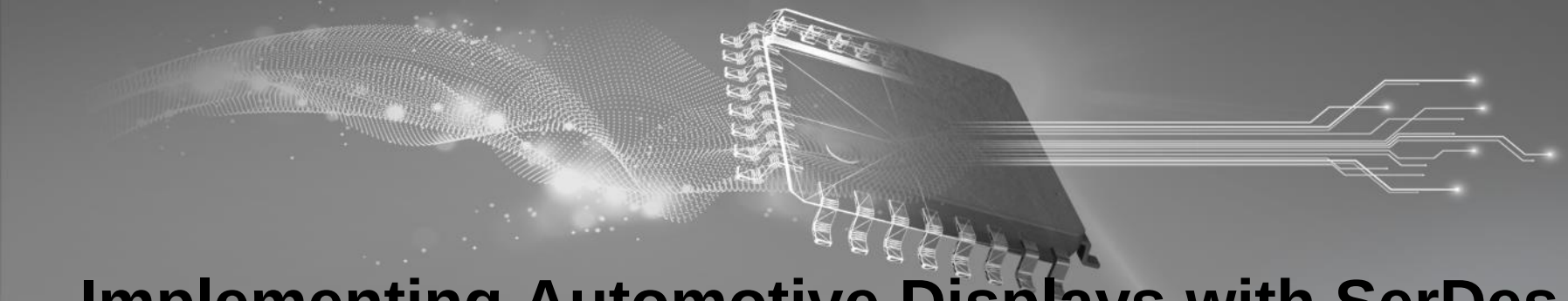
TI TECH DAYS



Implementing Automotive Displays with SerDes Daisy Chaining & Local Dimming Backlight Architecture

Logan Cummins

Systems Engineering & Marketing – Automotive Infotainment

TI Training - Summary

The automotive display market is continuing to evolve; the number of displays inside vehicles is drastically increasing while auto makers are looking to differentiate their customers' experiences through improving picture quality and display performance. This session will provide an introduction to the infotainment cockpit architecture, daisy-chaining display technology, and increasing picture quality through local dimming backlight architecture. A demonstration of the SerDes daisy chaining and local dimming will also be demonstrated.

Training level: Intermediate

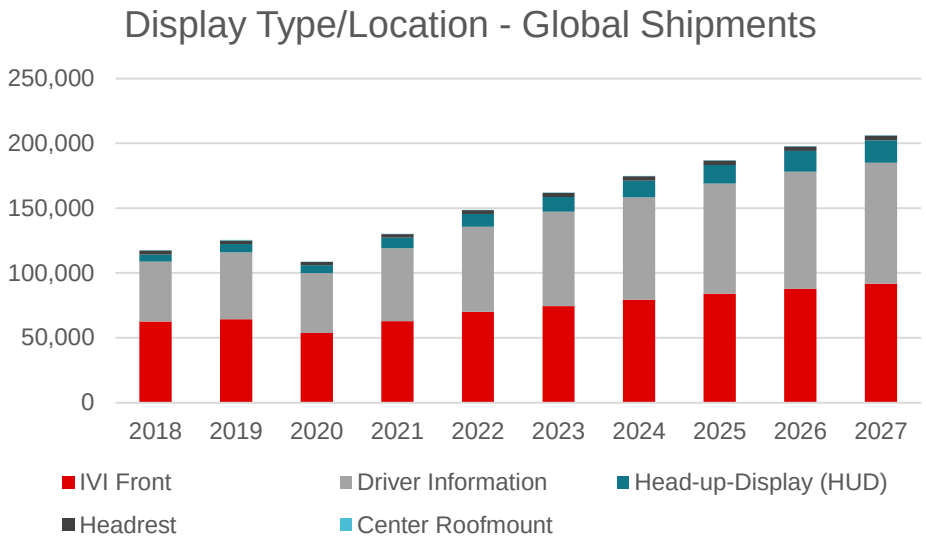
What you'll learn:
In this presentation you'll learn about the market trends, typical customer design challenges, and what types of designs TI has for local dimming and daisy chaining displays.

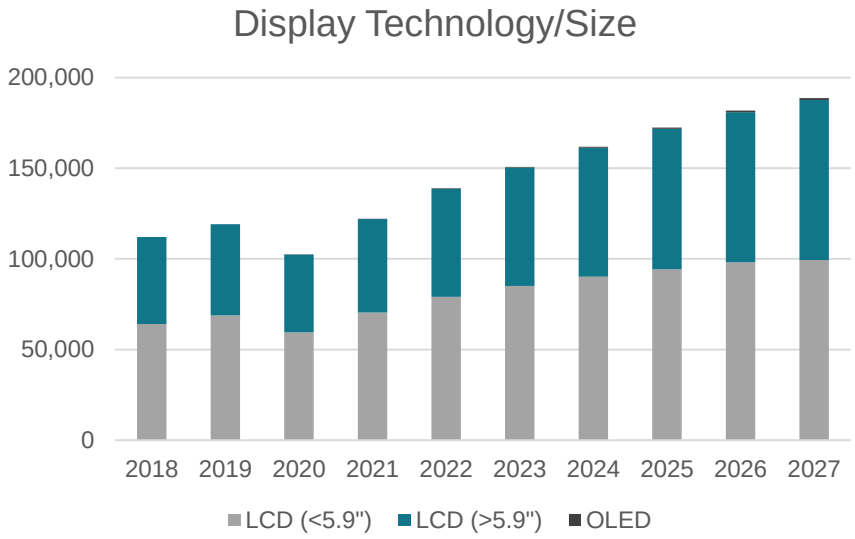
Questions/Dialog: Muted call, submit questions or comment via chat.

