TDLS Electronics with Computer Control

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DLS LAB

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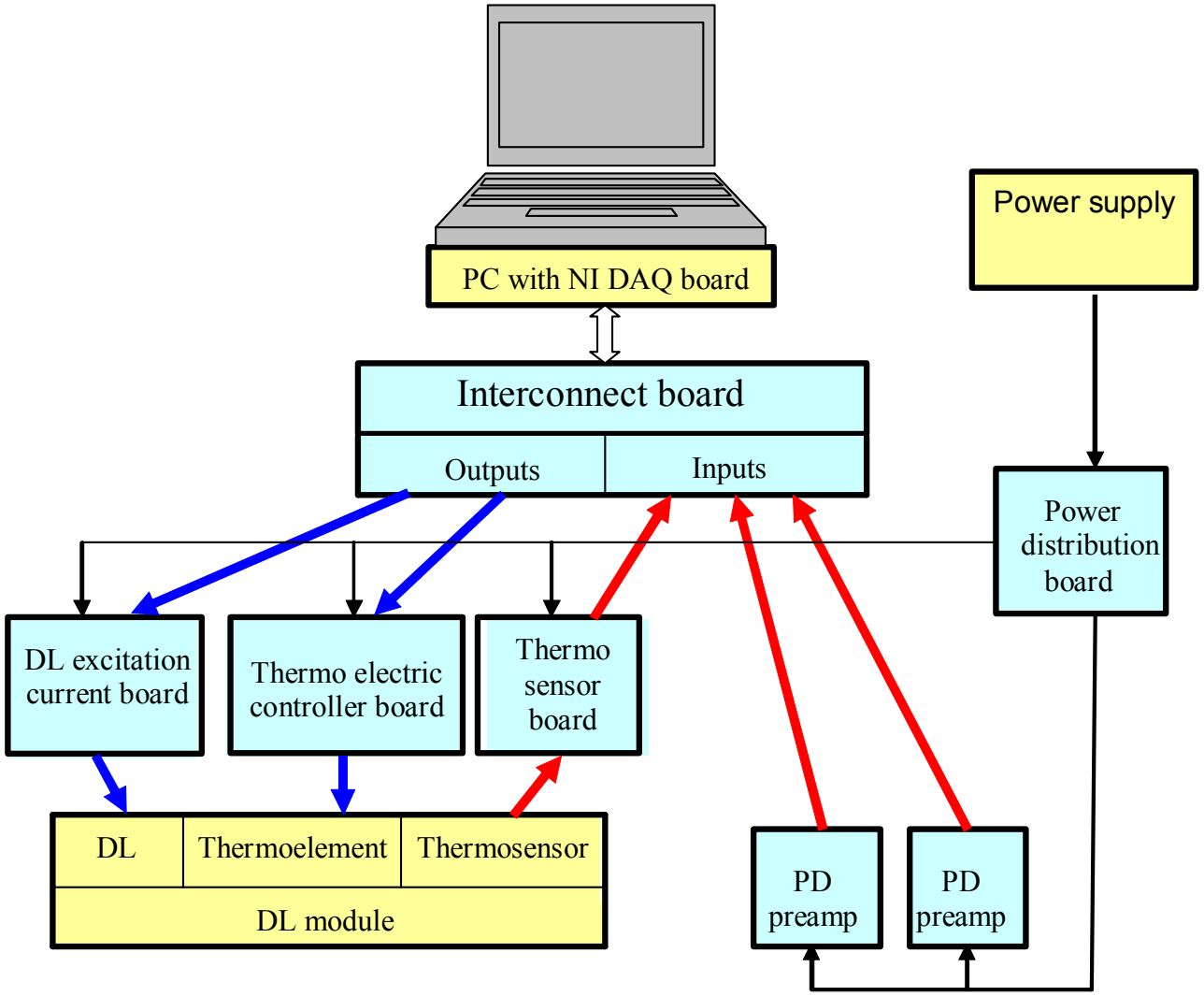
Abstract

A new generation of electronics was developed for use in TDLS systems. These electronics are operational under full computer control. Optional capability exists to use both PCI and USB National Instruments boards.
Electronics developed supported NIR and mid IR DL as well as VCSEL. All fiber optical connection is optional.
Results of tests of electronics system are presented and discussed. The electronics provided DL temperature stabilization at 3×10^{-5} K level. Minimum detectable absorption achieved with this electronics is 10^{-7}.
The electronics was tested both in Moscow and Albuquerque. Initial manufacturing run of 25 electronics units has been completed.

