

PHOTONICS

5b Optically powered sensors and sensory systems 2 part

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Other applications

Medical



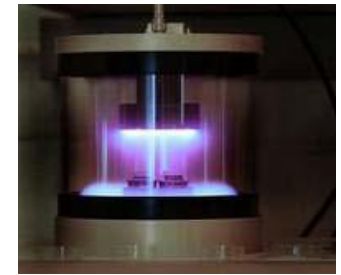
Magnetic resonance imaging

Wireless communications



Powering transceivers and antenna amplifiers
(GPS, cellular base stations, WiMa, etc.)

Industrial sensors



Test & measurement and
remote sensing

Energy



Current sensing in
high-voltage installations

Aerospace



Critical applications (fuel,
tanks, cabin door interlocks)

Defense



Actuators, gauges, sensor,
communications devices, etc.

Other applications

INDUSTRY	TARGET APPLICATION	KEY BENEFITS
Medical	Magnetic Resonance Imaging (MRI)	<ul style="list-style-type: none">▪ Enhance imagery (improve signal integrity)▪ Eliminate patient burn risk (fiber impervious to heat from high magnetic fields)
Wireless Communications	Powering low power transceivers and antenna preamplifiers <ul style="list-style-type: none">▪ Wireless base station deployments▪ GPS timing networks▪ HDTV remote antenna sites	<ul style="list-style-type: none">▪ Immune to RF, EMI, and lightning▪ Simple installation; reduced maintenance▪ Lightweight (compared to copper cable)
Energy	Current sensing in high voltage distribution grids	<ul style="list-style-type: none">▪ Voltage isolation▪ Simple installation; reduced maintenance▪ Eliminate instrument transformers

Other applications

INDUSTRY	TARGET APPLICATION	KEY BENEFITS
Industrial Sensors	Remote sensing – Oil and mining exploration EMI test measurements	<ul style="list-style-type: none">▪ Spark-free power▪ Operates over long distances▪ Withstands extreme temperatures
Aerospace	Critical applications – Aircraft fuel sensors and gauges – Cabin door interlocks	<ul style="list-style-type: none">▪ Spark-free power▪ Immune to EMI▪ Lightweight (compared to copper cable)
Defense	Sensing, control and interlock EMC test measurement Weapon control circuitry	<ul style="list-style-type: none">▪ Spark-free power▪ Immune to EMI and electromagnetic pulses▪ Lightweight (compared to copper cable)

Medical

Electrically isolated power unaffected by magnetic fields

Improve imaging

- Power RF coil amplifiers without interference for enhanced imaging quality

Patient safety

- Impervious to RF heating; eliminates possibility of patient burns

Power sensors in magnetic environment

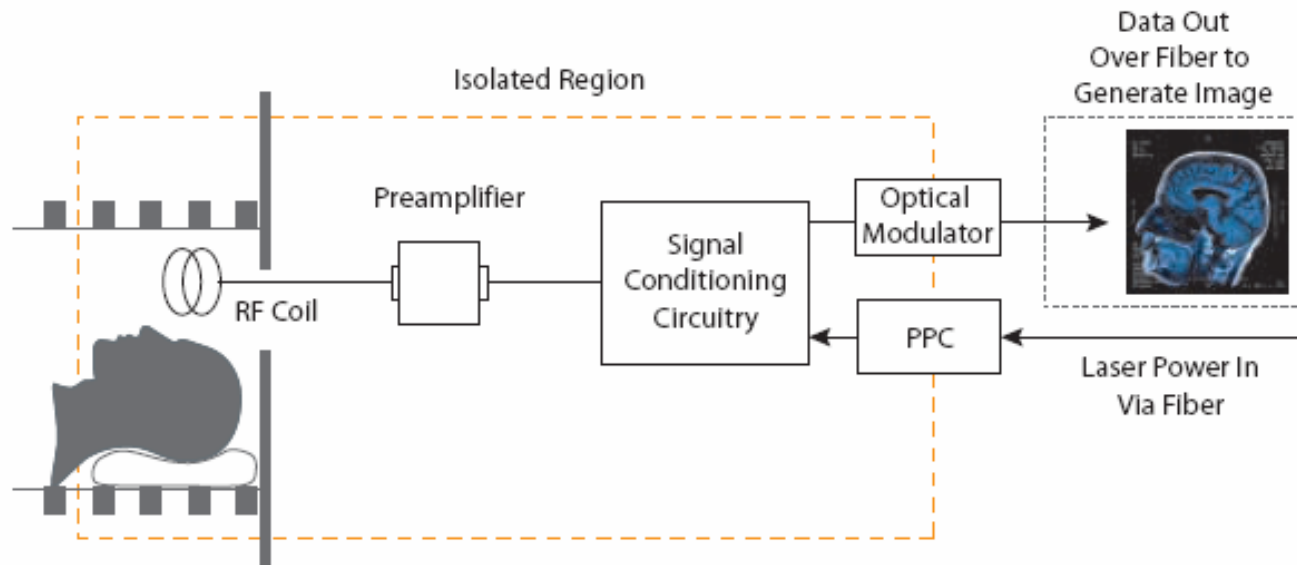
- Monitor patient condition with electrically isolated sensors



Medical

All-fiber solution for powering RF coil amplifiers and transmitting imaging data permits

