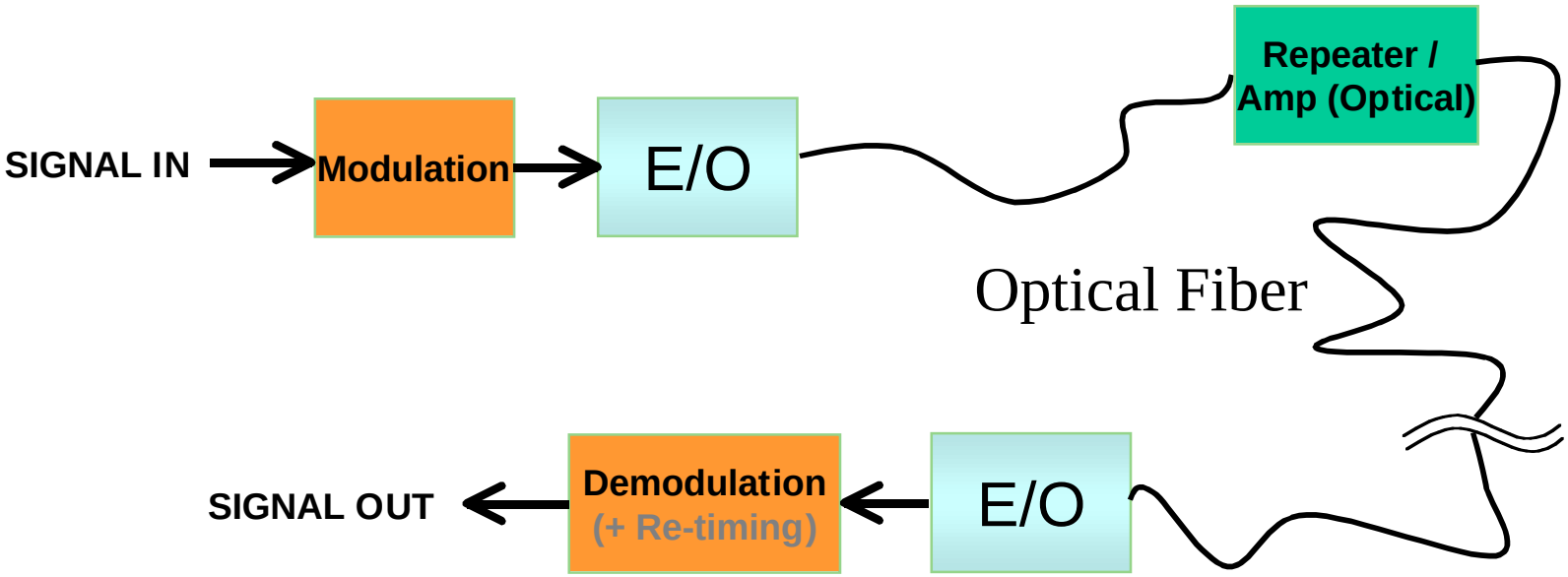
Using Digital Potentiometers in Laser Diode Applications

Introduction

- "Fiber Optic Communications"
  - Transmission of voice / data using light via Optical Fiber



Introduction

- Benefits of fiber optic communications
  - Fiber optic cable has lower losses than metallic lines
    - Longer distances with fewer repeaters
  - Fiber optic cable has higher BW than metallic lines
    - Useful BW is in the order of 100s of GHz
    - More data / voice channels per cable
  - Fiber optic cable impervious to electrical interference
  - Security

Focus on Digital Communications

- System Standard Examples

NAME	DATA RATE	APPLICATION / COMMENTS
FOIRL / 10BaseFL	10Mb/s	Small LAN - Office 2km fiber runs
Fast Ethernet / 100BaseFX	10Mb/s 100Mb/s	Medium LAN – Building 400m – 2km fiber runs
Gigabit Ethernet (GE)	1Gb/s	Medium LAN – Building 25 – 500m fiber runs
Fibre Channel Standard (FCS)	133Mb/s – 4Gb/s	High BW point-point serial link. Device-Station, Station-Station, SAN. 300m – 40km fiber runs
FDDI	100Mb/s	MAN, WAN Up to 500 Stations per network. 2 – 40 km fiber runs
ATM – with SONET/SDH Physical Layer	155Mb/s. 622Mb/s	(Medium - Long Haul) Telecom's, B-ISDN, SONET, SDH
ATM – with other Physical Layers	Up to 2.5Gb/s	Supported by optical network Physical layers other than SONET / SDH.