Electronics Block Scheme



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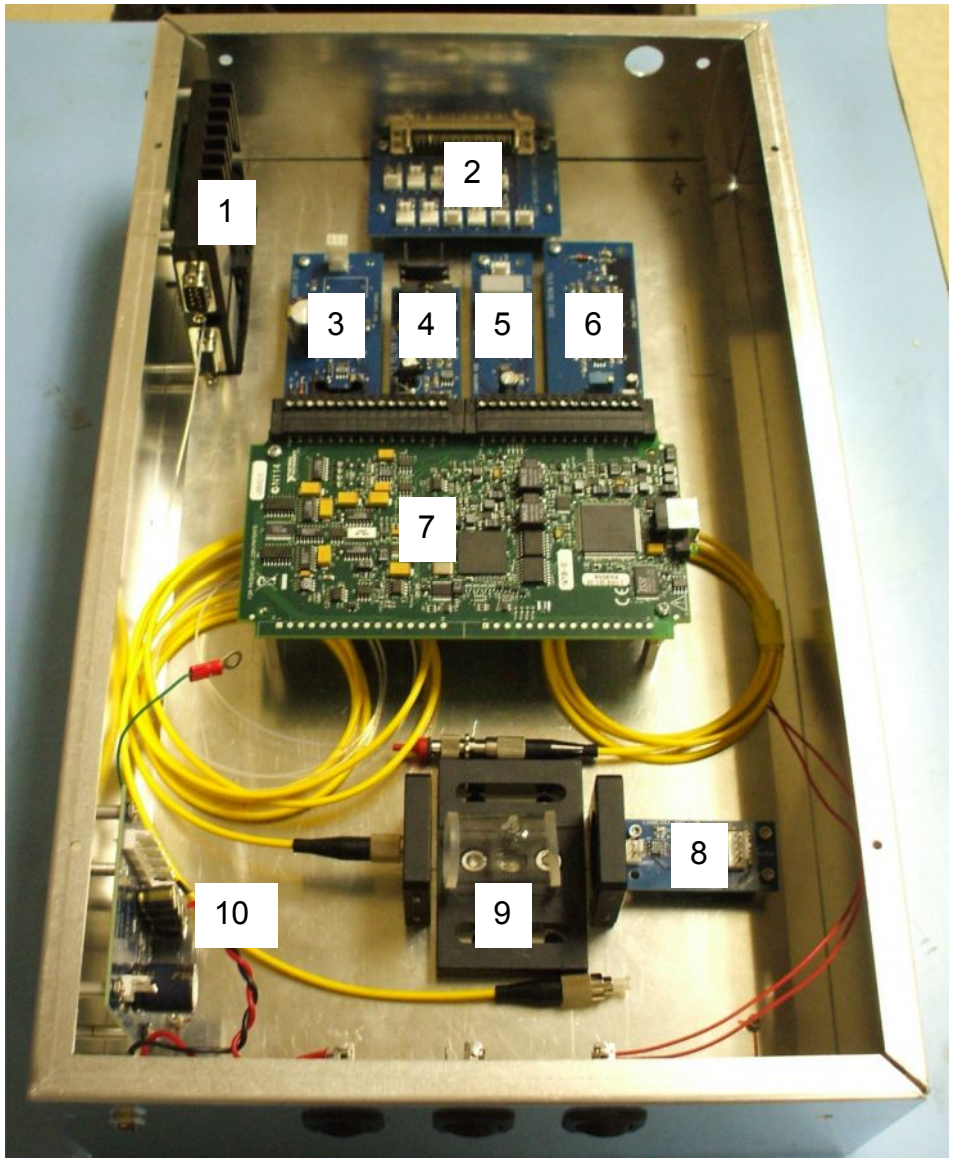
These electronics are operational under full computer control. Optional capability exists to use both PCI and USB National Instruments boards.

Electronic prototype



View of electronic prototype

Primary Components:

1. Diode laser module
2. Interconnect board for PCI NI DAQ
3. DL excitation current board
4. Thermo Electric controller board
5. Thermo sensor board
6. Power distribution board
7. USB NI DAQ
8. Photo diode with pre amplifier
9. Reference gas cell
10. Power supply board with 12 V DC or AC power

