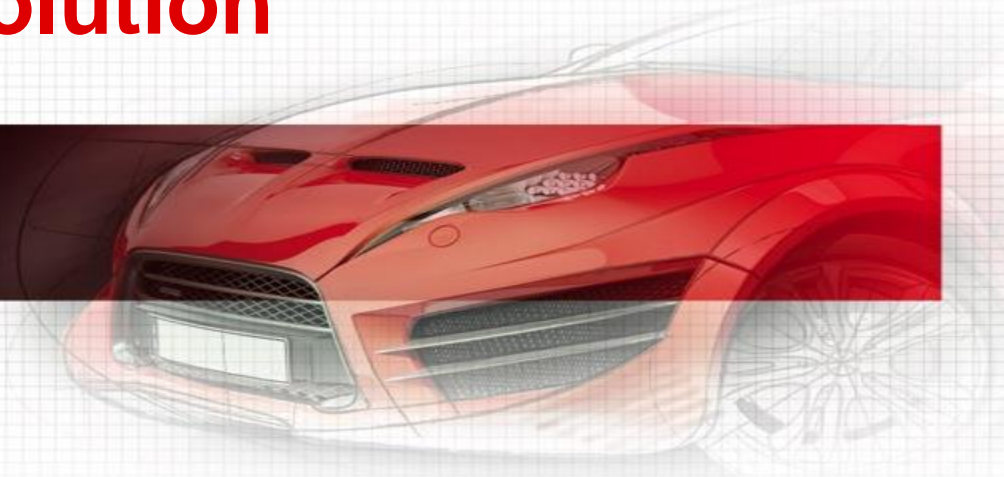# Digital Cluster EE Solution

China Auto FAE
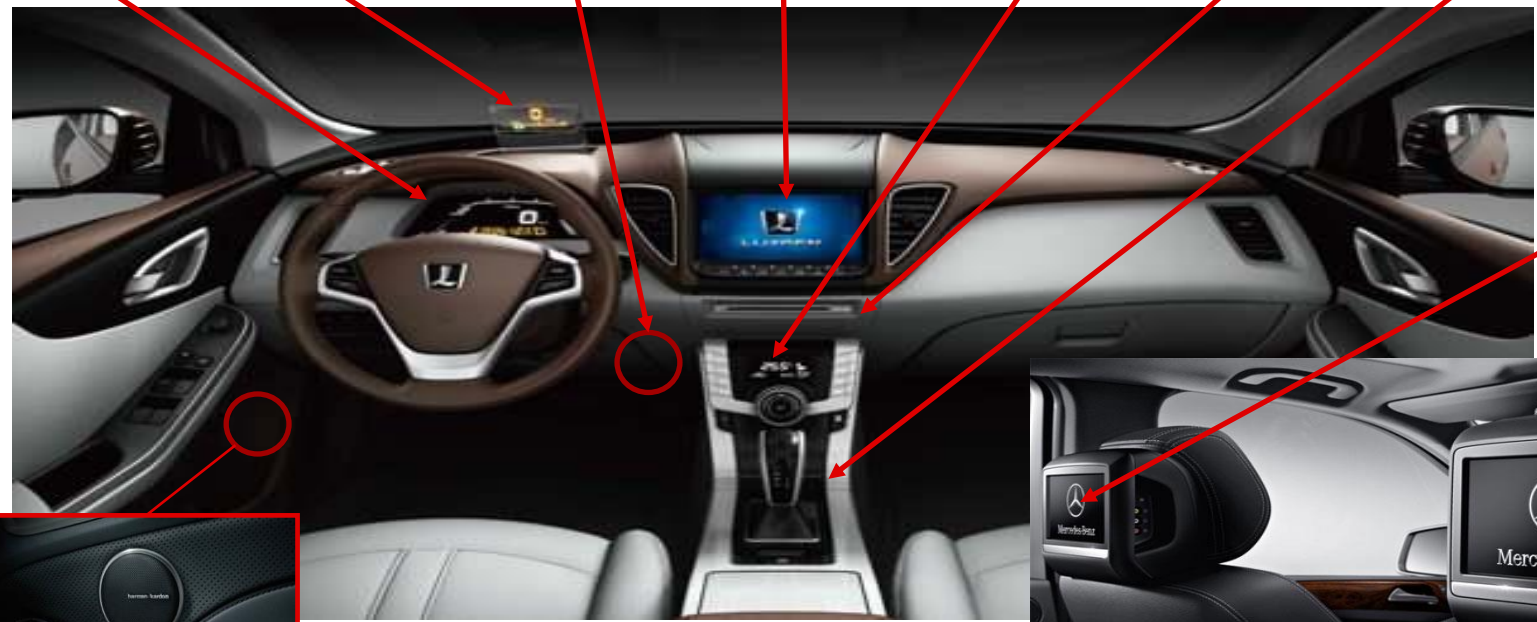
Martin. Ma

4Q 2018

Infotainment and Cluster Terms

Cluster

Heads Up
Display (HUD)

Telematics

Touch
Display

HMI

Head Unit

Media
Port

Rear Seat
Entertainment
(RSE)

Secondary
Display

Premium Audio

TEXAS INSTRUMENTS
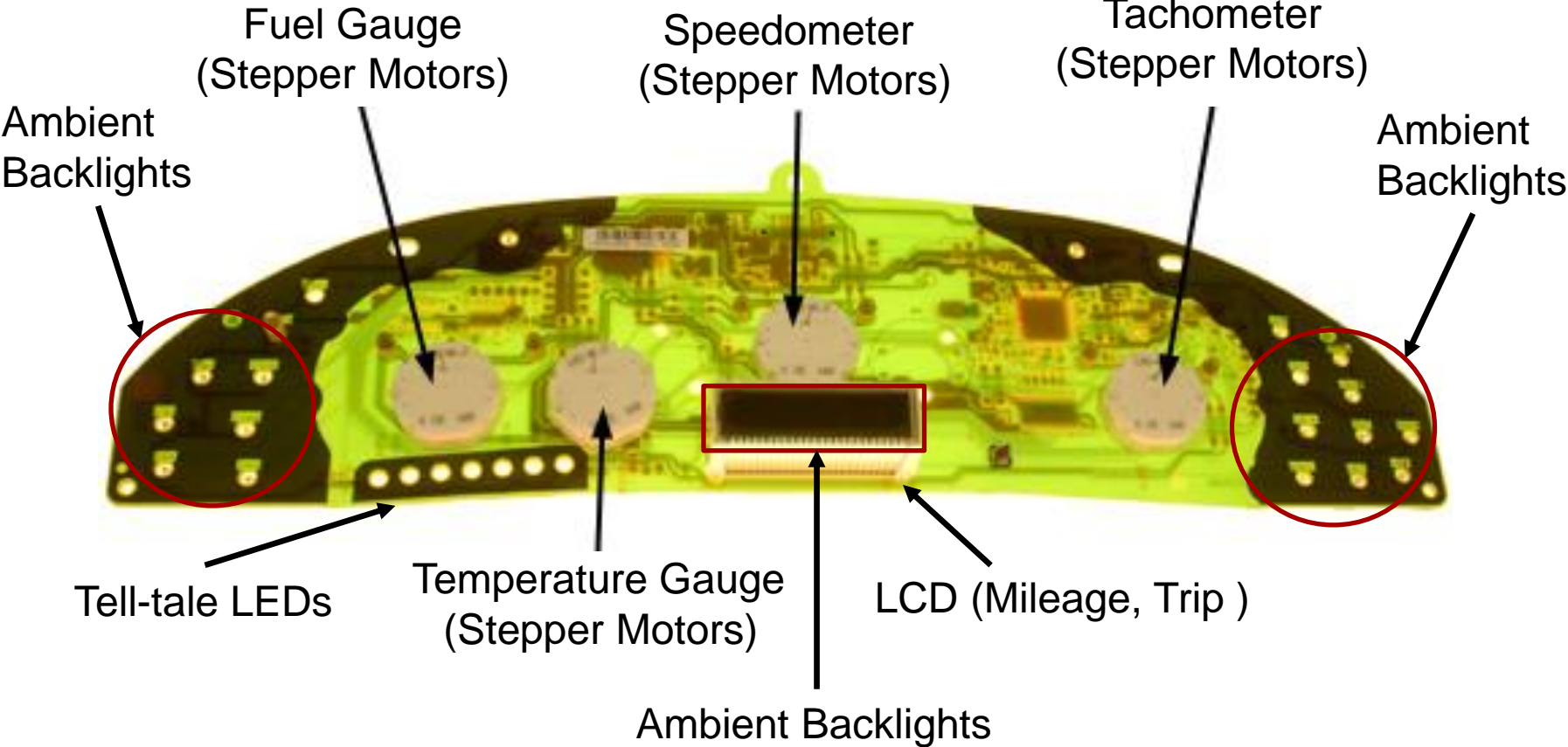
Hybrid Digital Cluster with Active Graphics Support

Hybrid Digital Cluster with Informational Graphics Support

Fuel Gauge (Stepper Motors)