- **Isolation from the surrounding environment**
- **More closely spaced coil arrays**
- **Elimination of risk of cable-induced patient burns**
- **Lightweight, more flexible alternative to copper cables**



Wireless

Cost-effective alternative to coax cabling

Lower installation cost

- Replace bulky coax with lightweight fiber
- Eliminate cost of lightning arrestors and booster amplifiers

Lower total cost of ownership

- Reduce truck rolls
- No damage from lightning

Simplify transmission medium

- Data and power carried over same fiber bundle

Low power transceivers

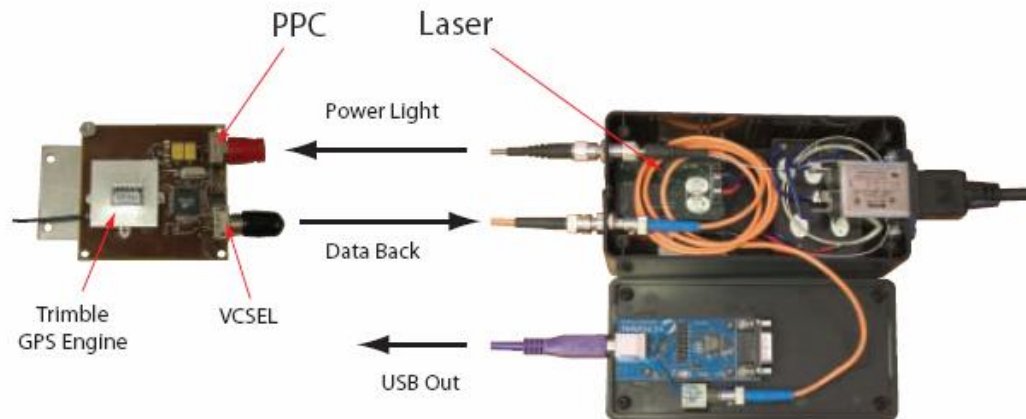
- GPS timing reference for cellular base stations, low power picocell transceivers



Wireless

All-fiber solution for powering GPS Engine and transmitting data permits:

- **Timing reference for mobile wireless application**
- **Isolation from the surrounding RF and EMI environment**
- **Installation distances up to 500 meters**
- **Flexible antenna positioning for enhanced view of GPS satellites**
- **Elimination of lightning arrestors and booster amplifiers**
- **Lightweight alternative to copper cables**
- **Fewer maintenance repairs**



