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## INTEGRATED APPARATUS TO VALIDATE AND TEST LEDS AND TRANSCEIVER PORTS

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### ABSTRACT

Presented herein is an integrated test apparatus that may be used to test both Light Emitting Diode (LED) and transceiver port features of a network device.

### DETAILED DESCRIPTION

Many network devices, such as switches and routers, are configured to use LEDs to indicate the current status of certain device features, such as port status. These LEDs indicating the status of device features are sometimes referred to as “Status LEDs” (e.g., Port Status LED shows the current port status). These features are 100% tested during the production process, but require a set of standalone LED test stations. There are several issues with this step.

In particular, network devices tend to have many ports to support different optical/Copper modules (e.g., SFP+, QSFP, and QSFP-DD) and the Status LEDs for each of these ports need to be 100% tested. In addition, the test time per network device is long and often inaccurate. The conventional testing techniques require separate test steps in the process that add more handling of the product, which in turn leads to quality implications. Moreover, continuous capital investment is needed to add more testers to align with production and the lead time to procure and build these testers is too long and not aligned with production ramp up.

In addition, electrical loopback modules (ELMs) are used to test each port at the board level. These ELMs are widely used to emulate optical modules features and test the electrical side of the host. Some of ELMs are sophisticated testers and can perform

parametric and function tests in addition to many other functions (e.g., voltage and temperature monitoring), thereby providing an adequate and economical test solution for ports testing.

In other words, both LED and transceiver port tests are essential for any network device. In conventional arrangements, LED and transceiver port tests are performed separately (e.g., parametric/functional tests are first performed using ELMs and then the status LEDs are tested). Although testing LEDs is not a universal manufacturing test step, there are three primary conventional techniques that may be used for testing LEDs, namely:

1. LEDs are randomly turned ON and OFF with an operator visually checking the status of the LEDs.
  - **Disadvantage:** Unreliable and requires long test time
2. LEDs are tested using standalone instruments such:
  - **Disadvantage:** Expensive and requires extra time to setup
3. Camera Based LED test Solution (Computer Vision Based Solution)
  - **Disadvantage:** Expensive and sensitive to the test environment (e.g., requires darkroom for accuracy in addition of a need of an array of cameras or a sophisticated robotized system).

All of the above tests fail to reproduce the real functionality of the product, since all these tests require a special version of the software to turn the LEDs on and off in order to check the brightness, the tone, and if they are indeed functioning or not. In addition, these tests do not replicate the real configuration of the product in the field.

For functional/parametric testing of the hosts in manufacturing environment, ELMs are usually used for mass production testing. These ELMs come in different form factors identical to the optical or copper modules that usually are inserted to populate the host ports.

To increase the product competitiveness and reduce transformation costs, there is a continuous demand to decrease the product overall test cost by: reducing test steps in the process flow, reducing test equipment investment, and reducing test time, which impact product yield. Accordingly, presented herein is an integrated test apparatus that is configured to test both Status LEDs and transceiver ports in a pluggable module form

factor. The proposed integrated test apparatus enables a single test step, which has tremendous cost saving and cost avoidance in addition to test time reduction.

As noted, network devices (e.g., switches, routers, etc.) use Status LEDs to indicate the port status. Users rely on these Status LEDs (on the front panels) to verify the proper operation of the port or perform troubleshooting to find a failure. Figure 1, below, illustrates the front panel of line card with QSFP and SFP+ Ports along, with their corresponding LEDs.