Focus on Digital Communications

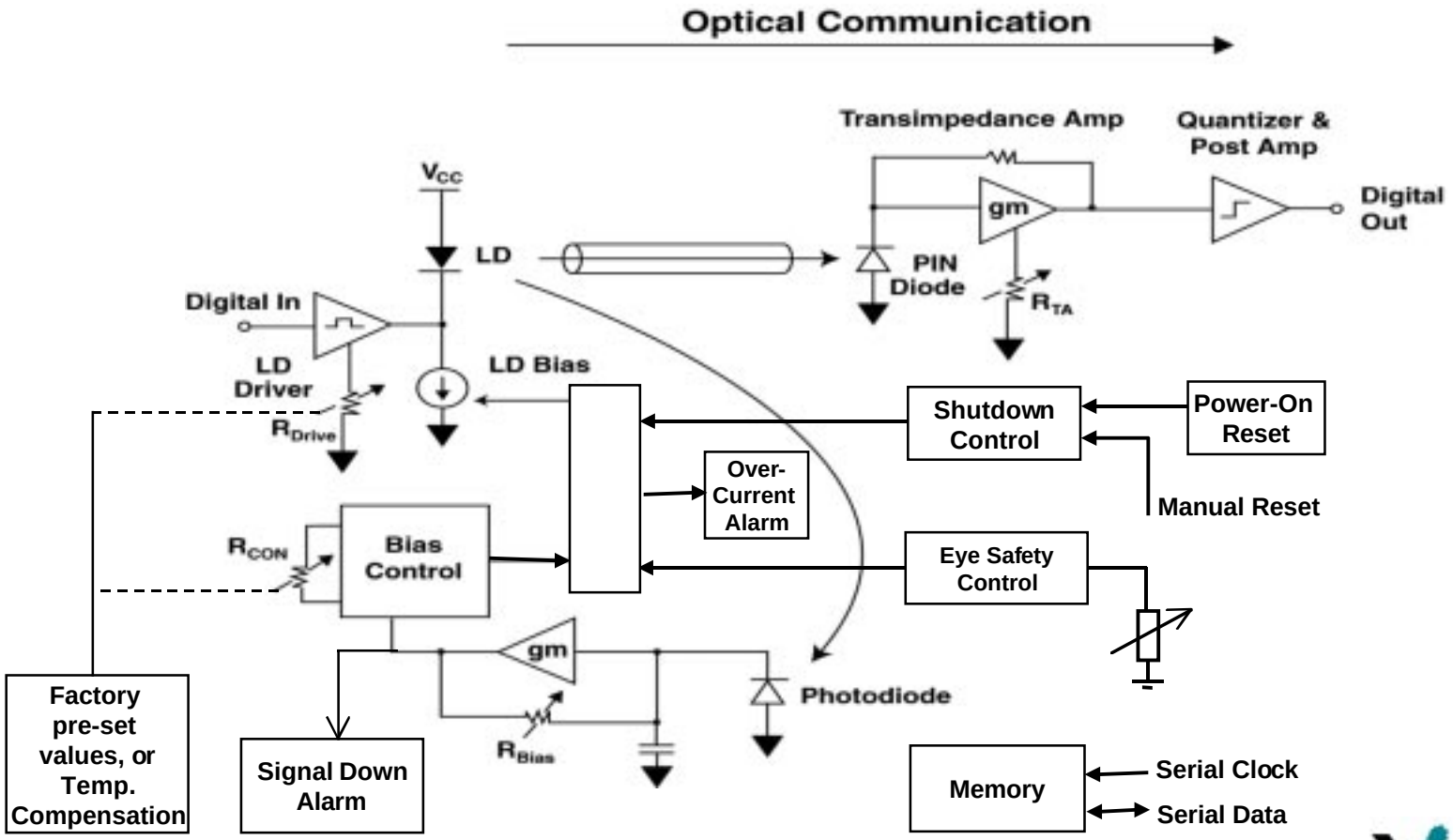
- Fiber optic comm's market trends / growth

APPLICATION	Fiber Usage (%) 1993	Fiber Usage (%) 1999
Long haul terrestrial	52.3	38.2
Submarine	22.6	7.5
Subscriber Loop	**14.7**	**35.3**
MAN	**4.3**	**6.8**
LAN / SAN	**6.1**	**12.2**

  - Demand increase driven by Internet, networking (WAN, MAN, SAN, etc).
  - System BW increasing (Eg. WDM, D-WDM)
  - Cost for fiber optic communications equipment decreasing

