RedWave Labs

# Universal Platform

## Advantages, uniqueness and applications

2024

# Overview

The Universal platform is a stand-alone and ready-to-use OEM subsystem for a number of applications. It covers all the electronics requirements for power, data processing, signal acquisition and control, data storage and external communications.

Multi-gas TDLAS systems remain a popular choice in multi-stack industrial setups for the monitoring of emissions or process control. A growing number of individual sensors and systems represent integration challenges for turn-key manufacturers of these systems. The Universal platform has been designed as an OEM control suite for multi-gas, multi-sensor environments.

The Universal platform can be also powered from a battery and, owing to its attractive SWAP characteristics, it is easily integrated as a part of UAV/drone-based sensing system therefore serving both fixed and mobile installations.

This OEM platform was originally developed as a solution for tunable diode laser spectroscopy (TDLS), providing a solution to many problems in the engineering of turn-key instruments for gas analysis. As a result of our engineering achievements, the Universal Platform is now a modular solution, adaptable to many applications, ranging from spectroscopy to quantum technologies.

The Universal platform is able to control a range of sensors and can operate some experimental lasers with a magneto-optical trap .

All necessary power rails are provided by the backplane with integrated charging capabilities.

A Linux based Kontron CPU (COM Express) with additional high-end FPGAs and MCUs allows to process all signals in real time and increases the overall system refresh rate. A deployed FPGA provides the opportunity to program the electrical systems that are required. Optional plug-ins can be installed depending on the end-user application. This allows additional cost and power saving. There are multiple options for display, 2 Ethernet ports, 4 USB ports and multiple ADCs and DACs. All boards can have conformal coating for humidity protection.

Tunable laser spectroscopy applications include direct measurement with averaging, wavelength modulation and various other solutions.

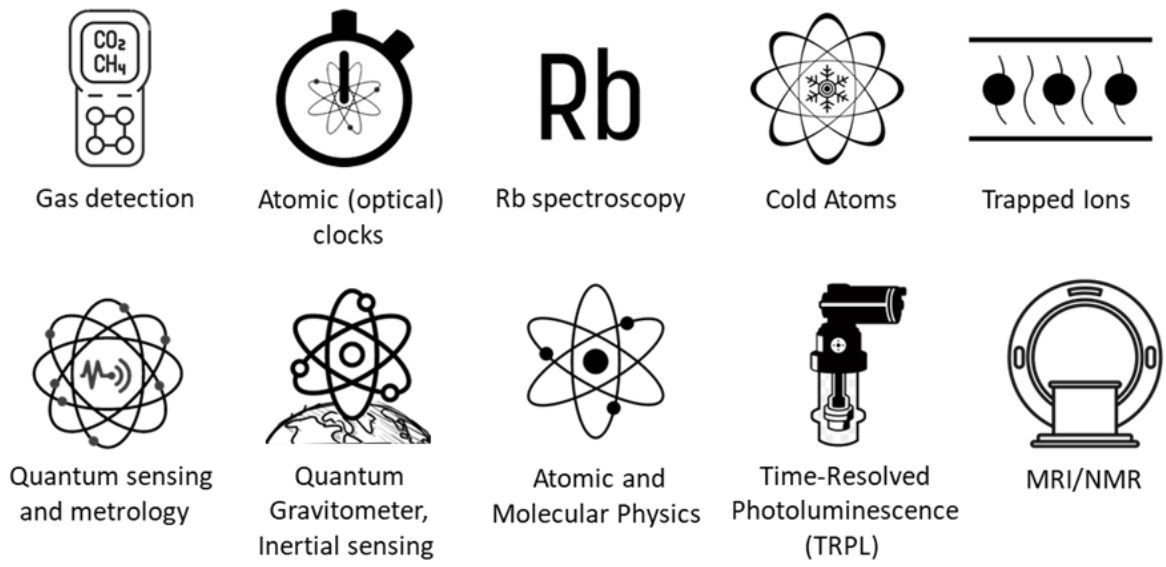
Various quantum related applications for line locking and frequency offset locking are also part of the current offering.