Electronics testing

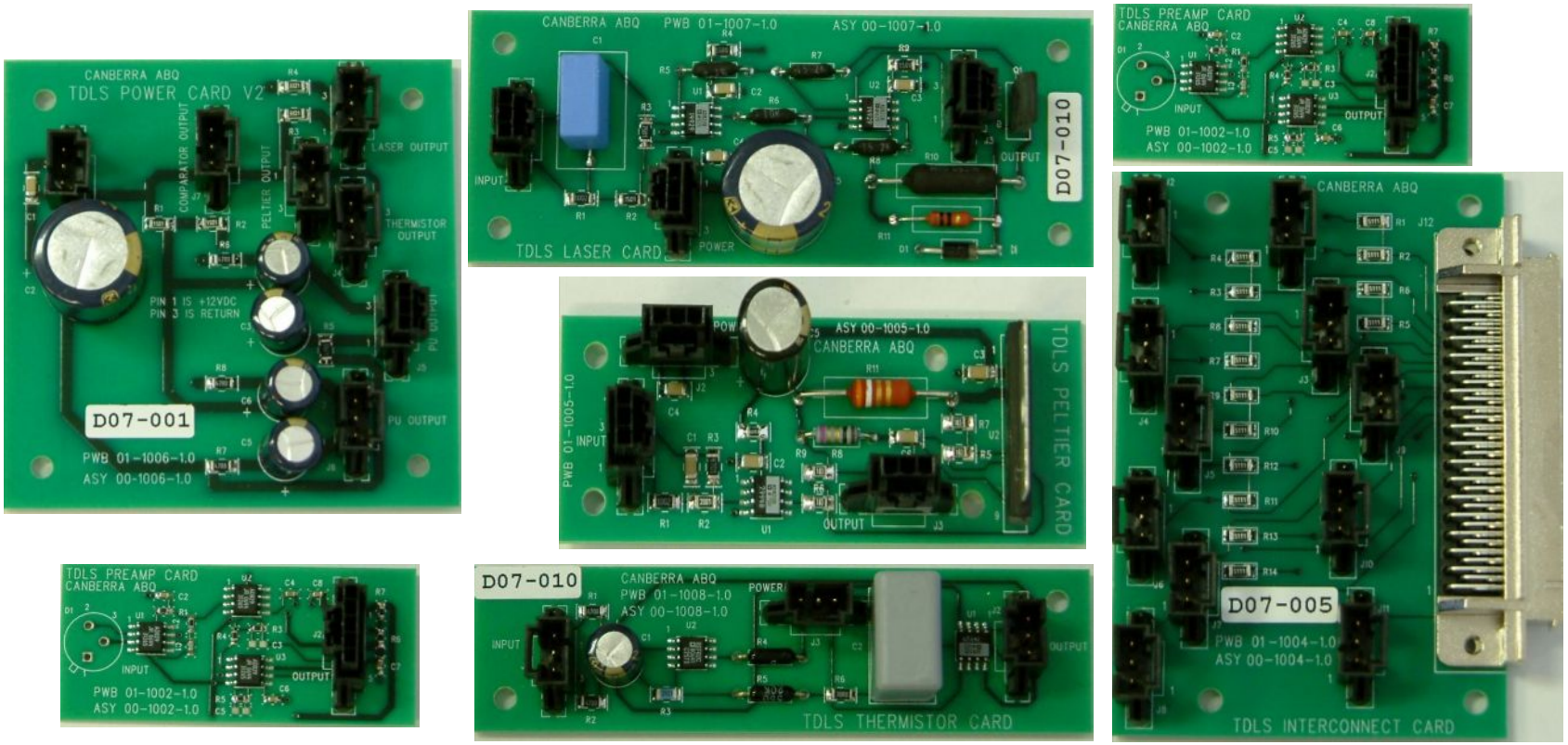
Initial manufacturing run of 25 electronics units has been completed

The electronics were tested both in Moscow and Albuquerque. Test stands, algorithms, and software were developed.

Tests were successful and showed the same results.

Examples of test results are presented.