Outline

- Automotive display trends
- Infotainment display architecture
- IVI SerDes & daisy-chaining
- Local dimming backlight architecture
- System implementation
  - Reference design
  - Demo videos and explanation
  - Future Work
- Wrap-Up
- Questions

Automotive Display Market: Global Shipments





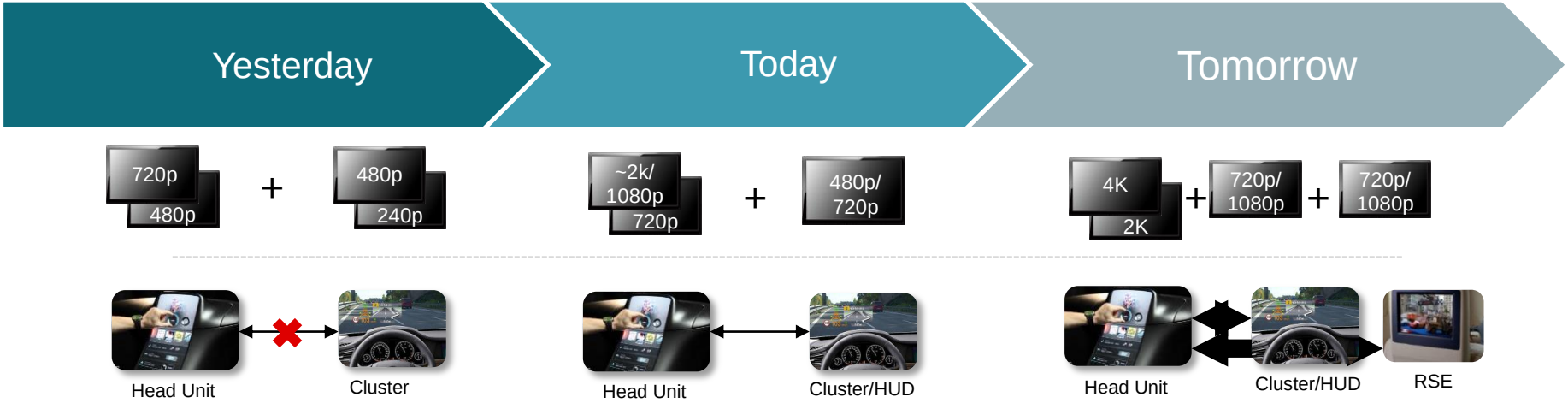
Automotive Display 2019-2024 CAGR: ***6.86%***

Average **~1.66 displays per vehicle in 2022** based on 89M vehicle shipments

Average **~2 displays per vehicle in 2027** based on 104M vehicle shipments

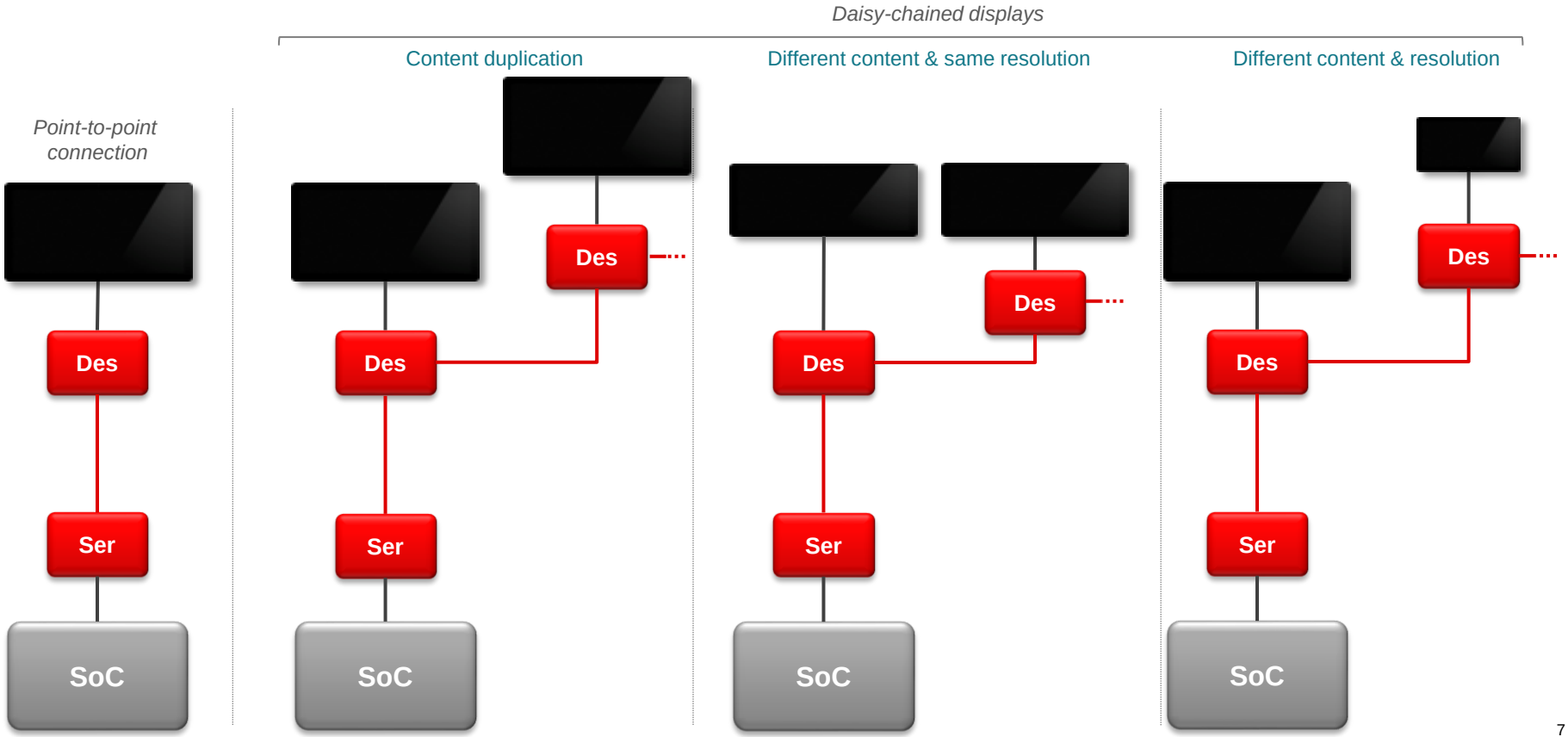
Data pulled from Stategy Analytics MetrixLive: Infotainment & Telematics

Evolution of Automotive Display



Re-architecting the cockpit

FPD-Link IV Daisy Chain Architectures



FPD-Link IV Serializer & Deserializer

Features & Benifits

Transmission of video, bidirectional control (I^2C, SPI), GPIO, and power over twisted pair or coaxial cable assemblies

FPD-Link → eDP/DP deserializer

- Supports Display Port1.4b HBR3/HBR2/HBR/RBR up to 8.1 Gbps/lane
- 2 x eDP/DP main link with selectable 1, 2 or 4 lanes each

Daisy-chaining and Splitter configurations

Video networking supported by:

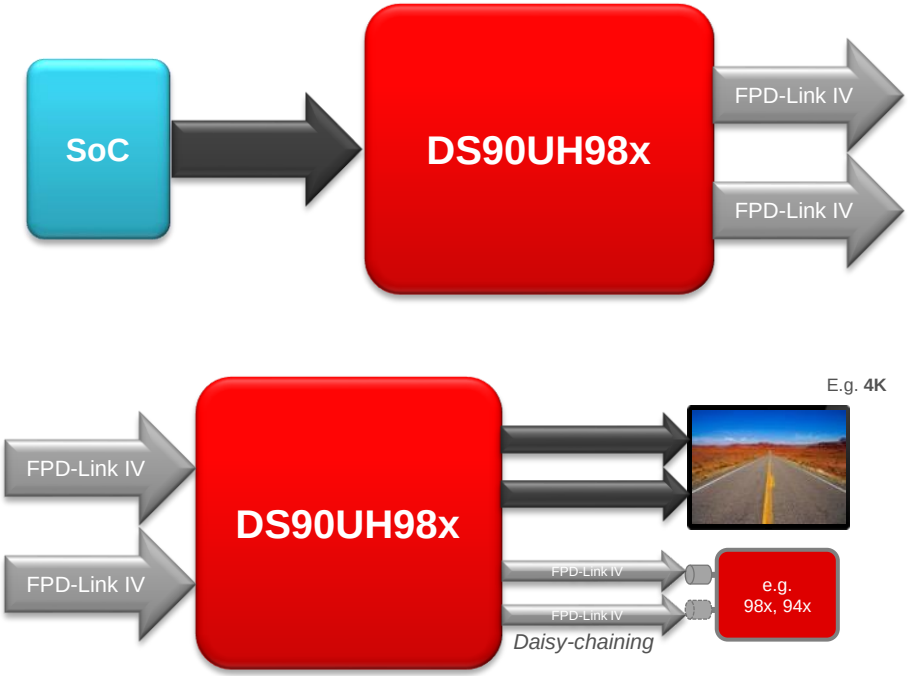
- Super-frame, MST based networking capability for multiple display architectures
- Daisy-chaining support

Multi protocol compatibility

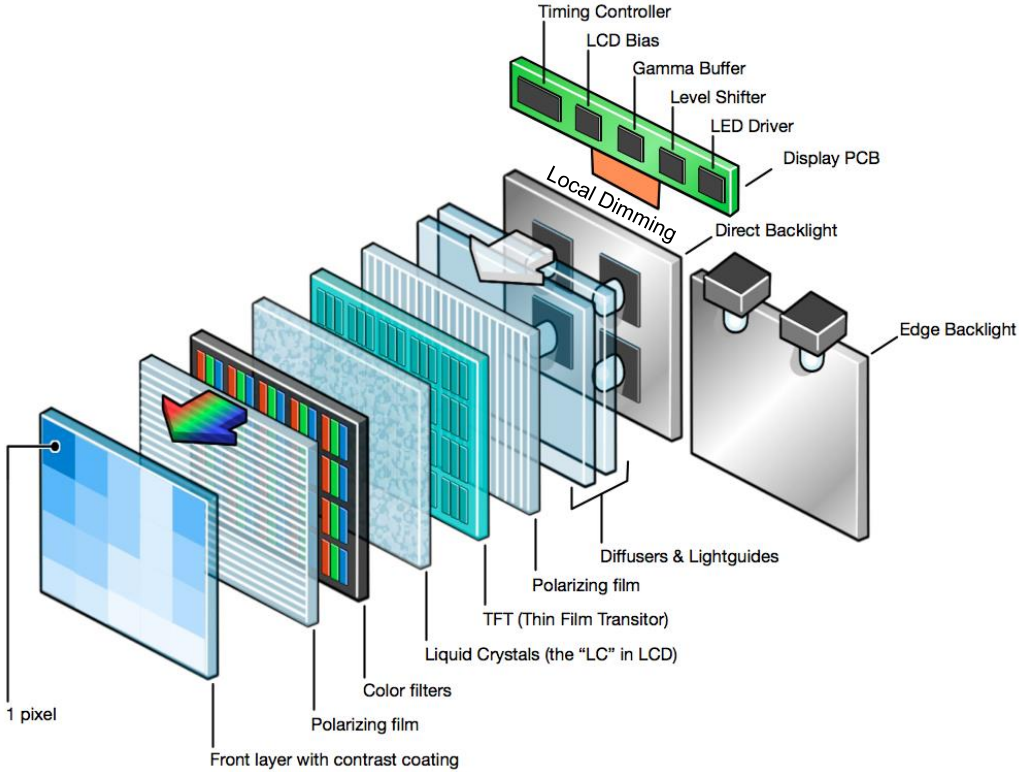
- Backwards compatibility with FPD-Link III serializers
- Backwards compatibility with FPD Link III deserializers

Diagnostic functions

- CRC and ECC support
- Embedded voltage and temperature sensors



Display Technology LCD TFT Technology

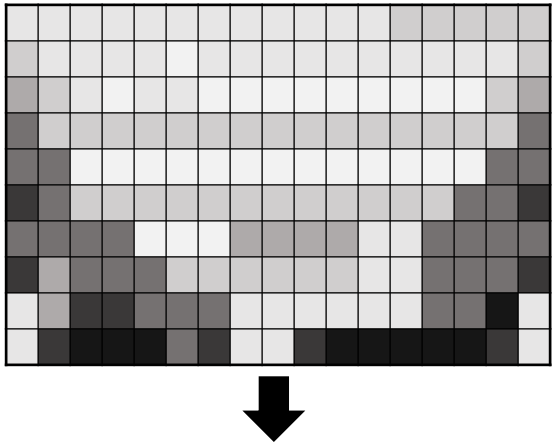


Source: Meko

- Fundamentals
  - Backlight illumination required
  - Liquid crystal layer blocks or passes-through the backlight per RGB sub-pixel to create each pixel
- Limitations
  - Liquid crystal can't block 100% of light during dark pixel
    - Dark/black pixels still partially illuminate; never a deep, true black
    - Dim backlight based on image content
  - Transmissivity of all-layers is only 5-10%
- Backlight types
  - Direct-lit, locally dimmed (left)
  - Edge-lit, globally dimmed (right)