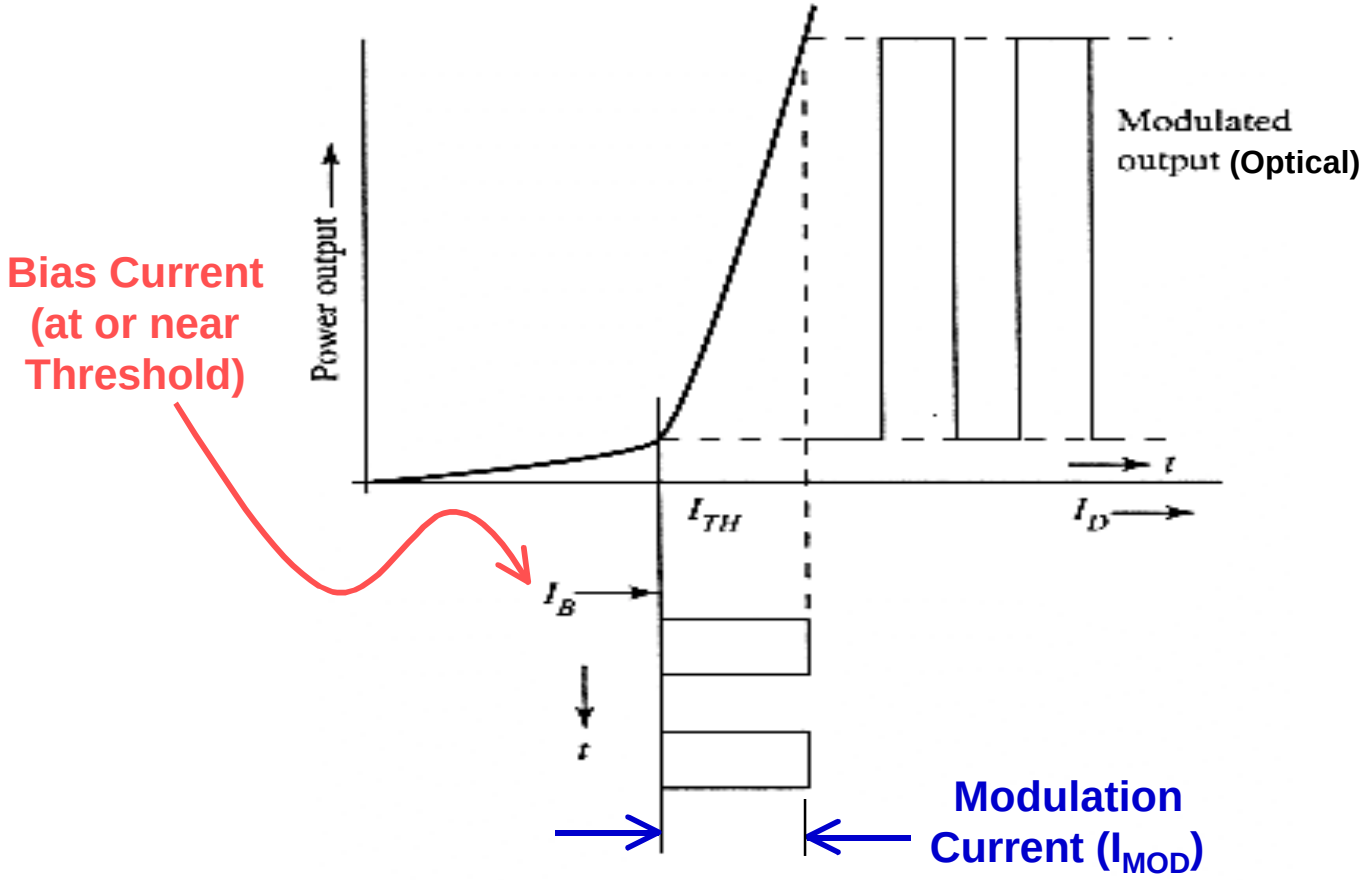
Laser Diode Control

- Example System Block Diagram



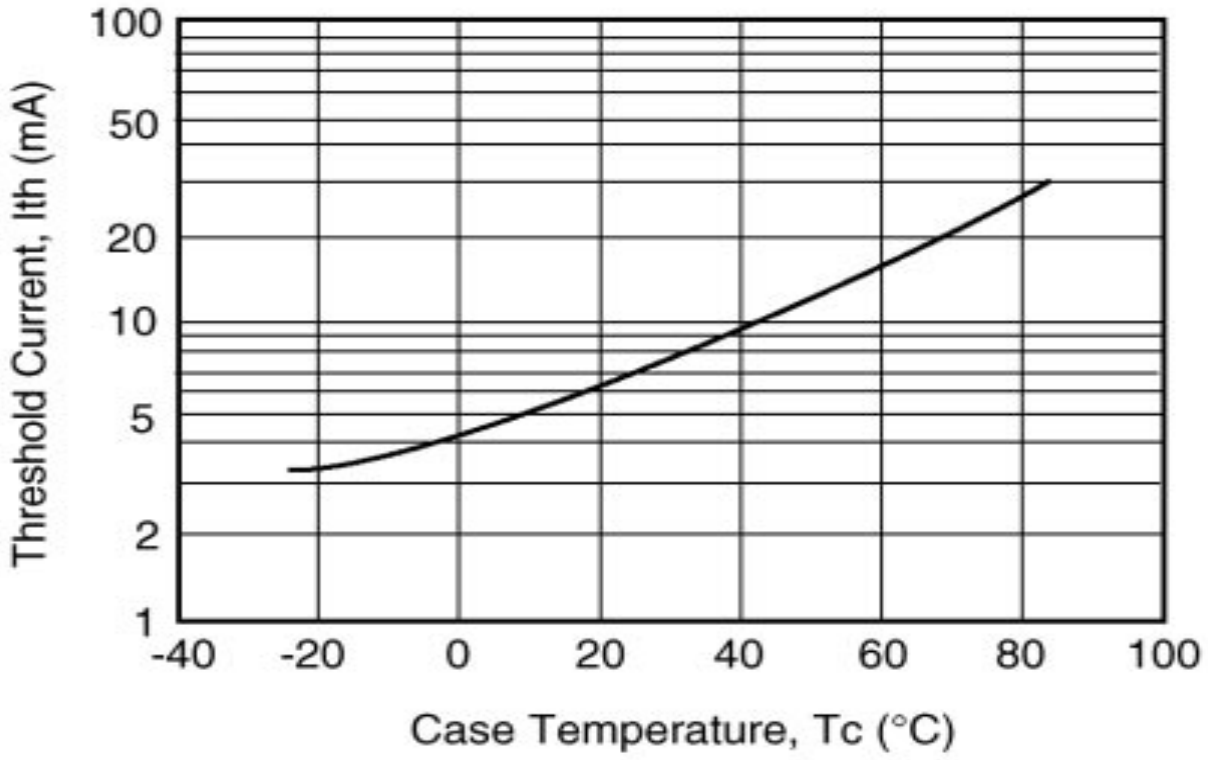
Laser Diode Fundamentals

- LD Modulation
  - Digital



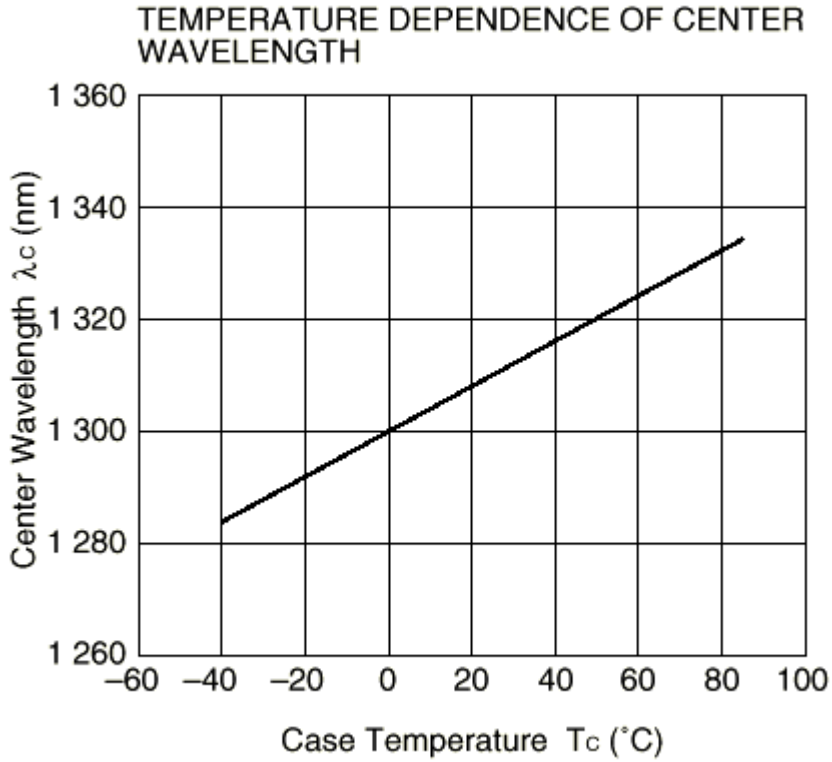
Laser Diode Fundamentals

- LD Temperature Characteristics
  - Threshold Current



Laser Diode Fundamentals

- LD Temperature Characteristics
  - Optical Output



Laser Diode Control

- Low BER at RX requires (in part) high extinction ratio (E_t)