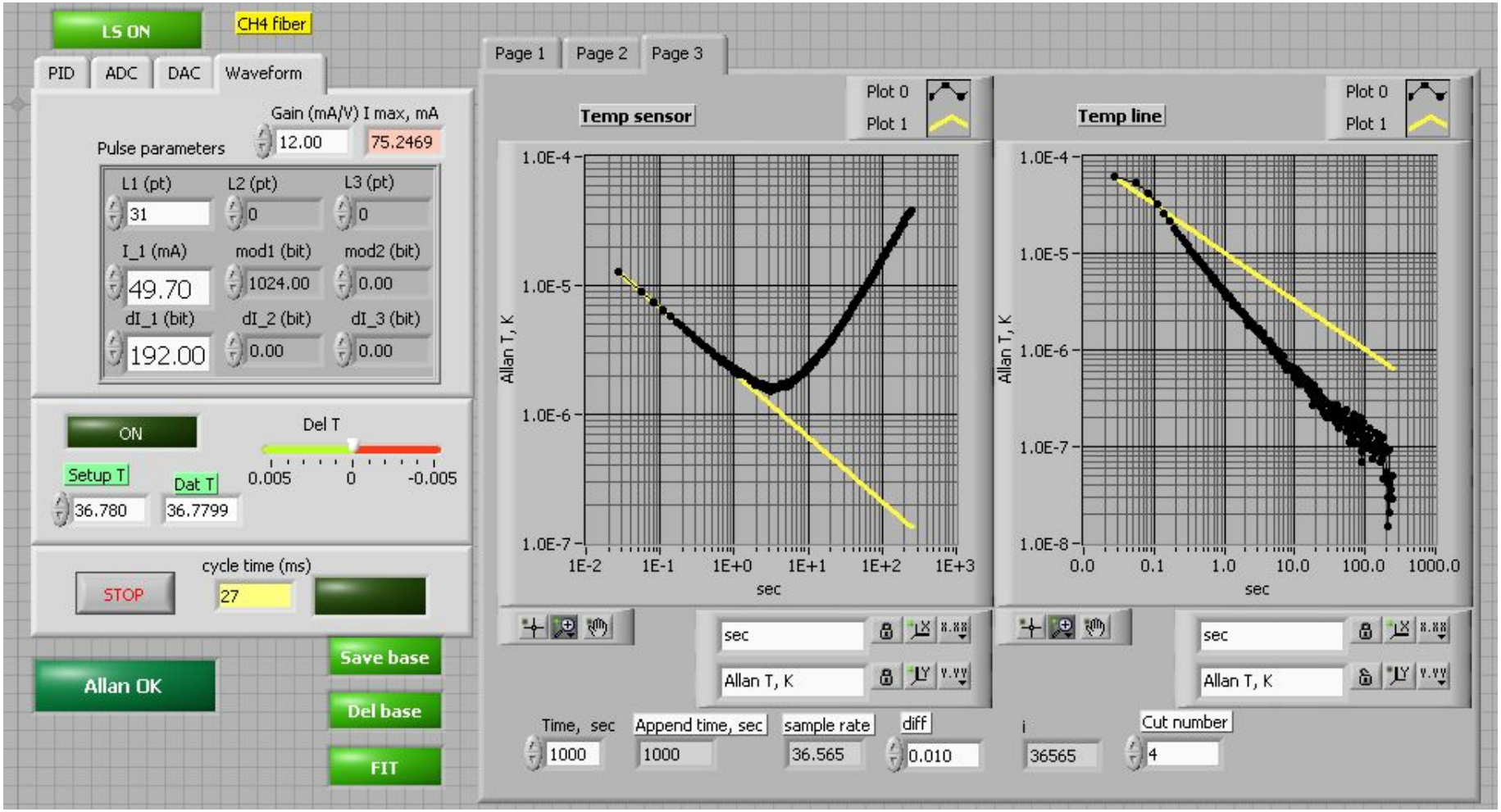
Electronics cards view



Set of cards for one DL based instrument shows electronics dimension

Software

Software was written using LabView 8.2.

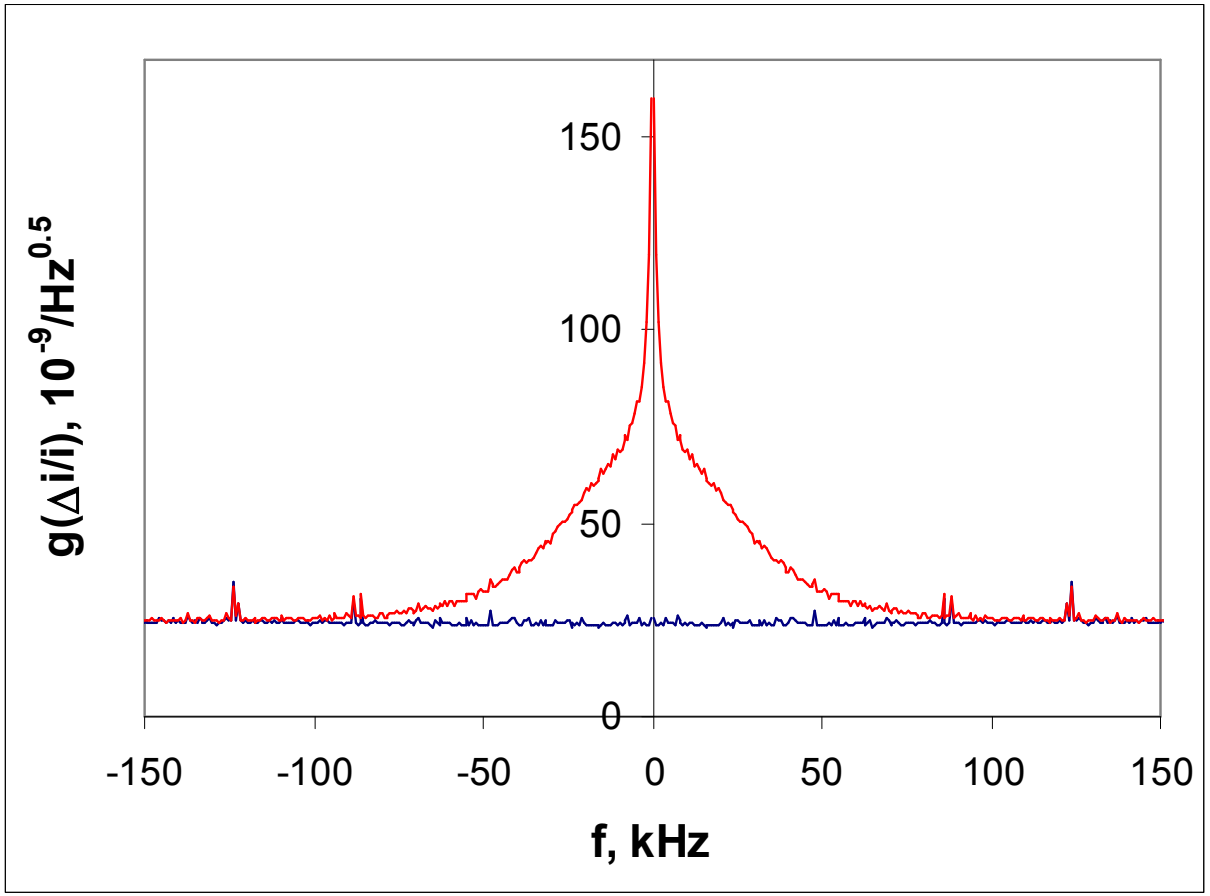


Example of program interface developed for investigation of DL frequency tuning cycles stabilization using reference spectral line. Presented result was obtained with electronic developed

No cross talking

Correct grounding resulted in absence of cross talking in electronics developed.