Local Dimming Concept

Backlight



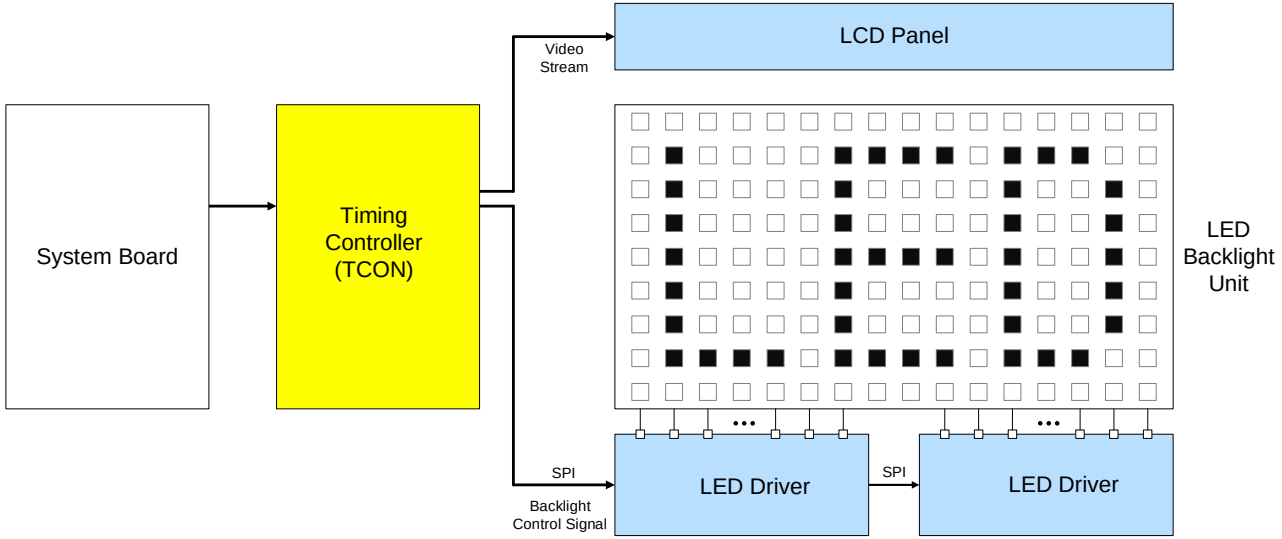
Image

- In Local Dimming backlight, LEDs under the LCD panel are divided into many small zones.
- The brightness of each zone is adjusted according to different display content.
- Automotive HMI – lots of black backgrounds

- Goals
  - Improve contrast ratio greater than ~1000:1 in traditional automotive displays
  - “Darker blacks” and “brighter whites”
  - Lower backlight power consumption

Local Dimming Architecture

	Global Dimming	Local Dimming
TCON	Process Video stream only	Process both Video stream and backlight control signal
LED Backlight Unit	Mostly edge-lit	Direct lit only. Each zone contains at least one LED
LED Driver	Channel current output global controlled	Channel current output individually controlled Digital interface cascaded



TLC6C5748-Q1

Sampling

48ch, 16bit PWM LED Driver with low headroom voltage and high output voltage

Features

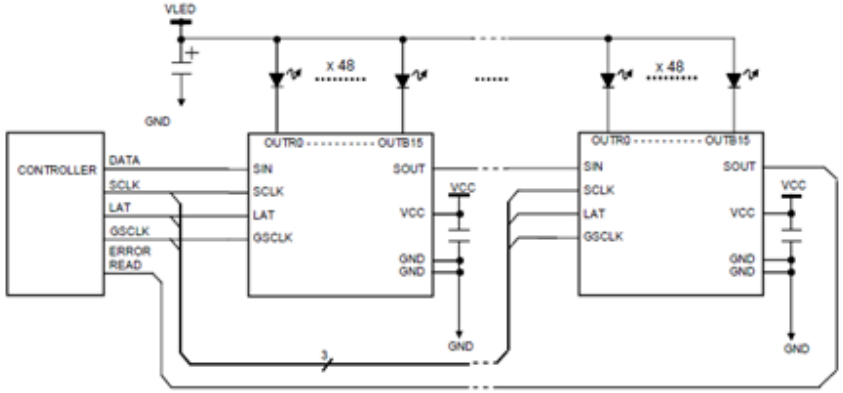
- 48 Outputs with 7bit DC for each output
- 16bit PWM Constant-Current with 7bit Brightness Control and 3bit Max Current Control for 31.9mA, no external RIREF resister
- IC Supply Voltage Range: 3.0 – 5.5V
- LED Breakdown Voltage: 11V
- Precise Constant Current Regulation:
  Channel-to-Channel: ± 2% (typ)
  Device-to-Device: ± 2% (typ)
- Low Headroom Voltage: 0.25V@19mA
- LED Open/Short Detection
- Over Temperature Detection
- Power Save Mode: 7uA consumption
- HTTSOP-56 Package (DCA) 6.1 mm * 14 mm
- Operating Junction Temperature Range: -40 C to +125C

Applications

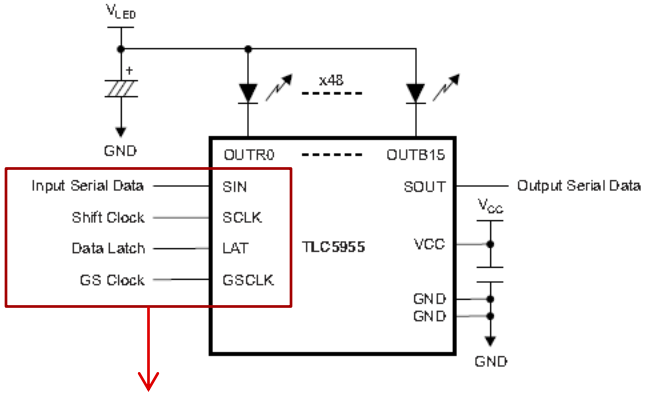
- Automotive Local Dimming Backlight
- Automotive Pixel Lamp
- Automotive RGB display

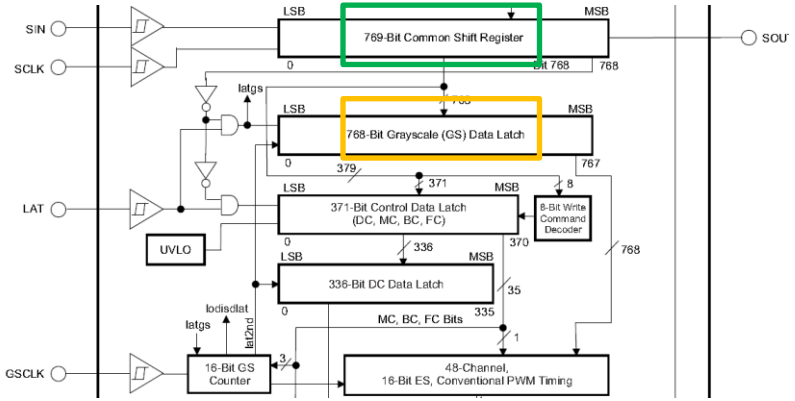
Benefits

- Best to drive 48 LED zones with uniformity
- Chip-on-LED-board architecture
- Direct daisy chain interface with TCON controller
- Max 3 single-junction LEDs/ 1 dual-junction LED in series
- Reduces system power consumption
- Reduces system cost



