MOBILE WORLD CONGRESS
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Ultra-Low Power Optical Links in Portable Consumer Devices

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Evolution of User Interface

- User interfaces of mobile and consumer electronic devices evolved from a couple of LEDs and mechanical switches to interactive touchscreen interfaces
- Increasing computing power yielded ability to process and display highest-resolution, deep-color video content at frames rates suitable for 3D-viewing

1984

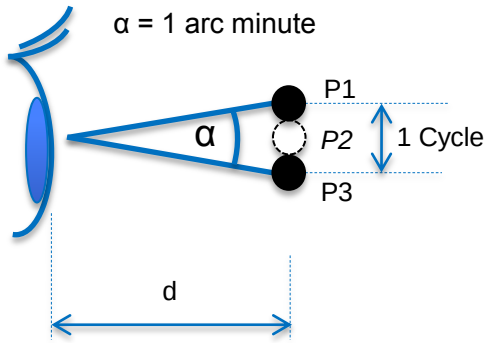
1996

2004

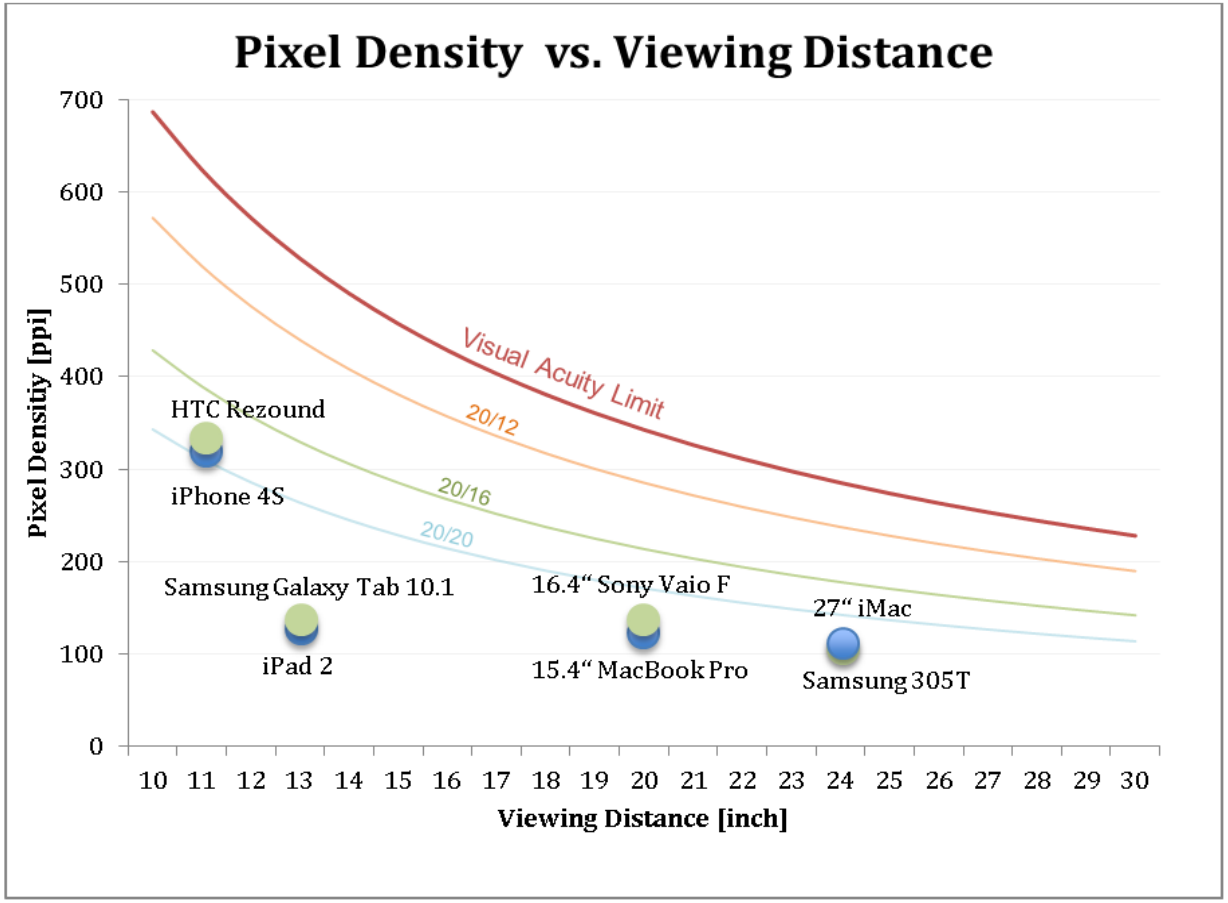
2011

Trends in Display Pixel Densities

20/20 Vision



Visual acuity is the spatial resolving capacity of the human eye as a function of the viewing distance



Wikipedia (Visual Acuity):
"…20/20 standard can best be thought of as the lower limit of normal (vision)…"
"…the average visual acuity of healthy eyes is 20/16 to 20/12…"

Resolutions of 'Visual Acuity' Displays

- Based on 20/10 Vision:

Device	Assumed Viewing Distance *[Inch]*	Pixel Density better than Visual Acuity *[PPI]*	Typ. Screen Sizes *[Inch Diagonal]*	Typ. Aspect Ratio	Caclualted Display Resolution		Total Number of Pixels
					Pixel Side 'A'	*Pixel Side 'B'*	
Smart Phone	11	625	4	3 : 2	2.081	1.388	2.888.428
Tablet	13	528	10	16 : 10	4.477	2.798	12.529.618
Laptop	20	343	15	16 : 10	4.363	2.727	11.897.090

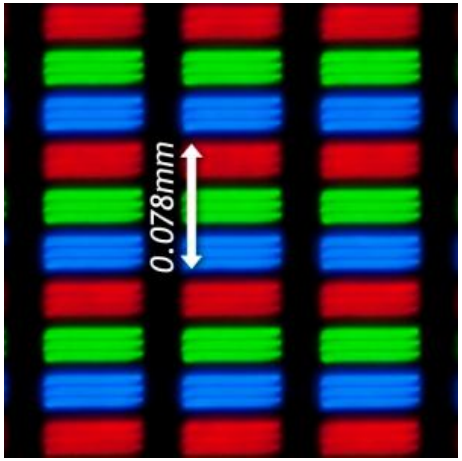
Aggregated Gross Data Rates

Visal Acuity Class: 20/10	Gbps
3D, 4" Smart Phone Display	12,5
3D, 10" Tablet Display	54,1
3D, 15" Laptop Display	51,3