Metering

Safe, cost-effective current metering

Lower installation cost

- Replace oil-filled transformers with lightweight fiber for faster installation

Lower Total Cost of Ownership

- Reduce maintenance and replacement expense

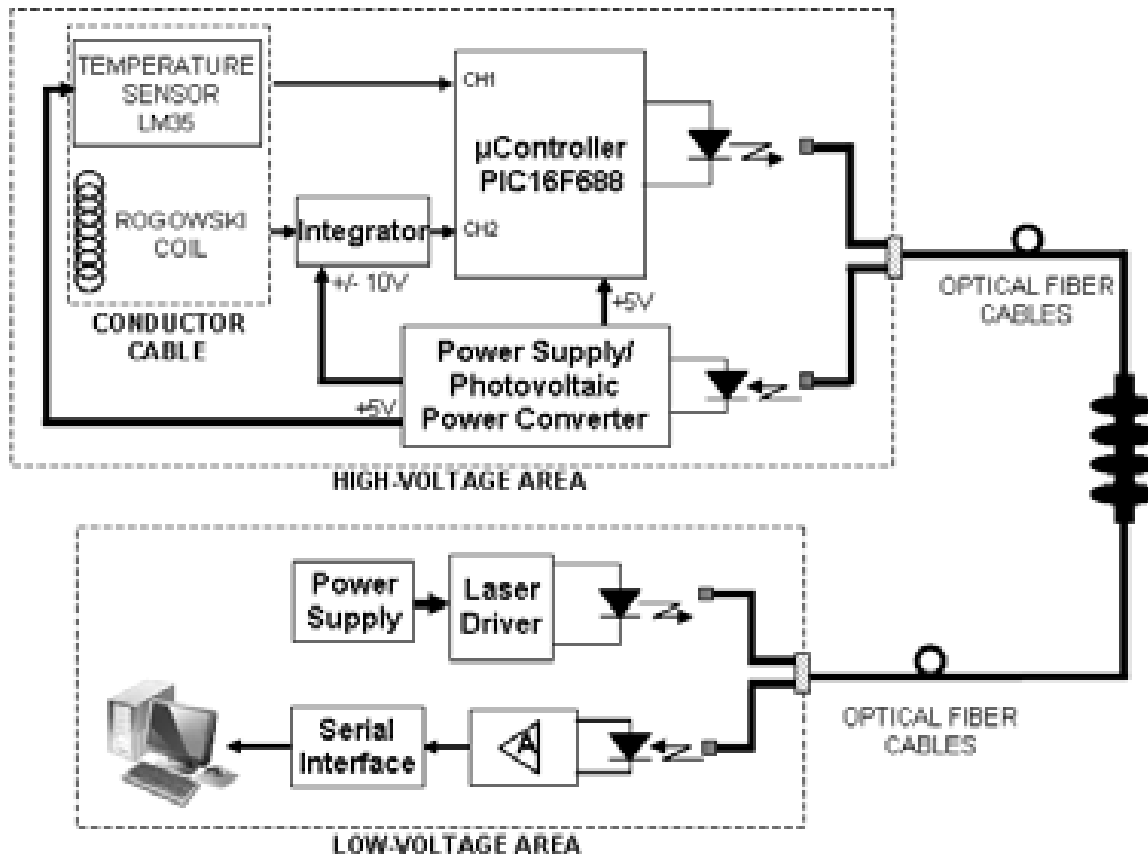
Simplify transmission medium

- Data and power carried over same fiber bundle

Rugged and safe

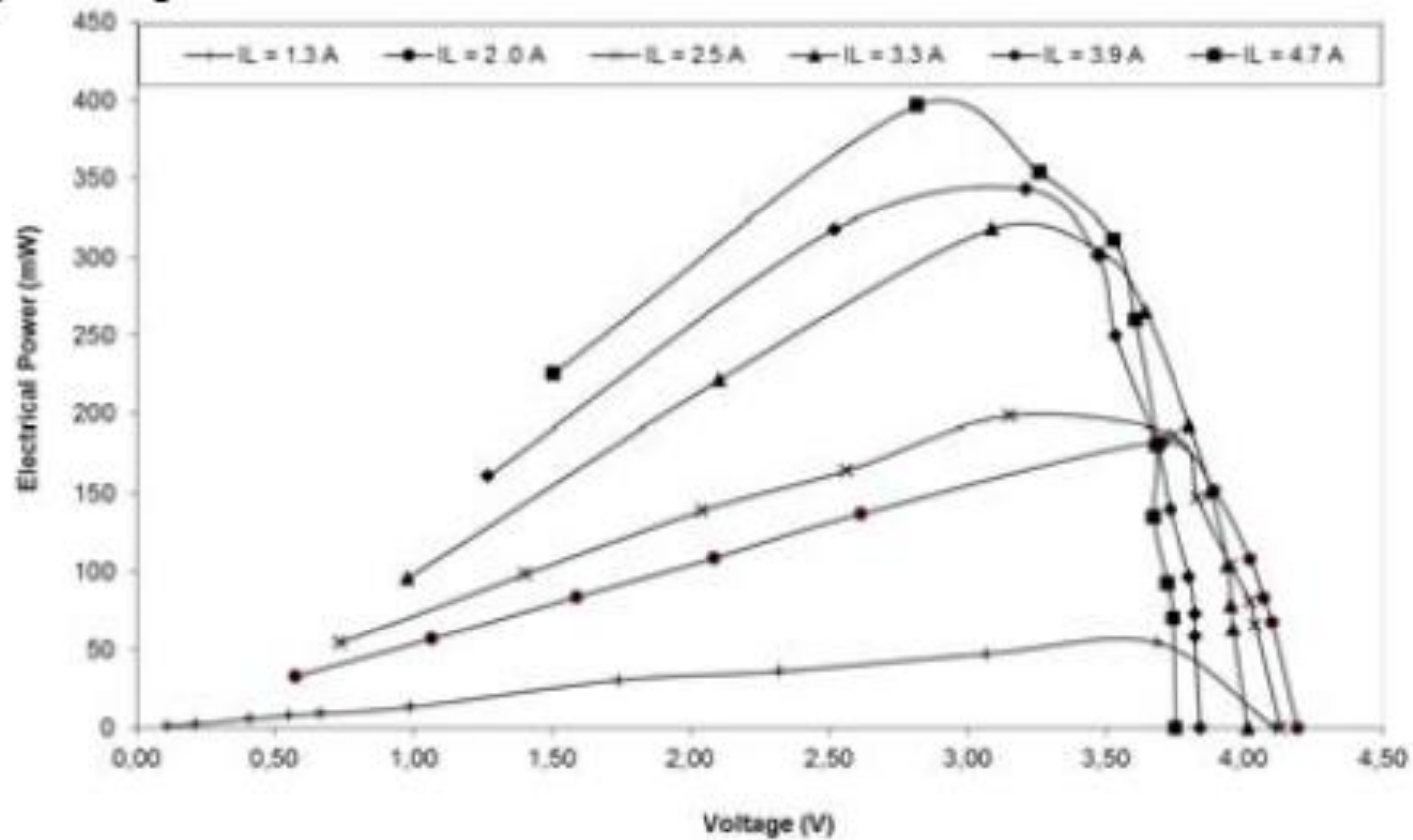
- No explosion or environmental leakage issues
- Operates in harsh environments
- Lightning-proof



