The Testing of SpaceWire Network Switching Devices

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Abstract

The SpaceWire standard [1] is being developed for reliable high-speed communication over a network of different devices. The implementing of connectivity between devices can be done using a variety of network switches. A set of network switches are currently under development for the SpaceWire networks. The developed Russian VLSI (like switches: MCK-01, MCK-02...) have a build-in RISC core, which allows for the development of software. In particular, the MCK-01 switch comes with the firmware – pre-installed software for the user. An important step when developing such equipment is testing the final product for their efficiency and performance under different conditions. A relevant task is to create a set of flexible and universal production tests that will allow testing individual types of switches without making great changes to the tests themselves. Thanks to the embedded RISC processor it is possible to create a set of tests that would have a wide array of parameters that the user would be able to change. This will allow for the collection of valuable statistical date that later would be used to investigate and analyze the parameters of the equipment in question.

I. Introduction

Testing is an important milestone in the development and operation of any device, it allow to see what the operability and its compliance with the specified characteristics is. [2] Typically, testing is divided into various stages. In the case of a SpaceWire switch it is divided into 3 stages:

1. Self-testing: these are test that are carried out by the device when it is turned on. These tests are part of the embedded software and are delivered in the finished product. Allow us to determine the operability of memory and other internal systems of the device. The user dose not take part in these tests.
2. Testing a single device.
3. Testing a single device in a network.

In this article we will discuss in detail the last 2 types of testing.

II. Main part

The main objective of any test - is to clearly determine if the device, its suitability for use. Therefore, it is necessary to test the device in its normal operating conditions, and in its critical. To solve this problem, a set of production tests is under development.

Developing a set of production tests allows for the testing of all parameters of the device, as in situations with small workloads, and simulated different critical situations. Also the developed set of tests allows the testing of switching devices in 2 modes: single device testing and testing in the network.

This test suite allows for the testing of various SpaceWire switching devices (MCK-01, MCK-02 ...) without significant changes in the test programs themselves. To change the device under study is sufficient enough to replace the project file which describes the address space to the appropriate device that will be studied next and just compile it.

A. Testing a single device

The tests suite for testing for a single device is aimed at assessing the performance and studying the main characteristics of the switching devices, such as connection speed, intensity of data transmission, packet size of the transmitted data, in which the device will working properly. With this type of testing the tests run on the device itself and the device is not connected to the network or any other device. SpaceWire ports are interconnected, forming a loop. The test program is the only thing that is running on the device.

The set of tests for a single device covers all the main characteristics of the switching device, and includes the following tests:

1. Tests of establishing a connection with the base speed.
2. Tests of speeds that can be achieved in a channel.
3. Transmission tests of packets at different speeds with different intensities (with checking the validity of an incoming packet)

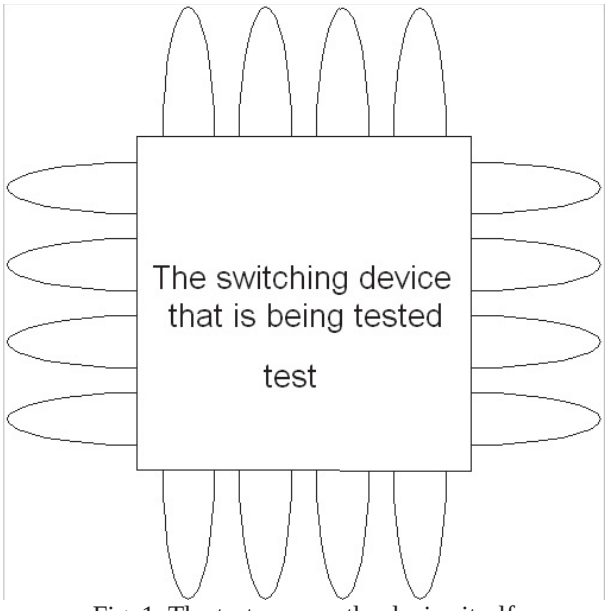

Fig. 1. The tests run on the device itself

For example, the data that is to be transferred can be formed according to a mask, the user of the test has defined, by repeating this mask as many times as necessary to completely fill the package of a given size. When checking the correctness of the packet we compare the data that was sent and the data that was received.

After the device has passed this suit of tests we can get the following characteristics:
1. The average time it takes for a connection to establish at different speeds.
2. The dispersion of the connection time at various speeds.
3. The minimum and the maximum speed available for this channel.
4. The average size of a packet that is transferred without error at different speeds.
5. The maximum intensity error-free transmission of different packets.
6. and so on...

B. Testing a single device in a network

When testing the switching device through the network, the testing is done to a device which has the same configuration as an end users device(i.e. board + firmware). The test runs on the testing device which is connected to the UUT device that we want to test, which is running the firmware. A SpaceWire switching device can also act a tester.