$$E_t = \frac{\text{Optical Power (1)}}{\text{Optical Power (0)}} \text{ [dB]}$$

- Switching speed of LD dependent on I_B and I_{MOD}

$$\tau_{delay} = \tau_{th} \cdot \ln \frac{I_{MOD}}{I_{MOD} + I_B - I_{th}}$$

- Biasing and modulation can affect LD Chirp

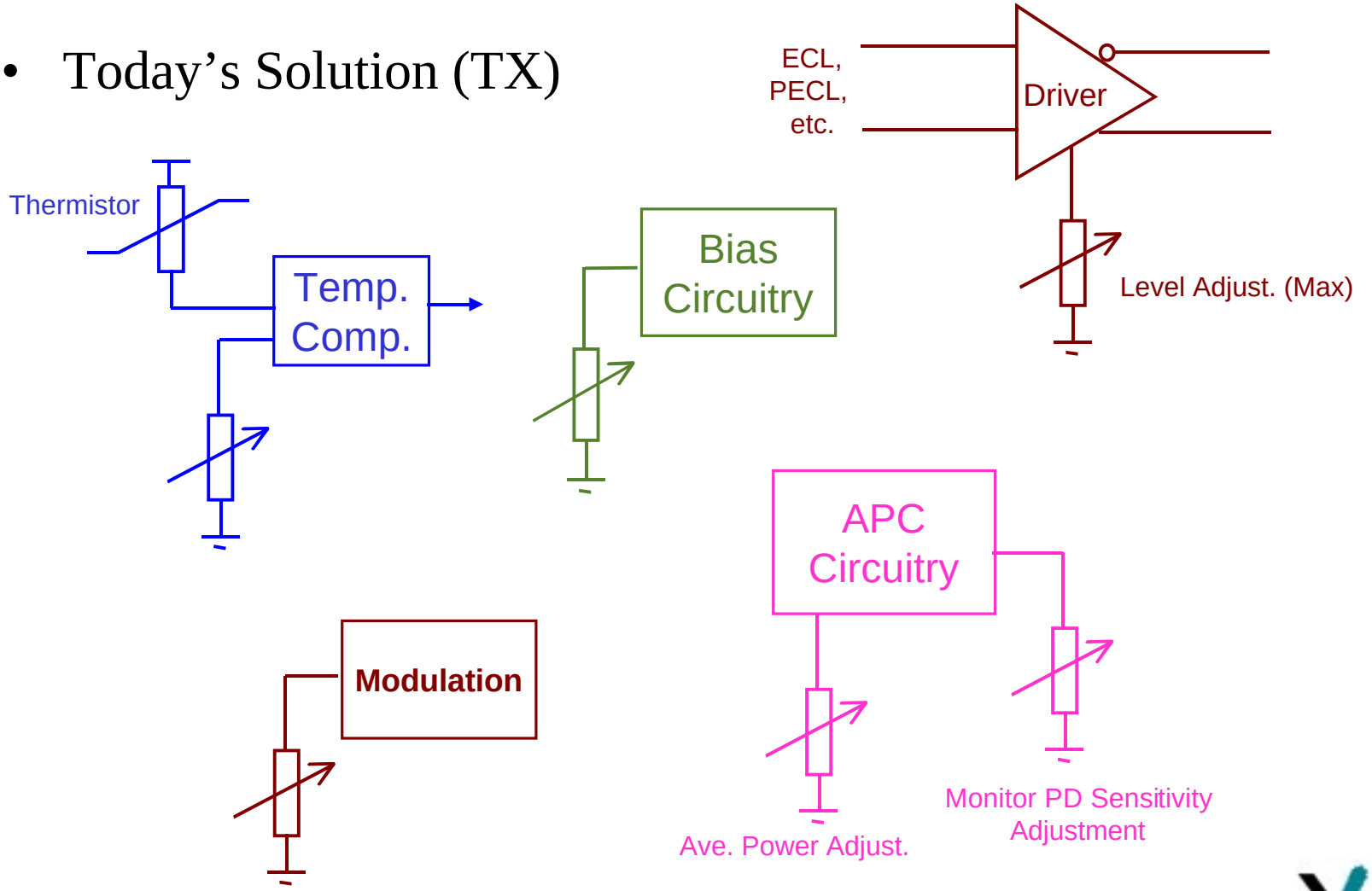
→ **Controlling I_B and I_{MOD} is very important**

Laser Diode Control

- Laser diode control requirements
  - Set max value for I_{MOD}
    - Avoids damage to LD due to excessive current
    - Maximize extinction ratio
  - Set value for I_B
    - Minimize τ_{delay} , Laser Chirp, etc.
    - Maximize Extinction Ratio
  - Maintain constant temperature
    - Centre wavelength shifts with temperature.
  - APC maintains a constant *average* optical power output by varying I_{MOD} and / or I_B dynamically
    - Compensates for changes in LD characteristics due to temp. variations, aging, etc.
    - Maintains high extinction ratio
    - Minimize system BER

Laser Diode Control

- Today's Solution (TX)



Laser Diode Control

- Laser diode driver solutions :
  - "Off the shelf " LD Driver ICs
    - Bias Control
    - Modulation Control
    - APC
  - Discrete implementations
  - Custom ASICs