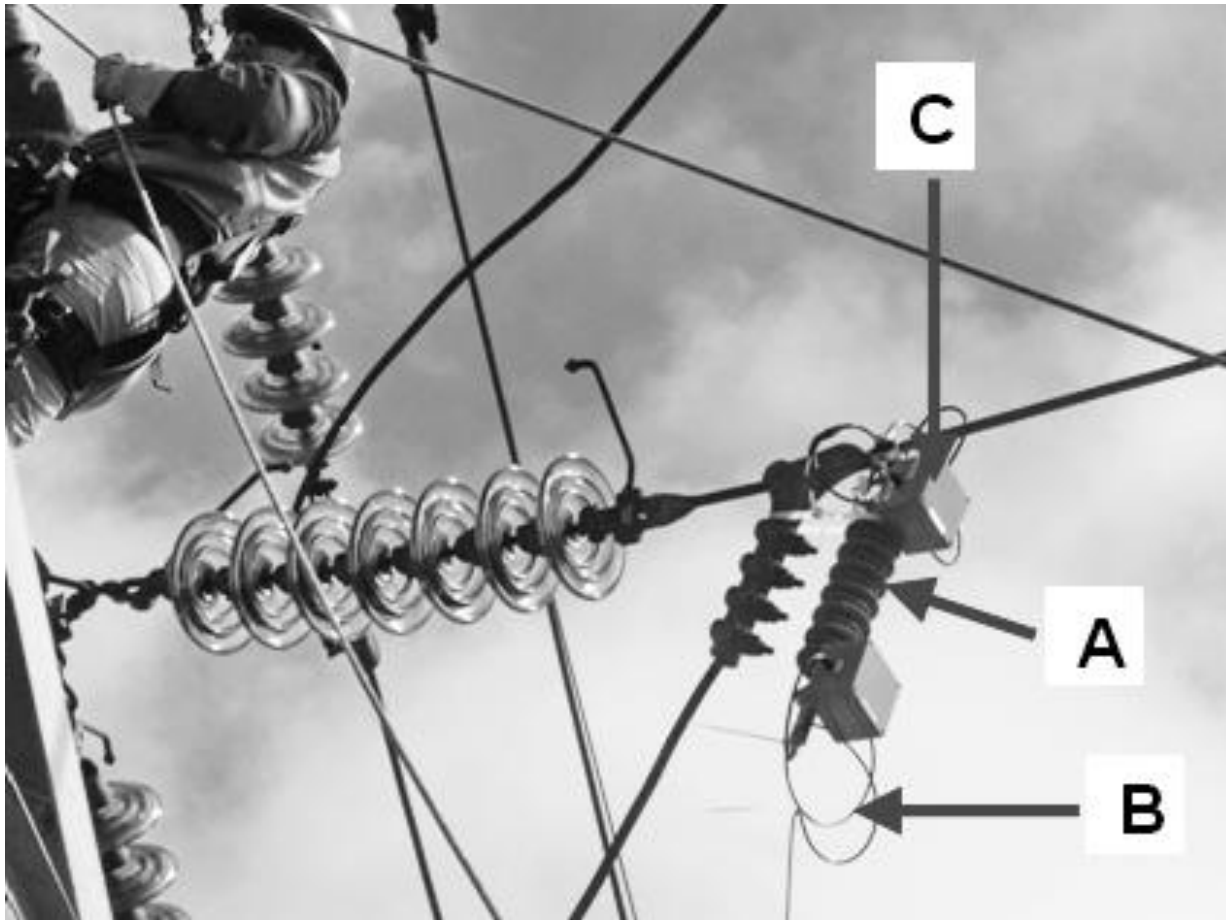


Hybrid optoelectronic current and temperature sensor probe (HOCT) for sag monitoring of conductors in 138 kV HV TL

- ❖ Rogowski current sensor, a temperature sensor, PPC, LP μ C with serial output and 850 nm LED FO Tx
- ❖ PP LD 1 W @ 830 nm to MM OF
- ❖ PPC at 40% efficiency producing 300 mW @ 3.5 V
- ❖ Sensory system consumption 90 mA



Power produced by the PPC as a function of LD current (IL).



HOCT field deployment:

A) 69 kV polymeric optical fiber insulator;

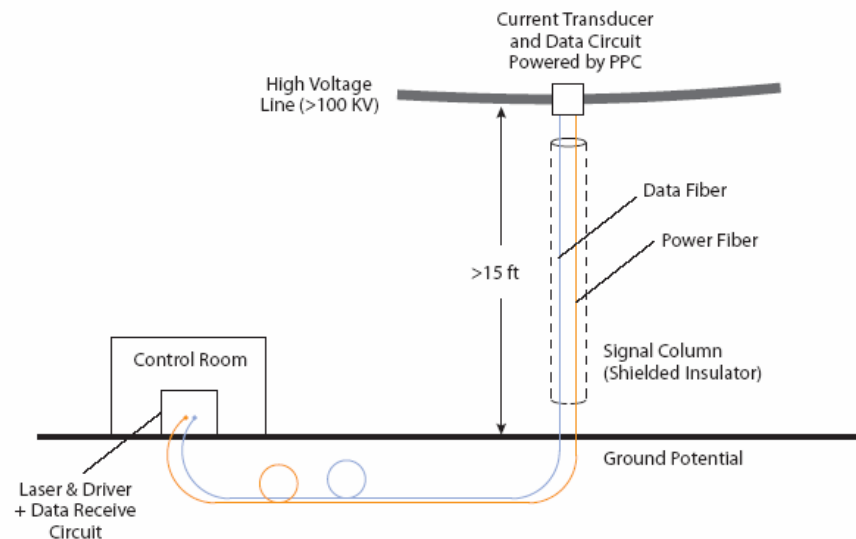
B) Optical fiber cables;

C) High voltage circuits enclosure.