(Gross Data Rate at 24-bit, 120 Hz, 20% Blanking OH, 8B/10B)

Actual Display Pixel Densities

2010

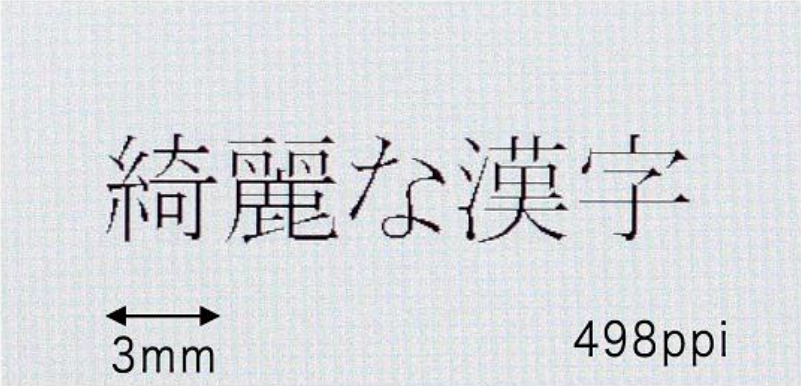


326 ppi

3.5“: 960 * 640 pixels

approx.: 1.5 Gbps (24b, 60Hz, incl. OH)

2011



498 ppi

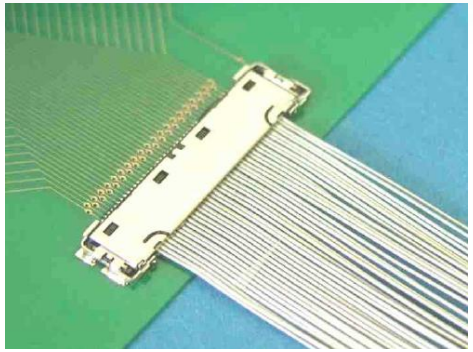
6.1“: 2560*1600 pixels

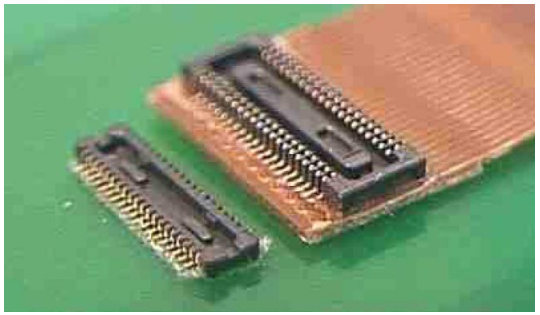
approx.: 9 Gbps (24b, 60Hz, incl. OH)

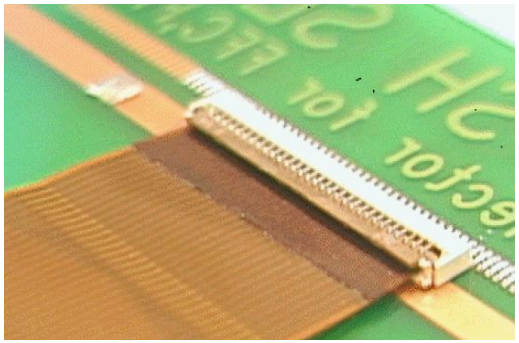
scaled up to 3D tablet screen size of 10“: 4224*2640 pixels

approx.: 45 Gbps (24b, 120Hz, incl. OH)

How to Get Data Across







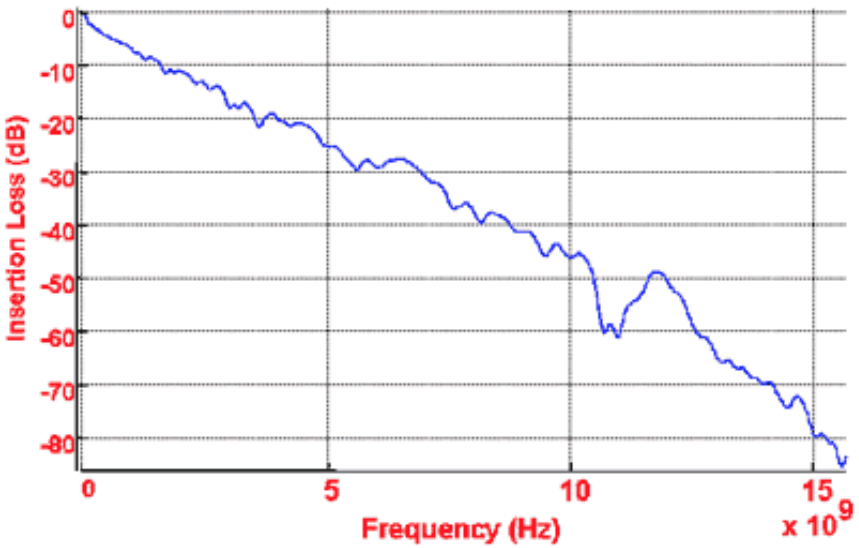
- Number of physical lines at respective aggregated data rate*:

		D-PHY		M-PHY			eDP	
Visal Acuity Class: 20/10	Gbps	1000 Mbps	1500 Mbps	Gear 2	Gear 3	Gear 4	2.7G	5.4G
3D, 4" Smart Phone Display	12	26	18	10	4	4	10	6
3D, 10" Tablet Display	54	110	74	36	18	10	40	20
3D, 15" Laptop Display	51	104	70	34	17	10	38	20

(8B/10B excluded)

* number of needed physical connections – number of differential lanes is half of that