→ **LD DRIVERS REQUIRE SETTING OF EXTERNAL VARIABLE RESISTANCES**

Laser Diode Control

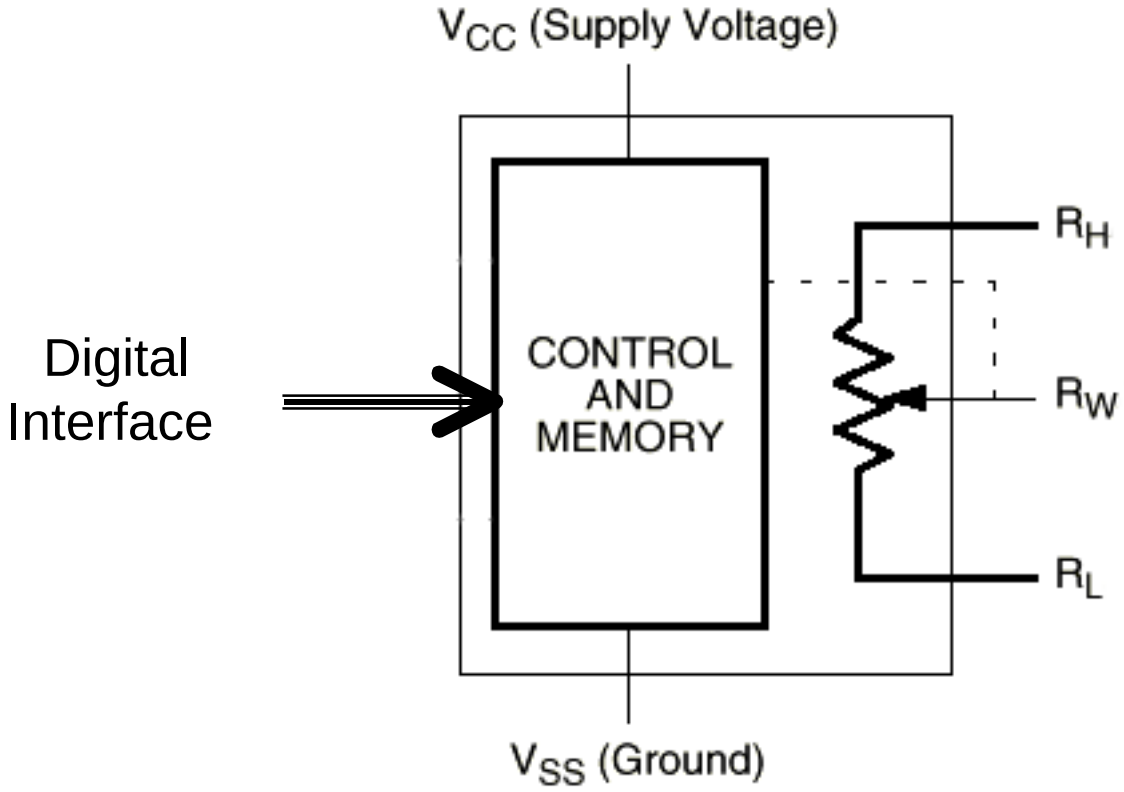
→ **LD DRIVERS REQUIRE SETTING OF EXTERNAL VARIABLE RESISTANCES**

OLD SCHOOL

Xicor Digitally Controlled Potentiometers (XDCPs™)

XDCPs in Fiber Optic Applications

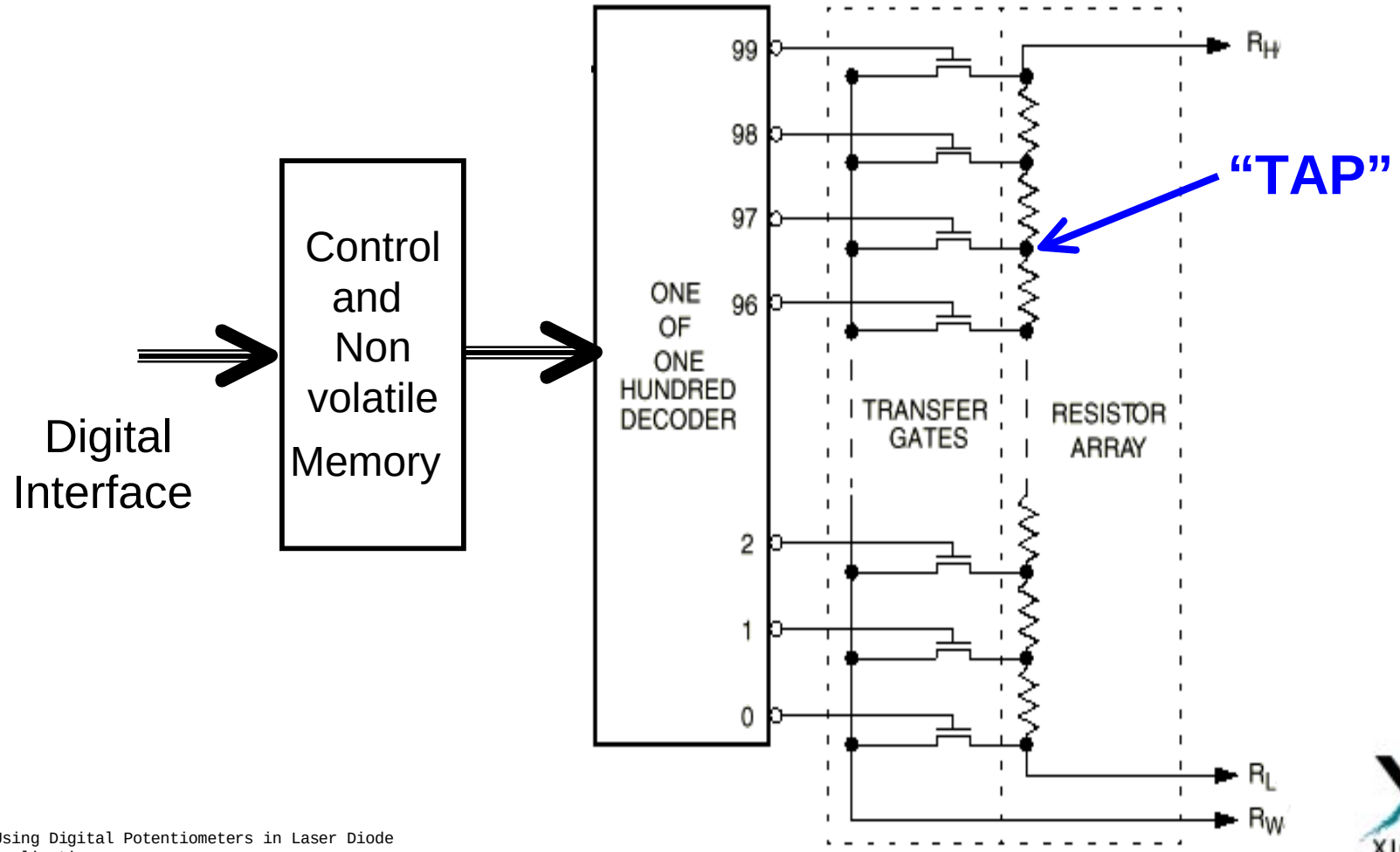
- What is a Xicor Digitally Controlled Potentiometer (XDCP)?