This provides achievement of S/N ratio close to 16 bit board resolution - **65536**



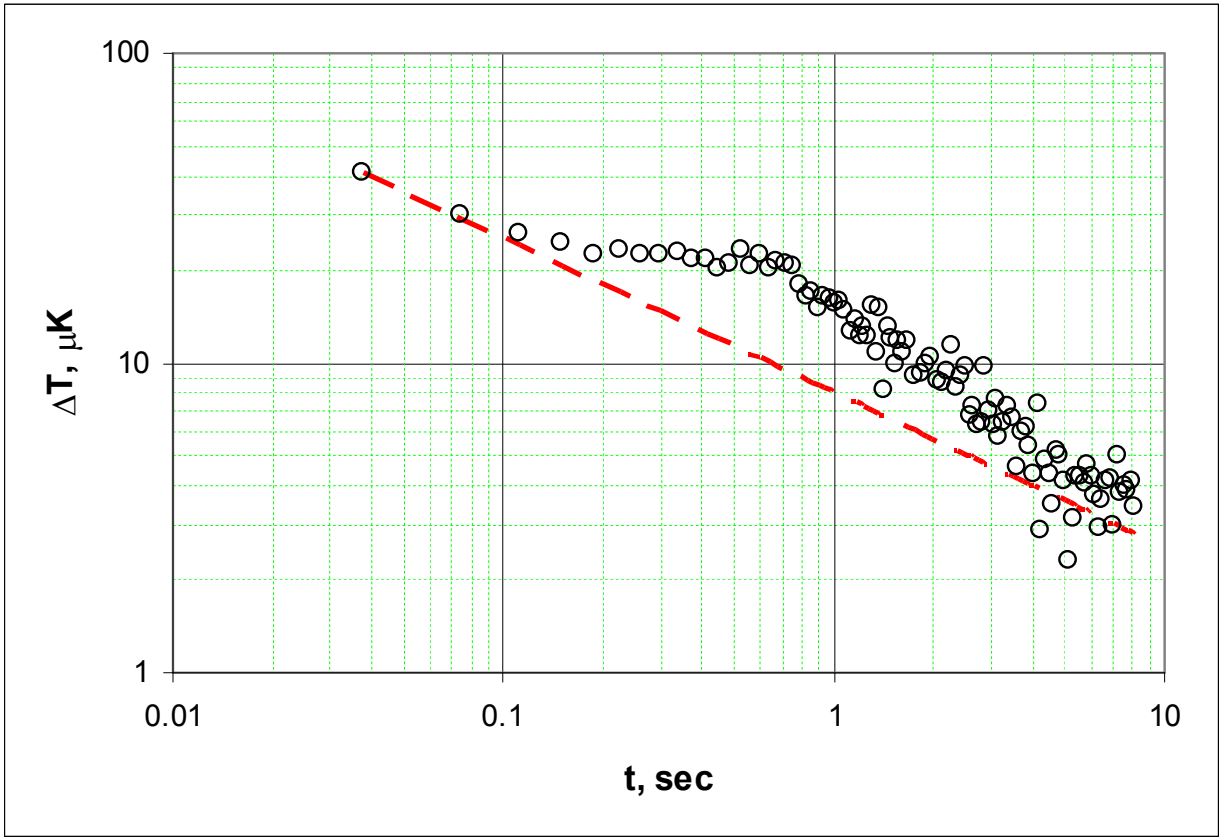
FFT spectra of PD signals with DL current off (blue curve) and on (red curve).

Small observable peaks are due to cross talking inside NI DAQ board itself.

DL on – photocurrent shot noise (broad) and DL flicker noise (narrow)