TLC6C5748-Q1 interface



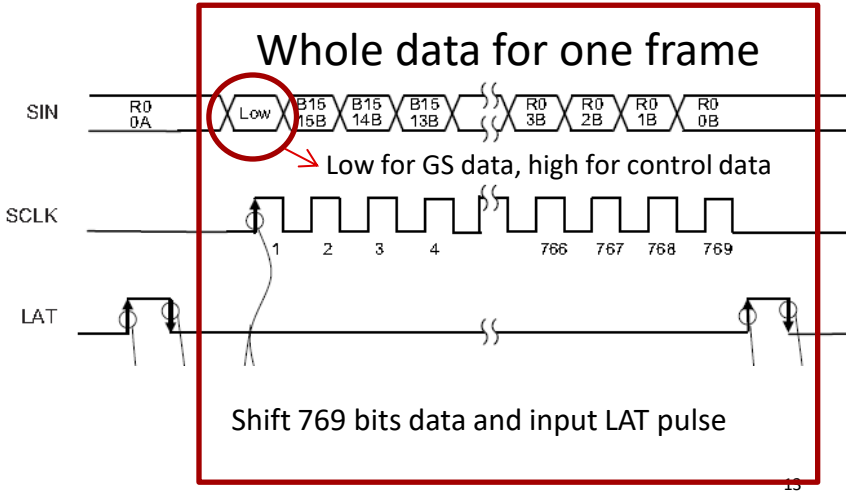


SIN: Serial data input for the 769-bit common shift register

SCLK: Serial data shift clock, SIN data is shifted to internal common register at the rising edge.

LAT: LAT is used to latch the data to GS register to display.

GSCLK: Reference clock for the grayscale (GS) PWM control for all outputs.



XTIDA-020036 384-Zone 12” Local Dimming Backlight Reference Design

Features

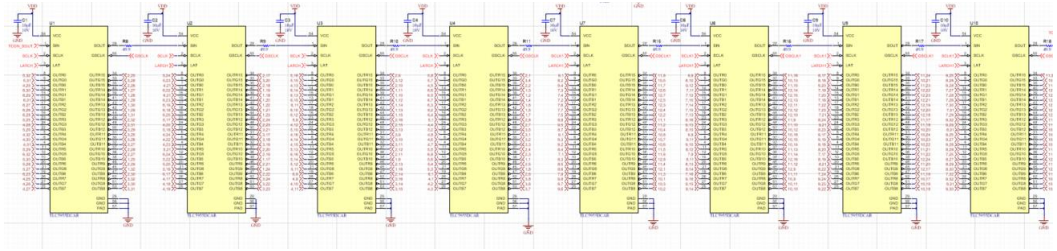
- 384 zones & LEDs
  - 12x32 matrix; 1S1P
  - 0.9 cm pitch
- PCB Specifications
  - Direct driver on back of PCB
  - 2 layer PCB
- SPI control for 8x daisy-chain
- 8x 48-ch low-side LED drivers
- Compatible with local dimming TCONs
- LED Specifications
  - OSRAM Mini TOPLED White 120° SMD
  - Size : 2.3mm x 1.9mm (91mil x 75mil)
  - Single junction @ 3.05V forward voltage
  - 20mA per LED

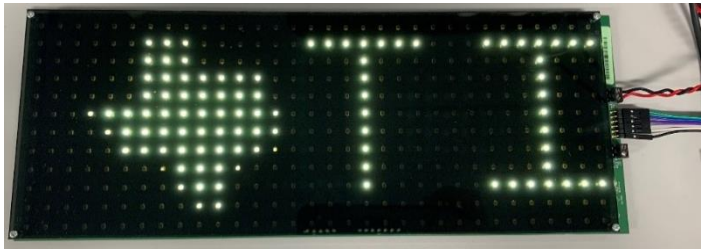
Tools & Resources

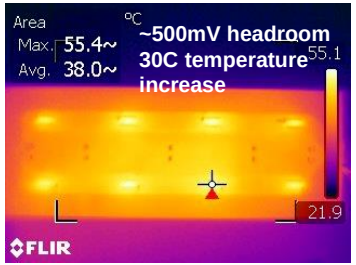
- **TIDA-020036 Folder**
- **Design Guide**
- **Design Files:** Schematics, BOM, Gerbers, Software, etc.
- **Device Datasheets:**
  - TLC5955
  - SN74LVC2G17
  - LCW MVSG.EC-BXCX

Benefits

- Provides data-points and guidance on signal integrity and thermals
- Can be retrofit into 12.3” display panel for local dimming demo with LCD
- Demonstrates high zone count with 2-layer routing







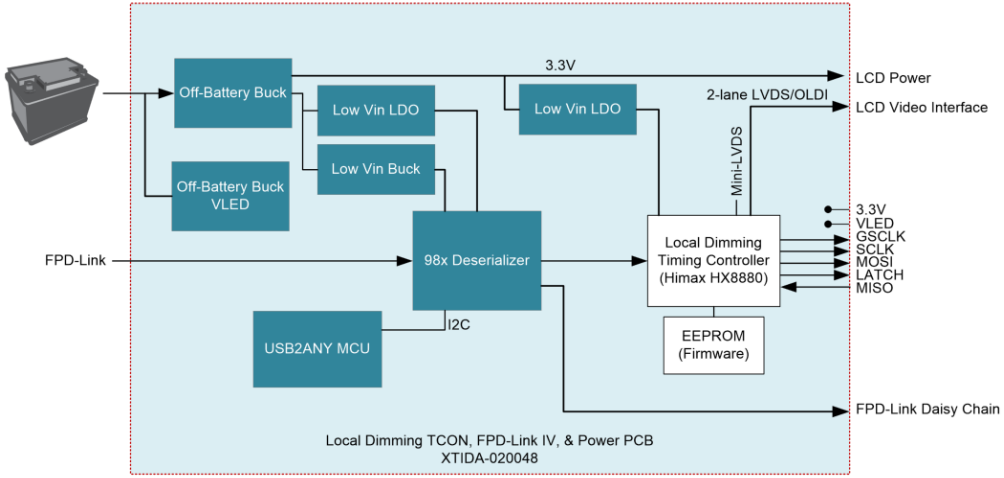
XTIDA-020039/48 Local Dimming TCON, FPD-Link 4, & Power Reference Design

Features

- Local dimming zone dimming calculations
  - HX8880-D03
  - Up to 448 local dimming zones (36 max row/col)
- Controls XTIDA-020036 384-zone backlight design
- System power & SPI interface for LED driver control
  - Data
    - GSCLK, SCLK, Latch, MISO, MOSI
  - Power
    - LED bias voltage: 3-7V
    - System Power: 3.3V
- Video Input Interface
  - XTIDA-020048
    - FPD-Link IV Deserializer DP output
  - XTIDA-020039
    - DP connector