Projected Channel Loss for Electrical Links



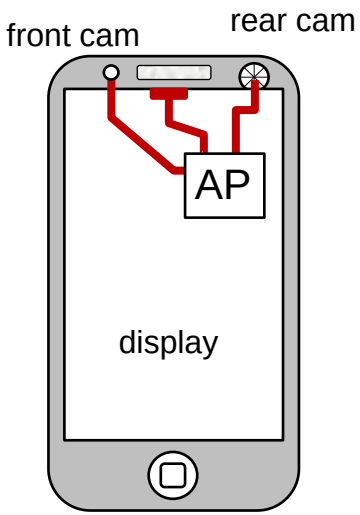
Simulated data of frequency-dependent loss for a 20-inch long electrical interconnect link

- ~ 50 dB loss at 10 GHz in a standard FR4 material
- To improve bandwidth lower loss material needed, more complex driver and equalization technologies needed
  → Increased cost
- Beyond 10 GHz → effect of reflections and crosstalk

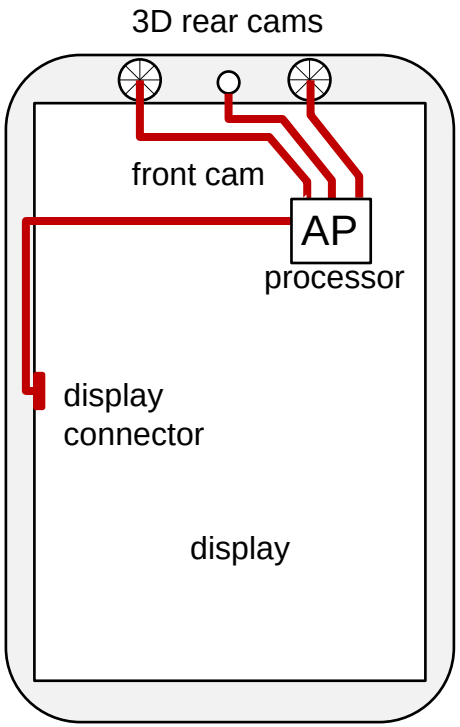
Source: „20050423_wsh.pdf“, E. Mohammed et al., Intel Corp.

Increasing Link Distances

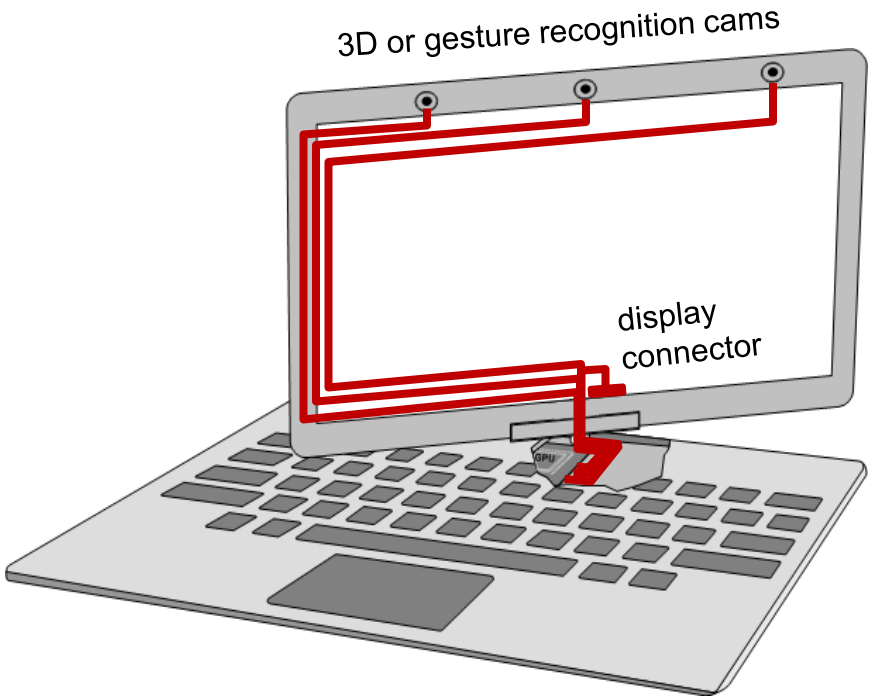
- Smartphone video interconnect distances: 1”~ **3**”



- Tablet video interconnect distances: 2”~ **10**”

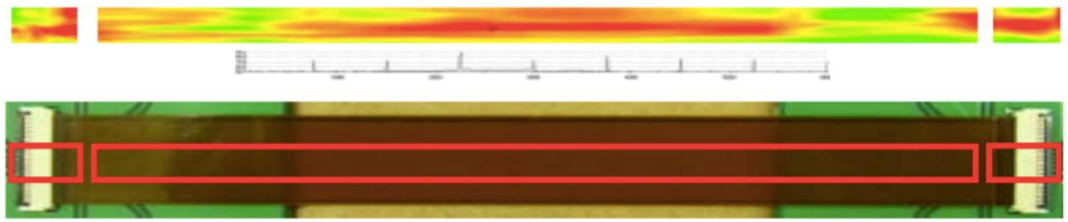


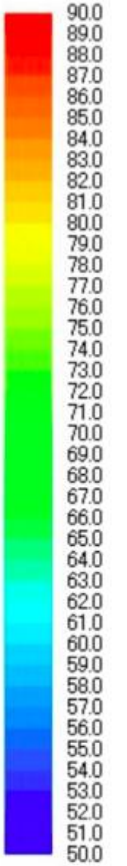
- Ultrabook video interconnect distances: 2”~ **20**”

