VTI Instruments / AMETEK PROGRAMMABLE POWER

WHITE PAPER

Programmable Power and Data Acquisition Energize University Research

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Energize University Research

Science, technology, engineering, and math (STEM) *programs are gaining significant emphasis in academic settings, driving students toward rewarding careers and enabling universities to conduct impactful research. These efforts promise advancements in aerospace, automotive, commercial power, power and energy, and semiconductor.*

Driving STEM

STEM programs are crucial in addressing various issues critical to our evolving world, including:

- The worldwide push toward clean energy and vehicle electrification.
- Commercial, government, and university-led space exploration.
- In the U.S., with the recent passage of the CHIPS and Science Act, semiconductor production capabilities have rapidly expanded to serve the needs of artificial intelligence (AI) and related fields.

Universities will not only train future engineers and scientists who will advance these fields but also conduct the basic research that will lead to significant advances that industry and governments will exploit.

Software-Driven Analysis

The education market poses unique challenges for test-equipment providers, as academic work is often more theoretical and heavily reliant on simulation compared to industry practices. In the early stages, the focus is on software-driven analysis, with projects existing as code in various simulation languages. Those languages might include MathWorks' MATLAB and Simulink, Typhoon HIL's TyphoonSim, and AMETEK® RTDS Technologies' RTDS Simulator for power, automotive, and aerospace applications. For applications involving aerodynamic performance evaluation, those languages include computational fluid dynamics (CFD) tools, such as ANSYS's CFD products.

As a project advances, the focus gradually shifts to hardware. For many applications, specific hardware resources replace software to form hardware-in-the-loop (HIL) simulation and testing in environments resembling real-life scenarios. Specifically, research could move to a physical wind tunnel for projects involving aerodynamics.

Power Hardware in the Loop

HIL can take various forms, including controller hardware in the loop (CHIL) and power hardware in the loop (PHIL). In the programmable-power space, PHIL configurations can utilize programmable DC power supplies, programmable AC + DC sources (including four-quadrant regenerative versions), and programmable electronic loads.

In a typical PHIL configuration, a programmable power product could act as an amplifier, in which it accepts an analog input signal and drives a motor or charges a battery, with feedback enabling closed-loop control. Figure 1 outlines a basic PHIL configuration, where a DC motor under test drives a mechanical load, such as a generator, whose output power is regenerated to the AC line. A programmable power supply, acting as a power amplifier programmed by an analog input, drives the motor under test. At the same time, computer simulations provide motor speed inputs and a programmable-load profile.

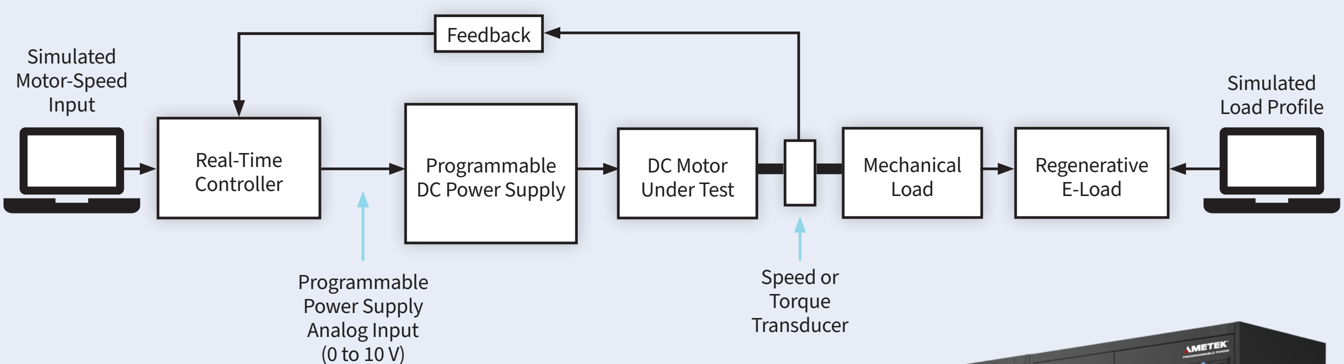


Figure 1. *In this hypothetical PHIL configuration, a programmable DC power supply serves as an amplifier in a closed-loop motor-test system.*

PHIL Breadth and Challenges

PHIL technology can be applied to a wide variety of equipment under test, in addition to DC motors. This includes photovoltaic inverters and microinverters, vehicle traction inverters, terrestrial or orbital photovoltaic (PV) arrays, batteries and battery-based energy-storage systems, fuel cells, and wind-turbine components. PHIL can also be applied to complete smart grid projects, smart-house projects, three-phase AC-motor projects, and energy-storage systems.