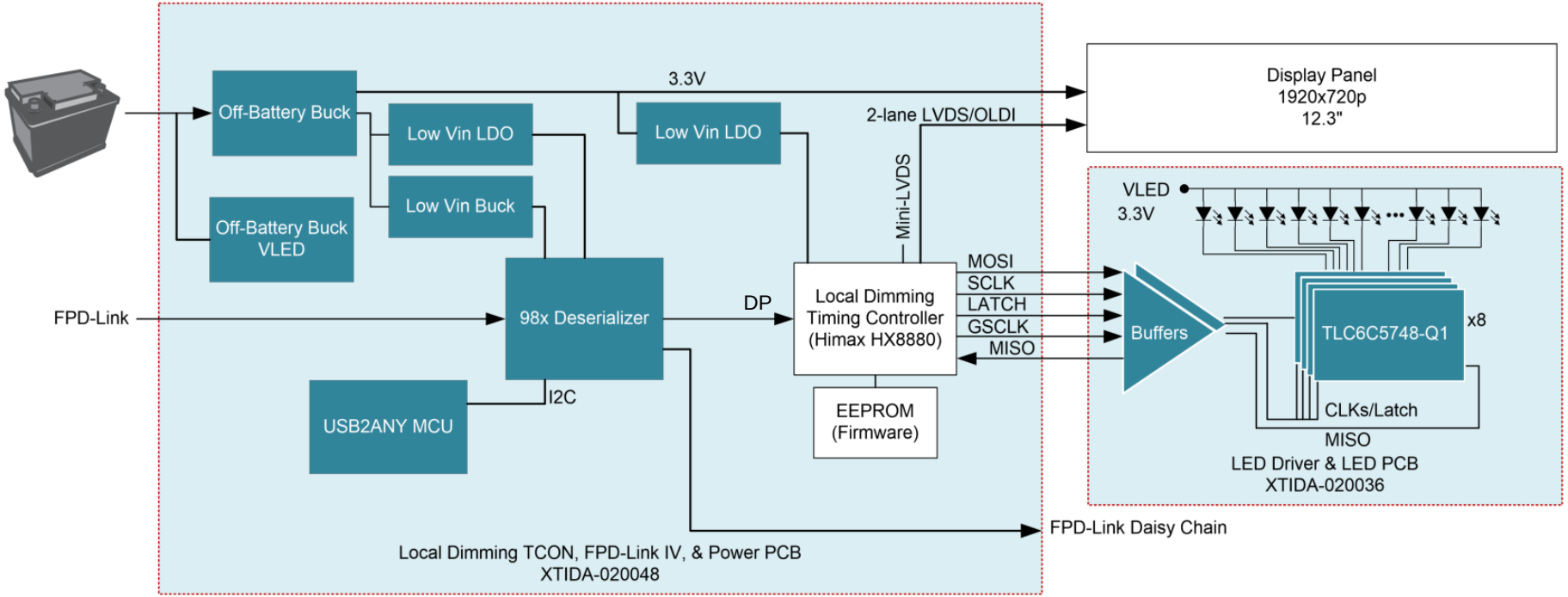
Benefits

- Provide end-to-end demonstration of SerDes to local dimming signal path
- Evaluate TCON local dimming generation based on input video