Speedometer (Stepper Motors)

Tachometer (Stepper Motors)

Ambient Backlights

Ambient Backlights

Tell-tale LEDs

Temperature Gauge (Stepper Motors)

LCD (Mileage, Trip)

Ambient Backlights

TEXAS INSTRUMENTS

Full Display Digital Cluster

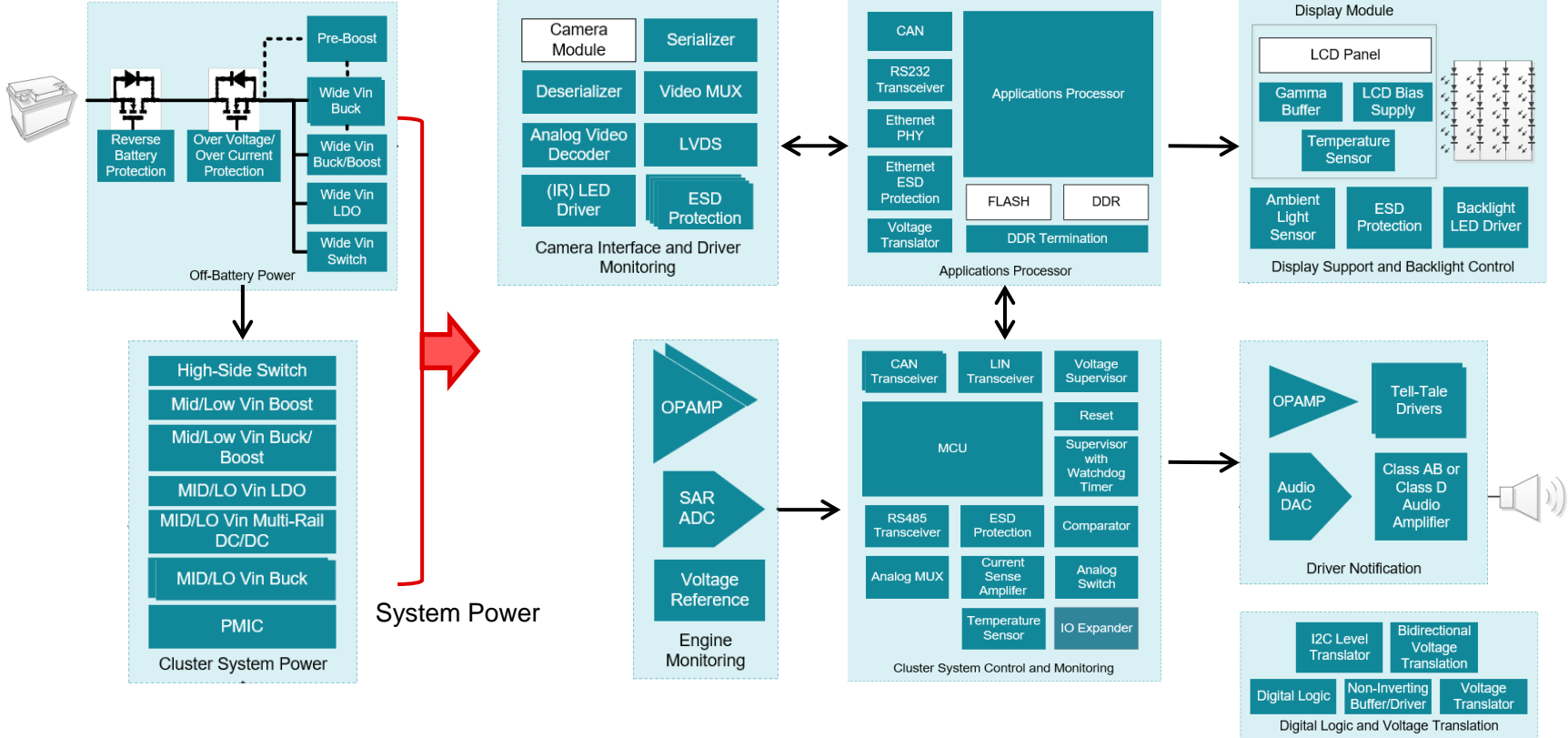FULL TFT
Display

TEXAS INSTRUMENTS

Advanced Reconfigurable Digital Cluster

- Advanced reconfigurable digital clusters allow you to choose different information layouts with a single hardware design. Reference designs and products enable you to design systems with high performance applications processors and integrated architectures that enable 3D navigation, animated gauges with high-definition video performance and interfaces to driver monitoring cameras and Head-Up Displays.

- Graphic display will have slowly changing graphics or information only such as:
    - I. Odometer
    - II. Navigation
    - III. Fuel efficiency
    - IV. Outside temperature
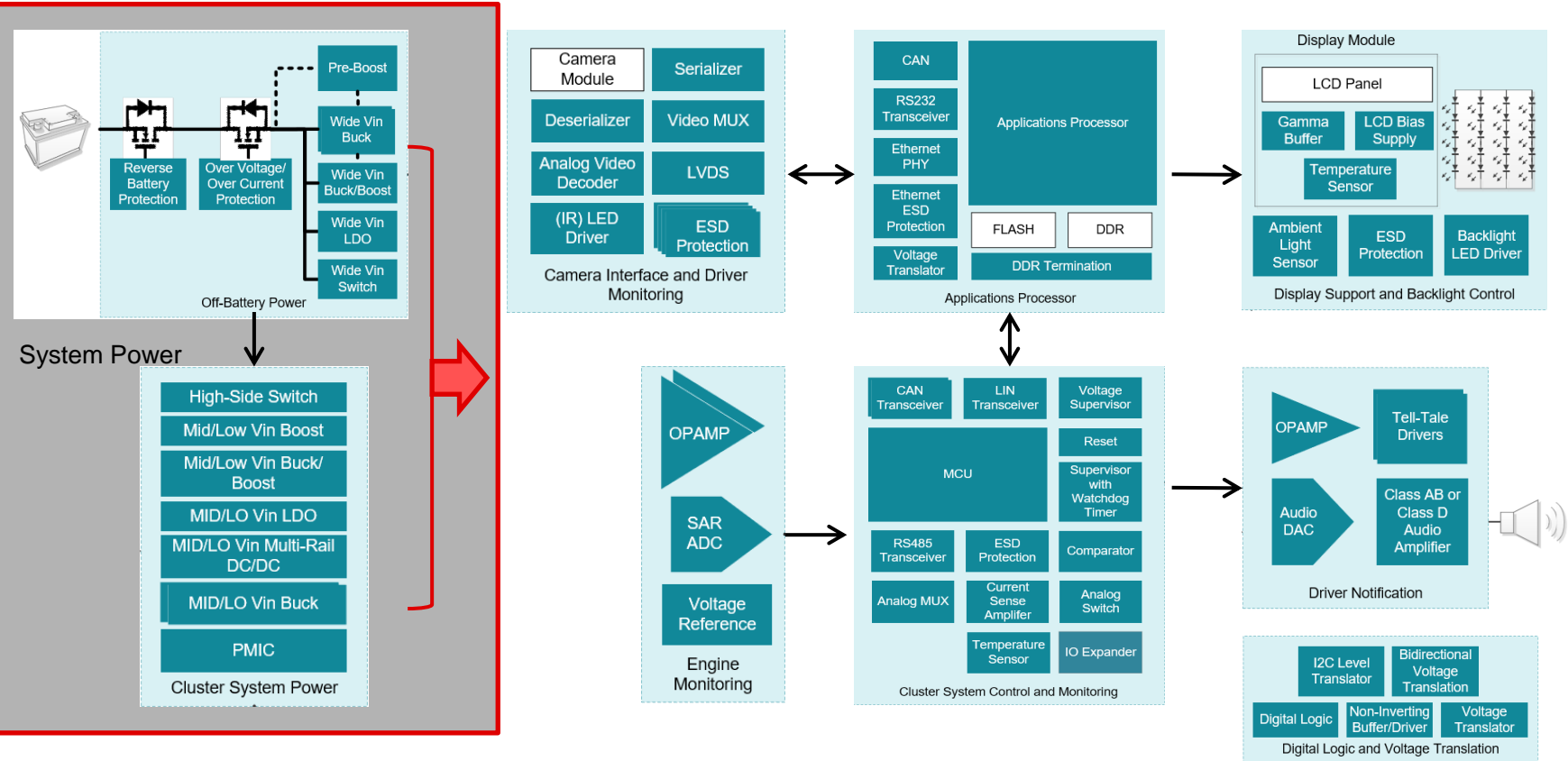   - V. Numeric speed reading
    - VI. Graphic image of the car