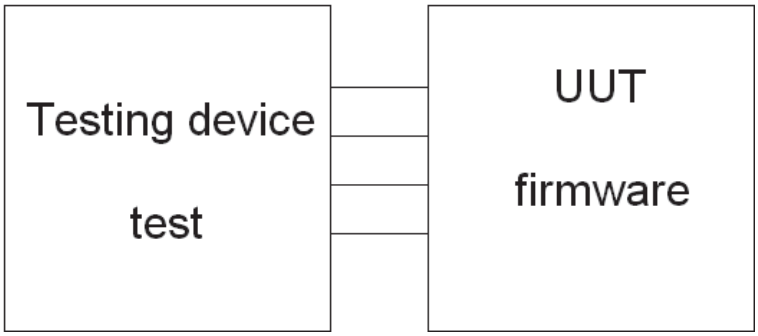

Fig.2. Testing a single device in a network

When testing network switching devices on the network we accomplish the following tasks:

1. Testing how the connection establishes different speeds.
2. Testing the transmission of packets at different speeds with different intensities.
3. Testing adaptive multicast routing.

To ensure that all of our testing is complete we need to provide a good variety of different combinations of parameters for these tests - different flow rate of packet transmission, packages of different types and at different speeds. The ability to combine the values of the parameters makes the developed test suite a flexible and suitable for studying a wide range of devices.

For example, parameters can be changed as follows:

1. Changing the speed.
   - Rise the speed to a maximum with a jump.
   - A smooth rise to the maximum speed (different length steps).
   - so on...
2. Changing the content of a paket
   - short header + short data
   - long header + short data
   - so on...

3. Changing the flow rate of the packets
   - A light workload
   - A havy workload

To create the maximum network load we connect additional boards to the network of the device that is being tested with the packet generating tests on them.

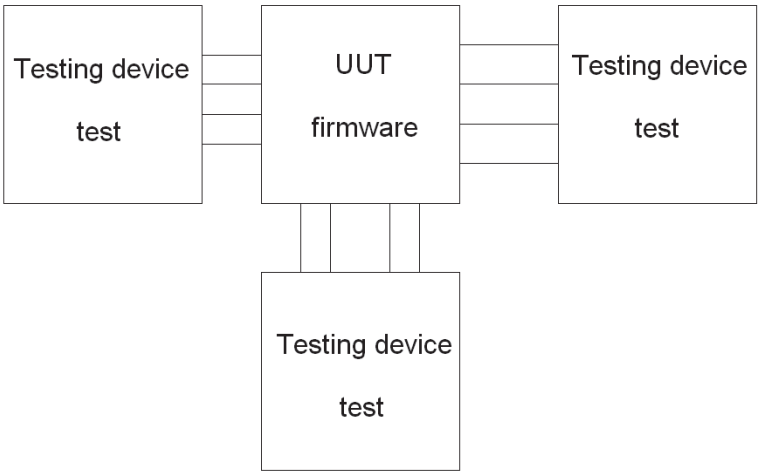

Fig. 3. Creating maximum network load

When testing the transfer of data packets we need to check the correctness of transmitted packets. To do this we can use RMAP packet, which have a confirmation the correctness of the packet that was sent. Also the RMAP packets can help in creating a large network load.

For example, you can create a situation like this:

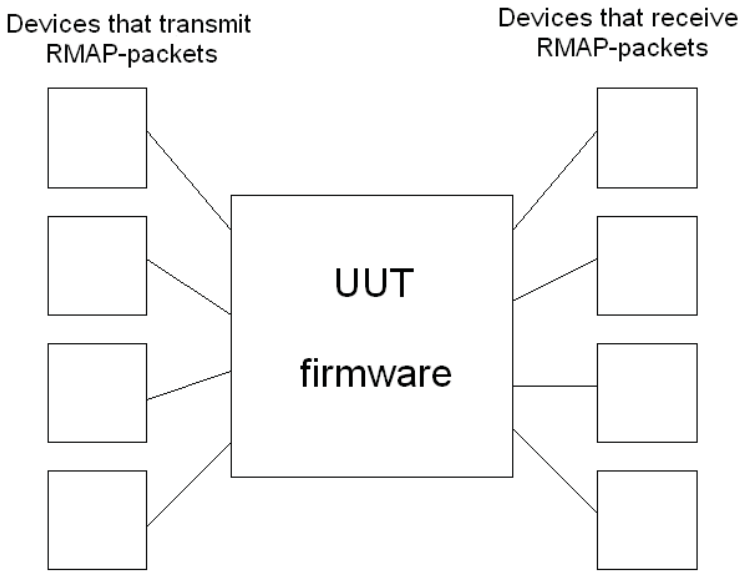

Fig. 4. Testing the transfer of data packets

In this case, our switching device is running on its firmware, we connect devices which are transmitters of RMAP-packets and devices that receivers RMAP-packets (any device capable of sending an answer about the correctness of the packet).

