Australian National University

Direct Differential Phase Recovery for Optical Sensors

Direct Differential Phase Recovery (DDPR) is a real-time phase measurement algorithm for the measurement of phase differences between two optical interferometric signals; without having to compute each signal phase independently.

This algorithm is extremely powerful when measuring small differences between two signals with a lot of common noise. The algorithm is designed for use on real-time digital signal processing hardware, such as FPGA systems. It is an open-loop architecture, requiring no feedback control.

In phase measurement applications, phase locked loops (PLLs) are the standard approach. These require feedback, and careful design consideration to maintain its ability to track a phase signal of interest. This can be challenging for weak signal phase recovery – where the signal of interest is small, and thus difficult to track, and for highly dynamic signals – where the signal of interest varies rapidly over time. We present an alternative method for phase recovery which is aimed at those two problem scenarios. In this instance, it would address applications where significant investment in PLL design would be required to achieve reliable measurement, or whether PLLs result in cycle slips and are unable to maintain reliable phase tracking.

Technology (TT2023-001)

The technique comprises of an algorithm designed to run at real-time speeds (FPGA/ASIC implementations). It takes inputs from the RF demodulation stages of two independent regular phase measurement channels (analogous to the first stage of a PLL). From here, the inputs to the algorithm are recombined in IQ space computing the in-phase and quadrature components of the differential phasor. This differential phasor can then be used as an input into a phase recovery algorithm, for example a PLL or arc-tangent. Critically, as it is the differential phasor being used for phase recovery, all common noise sources are cancelled and removed. This significantly reduces the requirements on phase tracking as it is solely focused on measuring the differences between the two signals of interest. We have demonstrated a common mode suppression of 99 dB (for context, it’s equivalent to being able to perfectly hear a normal conversation right next to an aircraft jet engine).

Potential benefits

- **Open-loop:** highly stable, extremely high common mode suppression.
- **Fibre Optic Gyroscopes:** Re-entrant fibre optic gyroscopes allow small fibre optic coils to be used for high sensitivity measurements- DDPR allows this measurement to be made using a continuous readout, thus eliminating the main drawbacks with a re-entrant fibre optic gyroscope architecture
- **Laser Ranging/Coherent LiDAR:** Laser ranging and coherent LiDAR have to contend with the measurement of common noise, often arising from the laser source. The removal of this noise is done with a reference measurement and is limited by the common mode suppression achieved. DDPR has demonstrated unmatched common mode suppression in this optical configuration and is a potential candidate technology to use in this scenario.
- **Dispersion Spectrometry:** Optical spectrometry requires the measurement of chemical signatures as a function of optical wavelength. It is often advantageous to use a single frequency laser for this purpose to maximise the detection sensitivity. This single wavelength must then be tuned over the desired wavelength range to obtain a completed spectrum. Doing this quickly results in significant common-mode noise as the laser tunes, which can be suppressed using DDPR. This makes it a good candidate for rapid acquisition spectrometry, especially when interferometric measurements are used for the measurement – such is the case in dispersion spectroscopy.

Potential applications

- Optical Interferometric Measurement
- Interferometric fibre optic gyroscope
- Laser ranging
- Differential Absorption Lidar
- Dispersion spectrometry/spectroscopy

Opportunity

Application specific R&D partnerships – how can we work to develop DDPR into a specific product in an area.
Feedback from industry on broad applicability and interest is also useful.

IP status

The IP is owned by The Australian National University and the subject of a provisional patent (Application no. TBC)

Key research team

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