## Name of the technology:An FPGA based General-purpose Lock-in Amplifier and PID Controller

**Introduction:** Active stabilization of any electronic signal requires accurate detection of the set-point. For this,the required electronic hardware are frequency generator for modulating the input signal, phase-sensitive *lock-in*for detection of the set point and a Proportional-Integral-Differential(PID) servo loop for dynamic correction of the input to keep it stabilized. Using the advanced digital electronics, all these three modules have beensoftware implemented and that are embeddedin a single Field Programmable Gate Array (FPGA) IC.

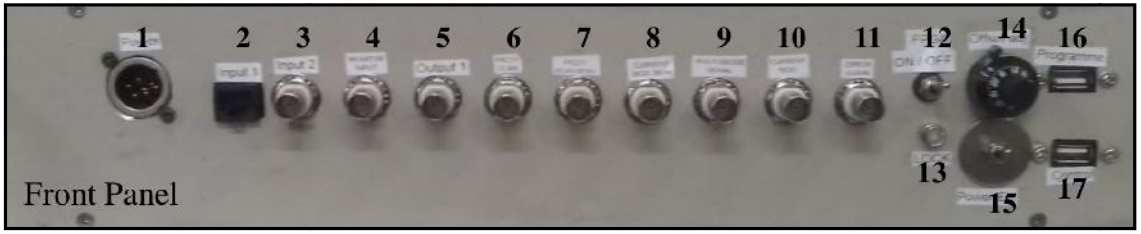


**Figure 1: Front panel of the instrument that contains all the input/output (I/O) ports as indicated by 1-17.**

**Readiness level of the Technology:**

| Idea | Concept Definition | Proof of Concept | Prototype | Lab Validation | Technology Development | Technology Demonstration | Technology Integrated | Market Launch |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

**Summary of the technology:**We have designed, fabricated and tested a new compact all-in-one instrument that compriseof a frequency generator,*lock-in* detector and PID controller, as shown in Fig. 1, and its specifications are given in Table I. Salient features of the developed instrument are: (a) **Compact** – size is reduced compared to total size offrequency generator, lock-in and PID since all of them are implemented in a single FPGA, (b) **Computer control** – the instrument can be fully operated from a remote PC via a user-friendly graphical user interface, (c) **Low noise** – no noise pick up due to digital signal processing,(d) Architectural freedom – easily configurable and re-configurable without any hassle of soldering, and (e) **Cost effective** –off-the-shelve componentshence the bill of material cost is very low.

**Notable users:**

Industries (communication, aviation, driver less transportation, signalling system, power distribution, anti-theft management*etc.*), maintenance system (stabilization of temperature, humidity, pressure, pH level,

vibration, laser parameter*etc.*), medical instruments (ECG, EEG, USG*etc.*), strategic sectors (secure communication, synchronization*etc.*), universities and research labs (material characterization, controlling experimental parameters and environment*etc.*) have wide applications of the developed instrument.

**Table I: Specifications of the Instrument**

| **Parameters** | **Frequency Generator** | **Lock-in Amplifier** | **PID** |
|---|---|---|---|
| Damage Threshold | ± 6 V | ± 6 V | ± 6 V |
| Resolution (I/O) | 12 bit (I/O), 16 bit (O) | 12 bit (I/O), 16 bit (O) | 12 bit (I/O), 16 bit (O) |
| Max Output Amplitude | 3.3 V and ± 5 V | 3.3 V and ± 5 V | 3.3 V and ± 5 V |
| Roll Off($4^{th}$ order filter) | NA | 6 dB/Octave, 12 dB/Octave | NA |
| Phase Resolution | NA | 0.02 deg | NA |
| Noise @ 10 kHz | 26 nV $Hz^{-1/2}$ | 26 nV $Hz^{-1/2}$ | 26 nV $Hz^{-1/2}$ |
| Modulation Frequency | DC to 100 kHz | DC to 100 kHz | NA |
| Modulation Type | Square,Sinusoidal, Triangle, Sawtooth | Square and Sinusoidal | NA |
| Bandwidth | 100 kHz | 100 kHz | 100 kHz |
| Signal Latency | NA | 5.7(1) µs | 5.7(1) µs |
| PI corner Frequency | NA | NA | 10 kHz |
| $K_P$, $K_I$ and $K_D$Gain | NA | NA | up to 60 dB |

**Related Patents:** Patent No: **Know-how**, Country: **Not applicable**, Publication Date: **Not applicable**; Grant Date: **Nil;** **Year of Introduction:** 2018

**Broad Area/Category:** Electronics & Instrumentation