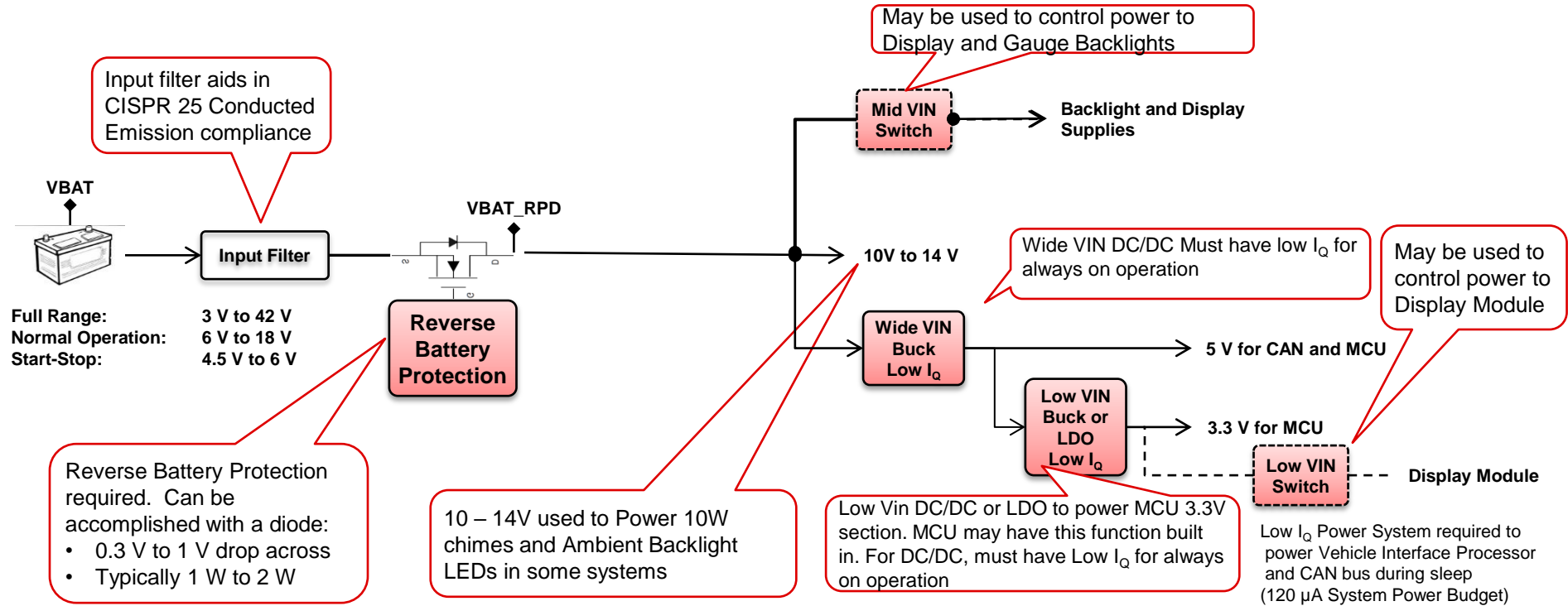# Typical Digital Cluster Block Diagram

Digital Cluster Block Diagram

Off-Battery Power
- Pre-Boost
- Wide Vin Buck
- Wide Vin Buck/Boost
- Wide Vin LDO
- Wide Vin Switch
- Reverse Battery Protection
- Over Voltage/ Over Current Protection

Cluster System Power
- High-Side Switch
- Mid/Low Vin Boost
- Mid/Low Vin Buck/Boost
- MID/LO Vin LDO
- MID/LO Vin Multi-Rail DC/DC
- MID/LO Vin Buck
- PMIC

System Power

Camera Interface and Driver Monitoring
- Camera Module
- Serializer
- Deserializer
- Video MUX
- Analog Video Decoder
- LVDS
- (IR) LED Driver
- ESD Protection

Engine Monitoring
- OPAMP
- SAR ADC
- Voltage Reference

Applications Processor
- CAN
- RS232 Transceiver
- Ethernet PHY
- Ethernet ESD Protection
- Voltage Translator
- Applications Processor
- FLASH
- DDR
- DDR Termination

Cluster System Control and Monitoring
- CAN Transceiver
- LIN Transceiver
- Voltage Supervisor
- MCU
- Reset
- Supervisor with Watchdog Timer
- RS485 Transceiver
- ESD Protection
- Comparator
- Analog MUX
- Current Sense Amplifer
- Analog Switch
- Temperature Sensor
- IO Expander

Display Module
- LCD Panel
- Gamma Buffer
- LCD Bias Supply
- Temperature Sensor

Display Support and Backlight Control
- Ambient Light Sensor
- ESD Protection
- Backlight LED Driver

Driver Notification
- OPAMP
- Tell-Tale Drivers
- Audio DAC
- Class AB or Class D Audio Amplifier

Digital Logic and Voltage Translation
- I2C Level Translator
- Bidirectional Voltage Translation
- Digital Logic
- Non-Inverting Buffer/Driver
- Voltage Translator

TEXAS INSTRUMENTS

Digital Cluster Block Diagram-Power

System Power

Off-Battery Power
- Reverse Battery Protection
- Over Voltage/ Over Current Protection
- Pre-Boost
- Wide Vin Buck
- Wide Vin Buck/Boost
- Wide Vin LDO
- Wide Vin Switch

Cluster System Power
- High-Side Switch
- Mid/Low Vin Boost
- Mid/Low Vin Buck/ Boost
- MID/LO Vin LDO
- MID/LO Vin Multi-Rail DC/DC
- MID/LO Vin Buck
- PMIC

Camera Interface and Driver Monitoring
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- Serializer
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- Video MUX
- Analog Video Decoder
- LVDS
- (IR) LED Driver
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Applications Processor
- CAN
- RS232 Transceiver
- Ethernet PHY
- Ethernet ESD Protection
- Voltage Translator
- Applications Processor
- FLASH
- DDR
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Display Support and Backlight Control

Display Module
- LCD Panel
- Gamma Buffer
- LCD Bias Supply
- Temperature Sensor
- Ambient Light Sensor
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Engine Monitoring
- OPAMP
- SAR ADC
- Voltage Reference

Cluster System Control and Monitoring
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- LIN Transceiver
- Voltage Supervisor
- MCU
- Reset
- Supervisor with Watchdog Timer
- RS485 Transceiver
- ESD Protection
- Comparator
- Analog MUX
- Current Sense Amplifer
- Analog Switch
- Temperature Sensor
- IO Expander

Driver Notification
- OPAMP
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- Class AB or Class D Audio Amplifier

Digital Logic and Voltage Translation
- I2C Level Translator
- Bidirectional Voltage Translation
- Digital Logic
- Non-Inverting Buffer/Driver
- Voltage Translator

Cluster System Power – MCU Wake on CAN Support

Input filter aids in CISPR 25 Conducted Emission compliance

May be used to control power to Display and Gauge Backlights

VBAT

VBAT_RPD

Input Filter

Mid VIN Switch

Backlight and Display Supplies

Full Range: 3 V to 42 V
Normal Operation: 6 V to 18 V
Start-Stop: 4.5 V to 6 V

Reverse Battery Protection

10V to 14 V

Wide VIN DC/DC Must have low I_Q for always on operation

May be used to control power to Display Module

Wide VIN Buck Low I_Q

5 V for CAN and MCU

Low VIN Buck or LDO Low I_Q

3.3 V for MCU

Low VIN Switch

Display Module

Reverse Battery Protection required. Can be accomplished with a diode:
- 0.3 V to 1 V drop across
- Typically 1 W to 2 W

10 – 14V used to Power 10W chimes and Ambient Backlight LEDs in some systems

Low Vin DC/DC or LDO to power MCU 3.3V section. MCU may have this function built in. For DC/DC, must have Low I_Q for always on operation

Low I_Q Power System required to power Vehicle Interface Processor and CAN bus during sleep (120 µA System Power Budget)

DCDC Innovation for EMI Performance
Hotrod packaging

Why We are Winning

Hotrod is a flip chip on lead frame QFN package

- Major performance enhancements
  - Lower Rds_on
    - Higher Efficiency @ 2.1MHz
    - 91% at VIN=13.5V, Vout=5V, Iout=3A
  - Smaller solution size
  - Lower inductance => dramatically lower switch node ringing (see bottom image)

Standard wire bond QFN package

Wire Bond
Silicon Die
Lead frame
Board
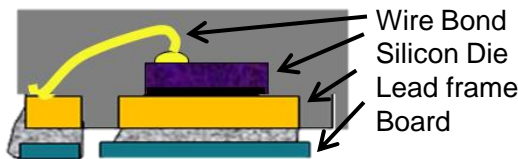
'Hotrod' flip chip on lead frame QFN