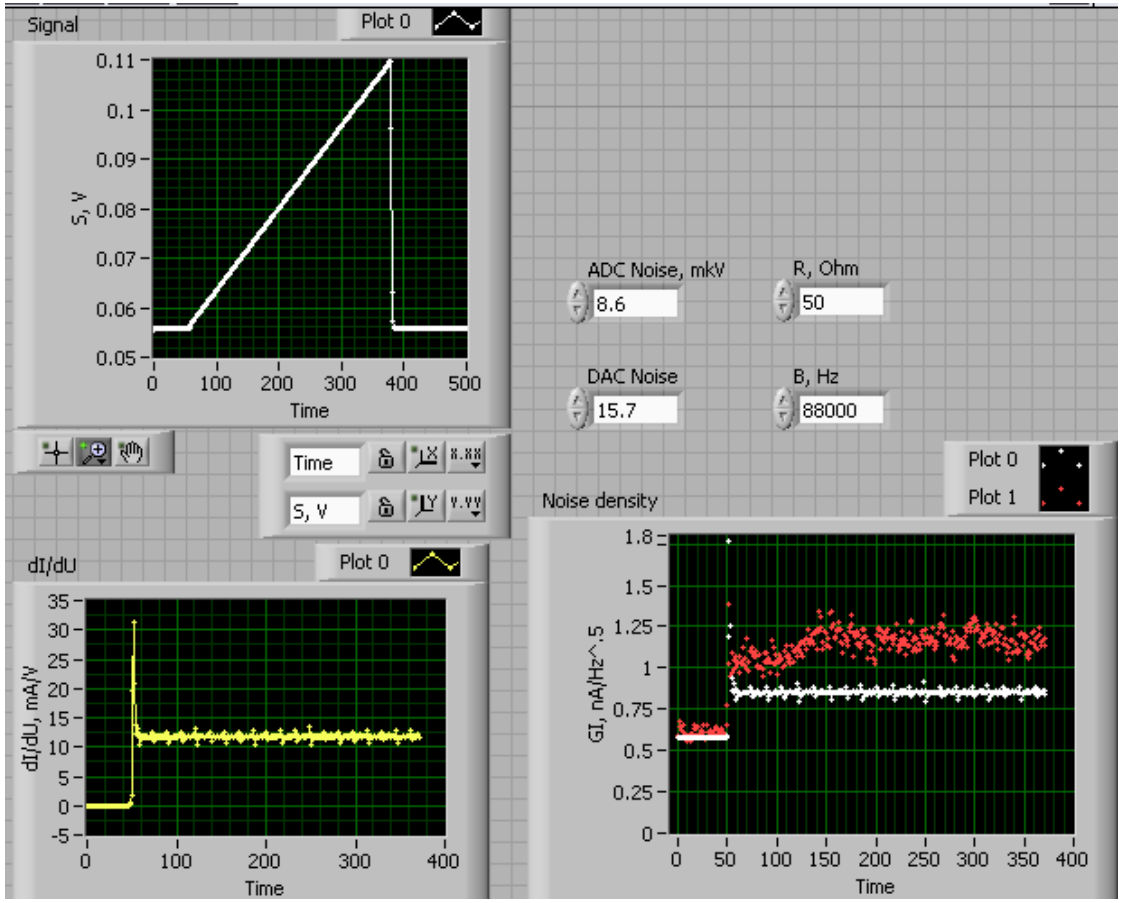
Temperature stabilization

Quality of DL temperature stabilization is important for TDLS applications.
Typical level of temperature stability published in literature is 1-5 10^{-3} K



Test result of electronics developed.
Temperature stability 2-3 10^{-5} K (two orders of magnitude better) was achieved for all investigated DL modules

DL excitation current module



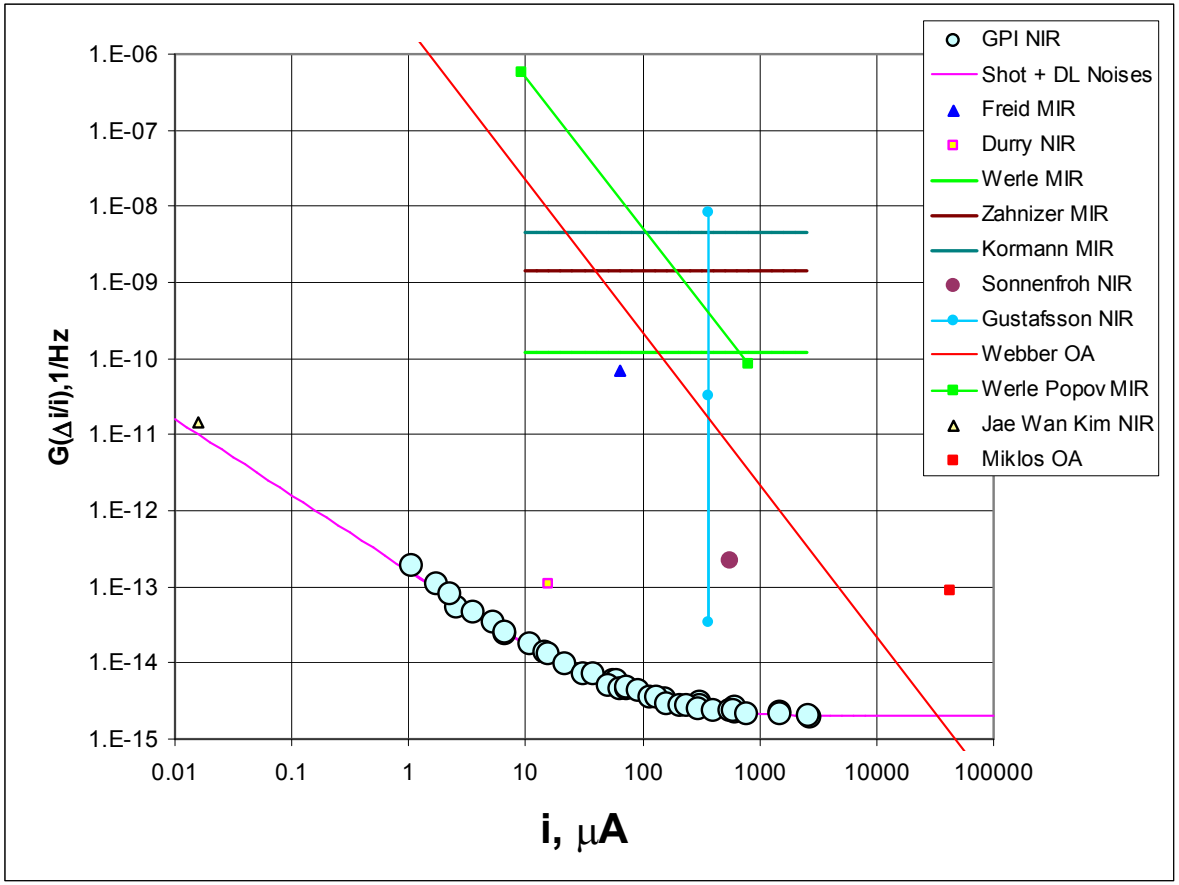
Modifications of electronics developed supported NIR and mid IR DL as well as VCSEL.