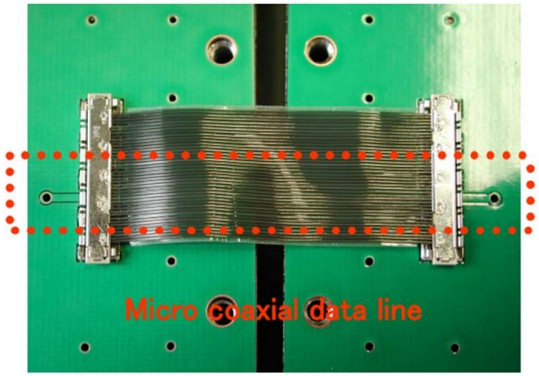


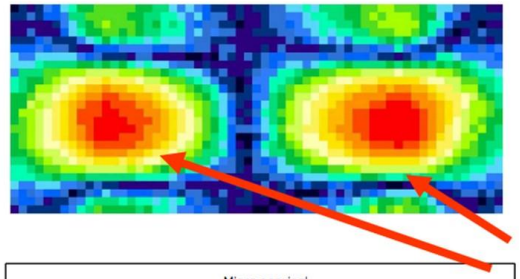
EMI Consequences

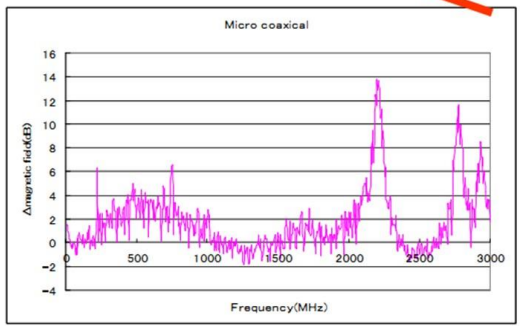
- EMI-Measurements taken from FPC and Micro-Coaxial Cable at 1.5 Gbps