Silicon Die
Copper bump
Solder
Lead frame
Board
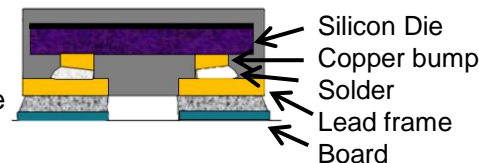
Die is flipped and placed directly onto the lead frame
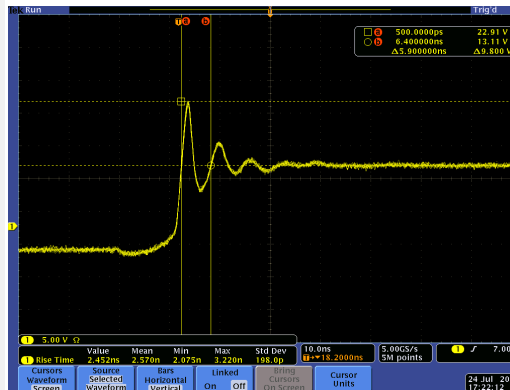
QFN
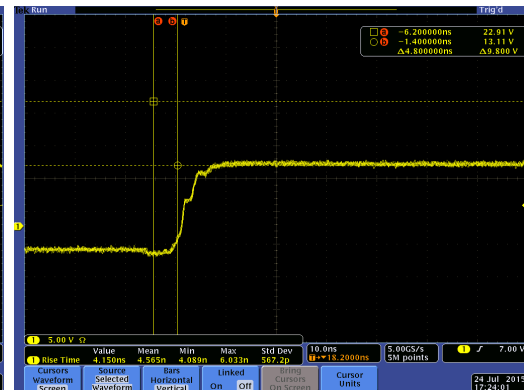
HotRod

Ringing overshoot reduced from +9V to 0V = Lower EMI/Noise

TEXAS INSTRUMENTS

DCDC Breakthrough Package Innovations
Wettable flank packages and high switching frequency

Why We are Winning

Wettable Flanks

- Wettable flanks guarantees visible side-wetting at good solder joints

- Enables 100% automotive visual inspection assembly processes

- Dual plated punched process with notch on underside of the package

2.1 MHz Operation

- True 2.1 MHz operation to avoid AM band

Switching Frequency vs. VIN

Maintains 5V, 3A output with 2.1MHz switching for VIN=6V

Test Conditions:
Force-PWM mode
Temp = 25degC

No Load
Iload=3A
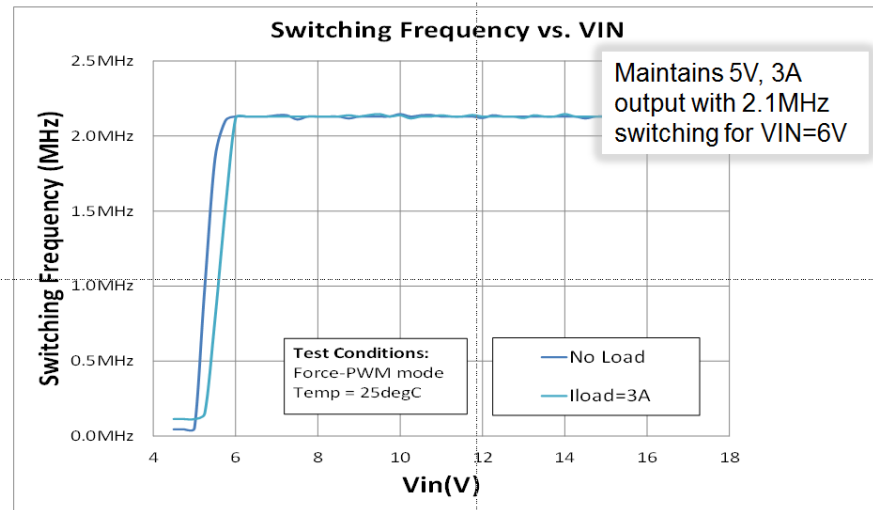
Holding frequency means no sweeping through AM Band when in Cold Crank

Standard QFN

Wettable Flanks

PLATED CAVITY

SOLDER JOINT

PCB PAD

Standard QFN

Wettable Flanks
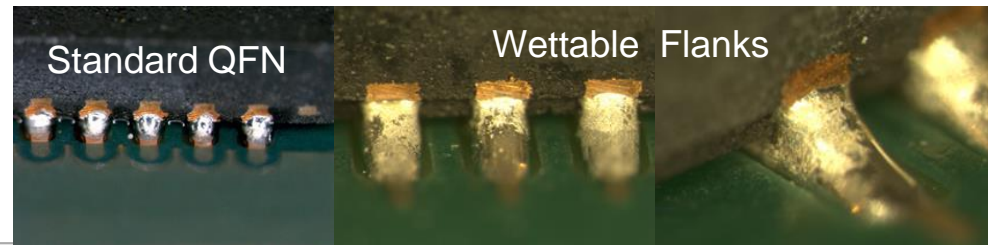
LMR33630/20-Q1

36V 2A/3A, Simple Switcher ® Synchronous Buck Regulators

Features

- **85/55mOhm Internal HS&LS RDS$_{on}$**
- **50 ns minimum on time (typical)**
- **<25µA quiescent current at no load**
- Vin range 3.8V - 36V
- Vout Range 1.0V to 95%Vin
- Switching frequency = 410 kHz, 1.4MHz, 2.1 MHz +-15%
- Minimum Off -Time = 75ns (typ)
- **QFN-12, Q Grade available**
- Vfb =1V +-2% over temperature
- Soft-start time = 5 ms
- Soft starts into pre-biased load
- Cycle by cycle current limiting
- Hiccup Short Circuit Protection
- Internal Compensation
- SOIC-8 and QFN-12 **3x2mm** package
- P2P compatible with 65V and 85V versions

Applications

- Media USB PD
- Industrial distributed power applications
- Space constrained industrial applications
- Space constrained automotive applications

Benefits

- **High frequency and tight current limit to lower inductor size**

- Wide vin operation to accommodate industrial and automotive line variation

- High efficiency with good thermal performance to withstand high ambient temperatures found in automotive electronics

- Compact solution size with high switching frequency
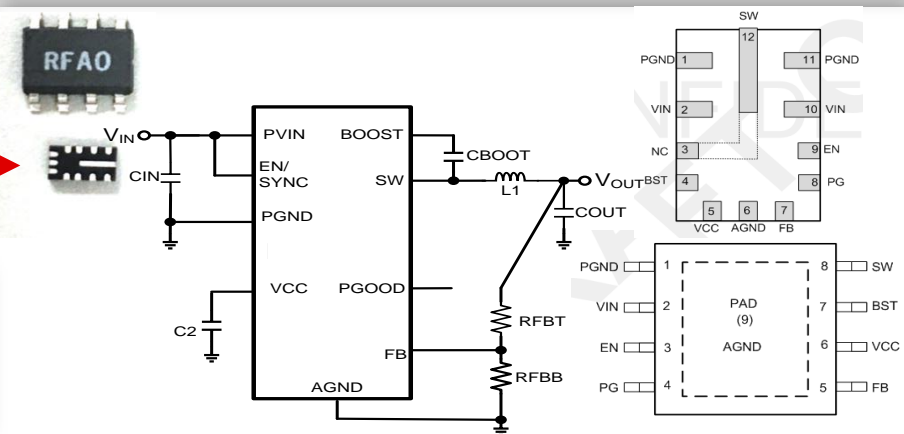
LMR33630 Efficiency Data

Key Specifications	Silicon (SOIC)	Silicon (HR QFN)
Efficiency (12V to 5V, 3A, 2.1 MHz)	**89.2%**	**91.6%**
Efficiency (12V to 5V, 3A, 400 kHz)	**91.3%**	**92.1%**
Rds_on (HS)	95mΩ	75mΩ
Rds_on (LS)	66mΩ	50mΩ
Quiescent Current (Iq)	31uA	30uA
Minimum On-time	34ns	33ns
Abs Maximum Vin	40V	40V
Minimum Vin	3.71V	3.70V

Vin=12V, Vout=5V, 400kHz
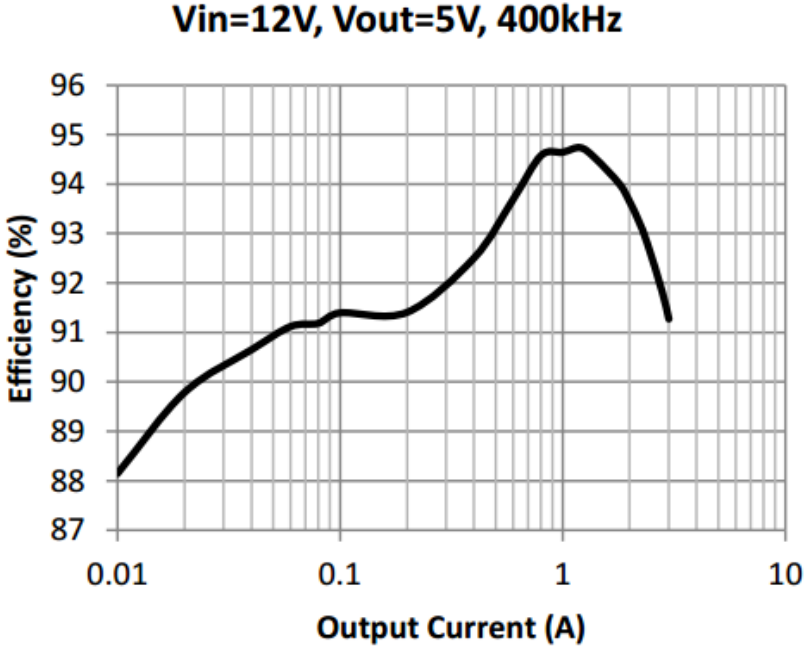
400kHz and 2MHz size comparison QFN Hotrod