SpaceWire switching devices are capable of adaptive multicast routing. Adaptive multicast routing allows the presence of redundant connection (a group) to redirect the flow of data from one device to another in the event of failure or excessive loading of one or more compounds from the group.

When testing adaptive multicast routing there are 2 options:

1. Some of ports in the group do not work and a packet has arrived on one of them, this packet is redirected to a working port group.

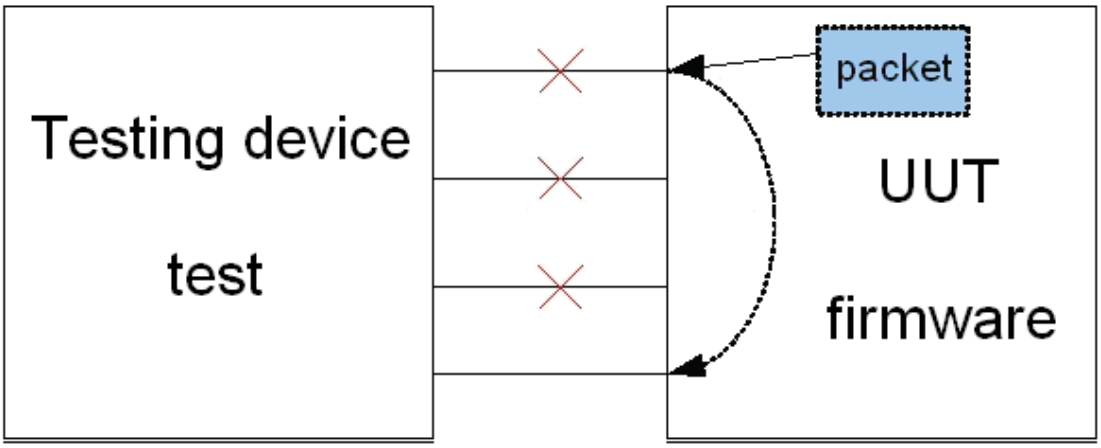

Fig. 5. Packet transmission with ports that don't work

The figures show the packet transmission between two switches MCK-01 connected with multiple channels.

2. A packet is sent and some of the ports are busy, to avoid a delay the packet is redirected to a free port.

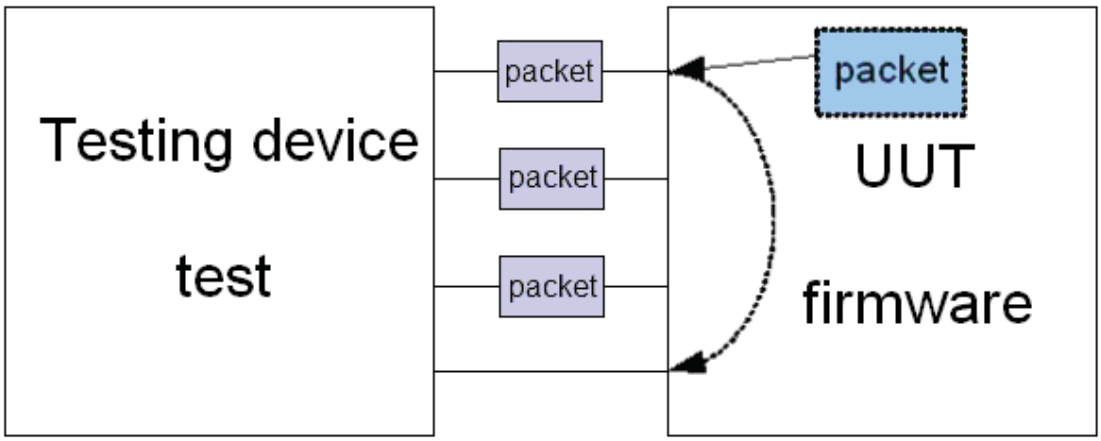

Fig. 6. Packet transmission with ports that are busy

In order to form this situation a heavy network load is formed for one or more ports from the group.

III. Conclusion

The set of tests in the article a allows us to define main characteristics of the device that is being tested, to evaluate the limits of external parameters. Combining the values of various parameters allows us to achieve a universal and maximally flexible test suit and evaluate the performance of each devices, not only in normal situation but in critical situations too. If the device successfully passes the testing, then we can make a foregone conclusion about its effectiveness and compliance of its network parameters and declared characteristics. Due to the versatility of these developed tests we can test with their help a wide variety of SpaceWire switching devices without significant change in the test programs.

References

[1] ECSS-E-50-12C. SpaceWire - Links, nodes, routers and networks. - European Cooperation for Space Standardization (ECSS), 31 July 2008.
[2] Nigel Barges. Network testing, http://www.ccc.ru/magazine/depot/05_07/