See www.xicor.com….. For primer on XDCPs

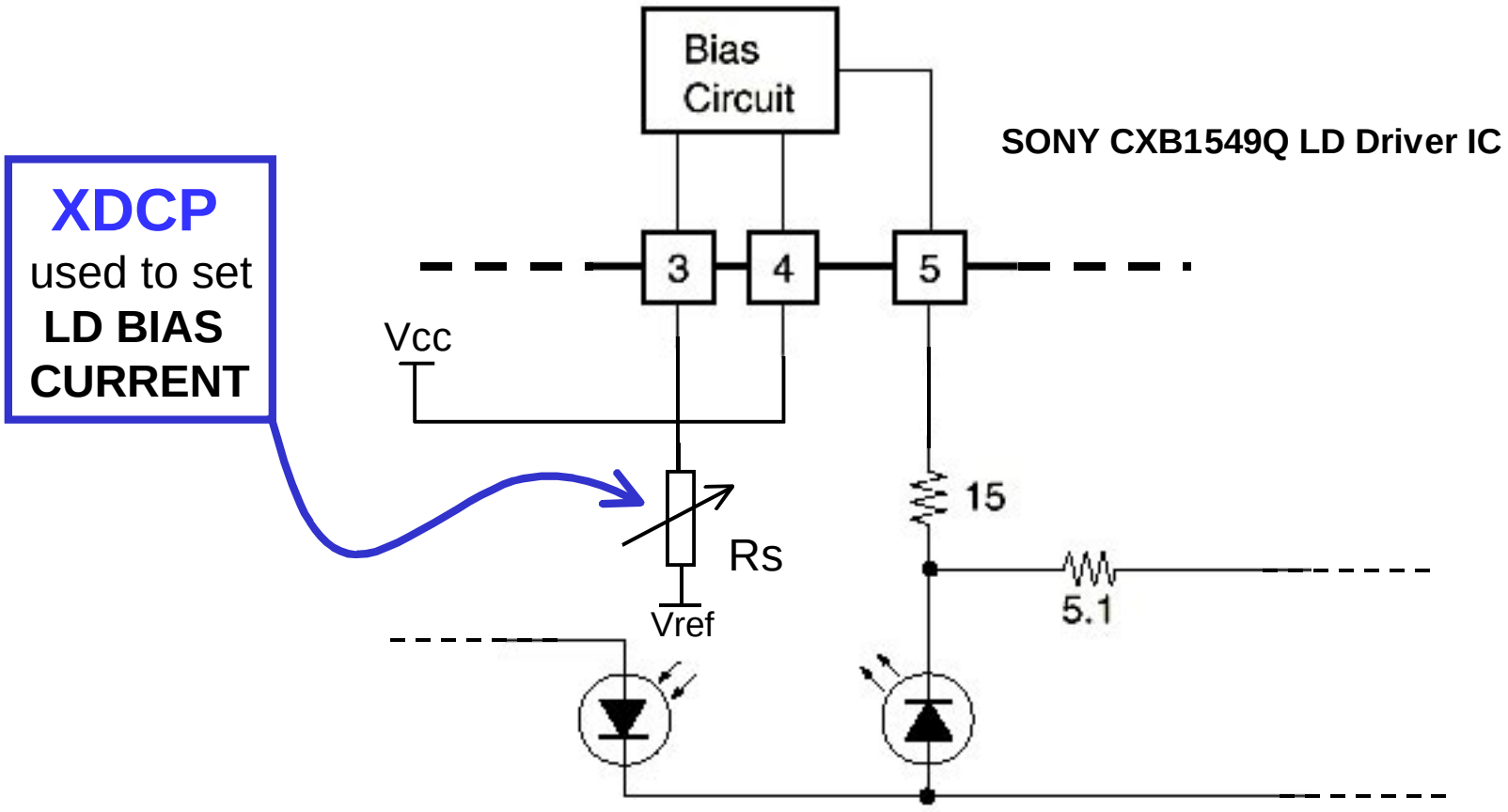
XDCPs in Fiber Optic Applications

- Internal XDCP Realization



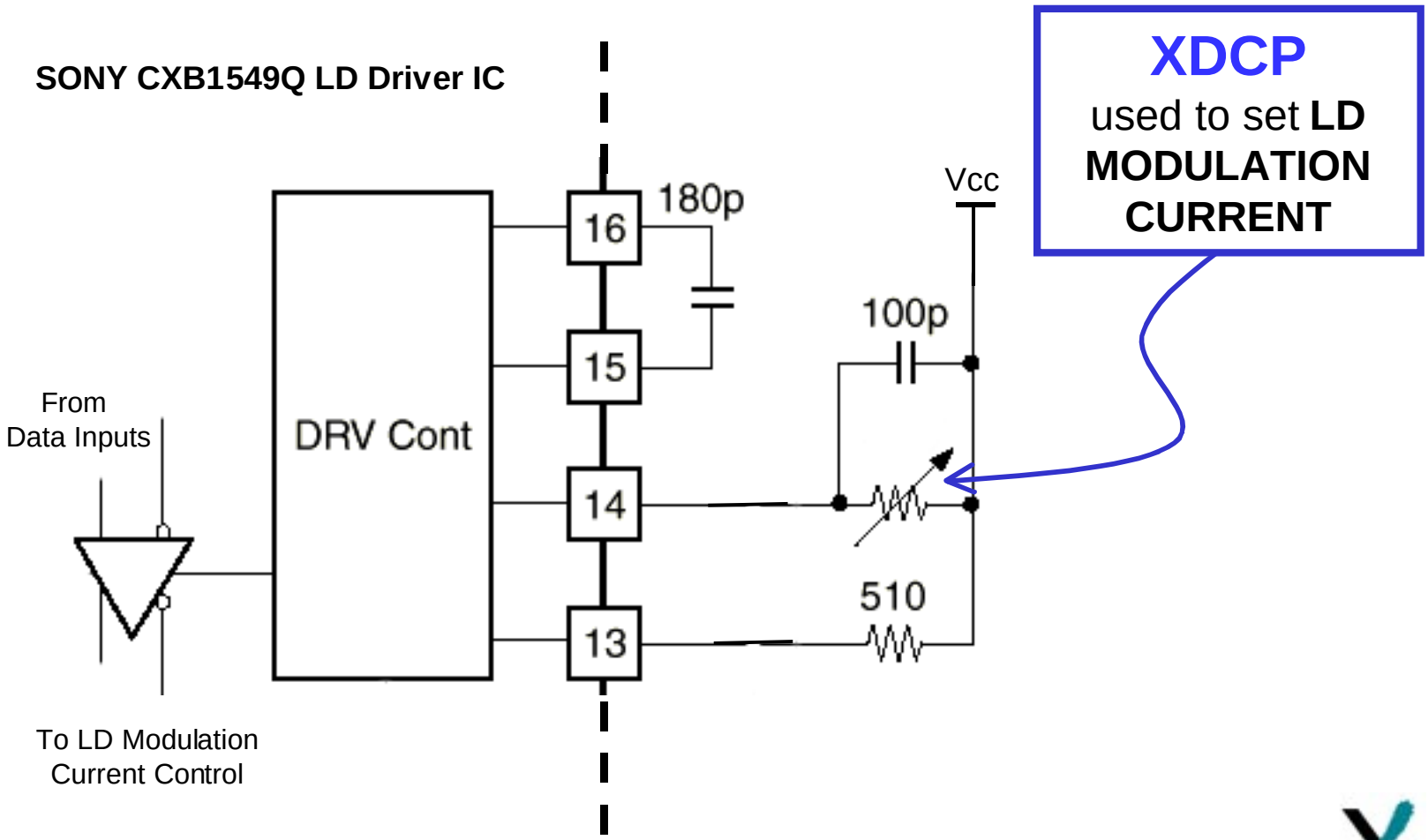
XDCPs in Fiber Optic Applications

- Example : XDCP to set LD Bias Current level



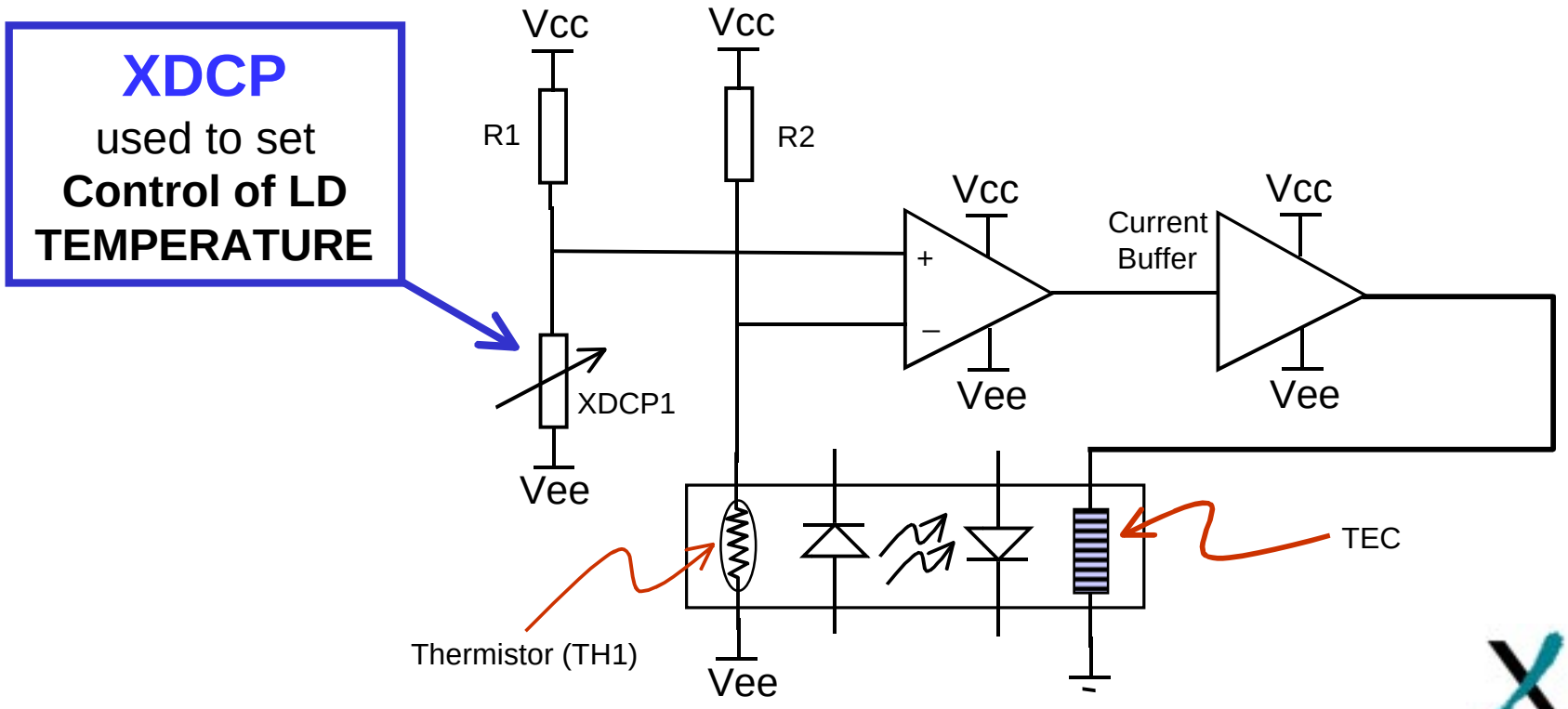
XDCPs in Fiber Optic Applications

- Example : XDCP to set LD Modulation Current level



XDCPs in Fiber Optic Applications

- Laser Diode Control Requirements
  - Temperature Control
    - Thermistor / Temperature Sensor
    - TEC (Peltier Cooler)



XDCPs in Fiber Optic Applications

- XDCP used to set LD operating levels
  - Simple set-and-forget functionality
    - Nonvolatile memory and control eliminates need for uC
    - Eliminates need for redundant EEPROM