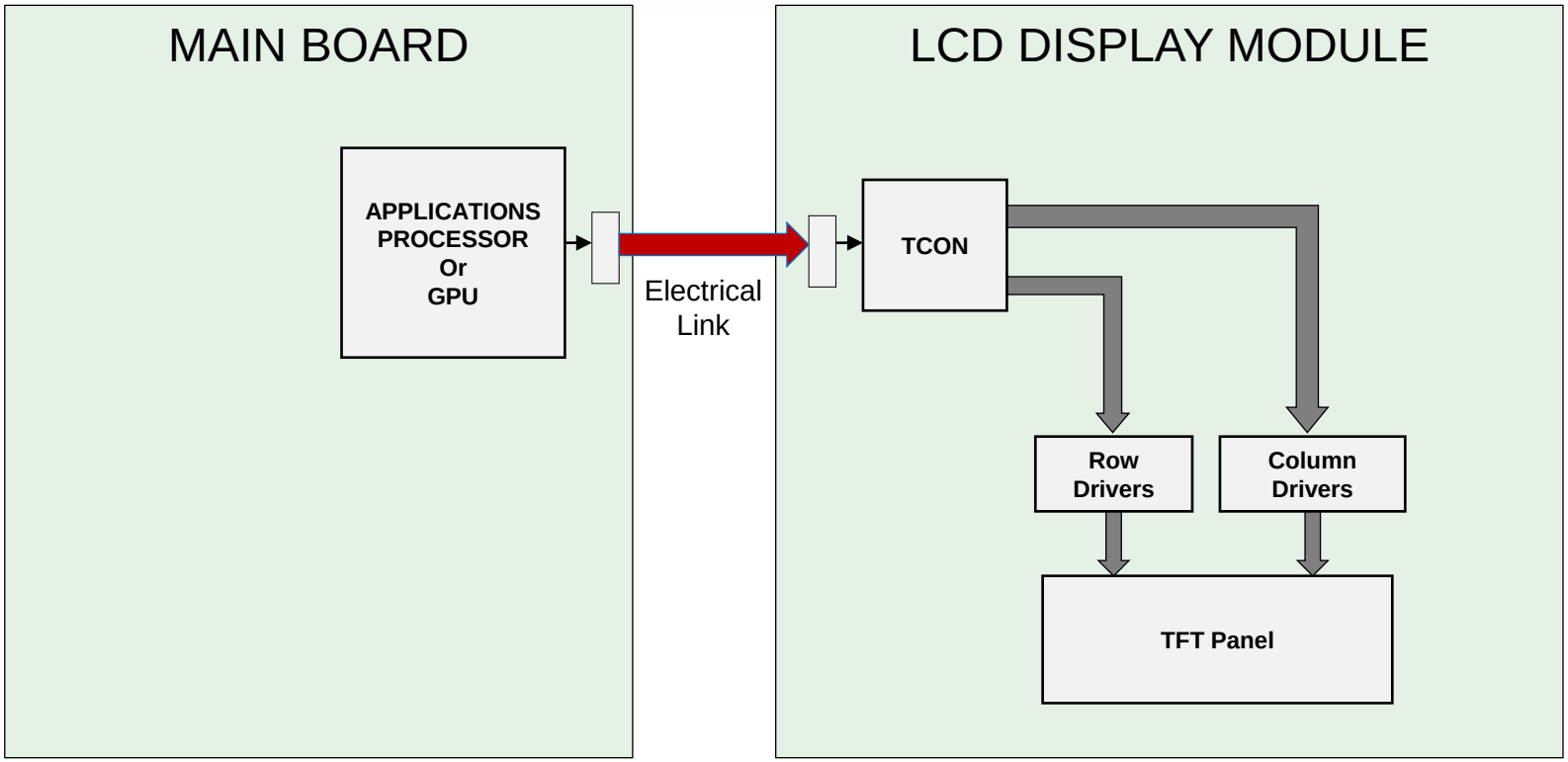








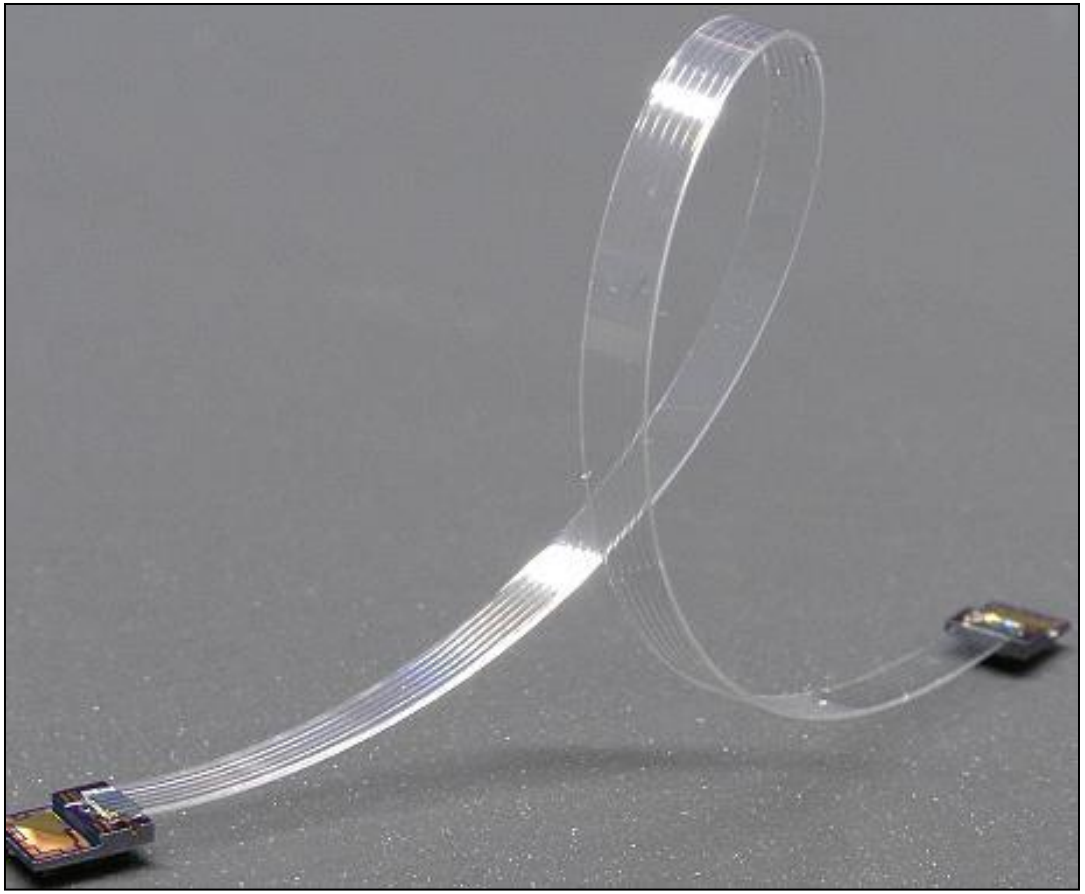
Constrained PCB Layout with Electrical Links



- MCX cable length must be kept as short as possible to limit EMI
- This constrains the placement of the electrical connectors
- This in turn constrains the placement of the ICs

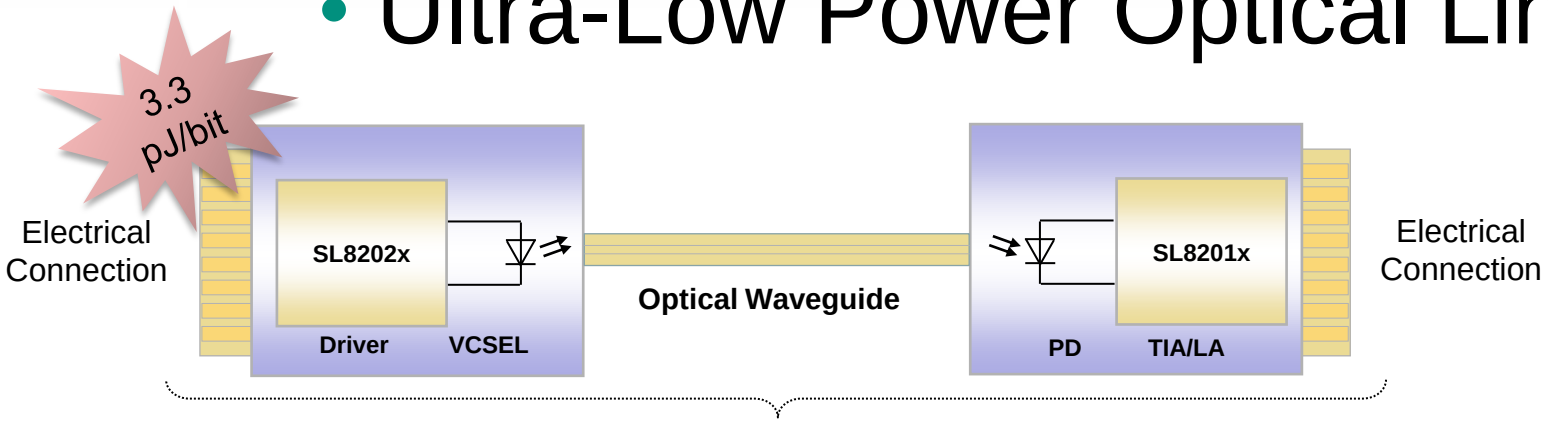
A Valid Alternative

- Ultra-Low Power Optical Links



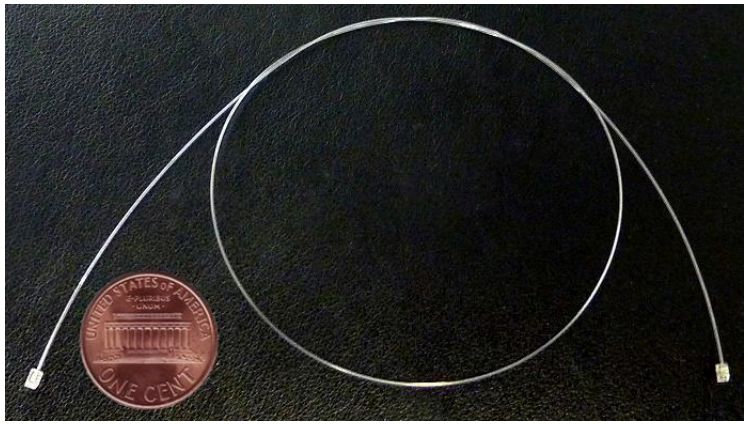
The Power Benefit

- Ultra-Low Power Optical Links



e.g.: < 10 mW @ 3Gbps (including far-end termination)

Source: Amphenol



Actual active optical cable based on Silicon Line ICs:
- Optical TX-size (L x W x H): 3mm x 1.8mm x 1mm
- Optical RX-size (L x W x H): 3mm x 1.8mm x 1mm