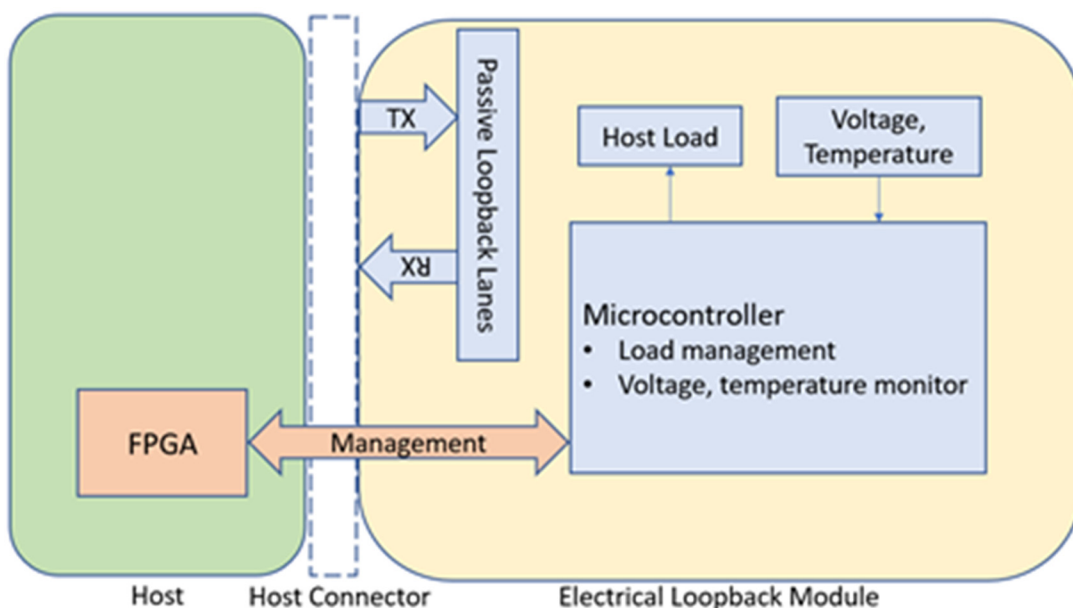
**Figure 1**

LED failure is a common failure mode in the field, especially Dead on Arrival (DOA) failures. Different failure mechanisms may cause LED failures, such as LED component issues, light pipe assembly issues, LED control circuit issues, LED port mapping mismatches, etc. LED port mapping mismatches, in particular, are troubling in that the decoupling between the software and hardware testing cannot be covered by the current solutions as there is no relationship and enforcement between the port and the LED tester.

Presented herein is the integration of LED testing into the ELM to provide an integrated test apparatus that can be used for both Function/Parametric testing and LED

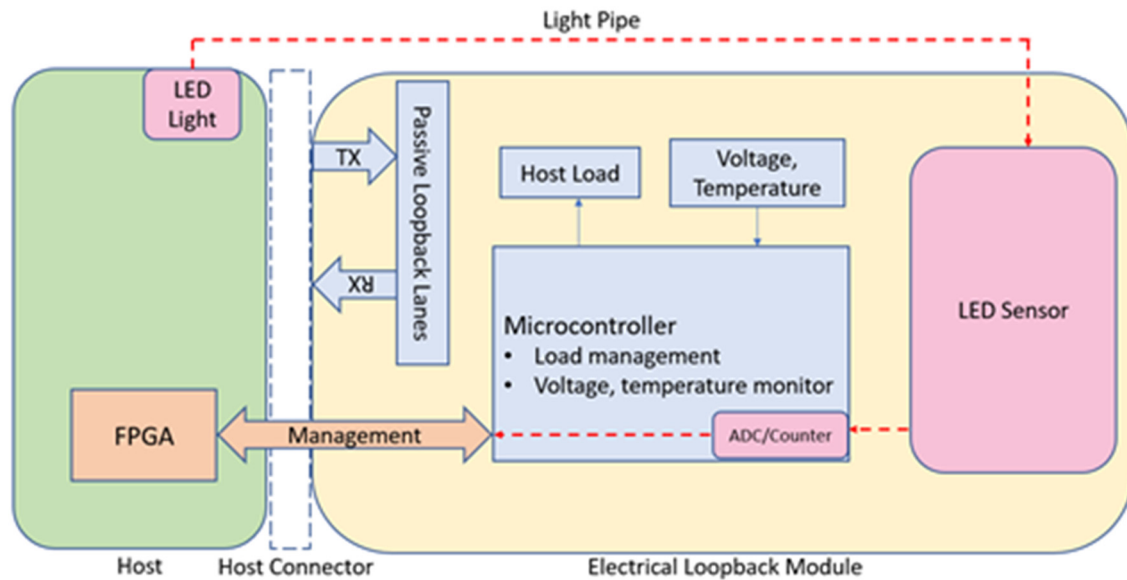
testing. It is to be noted that certain ELMs are sophisticated and have complex features, which are not part of the techniques presented. As such, for simplicity and ease of description, the integrated test apparatus is described with reference to a passive ELM to show the integration of LED testing.

Figure 2, below, is a block diagram of a passive ELM. As shown, a passive ELM is generally composed of three blocks, namely the High Speed Loopback Lanes, Low speed interface connected to a Microcontroller (e.g., voltage/temperature Monitor and Load Management), and Host Load Emulation.