Because a PHIL configuration is, by definition, a closed-loop system, it presents challenges not routinely encountered in programmable power test setups. Stability is one such challenge. Any closed-loop system can become unstable due to poorly compensated amplifiers that exhibit gain and phase errors. In a PHIL implementation, instability can compromise measurement results and potentially damage equipment. Consequently, gain and bandwidth considerations of a programmable power product acting as an amplifier must be addressed, and algorithms must be tuned to provide stable, real-world closed-loop control of parameters, such as motor speed.

Case Studies

Programmable power and data acquisition systems have been successfully applied in a variety of university settings. For example, a university in western Europe outfitted a new wind tunnel facility with a data acquisition system that includes instruments for measuring strain, temperature, and vibration. The university chose an LXI-based system that supports the IEEE 1588 Precision Time Protocol (PTP) standard.

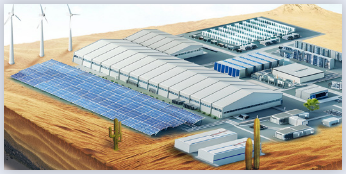
PHIL technology has been successfully applied in various STEM-related applications, such as:

Smart Grid Simulation

A project involving real-time simulation of a smart grid to develop controllers and to analyze various steady-state and fault conditions using a programmable AC power source as a power amplifier.

Smart House Project

A project involving a programmable DC supply used as a power amplifier. This PHIL experiment evaluated control logic, analyzed the effects of power transients, and examined interactions between houses in a neighborhood.



University of Lille Study

A study on microgrids, island networks, and a multiterminal high-voltage DC grid involving AC/DC and DC/AC converters. With appropriate feature sets, programmable products allowed researchers to integrate hardware into their software systems easily and quickly, providing the accurate models necessary to operate at real-time speeds.

SmartEST Laboratory

A laboratory for partners to optimize products and control strategies to analyze interactions with distribution systems using 960-kVA PV array simulators.

Power Electronics for STEM

AMETEK Programmable Power provides a range of reliable, high-performance programmable power and data acquisition products suitable for university environments.

For data acquisition, AMETEK Programmable Power's VTI Instruments brand offers:

EX1403A Precision Bridge and Strain-Gauge Instrument

The EX1403A features 16 channels of strain or voltage measurement capability with independent 24-bit ADCs per channel. This instrument is particularly applicable to wind tunnel flight load tests.

EX1401 Isolated Thermocouple and Voltage Measurement Instrument

This product offers 16 channels for isolated temperature and voltage measurements.

EX1402 16-Channel Isolated High Voltage Measurement Instrument

This product delivers accurate and highly repeatable voltage measurements by implementing fully integrated signal conditioning, 24-bit ADCs, on a per-channel basis.

For power electronics, AMETEK Programmable Power supplies:

Tahoe and Sequoia Precision Programmable AC and DC Sources

These sources use a silicon-carbide power-switching architecture for maximum efficiency and performance. Tahoe offers ratings to 1.08 MVA. Sequoia offers similar ratings and adds full four-quadrant regenerative capabilities for grid-simulation applications. An external-drive option enables analog signal control for PHIL applications.

For DC applications, AMETEK Programmable Power provides:

Intelligent-Bidirectional Energy AMplified (i-BEAM) Series

This series features full DC source and sink capabilities with power levels from 60 kW up to 1.3 MW.

Modular Intelligent-Bidirectional Energy AMplified (Mi-BEAM) Series

This series also features full DC source and sink capabilities but in a modular architecture that can readily adapt to evolving research requirements. Both can serve in battery simulation and test, electric powertrain test, fuel cell test, and solar inverter test.

Conclusion

STEM programs are well positioned to address the challenges in areas ranging from space exploration to green energy, providing research that industry can leverage while training the workforce that will power industry in the future. AMETEK Programmable Power is working to get high-quality power electronics into STEM programs and to support the installed systems to further the research that will address new trends and benefit new markets.