Simultaneous 1080-Channel Control and Measurement for Photonic IC

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Abstract: An integrated source-measurement unit (SMU) system that can be scaled up to 1080 channels is developed. This platform can drive and measure current and voltage for many use cases including photonic integrated circuits (PICs). © 2022 The Authors

1. Overview

We demonstrate a compact and efficient SMU platform to simultaneously drive and measure 1080-channel current and voltage from a control station (e.g., personal computer (PC) or laptop) through an Ethernet cable. Users can choose to control current and voltage using either a dedicated graphical user interface (GUI) or the Standard Commands for Programmable Instruments (SCPI). This platform system is suitable for sourcing and measuring low-power applications such as complex PICs.

2. Innovation

Nowadays, a single PIC has multiple components i.e., Mach-Zehnder interferometers (MZIs) [1,2], thermo-optic phase modulators (TOPMs) [3], micro-ring resonators (MRRs), laser diodes, semiconductor optical amplifiers (SOAs) [4] and others. The greater number of components leads to the crucial development of an electrical driver to control and test the PIC itself. The challenge occurs in how to create a compact and versatile electrical driver that can drive numerous active components and perform functionalities such as constant-voltage (CV) mode for Mach-Zehnder modulators (MZMs) and constant-current (CC) mode for laser diodes. However, before we apply this driver to mass-scale production, large-scale PICs need to be tested and characterized.

We developed an integrated SMU system for PIC test and characterization that is capable of controlling and measuring 1080 channels. We propose an innovation to scale up the number of channels that can be driven and measured at the same time for future large-scale integration. Our platform is scalable by putting the instruments in parallel and controlling all the channels simultaneously using only a PC/laptop connected via an Ethernet cable. Different types of signals like rectangle, ramp, sawtooth, etc. can be generated. Users can choose to use either GUI or SCPI which can be programmed using their preferred programming languages (Python, C#, LabView, MATLAB, etc.). Users can also utilize this platform to acquire the current-voltage (I-V) characteristics of the device-under-test (DUT) for multiple channels or simply apply a constant voltage or current for long hours (durability test). In the future, this system can be miniaturized to be a driver integrated circuit (IC) that can be heterogeneously integrated with PICs.

Table 1. Data of the Experiment

Number of Channels Controlled	Latency (ms)	Measurement Time (ms)
1	3	325
40	77	323
120	323	393
240	388	449
360	1054	1216
480	1326	1482
600	1560	1858
720	1816	1983
840	2074	2368
960	2408	2574
1080	2568	2872

From our latest experiment, we have demonstrated that the system could control 1080 channels perfectly with a relatively quick response time and value change time. In this experiment, all 1080 channels were connected to the control station. We measured the response time and value change time when a particular number of channels were controlled. To get the response time, we recorded the time between when the voltage was set and when the hardware responded with ”OK”. To get the value change time, we compared the time when the voltage was set and when the measured voltage also had the same value.

For CV mode, we achieved a setting accuracy of ±131.6 μV and a measurement accuracy of ±87.9 μV and for CC mode, we got a setting accuracy of ±2.5 μA and a measurement accuracy of ±1.8 μA. From Table 1, even though the controlling process run continuously, we only needed 3 ms to control a single channel. When controlling all the 1080 channels, the SMU system responded after 2568 ms and all channel voltage were successfully set after 2872 ms.

3. OFC Relevance

This demonstration is relevant to the 2023 OFC Demo Zone topic category of programmable networks, which includes programmable hardware [5].

4. Demo Content and Implementation Section

4.1. The Objectives and the Configuration of the Demo

This demo aims to prove that it is possible to drive and measure 1080-channel current and voltage simultaneously. The performance is evaluated by looking at several parameters such as control time or latency, accuracy, and measurement speed.

4.2. Demonstration Setup

We will use our integrated SMUs, Ethernet cables, one laptop, and power supplies. Power supplies will be used to power SMUs. SMUs will connect to the laptop using Ethernet cables. The laptop will be used to control and read the measurements from SMUs.

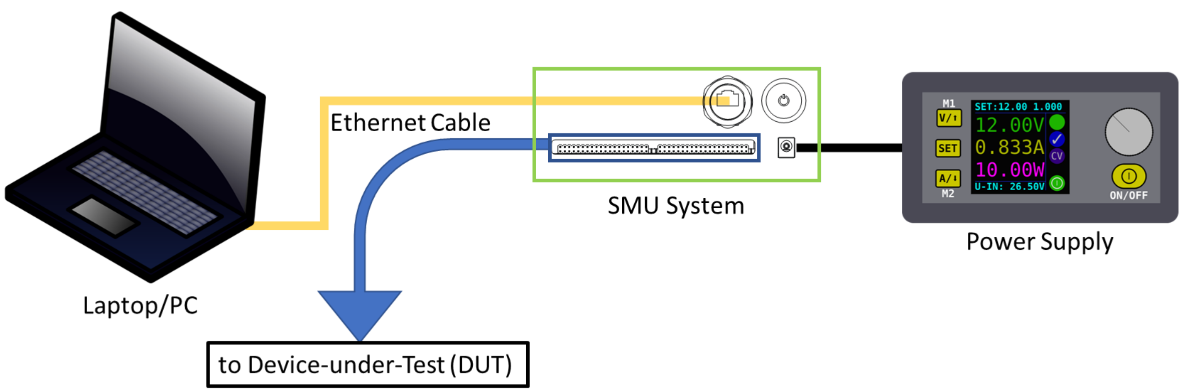

Fig. 1. Demo equipment setup.

4.3. How the Demo Will Be Presented to Attendees

The equipment will be set up on-site and we will do a live demonstration of controlling and measuring 1080-channel current and voltage simultaneously using both GUI and SCPI.

4.4. Interaction with Attendees

Attendees can try to use the dedicated GUI that we developed to change different settings and read the measurement of current and voltage. They will also be able to take a look at our integrated SMUs.

5. References

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