LMR33630

3A @ 400kHz

LMR33630

3A @ 2MHz

25.5 mm

12mm

306mm^2

14mm

12mm

168mm^2

Texas Instruments
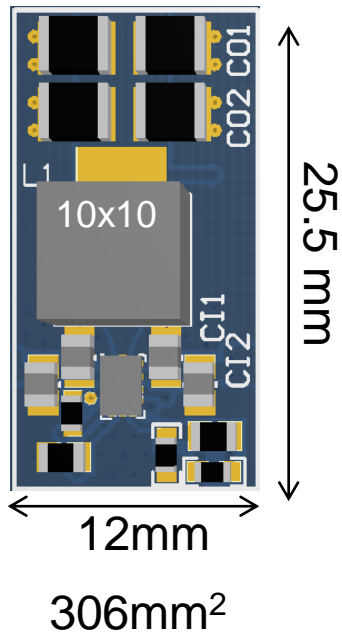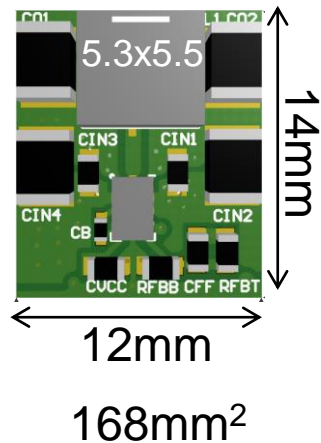
LMR33630/20-Q1 : HR vs SOIC Footprint
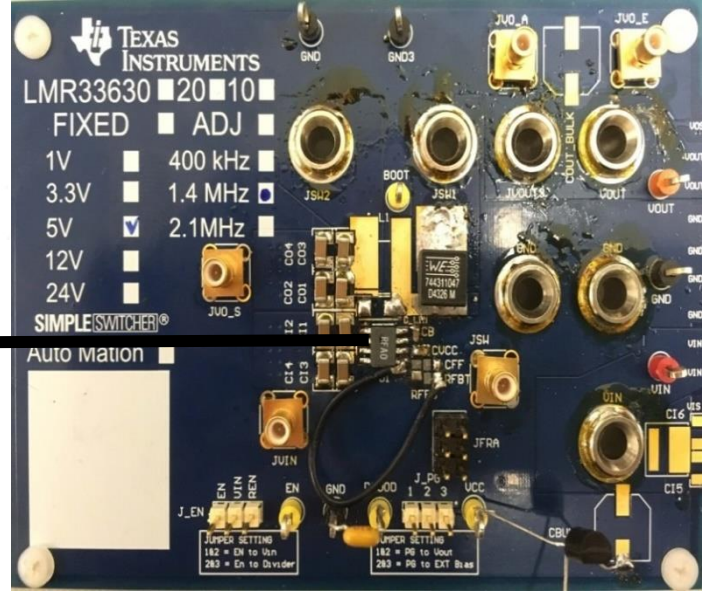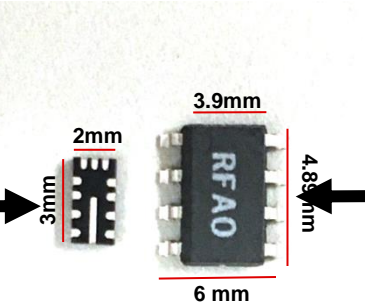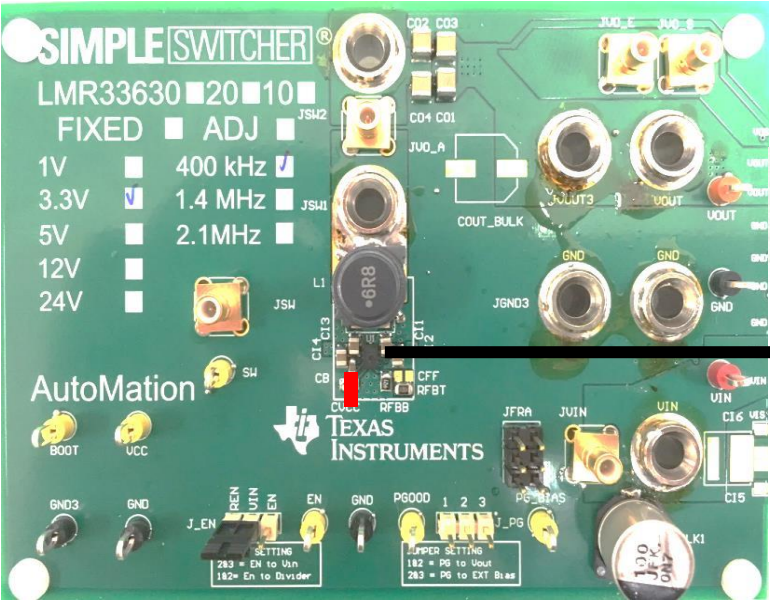
LMR33620/30-Q1 Overview

The LMR33620/30-Q1 is the latest device wide vin 2/3A, 36V device on the latest LBC9 process node

- Wide input voltage range from 3.8-36V (42V transients) helps reduce input protection circuitry for 12V automotive and 24V industrial systems

- Low <25uA Iq for better light load performance and for always on applications

- 3 frequency options of 400kHz, 1.4MHz, or 2.1MHz to optimize for efficiency or solution size

- 94.5% peak efficiency at 400kHz with leaded (SOIC8) or HR QFN package

- Highest energy density on the market for QFN HR12 package

TEXAS INSTRUMENTS

LM73605Q1 and LM73606Q1 Overview
High-Performance Synchronous DC-DC Converter Family

Features	Benefits	Applications

• LM73605/5: 36V, 5A/6A
• LM76002/3: 60V, 2.5A/3.5A
• > 90% full l0ad efficiency
• 15µA operating quiescent current
• Internal Compensation
• f_{sw}: 350kHz to 2.2MHz
• Wettable Flank QFN
• AECQ100 qualification
	• 36V and 60V family handles high voltage transients common in Industrial/Automotive/Comms
	• Easy to manage thermal design
	• Wettable flank allows visual inspection in leadless package
	• Small Solution Size: High integration yields low BOM count
		• Industrial:
		  • Factory & Building Automation
		  • Medical/Health
		• Automotive:
		  • Connectivity (USB)
		  • ADAS
		• Communications:
		  • Remote Radio Head (RRH)

Value Proposition

Efficiency Performance

5V, 500kHz

VIN = 12V
VIN = 18V
VIN = 24V
VIN = 28V
VIN = 36V
VIN = 42V
VIN = 48V
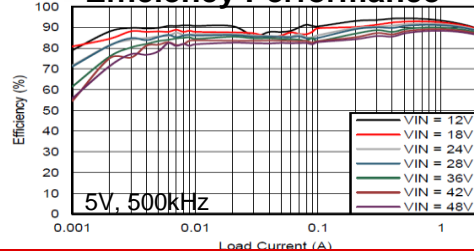
Thermal Performance
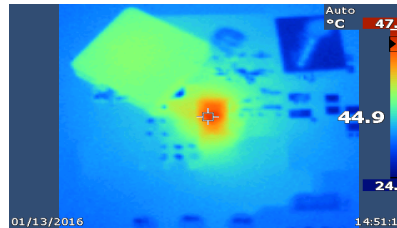
Small Total Solution Size

TEXAS INSTRUMENTS
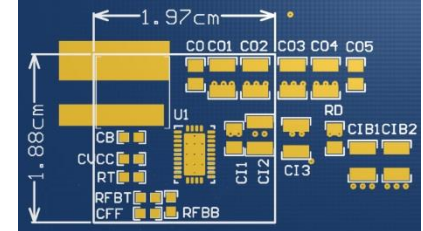
High Power. High Performance.