Current sensing

All-fiber solution for powering current transducers in high voltage (>100 kV) environments permits:

- High accuracy for metering applications
- Environmentally friendly, dry technology (no oil or SF-6 gas)
- Elimination of ground loops
- Rapid, low cost installation
- Immunity to lightning
- Reduced maintenance expense



Industrial sensors

Electrically isolated, EMI-free measurement

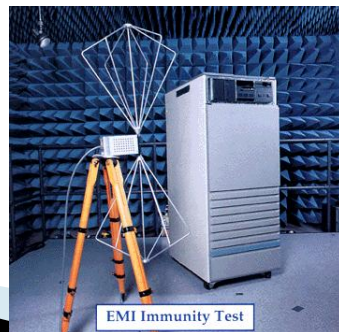
Downhole exploration

- Replace bulky copper with lightweight fiber
- Lower power delivery and installation costs
- Provide spark-free power in harsh environments and over long distances



EMI measurements

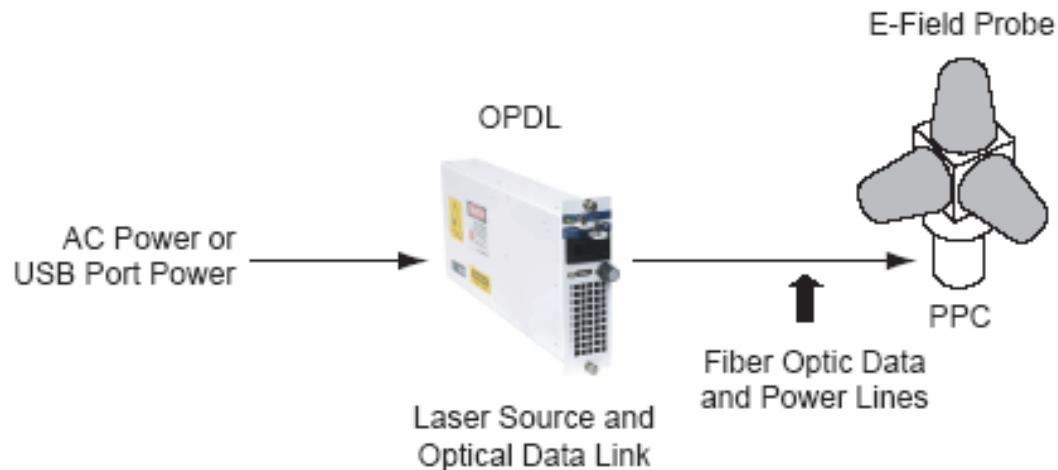
- Reduce cost and test time by eliminating need for battery power
- Eliminate extraneous interference to EMI measurement



Industrial sensors

All-fiber solution for powering electric field probes permits:

- Electrically isolated power source that will not affect test measurements
- Elimination of batteries and charging
- Faster completion of tests
- Use of more compact probes for reduced field perturbation



Aerospace

Electrically-isolated, spark-free power

Fuel gauges and actuators

- Spark-free power eliminates risk of explosion

Communication equipment

- Lightweight alternative to copper or coax
- EMI-free

Sensors

- Lightweight, spark-free power source for aircraft sensors



Defense

Electrically-isolated, spark-free power

Arming and fuzing actuation

- Isolated power eliminates risk of premature explosion

Communication equipment

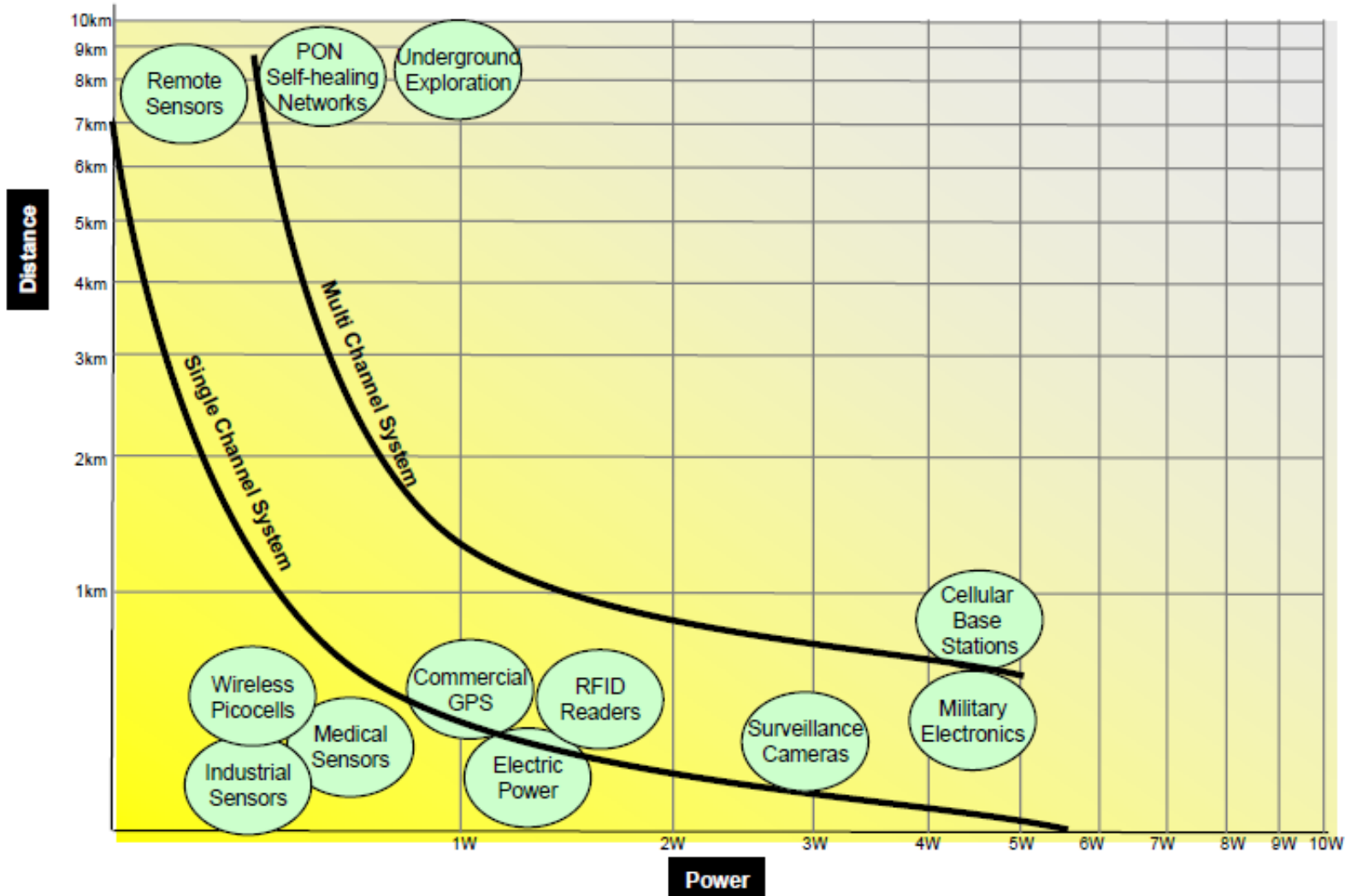
- Lightweight alternative to copper or coax
- EMI-free