# Technology Highlights & Applications

## Technology highlights

- Precise light control / lasers and laser controllers from low noise laser control systems to RF control up to 10 GHz
- Light detection
- Data processing: ARM, DSP, FPGA from small to high end systems. Eliminates bottle neck between data collection and processing.
- Temperature control of laser, detectors, and full systems: below 1mk stability and 10 micro K resolution
- Pressure control
- Additional electronics development and modifications, incl. line-lock, offset lock function

## Applications



# Universal Platform Version 1

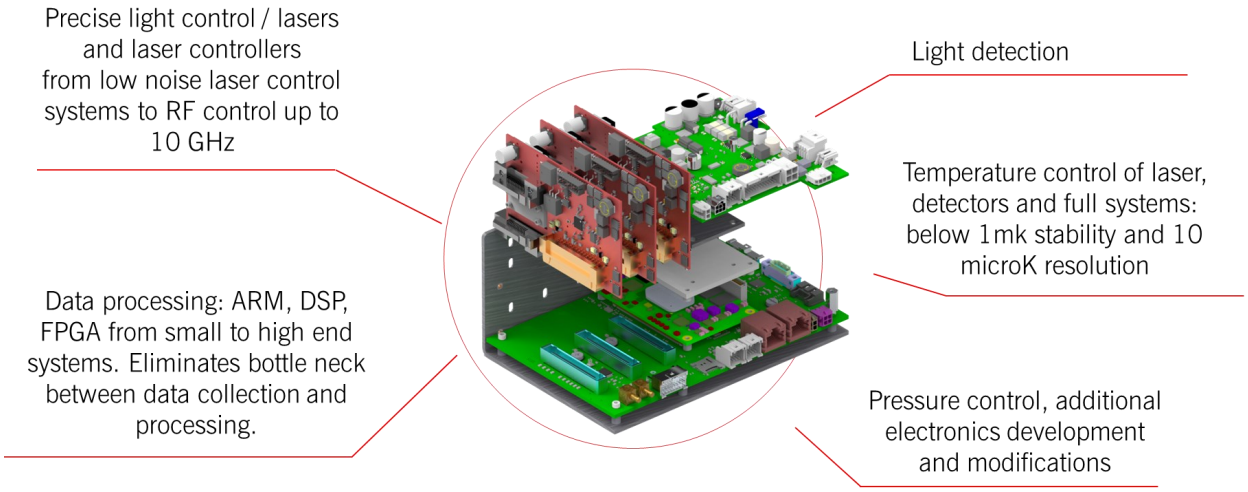
**The Universal Platform for spectroscopic instruments version 1** is our standard platform for tunable laser diode spectroscopy. It allows synchronous use of 3 lasers and two separate detectors. All standard direct measurements are covered including wavelength modulation spectroscopy. **Real time measurements can be averaged on the FPGA for efficient data management.** Gas concentration updates can be well in excess of 10 Hz. This can also be used for Eddy covariance flux measurements. An external GSM mobile phone data slot is available if needed.

## Technology Brief

The Universal platform for spectroscopic instruments covers all electronics requirements for power, data processing, signal acquisition and control, data storage and external communications.

The full system has the following parts:

1. Com Express Type 10 CPU.
2. Backplane with dedicated FPGA with synchronous 2MS/s 16 bit DACs and ADCs, 24 bit ADC with 1 kS/s. Integrated pressure controller with digital PID.
3. Full power management with integrated battery charger. 10-30 DC input voltage.
4. Multiple laser controller plug-in cards to accommodate various pin-pout types: C155 NEL (C156 EagleYard).
5. Linux OS with full set of libraries and extensive examples.