WHY WERE THESE PRODUCTS DEVELOPED

- To enable the engineer to handle **increased current requirements** with high-efficiency synchronous buck converter

WHAT PROBLEMS DO THESE PRODUCTS SOLVE

- These products **simplify the design cycle** and enable engineers to get to market faster
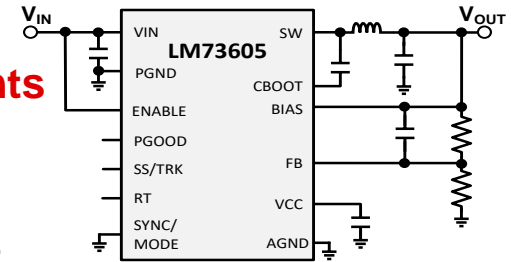
Performance Features:

- ✓ AECQ1 Qualification
- ✓ 36V, 5A/6A pin compatible
- ✓ >90% Efficiency at 2.2Mhz
- ✓ 15uA Standby Current
- ✓ 60ns min on-time
- ✓ Pin-selectable FPWM or Auto mode
- ✓ Bias circuitry improves Iq and reduces power dissipation

Ease of Use Features:

- ✓ Large thermal pad helps get heat out
- ✓ Low EMI PCB layout support
- ✓ Internal Compensation
- ✓ Low BOM Count
- ✓ Wide >,5mm pin pitch
- ✓ Wettable Flank Package
- ✓ Self-service design tools: WEBENCH, E2E, TI Designs

LM73605Q1 & LM73606Q1
36V, 5A/6A Synchronous Buck Converter for AECQ1

Features

- Wide Vin range **3.5V - 36V**, Vout range 1.0V to 95%Vin
- **Min ON time = 60ns (typ), min OFF time = 80 ns (typ)**
- **Fully Synchronous Rectifier**
- Internal Compensation
- Default operation when feature pins floating
- **Wettable Flank QFN 4x6mm package**
- **51/30 mOhm Internal HS&LS Rdson**
- **15 µA standby current**, PFM operation at light load
- External bias input to improve efficiency
- Adjustable / synchronizable switching frequency range 350kHz – 2.2MHz (default 500kHz when RT pin floating)
- Pin selectable **FPWM or Auto mode**
- Internal soft start / Prebias SS / extendable SS time / Tracking
- PGood flag
- Cycle by cycle current limiting
- Hiccup Short Circuit Protection
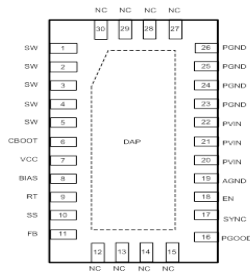
Applications

- Automotive ADAS
- Automotive Body Control & Lighting
- Automotive Connectivity
- Automotive Infotainment

Benefits

- **Easy to use**: no external power diode, minimum BOM count, visual inspection, small solution size ➔ save design time, save board space / cost, visual inspection

- **High Performance**: high efficiency at heavy load and light load, good thermal, long standby time

- **Wide Range** of Vin/Vout/fsw: easy system optimization, current scaling, easy reuse, and single stage step down from high Vin

- **Flexible** system optimization options, monitoring and protections features

TEXAS INSTRUMENTS
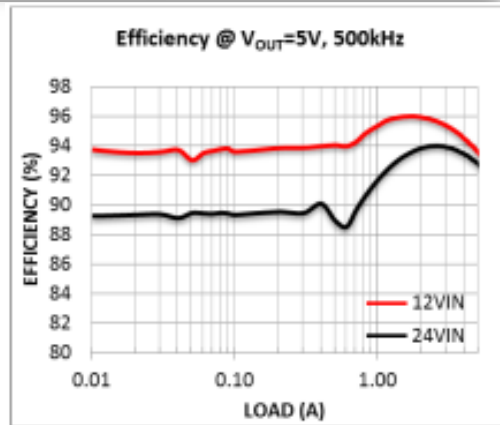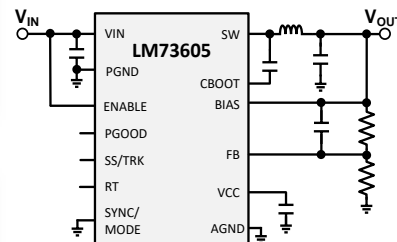
LM73605Q1 Layout
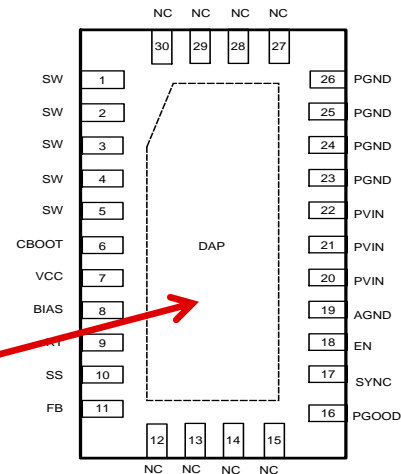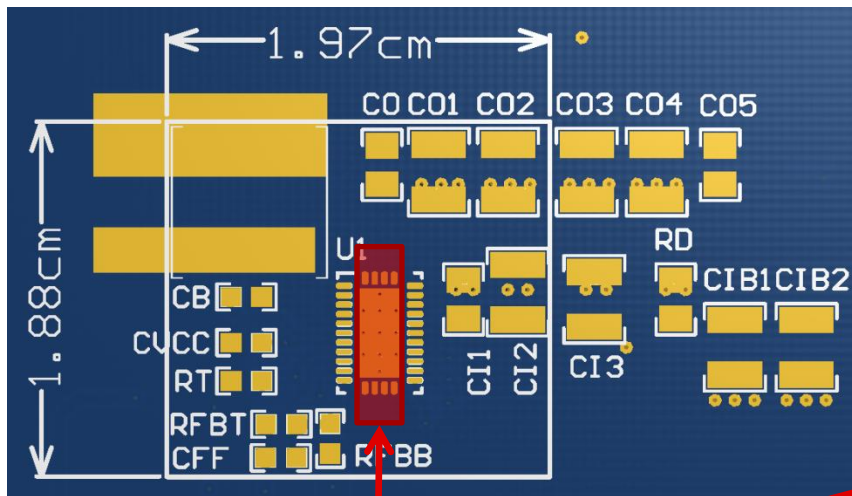
- Continuous GND for Thermal Relief right underneath IC

THERMAL METRIC[1]		PWP	UNIT
θ_{JA}	Junction-to-ambient thermal resistance[2]	29	°C/W
θ_{JC_T}	Junction-to-case (TOP) thermal resistance	24.3	°C/W
θ_{JC_B}	Junction-to-case (BOTTOM) thermal resistance	1.7	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	0.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	13.6	°C/W

TEXAS INSTRUMENTS

LM73605Q1 Thermals

LM73605Q1 12Vin 5Vout 500kHz
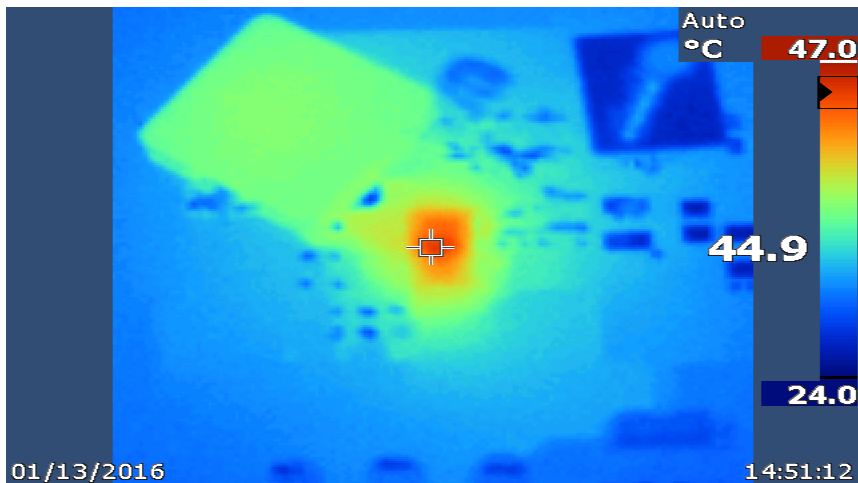
LM73605 Temperature is at 44.9 deg C at 5A Load

LM73605Q1 24Vin 5Vout 500kHz
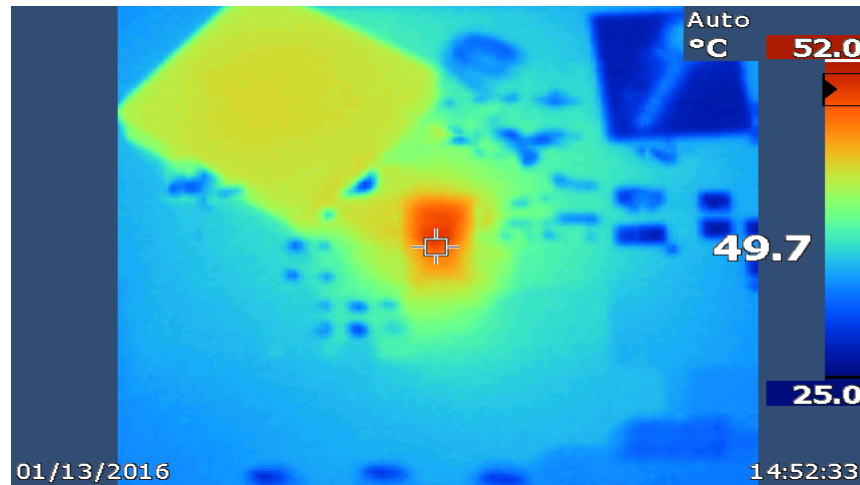
LM73605 Temperature is at 49.7 deg C at 5A Load