Interface of program developed to test DL excitation current module

Test parameters of different DL excitation current module modifications

	VCSEL	NIR	MIR
K, mA/V	1	12	90
G, nA/Hz$^{0.5}$	0.09	1.0	7.8

Noise spectral density

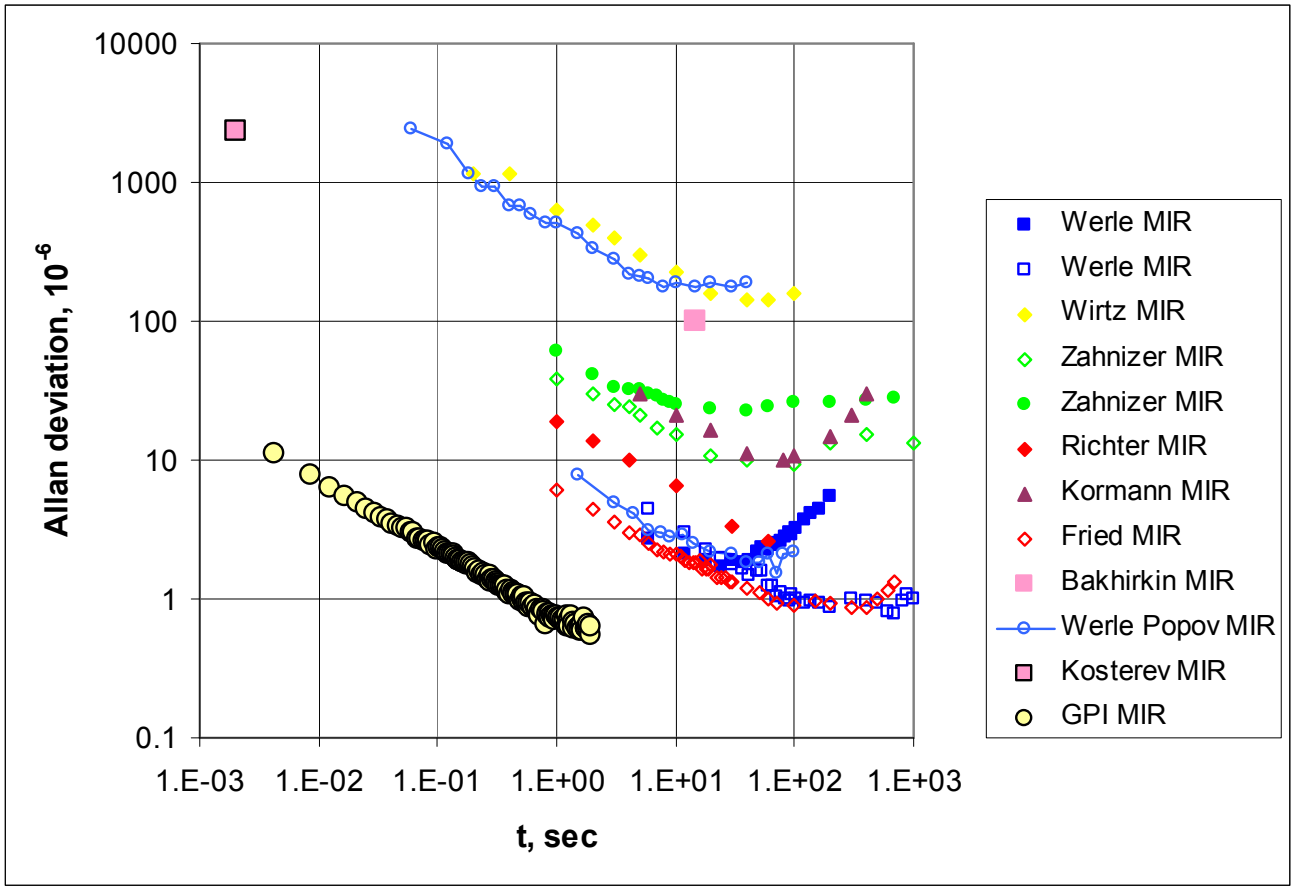


Spectral density of relative photocurrent noise is important characteristic of DL based instruments

Comparison of electronics developed test results with best results known from literature. Fundamental limit of sensitivity is determined by photocurrent shot noise and DL quantum noise (solid curve)

Using electronics developed technical noise sources were suppressed and sensitivity fundamental limit was achieved being from several times to several orders of magnitude better than best published results