Test and Measurement

- Interference-free power source for electromagnetic compatibility testing



Greater Output Power, Longer Wavelengths Enable More Applications



Products

High Power Optical Data (HiPOD) System

- 5W Electrical Power Output
- Uplink and Downlink Data Channels



Photonic Power Modules (PPM)

- Includes PPC, laser, driver, electronics
- 'Electrical in – electrical out'



Photovoltaic Power Converters (PPC)



- Conversion efficiency up to 50%
- 2-12 VDC, up to 1W electrical output
- Impervious to harsh environments

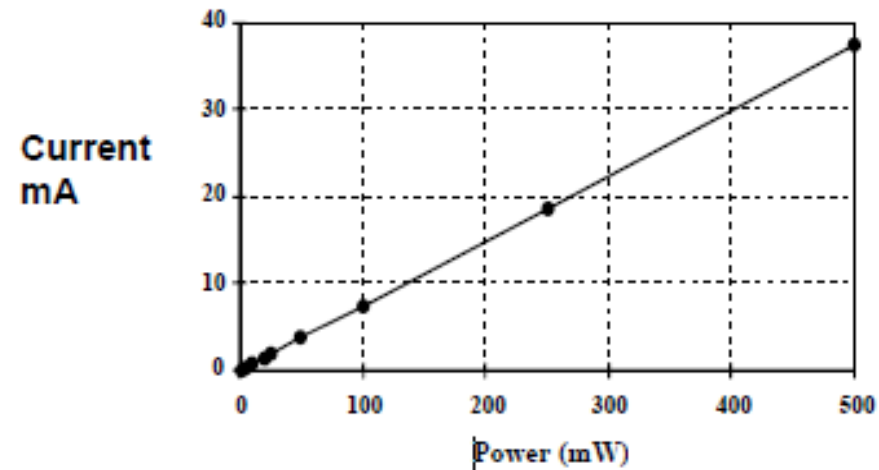
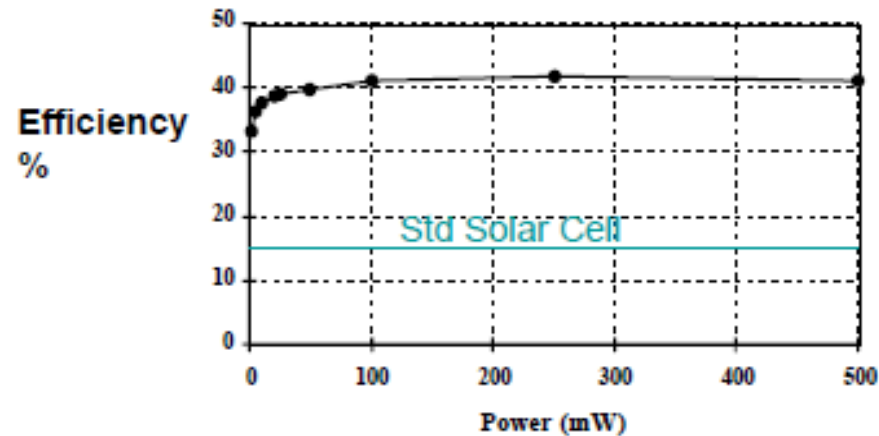
Photovoltaic Power Converter (PPC)

- Delivers fully isolated electric power through noise immune, non-conductive optical fiber
- Converts laser light to electrical power with up to **50% efficiency**
- Provides **voltages from 2 -12 VDC**
- Operates with laser diodes in **790 to 980 nm** wavelength range, **1300-1550 nm in near future**
- Utilizes **common 62.5 μm or 105 μm fiber**



PPC Technology

- Semiconductor device made from AlGaAs, GaAs, InGaAs or InP – similar materials & processing techniques as power Laser Diodes



Photonic Power Module (PPM)