TEXAS INSTRUMENTS

Digital Cluster Block Diagram-Display
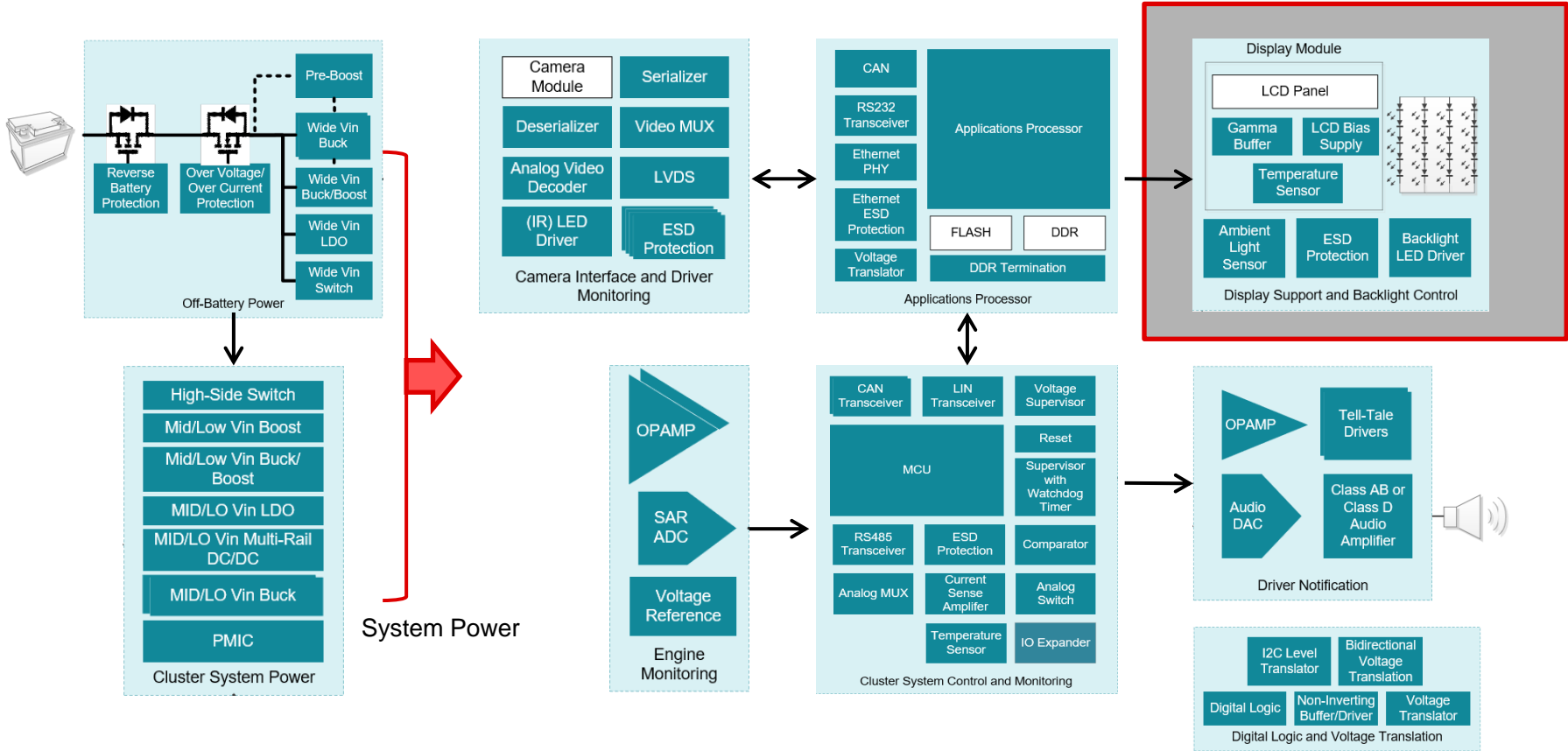
Backlight Driver Features

Wide Operating Voltage
- ✓ Operate during transient battery conditions, incl. 3V cold crank & 40V load dump
- ✓ Boost & SEPIC operation modes with int or ext FET

Low Noise/EMI Performance
- ✓ Programmable switching frequency from 100kHz to 2.2MHz
- ✓ Avoid interference by operating around AM radio band
- ✓ Built-in spread spectrum, phase shift, hybrid dimming option

Efficient Brightness Control
- ✓ Individual string control with PWM, I2C, SPI brightness control options
- ✓ Up to 32000:1 dimming ratio to achieve ultra low to high brightness range
- ✓ Adaptive output voltage control to improve power and thermal efficiency
- ✓ Advanced "sloper" response for smooth brightness transition

Protection & Diagnostics
- ✓ Under/overvoltage, overcurrent, overtemperature protection
- ✓ Open/Short LED detection
- ✓ Powerline (V_{bat}) FET option to protect against inrush & reduce Iq_{off} standby
- ✓ Fault reporting through I2C, SPI or FAULT pin flag

Automotive Backlight Driver Roadmap
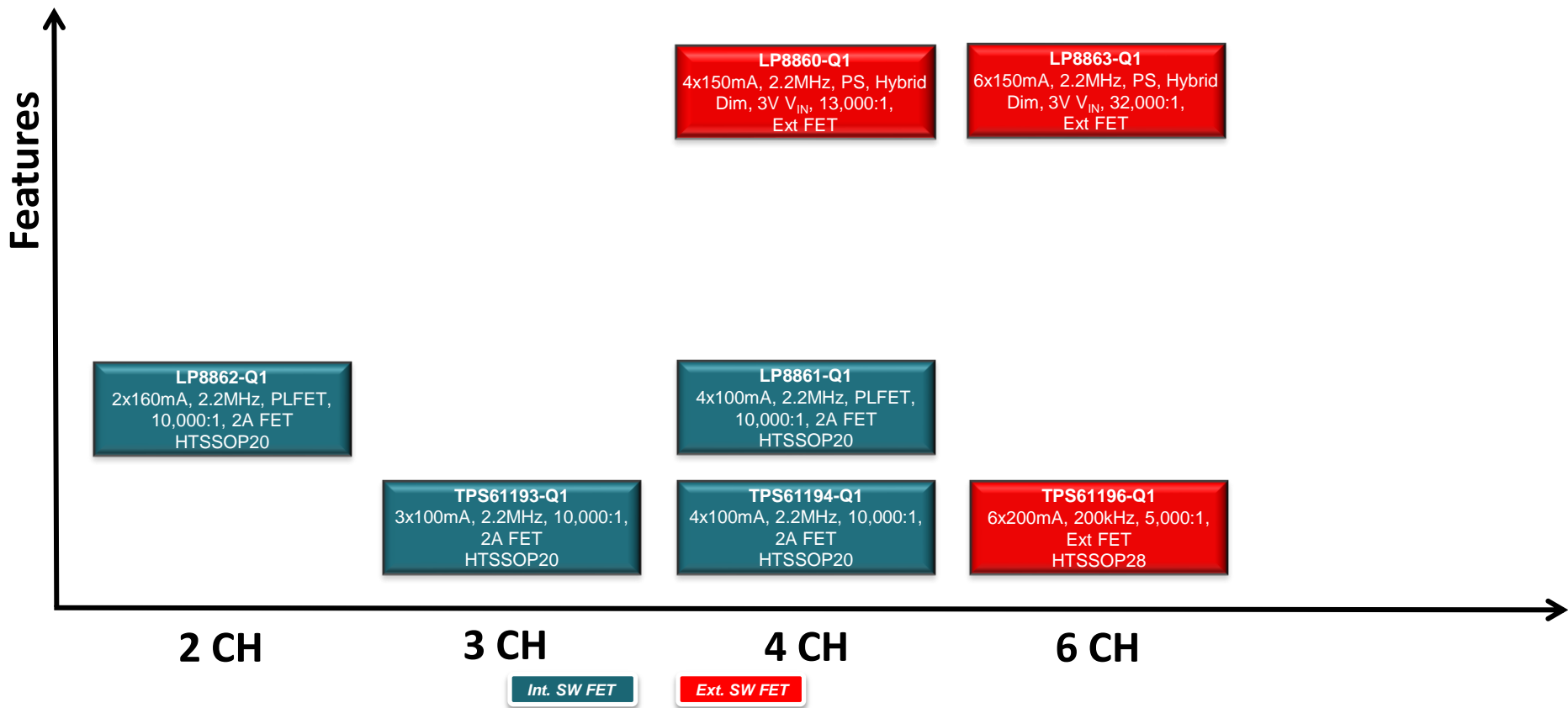
Automotive LED Backlight Driver Selector