  - Reliability over mechanical solutions
    - No mechanical wear
  - Shock proof
  - Moisture proof
  - Dust proof

XDCPs in Fiber Optic Applications

- XDCP used to set LD operating levels
  - Repeatable R settings
  - Standard semiconductor reliability
  - Tamper-proof
    - User cannot use simple screwdriver cannot change LD bias !
  - Low cost of ownership
    - Automated adjustment
      - Saves money in test and calibration
    - Fast adjustment
    - Eliminates human error

XDCPs in Fiber Optic Applications

- Power supply requirements
  - Single supply devices
    - 2.7V to 5.5V operation
  - Other supply options

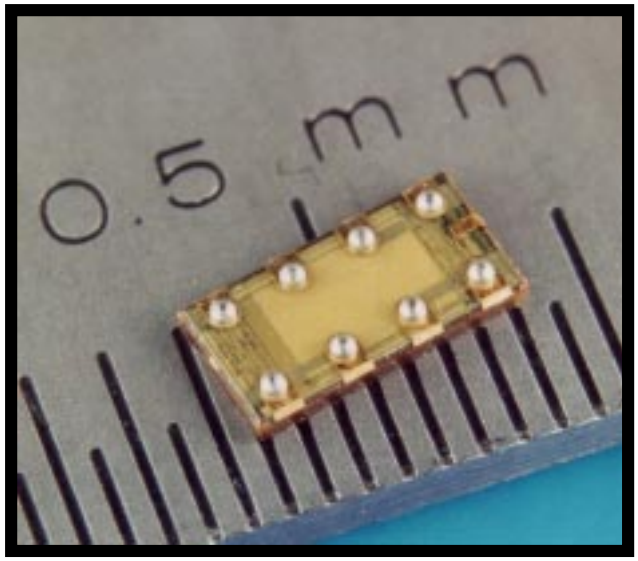
- Range of digital iInterfaces
  - 2-wire
  - SPI
  - 3-Wire UP/DOWN
  - PushPot