Pic. 1 Universal Platform ver 1. Scheme

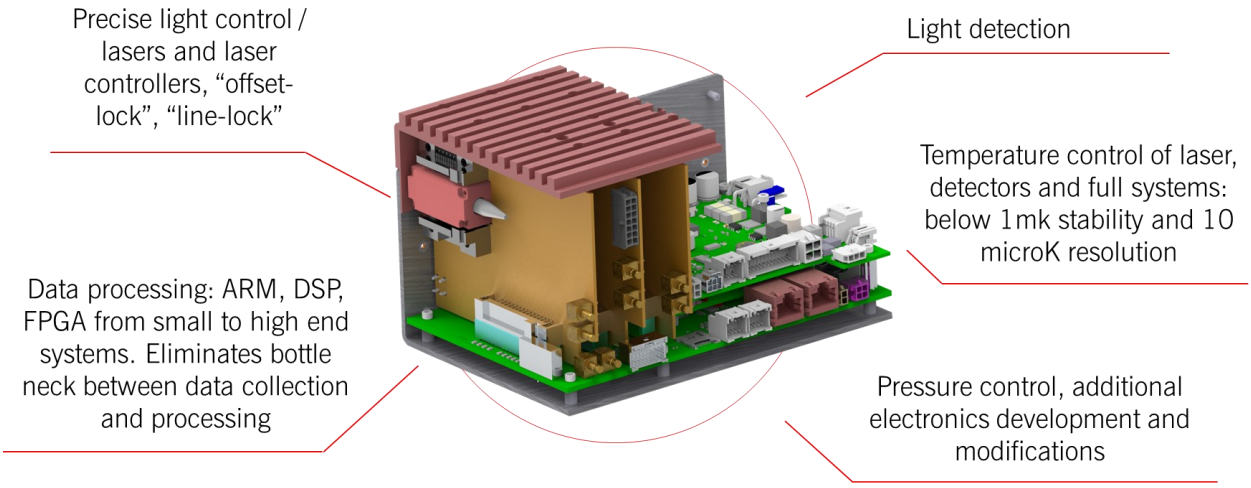
# Universal Platform Version 2

**The Universal Platform Version 2** has been developed for laser frequency stabilization and control. Laser plug-ins have much more extended functionalities and features. Lasers can be locked to the atomic or molecular absorption with fully integrated scan and lock features. The software provided allows to choose the transition to lock to.
An additional plug-in Offset lock allows to maintain the optical frequency difference between master and slave laser. The frequency offset can be selected via the software and can be varied continuously or discreetly in steps. Offset values can be preloaded onto the plug-in controller and triggered by fast digital signal with very low

## Technology Brief

The full system has the following parts:

1. Com Express Type 10 CPU.
2. Backplane with dedicated FPGA with synchronous 2MS/s 16 bit DACs and ADCs, 24 bit ADC with 1 kS/s.
3. Full power management with integrated battery charger. 10-30 DC input voltage.
4. Multiple laser controller plug-in cards to accommodate various pin-pout types, plug-in “Offset lock” (RF Control up to 10 GHz) and “Line lock”
5. Linux OS with full set of libraries and extensive examples.