**Figure 2**

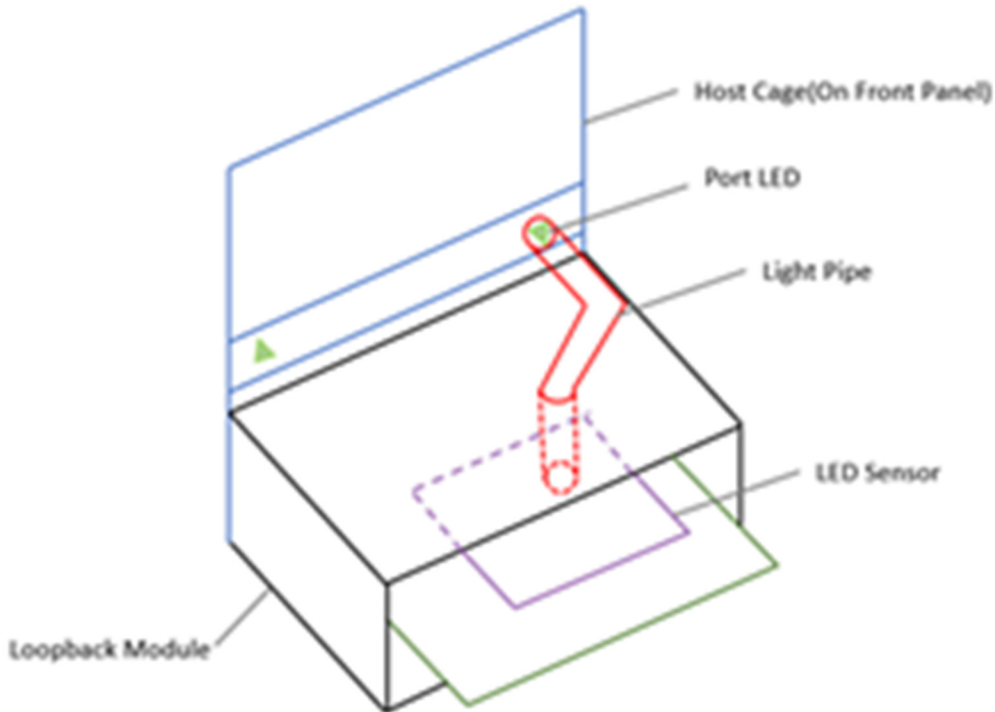
Figure 3, below, illustrates an integrated test apparatus in accordance with embodiments presented herein (e.g., passive ELM with integrated LED test functionality).



**Figure 3**

As shown in Figure 3, in addition to the standard passive ELM, the integrated test apparatus presented herein also integrates the several functional blocks (highlighted in light pink color in Figure 3). These additional functional blocks include the LED sensor, light pipe (mechanical), and communication channel (e.g., using ADC/counter inside the microcontroller and leveraging original management channel between the host and the microcontroller).

Figure 4, below, is a concept rendering of the mechanical structure for an integrated test apparatus presented herein.



**Figure 4**

The light pipe can be customized to guide the LED light to the LED sensor for different types of transceiver ports. As such, the operation does not need to align the LED with the integrated test module. The references that will be used to align to the LED output on the front panel to this light pipe are covered by the module specifications. In this case, the light pipe may be referenced to the shell of the module to guarantee coupling that does not need extreme accuracy to guide the light.

It is noted that there may be different implementations where one ELM can support testing one LED, but some mature products may require use of an adapter/fanout to cover multiple LED testing with one module.

There are a few steps to follow to test both the functionality of the port as well as the LED through the use of an integrated test apparatus presented herein. These steps include:

- Insertion of the integrated test apparatus into a transceiver port.
- Running diagnostic software and other scripts to test the high-speed links, low speed interface and other port features such as load, temperature and voltage.

- Diagnostic software plus other scripts confirm that an integrated test module is in the right port.
- Run diagnostic software and other scripts to turn on/off the LED of the port based on LED test algorithm.
- Diagnostic software and other scripts read out the LED sensor result via the management channel, including LED brightness and color. The data is then compared to the specifications and a pass or fail test result is generated.
- Test system records all test results.

There are many drivers and constraints that impact how vendors manufactures and services products across the globe. These are not limited to supply chain issues, but instead also extend to customer service segments of the organization in dealing with customers immediate needs, such as Return Merchandise Authorizations (RMAs) and Failure Analysis (FA). Over the course of just last year, many typhoons, earthquakes, geopolitical issues (e.g., Brexit, tariffs, etc.), high product demand volatility, etc. have placed extreme stress on vendor's supply chains. While some of these challenges were easy to manage as they were under the control of supplier agreements, others were not under any control, such as the procurement of test instruments. These tend to have longer lead times and are sourced from particular locations around the globe that make them one of the key items in building any risk mitigation plan.

Creating a plan for procuring test instruments from duplicate manufacturing sites may be a difficult problem to solve. While some of these test instruments have alternatives (e.g., embedded test modules that are built similar to products and used for testing purposes thus illuminating the need of third-party instrumentation), LED testers are still a bottle neck. As such, the decision is often made not to run the LED tests (if LED testers are unavailable), which in turn leads to many returns of the products from the field. In addition to this, reducing the capital cost (cost of the equipment, test development and support and sustain costs) for testing is becoming a major issue as it impacts directly the margins of the products and, as such, there is a need to focus on its reduction or illumination. To be flexible enough to move production from any site to any site around the globe can mitigate the effects of geopolitical issues and natural disasters on the supply chain.



The integrated test apparatus presented herein assists in achieving these objectives. In particular, the integrated test apparatus is easy to deploy, combines two originally separate test stations into one test station, and enables a “plug-and-test” approach (e.g., no need for operator to align the LED port with the LED light pipe). The integrated test apparatus presented herein is also cost efficient, with low test module cost and providing savings in both test set up time and actual test time. The integrated test apparatus presented herein is also reliable and provides flexibility for vendors to run any production anywhere around the globe. In other words, the integrated test apparatus presented herein provides manufacturing cost savings, increase manufacturing productivity, and improved product quality for customer satisfaction.