XDCPs in Fiber Optic Applications

- Taps
  - 16, 32, 64, 100, 256 taps
  - 1024 taps (E.S. Available End Q2'00)
  - Single, dual and quad devices

- Temperature co-efficient (T/C)
  - Typical ±300ppm / °C
  - Methods exist to shift T/C dependency
  - Use as V divider → Ratiometric T/C = ±20ppm / °C

XDCPs in Fiber Optic Applications



- Packaging
  - DIP, SOIC
  - TSSOP, MSOP
  - Naked die
  - Xicor Ball Grid Array (XBGA)
    - Chip scale package with solder bumps
    - First XDCP products in XBGA being announced this month
    - Reduced board size

XDCPs in Fiber Optic Applications

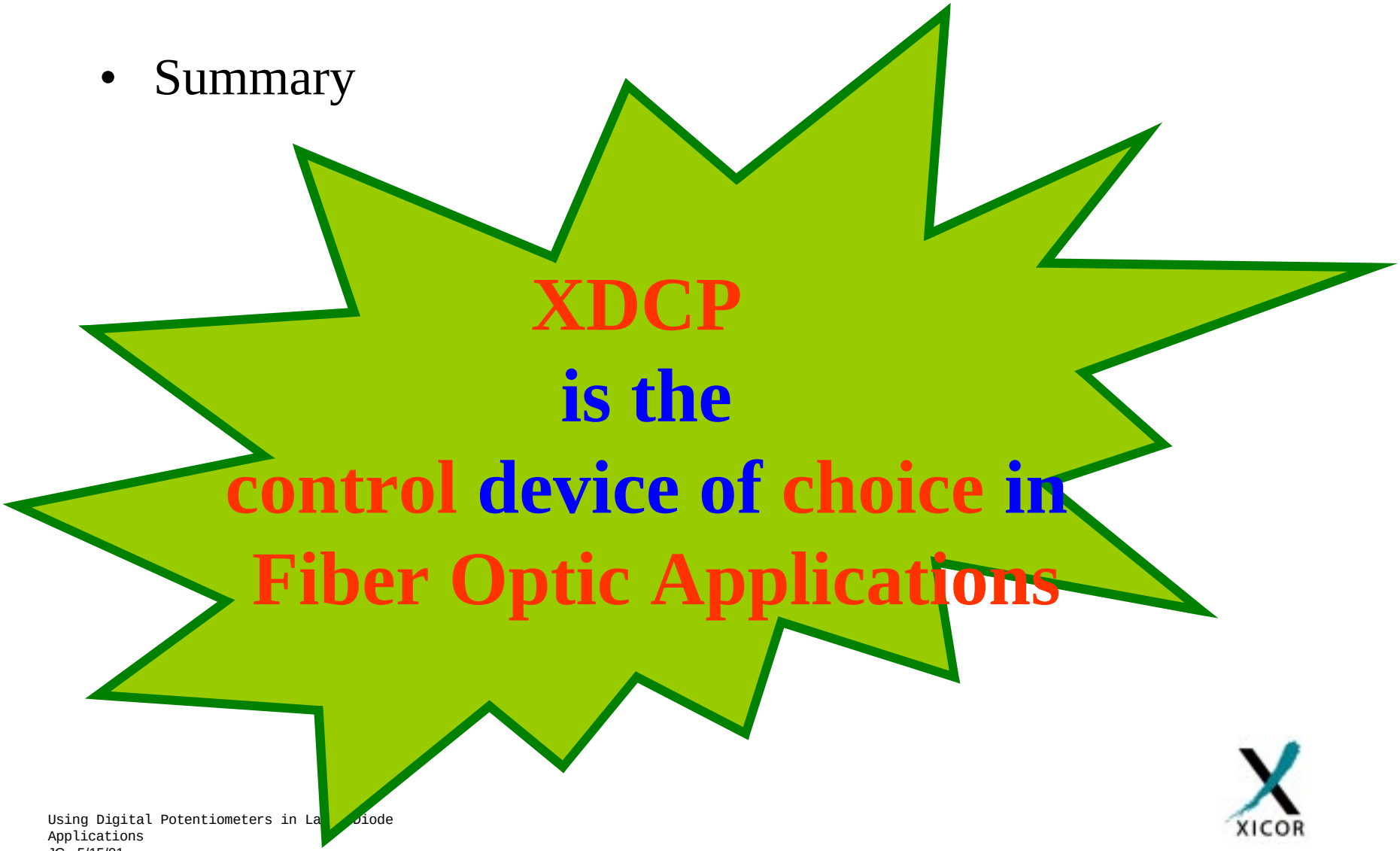
- Mixed Signal Devices
  - X9430 / X9438
    - Integrated dual XDCPs
    - Integrated dual op-amps
    - Fully user configurable
  - X9440 / X9448
    - Integrated dual XDCPs
    - Integrated dual comparator
    - Fully user configurable

XDCPs in Fiber Optic Applications

- Summary
  - Adjustment of LD control parameters are important:
    - Bias, modulation, temperature control (etc)
  - Adjustments often require external variable resistances
  - Xicor Digitally Controlled Potentiometers provide
    - Simplified system set-up
    - Higher reliability
    - Low cost of ownership

XDCPs in Fiber Optic Applications

- Summary



Abbreviations / Glossary

APC	Automatic Power Control
ATM	Asynchronous Transfer Mode
BER	Bit Error Rate
BW	Bandwidth
D-WDM	Dense Wavelength Division Multiplexing
FCS	Fiber Channel Standard
FOIRL	Fiber Optic Interconnect Repeater Loop
GE	Gigabit Ethernet
LAN	Local Area Network
LD	Laser Diode
MAN	Metropolitan Area Network
PD	Photodiode
RX	Receiver
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network
TEC	Thermo-Electric Cooler
TX	Transmitter
WAN	Wide Area Network
WDM	Wavelength Division Multiplexing

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Chirp - Sometimes known as “Frequency Chirp” is a phenomena whereby wavelength of optical output changes with time.

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