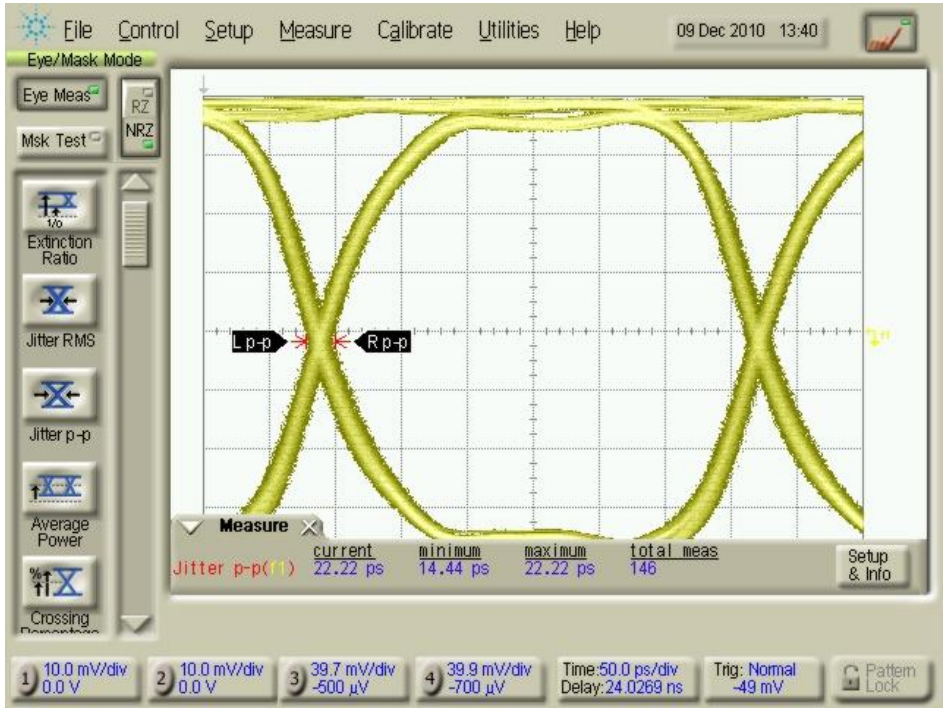
Key Data for Laser Driver and TIA/LA

- Data rate support up to 12.5 Gb/s
- Ultra low power consumption
  - e.g. <1 mW @3Gbps (Driver)
  - <5 mW @3Gbps (TIA/LA)
- Sub-LVDS Electrical I/O (SLVS-200)

VCSEL - Vertical Cavity Surface Emitting Laser
TIA/LA – Transimpedance Amplifier with Limiting Amplifier

Signal Integrity Benefit

- 50 cm optical fiber link @ 3 Gb/s



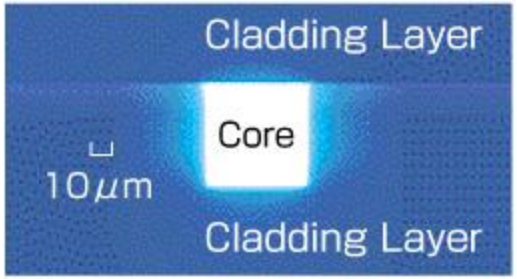
TX: Single supply (2,5 V)
RX: Dual supply (1,2 & 2,5 V)

Total power: 11.7 mW

VCSEL - Vertical Cavity Surface Emitting Laser
TIA/LA – Transimpedance Amplifier with Limiting Amplifier

The Mechanical Benefits

Cross-sectional core image

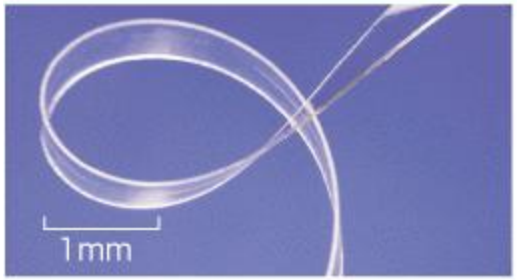


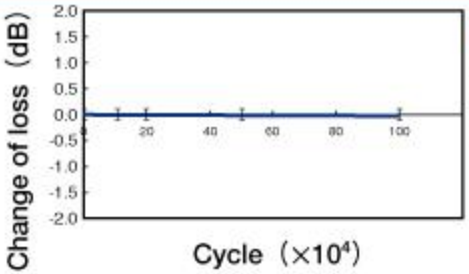
Low propagation loss

0.07dB/cm(@850nm) for POW

0.004 dB/cm (@ 850 nm) for POF

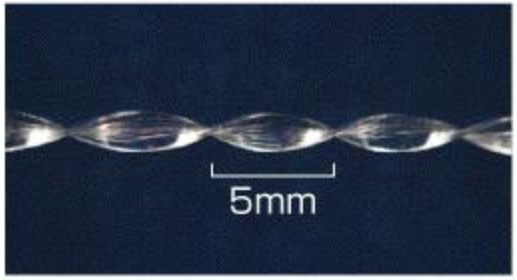
Flexible durability

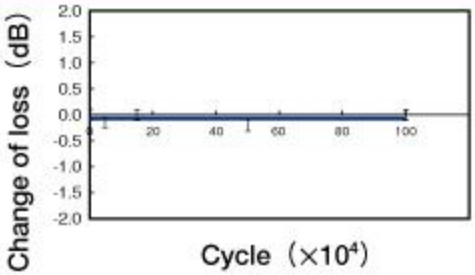




Bending radius
R=1mm
passed 1million bending test

Twistable durability



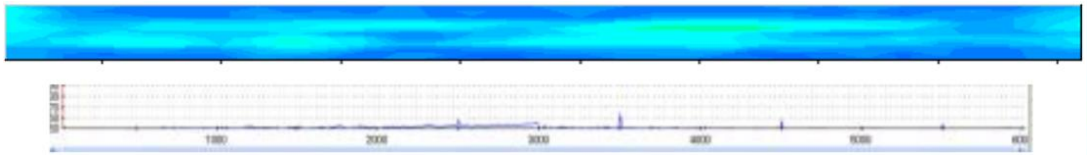


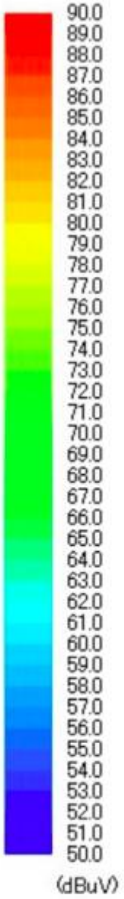
Twisting length
L=5mm
passed 1million twisting test