Sensitivity with Mid IR DL

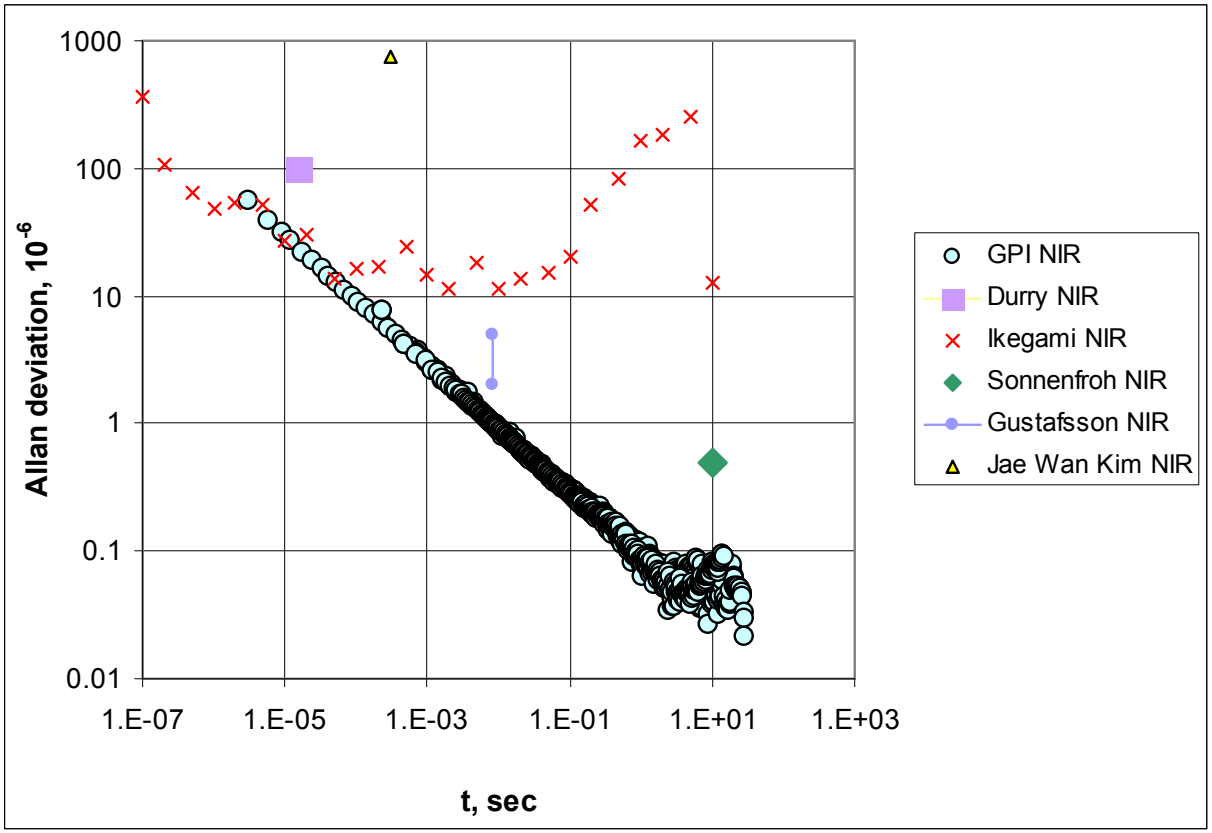


Allan plots of minimum detectable absorption as function of averaging time is widely using to determine TDLS sensitivity

Comparison of electronics developed test results with best results known from literature for Mid IR DL

Using electronics developed technical noise sources were suppressed and sensitivity fundamental limit was achieved being from several times to several orders of magnitude better than best published

Sensitivity with Near IR DL



Allan plots of minimum detectable absorption as function of averaging time is widely using to determine TDLS sensitivity

Comparison of electronics developed test results with best results known from literature for Near IR DL

Using electronics developed technical noise sources were suppressed and sensitivity fundamental limit was achieved being from several times to several orders of magnitude better than best published results

FEATURES & SPECIFICATION

Electronics

DL excitation current module: Voltage into current transformation – from 1 to 100 mA/V. Any waveform with modulation up to 333 kHz.

Thermo Electric controller module: Bipolar current source ($|I| < 1$ A).

Interconnect board: Easy and quick connection to any inputs and outputs of NI DAQ. Possibility of additional connection (temperature, pressure sensors, etc).

PD preamplifier: Optimized trans-impedance preamplifier with second-order low-pass Bessel filter. Differential output.

Power: – 12 to 15 VDC (AC/DC adaptor or batteries), 1.2 – 2.5 A max.

Dimensions: 33×4×16 cm with DL module and reference cell

General: Prototype has 2 years nonstop operation without service.

Optional

DL module and reference channel

Tested NI DAQ board

Tested computer

Conclusion

1. A new generation of electronics operational under full computer control was developed for use in TDLS systems.
2. Initial manufacturing run of 25 electronics units has been completed.
3. Test procedure was developed. The electronics were tested both in Moscow and Albuquerque. Tests were successful and showed the same results.
4. Temperature stability 2-3 10^{-5} K was achieved - two orders of magnitude better than best published results.
5. Using electronics developed technical noise sources were suppressed and sensitivity fundamental limit was achieved.
6. Minimum detectable absorption achieved with this electronics is 10^{-7} being from several times to several orders of magnitude better than best published results.
7. Prototype has 2 years nonstop operation without service.