Pic. 2 Universal Platform ver 2. Scheme

# Application Examples

## Q3MD: Universal Platform for Gas sensing applications

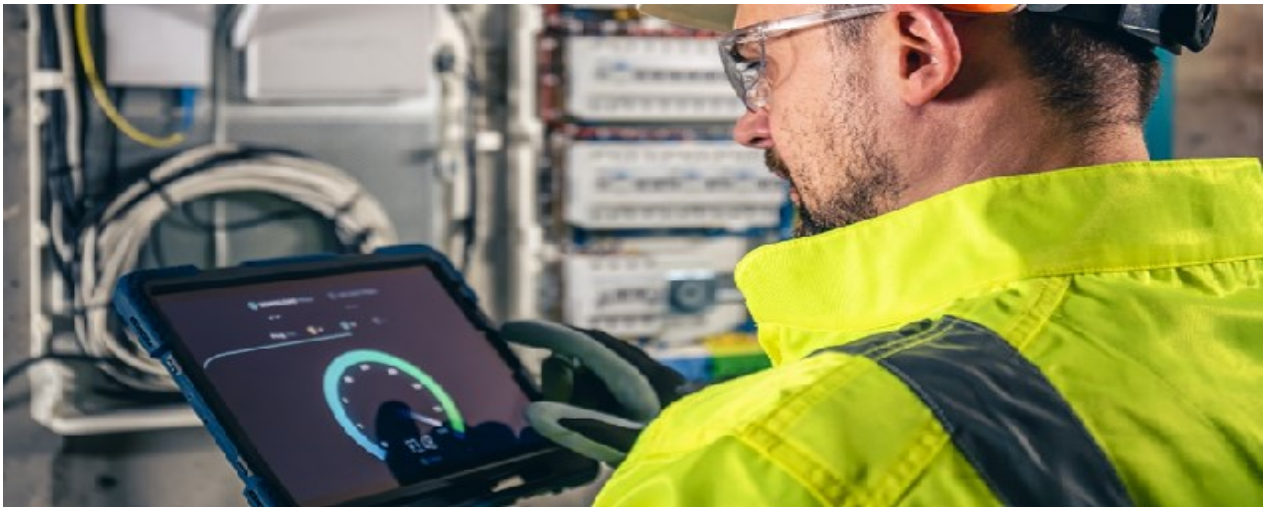
**Application:**
A single photon sensitive detector for **methane gas detection** operating at 3$\mu$m. Methane can be detected at much lower concentrations at this wavelength than at the 1.65$\mu$m used in commercial detectors. This project is part-funded by Innovate UK.

**Description:**

For the UK to reach a zero-carbon economy, the measurement, regulation, and enforcement of greenhouse gases (GHG) emissions needs to rapidly expand. Natural gas (primarily CH4 methane) remains the dominant fossil fuel and industrial leaks are a leading source of GHGs.

The technical approach is to combine unique III-V alloy material developments with innovative science and engineering at Bay Photonics (optics packaging), Redwave Labs (control electronics) and QLM (signal processing and spectral analysis). The aim is to optimize solid state cooling to bring the detector to very low temperatures without having recourse to Stirling engines. The project specifications, modelling and detector validation for methane applications are led by the channel partner QLM. The overall goal is a detector resolvable to single photon/few photon level at 3 $\mu$m and evaluated in bench top prototype form.

By applying Differential Absorption Lidar and Time Correlated Single Photon Counting, we can extend the remote spectroscopy capabilities to increase the distance range or decrease the response time; by accessing the 3$\mu$m spectral region, low concentration sensitivity is to be increased up to 50-fold. In addition, we can expand the gas species and target other applications are that currently not addressable with a SWIR wavelength.



**Link**: https://gtr.ukri.org/projects?ref=10032014

# Application Examples

## High Precision Inertial Guidance System

**Application:**
Quantum Positioning' Systems (QPS) for
- Unmanned aerial vehicles
- Subterranean / submarine transport
- Self-driving cars
- Defense critical platforms

**Description:**

Project will be based on CPI TMD Technologies' existing quantum technology, including the compact grating magneto-optical trap (gMOT) subsystems and Calcium Ion Frequency Source (CIFS) clock, which provides unprecedented precision and accuracy in timekeeping.

CPI TMD Technologies and its partners will develop exceptionally high-precision quantum-enabled positioning, navigation and timing systems that can be used to identify an object's exact position in time and space without the use of satellite signals. Unlike the global positioning system (GPS), which relies on the transmission and receipt of external signals, these quantum systems provide timing and positioning data through internal synchronization. This allows the systems to calculate accurate time and positioning data through dead reckoning, rather than by depending on satellite signals. As a result, the inertial guidance system is useful in locations and situations where satellite signals are impractical, such as underground transit systems, and for defense and military end uses.

**Link**: https://www.cpii.com/news.cfm/cpi-tmd-technologies-project-awarded-more-than-4-million-to-develop-compact-high-precision-inertial-guidance-system

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