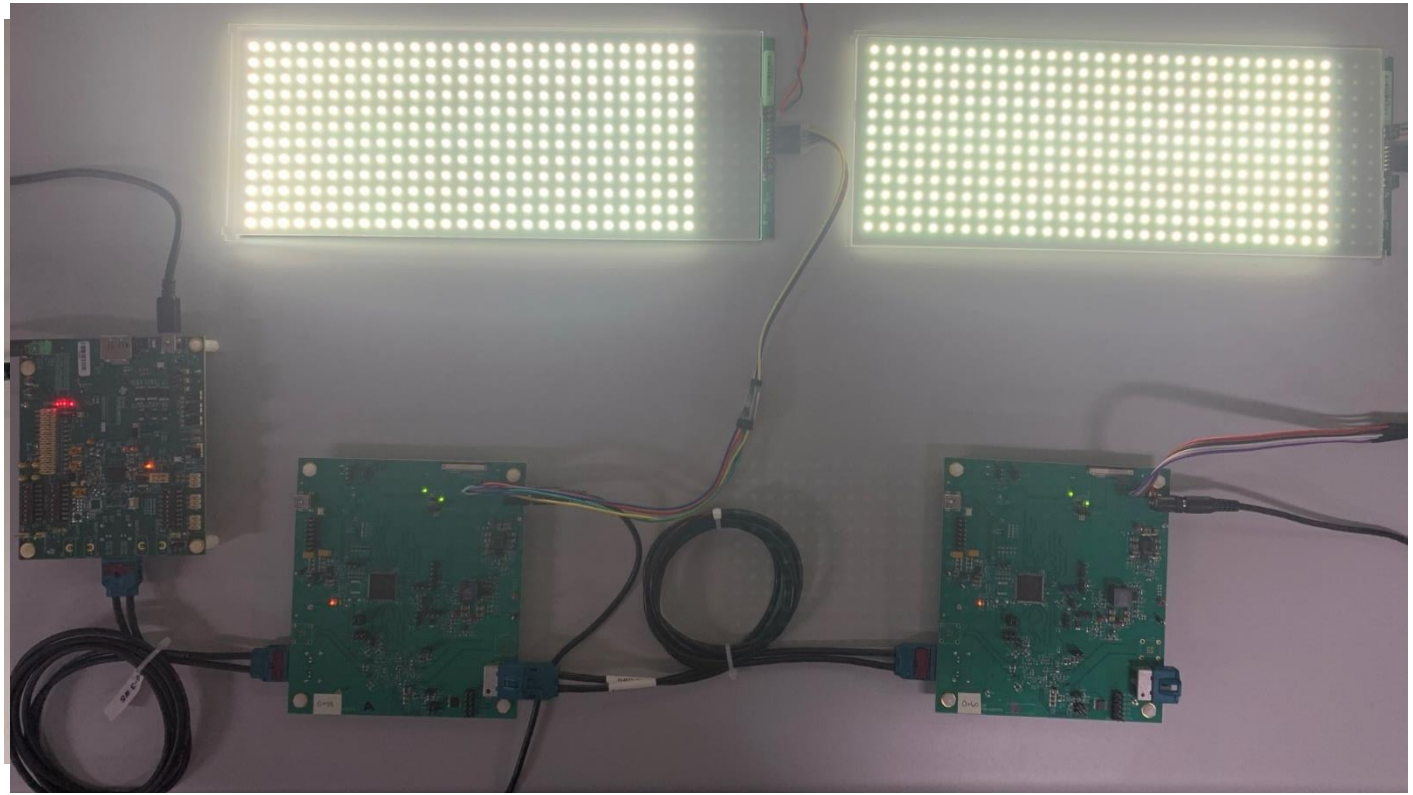


*XTIDA-020039 doesn't have FPD-Link, and instead used DP input

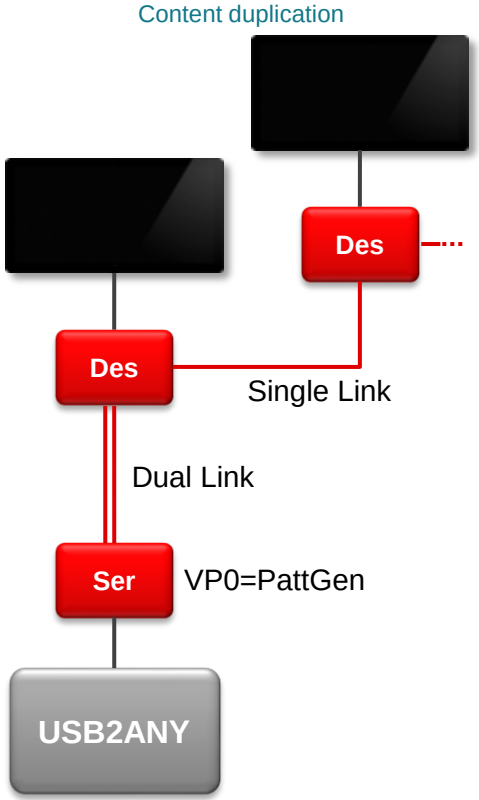
Automotive Display Demo SerDes Daisy Chaining & Local Dimming Backlight

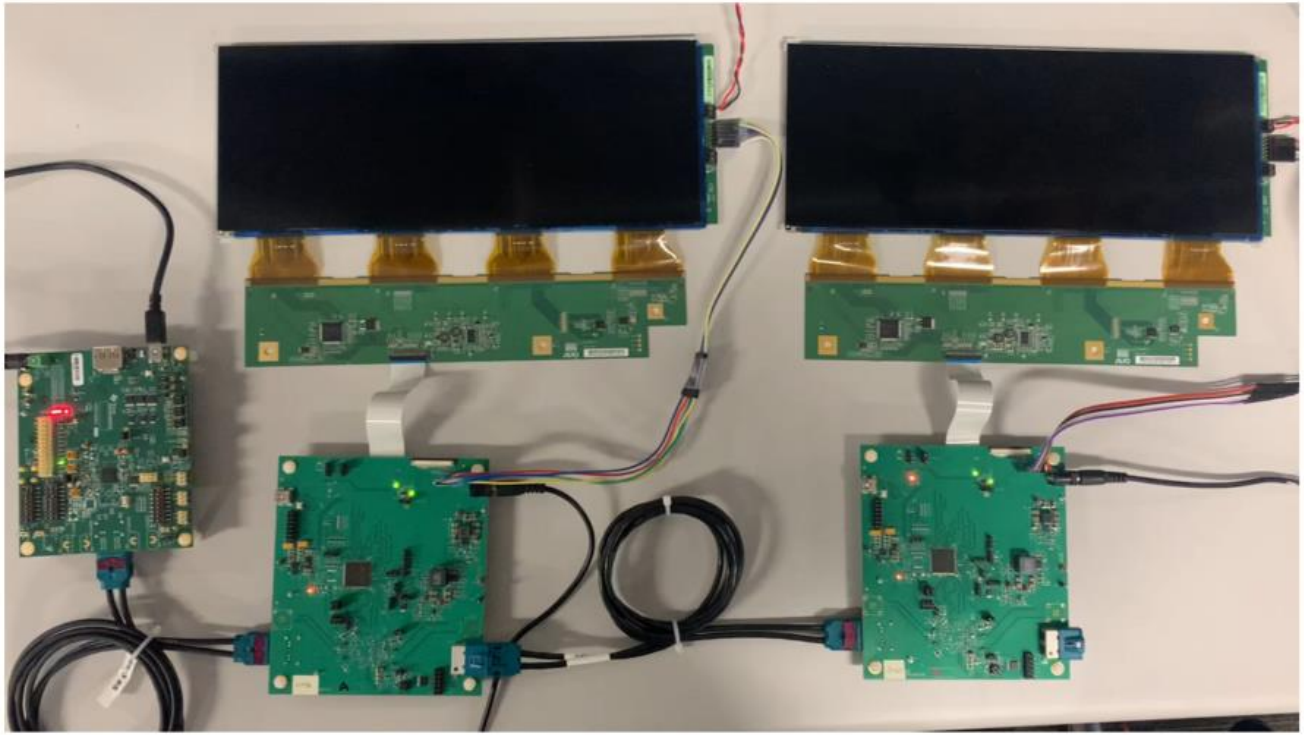


Demo Hardware Setup & Overview



2x Daisy Chain of 1920x720p 12.3” Display Panels
Based on 983 Pattern Generation Output

