 09:15:06	2	1e8071864100602ca4a00a000e1	Load	Delete
3	2020-09-07 09:50:58	3	1e8071864100602ca4a00a000e1	Load	Delete
4	2020-09-07 09:52:29	4	1e8071864100602ca4a00a000e1	Load	Delete
5	2020-09-07 09:54:15	5	1e8071864100602ca4a00a000e1	Load	Delete
6	2020-09-07 10:05:01	0	1e8071864100602ca4a00a000e1	Load	Delete
7	2020-09-07 10:23:10	0	1e8071864100602ca4a00a000e1	Load	Delete
8	2020-09-07 10:23:10	1	1e8071864100602ca4a00a000e1	Load	Delete
9	2020-09-07 13:13:42	hybrid_name	1e8071864100602ca4a00a000e1	Load	Delete
10	2020-09-07 13:19:41	0	1e8071864100602ca4a00a000e1	Load	Delete
11	2020-09-07 13:21:27	9	1e8071864100602ca4a00a000e1	Load	Delete
12	2020-09-07 13:24:15	10	1e8071864100602ca4a00a000e1	Load	Delete
13	2020-09-07 13:27:44	11	1e8071864100602ca4a00a000e1	Load	Delete
14	2020-09-07 13:29:38	11	1e8071864100602ca4a00a000e1	Load	Delete
15	2020-09-07 13:30:50	12	1e8071864100602ca4a00a000e1	Load	Delete
16	2020-09-08 15:55:46	New date	1e8071864100602ca4a00a000e1	Load	Delete
17	2020-09-09 10:27:24	Name moved	1e8071864100602ca4a00a000e1	Load	Delete
18	2020-09-09 10:30:11	Name2	1e8071864100602ca4a00a000e1	Load	Delete
19	2020-09-15 10:18:20	New db window	1e8071864100602ca4a00a000e1	Load	Delete

Figure 8: Database window

A click on the button *Database management* in section 7 then opens another window. On the left side are two entries: One entry for a search term and one entry that specifies the database file. Results are then shown below. One of the records in the search results can then be loaded, and the complete content of the record is displayed on the main screen. The other option is to delete the record.

On the right side of the database window is the green button *Save current record*. If the user clicks this button, either the currently measured record is saved to the database, or a record that has been loaded before.

3.6 Label printing

After the test is done or a measurement is retrieved from database, a label can be printed. As with saving to DB, the Name field should be filled in (beneath the *Execute entire test* button). In section 2, below the button *Print Label*, the Row and Column entries for the positioning of the label on the label paper are shown. Here the position of the label on the label paper should be entered. The button *Label preview* in section 7 can be used to show the preview pdf to check the correct positioning and to view the information in the label.

The printing of a larger number of labels can be done using two “strategies”, either by putting a stack of several label papers in the printer and always print the same position until the paper runs out, then reload the papers and move the position. The second option is to use the same paper every time – after each printing action, but the label paper back into printer and move the position.

Figure 9: Text entry for hybrid name, button for label printing and positioning of label on label paper (row and column entries)

3.7 Turning hybrid on/off

A hybrid can also be turned on or off manually, through the button *VMM Power On/Off* (first one from the top in section 7).

This is needed for the temperature measurement (outside of main test) and for changing the FPGA firmware.

3.8 Measuring the temperature

As described in the previous chapter, the hybrid must be turned on first. After turning it on, wait about 3 seconds. Then you can press the button *Measure temperature* (bottom of section 7).

3.9 Changing the FPGA firmware

The VTC software allows the user to change the firmware of the FPGA – temporary (until powered off) or permanently by writing to the configuration flash. In the background, the standard *Impact* programming software from Xilinx is still used, the VTC just facilitates the whole programming process.

In the section 2 of the GUI, there are two buttons and three entry fields related to programming. The bottom-most entry is used to set up the path to the *Impact* program. If it is already stored in the *PATH* variable, then this step is not needed. The path to the bitstream file should be filled into the text entry beneath the *Program FPGA* (temporary) or *Program Flash* (permanent) button. The *Browse* button next to these fields will open a standard file dialogue. For temporary re-programming the files have the extension *.bit*, whereas permanent ones end with *.mcs*.

As next step, turn on the hybrid with the *VMM Power On/Off* button and then click the chosen programming button. During programming, a blue circle should appear next to the button. After the programming is finished, it will change either to a green checkmark (success) or a red cross (fail). After that the hybrid can be turned off.

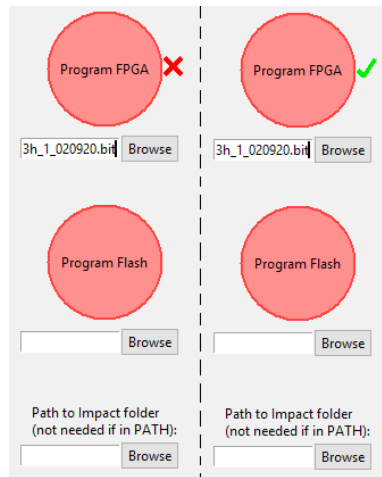


Figure 10: VTC GUI buttons and text entries for programming the hybrid

4 Diagnostics of test errors

This chapter describes possible reasons that cause the test on a particular hybrid to fail.

4.1 HDMI pins

If some HDMI pins are failing the test, check the connection of the HDMI cable and AUX cable to their ports. Possibly try other HDMI cable.

On some hybrids the HDMI connectors have not been correctly soldered, and need to be resoldered.

4.2 No I2C

If the VTC cannot find any devices over I2C, check the HDMI connection and verify whether the FPGA firmware has been loaded. Also make sure that the JTAG adapter is not connected during the test.

If only FPGA cannot be found, the FPGA uses most likely an older version of the firmware. In this case the baseline check will also not work.

4.3 Zero baselines

If the test finishes and baselines of one or two VMMs are all zero, there could be a short to ground somewhere, e.g. on the VMM pin, or the connection between analog output and uADC.

4.4 Programming firmware failing

Check the console that opens together with the program. Messages there help decide, whether the problem is with locating Impact or connecting to the programmer.

If Impact loads correctly, the programmer is found, but errors appear when finding the FPGA, check the correct connection of the programmer to the hybrid. If the problem persists, try using newer small white adapter, they sometimes wear out.