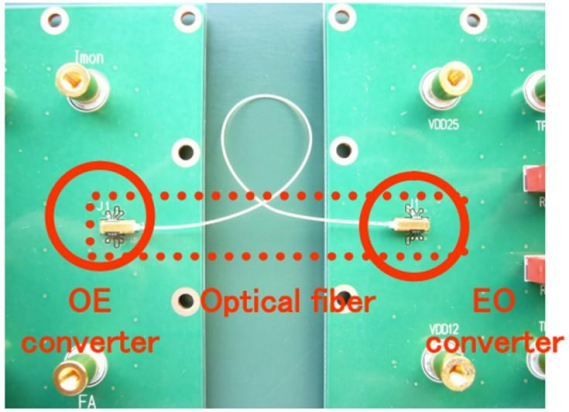
Source: http://www.omron.com/ecb/products/opt/1/film.html

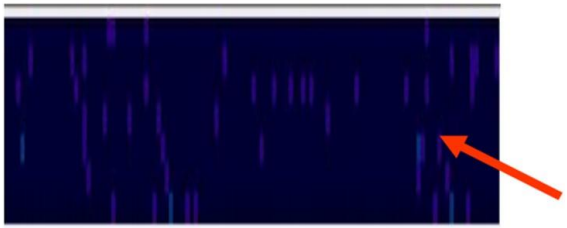
The EMI Benefit

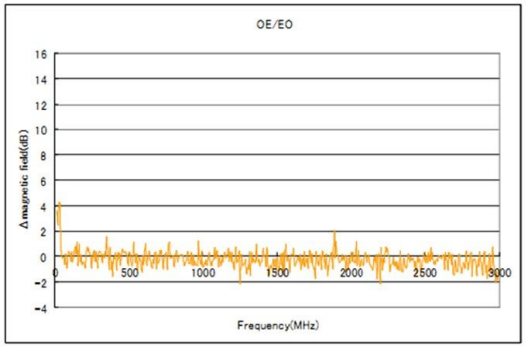
- EMI-Measurements taken from FPC with included planar optical waveguide and an optical fiber link











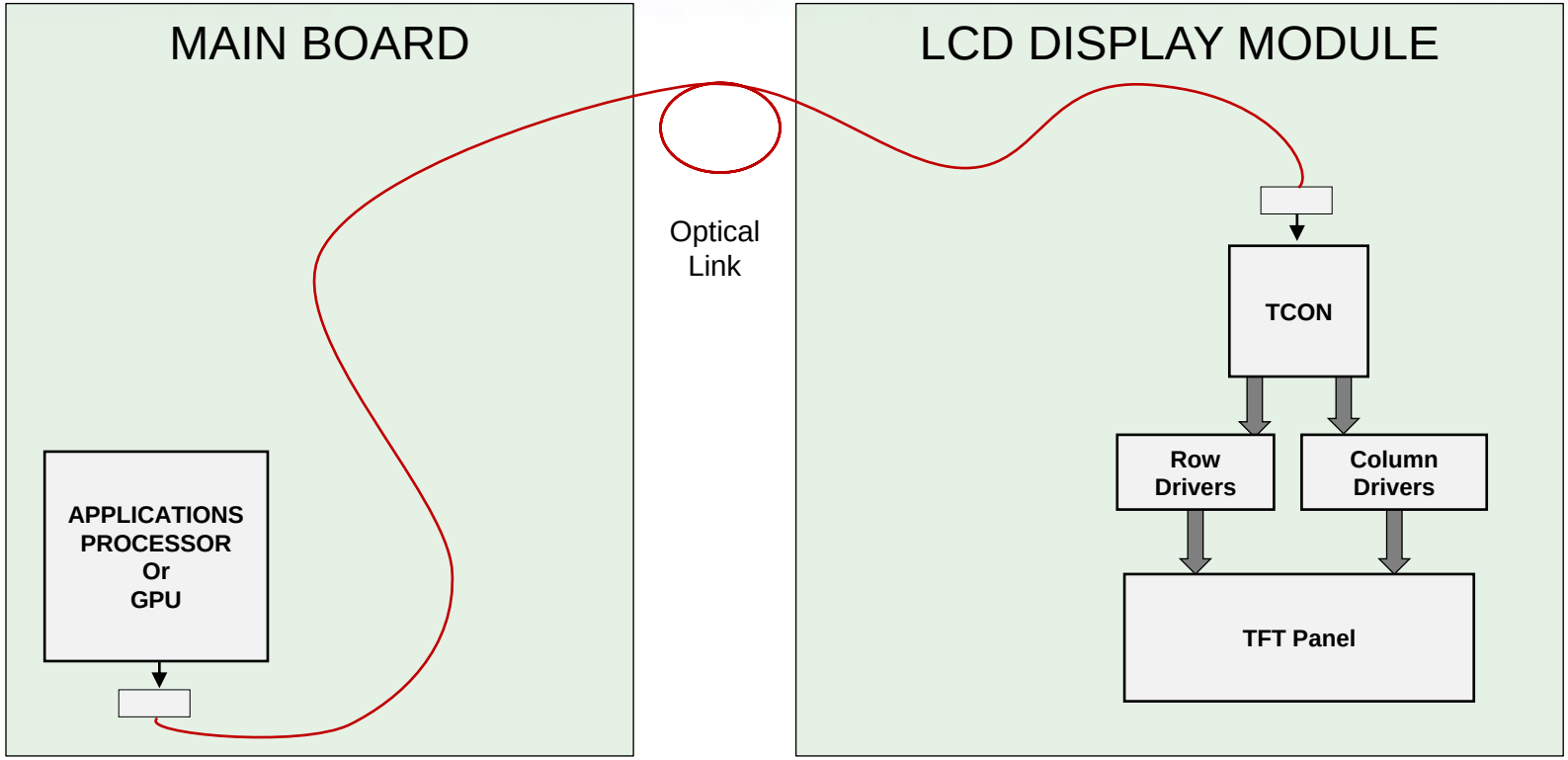
The Link Number Benefit

- Number of optical links at respective aggregated data rate:

		D-PHY		M-PHY			eDP		Optical Link
Visal Acuity Class: 20/10	Gbps	1000 Mbps	1500 Mbps	Gear 2	Gear 3	Gear 4	2.7G	5.4G	
3D, 4" Smart Phone Display	12	26	18	10	4	4	10	6	1
3D, 10" Tablet Display	54	110	74	36	18	10	40	20	
3D, 15" Laptop Display	51	104	70	34	17	10	38	20	

(8B/10B excluded)

Flexible PCB Layout with Optical Links



- Cable length is not constrained, no EMI issues
- Optical connectors can be placed anywhere on the boards
- ICs can be placed anywhere on the boards
- Enables customer to conceive new mechanical form factors and design

Bridging to Optics

- Optical friendly signalling (e.g. DC-balanced 8B/10B endcoding)
  - MIPI M-PHY
  - DisplayPort, embedded DisplayPort
  - SATA, USB 3
  - Next generation peripheral link (e.g. Thunderbolt, USB “4.0“) …

All above standards are defined electrically, but have optical-friendly signalling or explicit support for optics.

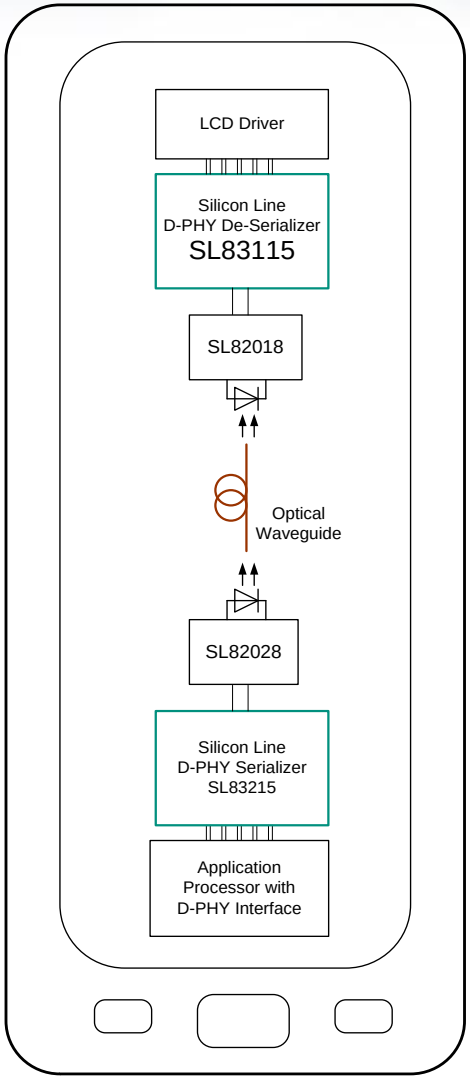
- Serialization of parallel interfaces
  - MIPI D-PHY
  - DisplayPort, embedded DisplayPort
  - RGB, LVDS

Ultra-low power serialization technologies for D-PHY, eDP, etc. are readily available as bridge ICs or IP enabling a smooth transition to optical link technology

Serializing D-PHY Signals

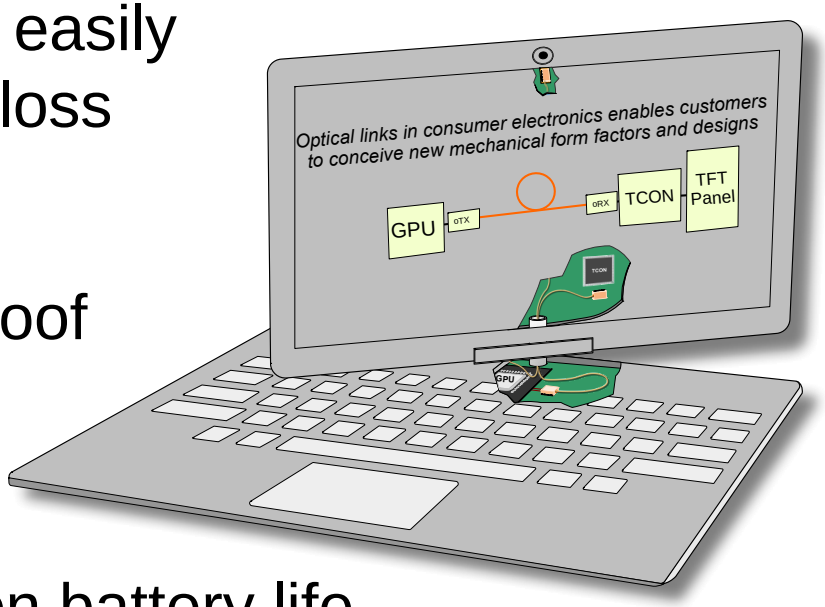
SerDes Products for MIPI D-PHY Cameras and Displays

- Ultra-low power, high performance serial D-PHY bridge IC
- Bandwidth scalable up to 6 Gbps which supports:
  - The latest generation of high resolution cameras and 3D displays
- No EMI issues → No RF reception problems
- Small size and footprint enables ultra-small and thin form factor designs
- Optional galvanic link feature supports bi-directional low power data transmission (LPDT)



Optical High-Speed Video Interconnects

- Optical links enable system designers to conceive new mechanical form factors and designs
- High-speed optical link bridge easily several meters without signal loss
- No EMI (aggressor or victim)
- Bandwidth scalable, future, proof to 100 Gbps and beyond
- Small in size and footprint
- Ultra-low power, little impact on battery life
- All video transport protocols are supported for smart phones, tablets and notebooks



Thank you!

- For more in information please visit us at:

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or send an e-mail to:

holger.hoeltke@silicon-line.com