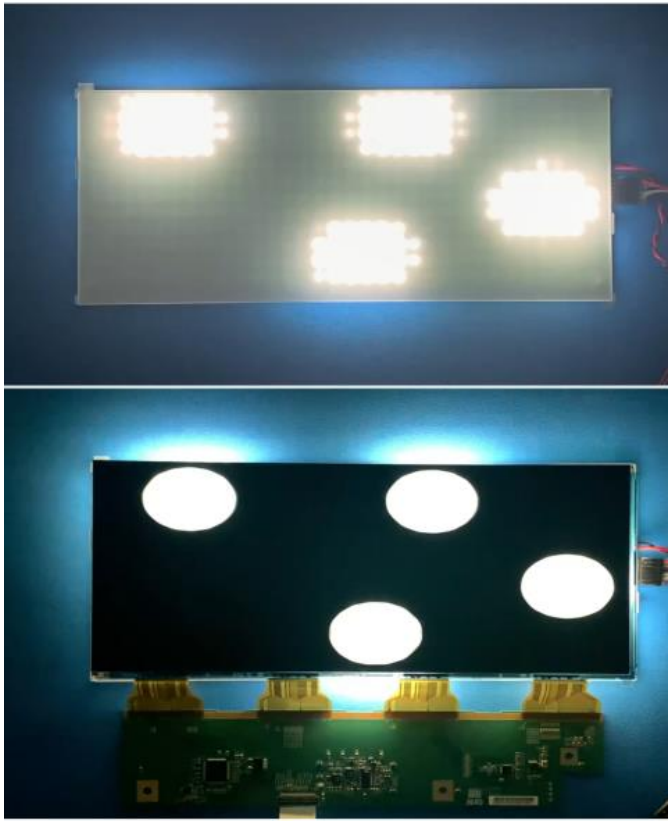




Locally Dimming Demo

Backlight

Result

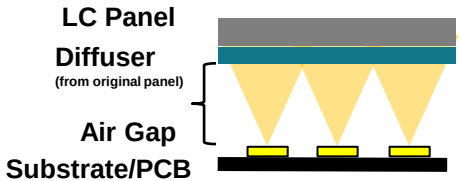


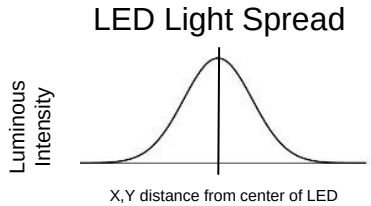
- Local dimming performance depends on:
  - **Zone count**
  - Native contrast ratio of the panel
  - LED/zone locality (bleed into neighboring zones)
  - Dimming algorithm
    - Spatial filtering, thresholds, aggressiveness

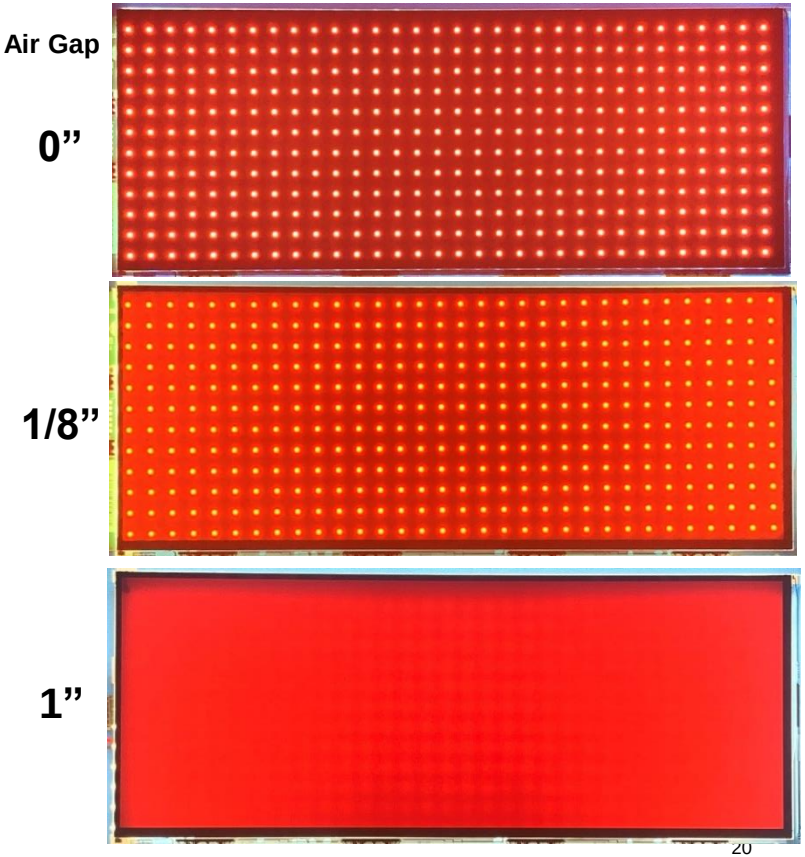
Module Height vs. Light Uniformity Comparison

- Uniformity depends on
  - LED pitch
  - LED angles
  - Air gap
  - Diffuser films
  - Light guide & grids

- Potential improvements
  - LEDs with wider radiation pattern
  - Stronger diffuser
  - More LEDs
  - Light guide/grid







Future Work & Resources

- Future Work
  - Continue to develop daisy chain and local dimming demo
    - Daisy chain
      - Showcase super-frame example from GPU
    - Local dimming
      - Optimize optical stack-up
      - Power and contrast comparison analysis

- Resources & Collateral
  - End Equipment Pages
    - Central Information Display
    - Cluster Display
  - Local Dimming Contributed Article
    - EEWorldOnline.com & PowerElectronicsTips.com
      - A better automotive display from pixel to picture with local dimming
      - Higher contrast, better resolution: Automotive display full-array local dimming

Stay tuned in with your local FAE for hardware updates and most recent collateral!

Wrap-Up

- Automotive display market is growing and experiencing new technology adoption
- Head-unit to cockpit transition brings opportunity for daisy-chaining architecture
- Automotive displays lagging in optical and visual performance.
  - Full-array local dimming can bridge gap between low-contrast LCD and OLED options

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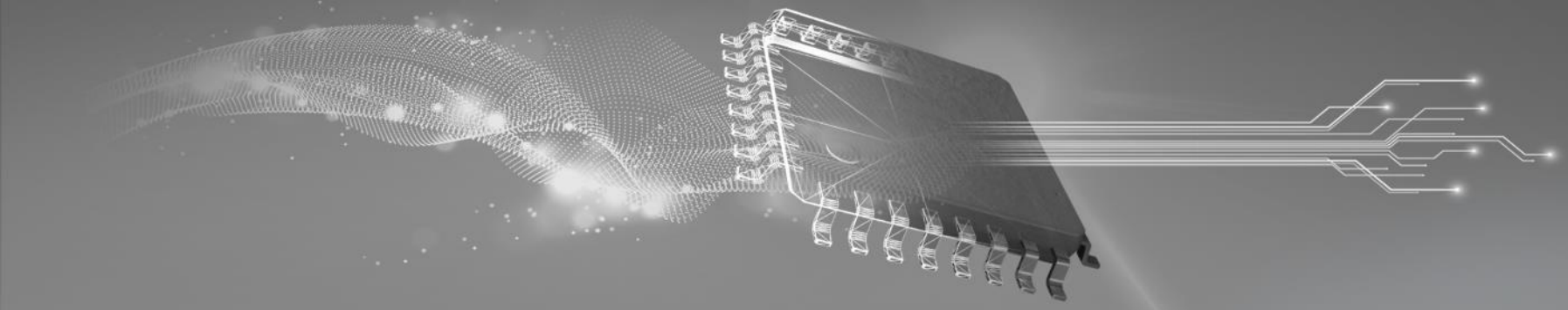

Questions?

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