- **Turnkey solution**
 - Includes laser, driver, & PPC
 - Optimized for maximum electrical output power
- **Up to 1 watt delivered power**
- **Common 62.5 & 100 μm fiber interconnect**
- **Standard voltage outputs: 2.8, 3.3, 5, 10 V DC**
- **Laser module easily mounts as daughter board on main PCB**
- **Distances of 1km (MM OF) to >10km (SM OF)**

Power to drive:

- Modulators (bias Mach-Zehnder): 1mW
- Data Links (>1Gbps): 100mW
- Actuators/Sensors: 0.5W
- Transceivers/Switches:
 - 1W (single link)
 - 5W (parallel links)



High Power Optical Data (HiPOD) Link

Self-Powered Data Transmission over Fiber

Isolated Power Delivery

- 5 Watts
- Converts laser light to 5 W electrical output
- Drive remote electronics (e.g., sensors, receivers, transducers)
- Combines multiple laser channels for maximum power
- Distances over 500 meters (62.5 or 100 μm fiber)
- Immune to high voltage, RF, EMI, and magnetic hazards

Enhanced Safety, Reliability, and Maintainability

- Power and safety monitoring of individual channels
- Automatic channel shutdown (fiber disconnect/break)
- Operation in extreme environmental conditions
- Continued operation with up to two failed channels
- Hot swappable laser modules—Convenient rack mount laser drawer
- Power/temperature displays & on/off control per module

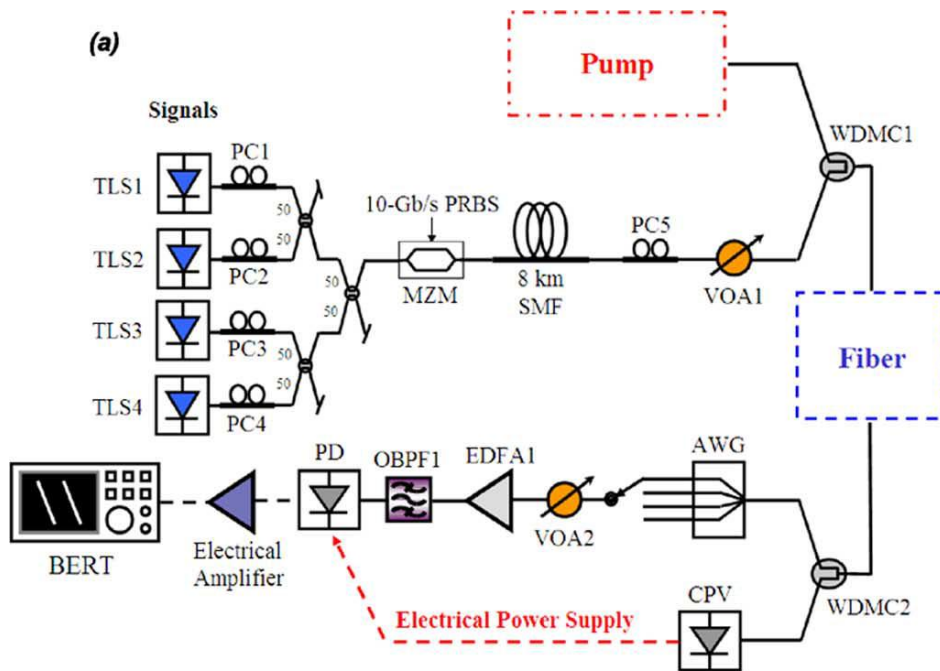
Duplex data transmission up to 12 Mbps

Remote Module
Up to 8 Power Converters



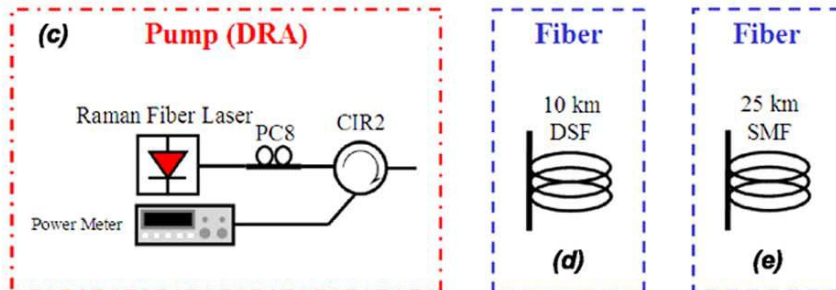
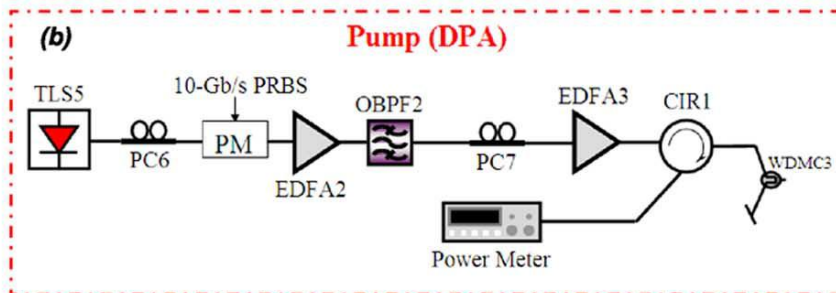
Local Module Chassis
Up to 8 Laser Modules

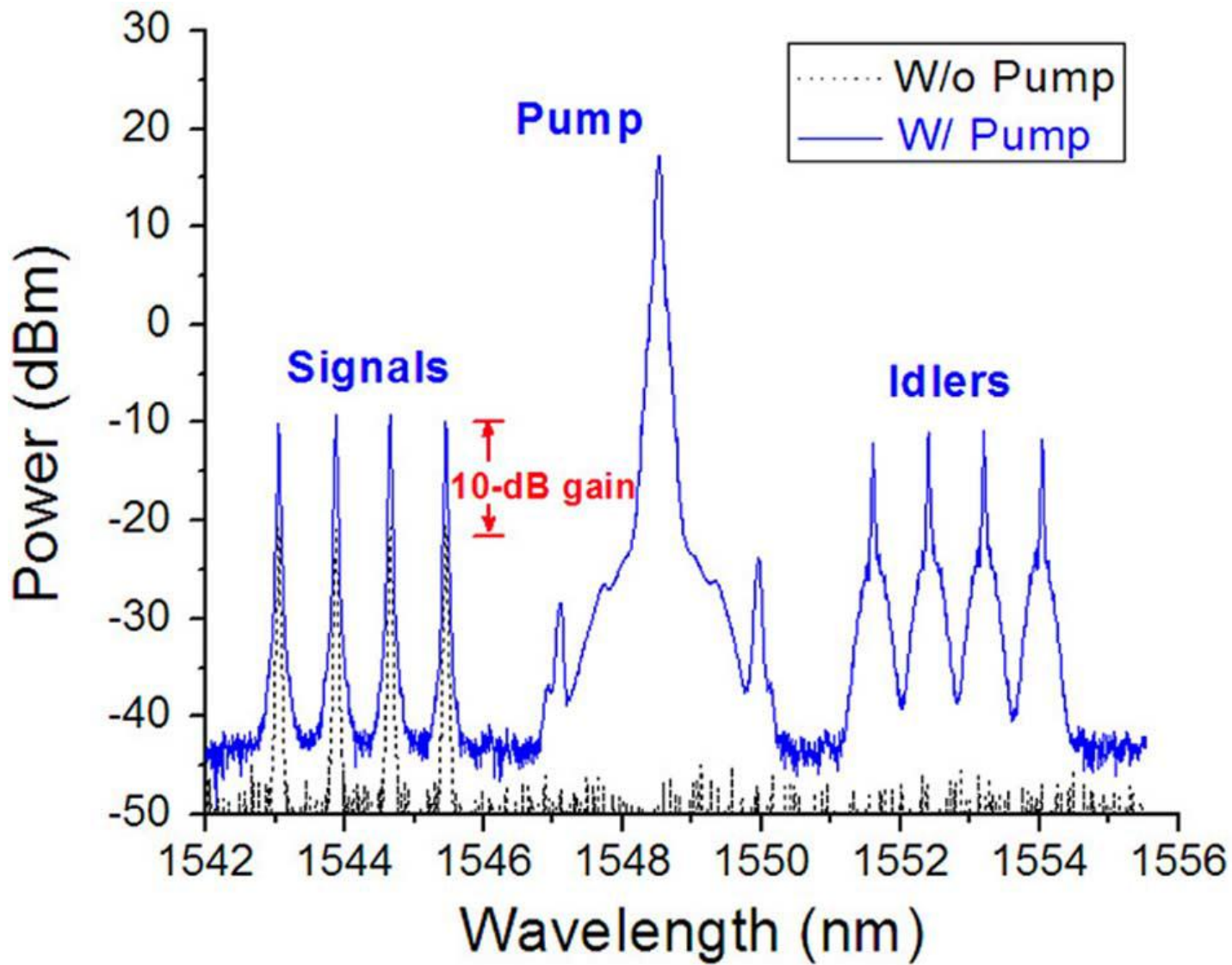




PP communication network PP distributed Raman Amplifier in DSF

Experimental setup:
 (a) main setup for the optically powered WDM signal transmission system with distributed amplification;
 (b) Setup of the parametric pump for the DPA case;
 (c) Setup of the Raman pump for the DRA case;
 (d) 10-km DSF used for both DPA and DRA;
 (e) 25-km SMF used for DRA. PM: phase modulator, WDMC: WDM coupler, AWG: arrayed-waveguide grating





Optical spectra at the output of DSF with (blue solid line) and without (black dotted line) pump. (OSA resolution bandwidth: 0.02 nm).

Conclusions

- ❑ **The benefits of OPSS are now evident**
- ❑ **Key elements of such a systems**
High- power LD and efficient PPC - are now commercially available
- ❑ **Price of optimized Optical Power Links (OPL) is moderate and is expected to decrease in the near future**
- ❑ **The available wide range of fiber optic communication solutions**
- ❑ **Relatively cheap low-power microelectronic sensors of different measured**
- ❑ **Promote elegant and sophisticated solutions for many industrial applications**

Conclusions

Main application areas of OPSS

- ❑ High voltage technology
- ❑ Medicine
- ❑ Power electronics
- ❑ Military, avionic and aerospace systems

Fiber optically powering technology

will be spread in the wide range of commercial applications

- ❑ EMC
- ❑ Nanotechnology
- ❑ Communications
- ❑ Robotics
- ❑ Intelligent manufacturing systems,
- ❑ Automotive industry
- ❑ Surveillance system

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