|	Specs	LP8860-Q1	LP8863-Q1	LP8861-Q1	LP8862-Q1	TPS61193-Q1	TPS61194-Q1	TPS61196-Q1
LED Driver	#LED Strings	4	6	4	2	3	4	6
	LED Current max per String	150mA	150mA	100mA	160mA	100mA	100mA	200mA (Ave)
	LED Current Matching	+/-0.5% typ	+/-1% typ	+/-1% typ	+/-1% typ	+/-1% typ	+/-1% typ	+/-1.5% typ
	Dimming Mode	PWM or Hybrid	PWM or Hybrid	PWM	PWM	PWM	PWM	PWM
	Dimming Ratio	>13,000:1@ 100Hz	32,000:1@150Hz	10,000:1@200Hz	10,000:1@200Hz	10,000:1@200Hz	10,000:1@200H	500:1@ 200Hz
	PWM Synchronization	VSYNC, HSYNC	✖	✖	✖	✖	✖	✖
	Phase Shift	Yes, I2C config	Yes, Automatic	✖	✖	✖	✖	✖
Boost	VIN	3v to 48v	3v to 48v	4.5v to 40v	4.5v to 40v	4.5v to 40v	4.5v to 40v	8v to 30v
	VOUT	16v to 48v	7v to 47v	Up to 45v	Up to 45v	Up to 45v	Up to 45v	VIN to 120v
	Boost FET/Rdson	External	External	Internal/240mΩ	Internal/240mΩ	Internal/240mΩ	Internal/240mΩ	External
	DC/DC Type	Boost	Boost, SEPIC	Boost, SEPIC	Boost, SEPIC	Boost, SEPIC	Boost, SEPIC	Boost
	Switching Frequency	100k to 2.2MHz	300k to 2.2MHz	300k to 2.2MHz	300k to 2.2MHz	300k to 2.2MHz	300k to 2.2MHz	100k to 800kHz
	Switch Current Limit	2A to 9A	Up to 10A	2A/2.5A	2A/2.5A	2A/2.5A	2A/2.5A	4A (w/ 100mΩ Risense)
	Spread Spectrum Clock	✔	✔	✔	✔	✔	✔	✖
	External SYNC Clock Input	✔	✔	✔	✔	✔	✔	✖
	Battery isolation FET	✔	✔	✔	✔	✖	✖	✖
	Boost Discharge Function	✖	✔	✖	✖	✖	✖	✖
Faults	VIN UVLO	✔	✔	✔	✔	✔	✔	✔
	VIN OVP	✔	✔	✔	✔	✔	✔	✖
	VIN OCP	✔	✔	✔	✔	✖	✖	✖
	Boost OCP/OVP	✔	✔	✔	✔	✔	✔	✔
	Open / Short LED	✔	✔	✔	✔	✔	✔	✔
	Thermal Shutdown	✔	✔	✔	✔	✔	✔	✔
	Fault Reporting	I2C, SPI, Pin Flag	I2C, SPI, Pin Flag	Pin Flag	Pin Flag	Pin Flag	Pin Flag	Pin Flag
Control	Brightness control Methods	PWM Pin, I2C,SPI	PWM Pin, I2C,SPI	PWM Pin	PWM Pin	PWM Pin	PWM Pin	PWM Pin
	Independent String control	✔	✔	✖	✖	✖	✖	✔
	Temperature Compensation	✔	✖	✖	✖	✖	✖	✖
	Support External NTC	✔	✖	✖	✖	✖	✖	✖
	Device Configuration	EEPROM/Pins	Pins	Pins	Pins	Pins	Pins	Pins
	VDD	3V to 5.5V External	3V to 5.5V	5V Internal	5V Internal	5V Internal	5V Internal	6V Internal
	Package	32-L HLQFP	38-L TSSOP	20-L TSSOP	20-L TSSOP	20-L TSSOP	20-L TSSOP	28-L TSSOP
	1ku Price	1.45	1.88	1.30	1.20	1.18	1.18	1.30
	Ambient Temp Range	-40~125°C	-40~125°C	-40~125°C	-40~125°C	-40~125°C	-40~125°C	-40~125°C
	Production	e	✔	RTM 1Q17	✔	✔	✔	✔

LP8863-Q1
Integrated High Efficiency 6-Channel LED Driver for Automotive Lighting

Features

- Six High-Precision Current Sinks
  - Output Current up to 150 mA/Channel
  - Current Matching 1% (typical)
  - Up to 16-bit LED Dimming Resolution
- Individual LED String Brightness Control
  - For Whole Screen or Individual String Dimming Control
  - Dimming Ratio 32,000:1 @ 100Hz PWM
- Simple Configuration
  - Resistor configuration for Boost Frequency, LED PWM Frequency and LED Current
- Automatic String Configuration Detection
  - Tie unused strings to GND
  - Automatically adjusts phase shift for number of LED strings
- I2C, SPI and PWM Brightness Control Modes
- Boost Controller for LED String Power
  - Switching Frequency 300 kHz to 2.2 MHz
  - Boost SYNC input
  - Spread Spectrum for lower EMI
  - Adaptive Voltage Control for Power Optimization
  - Discharge function when boost is disabled
- Input Voltage Operating Range 3 V to 48 V (TBD)
- Extensive Protection Features
  - Open and Shorted LED Fault Detection
  - Boost Output OVP and OCP
  - Boost Input UVLO, OVP and OCP
  - VDD UVLO and Thermal Shutdown

Benefits

- Build-in EMI Reduction
  - Phase shifted LED outputs
  - Boost converter Spread Spectrum
  - Hybrid Dimming (Linear + PWM)
- Boost synchronization input
- Automatic detection of LED string configuration
- Power line FET control (inrush current protection, standby energy saving)
- Safety and Fault tolerance features

HTSSOP-38 AECQ 100
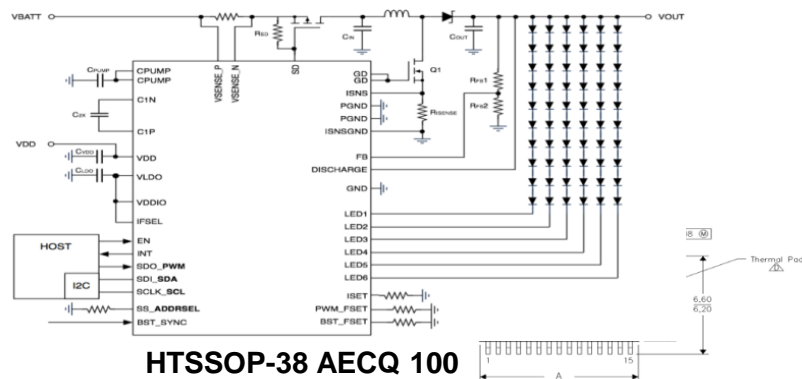
LP8863 Dimming Ratio

The LP8863-Q1 and LP8880-Q1 support over 32,000:1 dimming ratio through PWM Duty Control, PWM Dithering, Hybrid Dimming and PWM Low Brightness pulse skipping. The LED driver current sinks support a minimum LED output PWM pulse width of 200ns ([1/152Hz] / 200ns = 32,895:1) which is typically the limiting factor. Up to 16-bit dimming resolution (brightness step size) can be achieved from the minimum pulse width to 100% brightness.

PWM Duty Control:
> The LED output frequency is generated from the 20MHz internal oscillator. Output frequencies of 152Hz to 19.54kHz are supported which result in 16bit to 10bit dimming resolutions (65,000:1 to 1,000:1 dimming ratios).

PWM Dither Control:
> Up to 4-bits of temporal dither can be enabled using the DITHER_SELECT[2:0] when PWM Duty control dimming resolution is less than 16-bits. A total of 16-bit PWM duty and Dither resolution is supported.

Hybrid Dimming:
> The LP8863-Q1 can begin dimming with 12bit current DAC steps from 100% (0xFFFF) to 12.5% (0x2000) input brightness. Below 12.5% brightness up to 16-bit PWM resolution can be used (PWM Duty Control + Dither Control). Benefits of Hybrid dimming are reduced EMI, lower boost output ripple / audible noise, improved LED optical efficiency and increase dimming resolution/ratio for a given LED PWM frequency.

PWM Low Brightness Pulse Skipping:
> When the input brightness duty / brightness register calls for a output LED PWM pulse width below 200ns the LP8863-Q1 will begin to skip output pulses to further reduce the LED output brightness. This results in a temporal dithering of the PWM frequency. This feature allows use of higher PWM frequencies at higher brightness levels while still allowing high dimming ratio.

TEXAS INSTRUMENTS
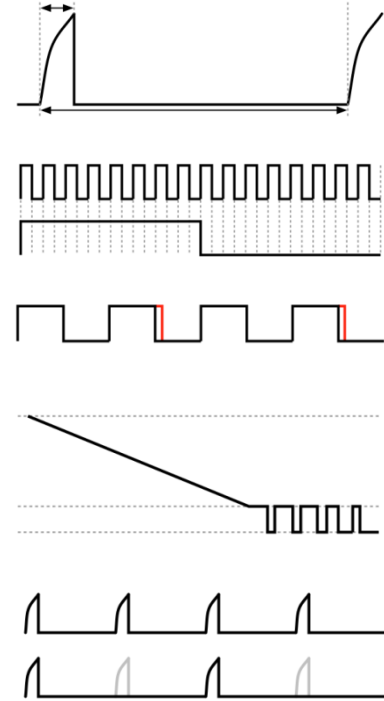
LP8863 External & Automatic Configuration

The LP8863 supports external configuration or automatic detection for most important backlight options. I2C control is also still an option.

Battery Isolation: PFET connection shown. If not used, VSENSE_P/N tied to VBATT & SD left floating.

VDD Level: For 3.3V LDO the 2x CP is used. For 5V LDO, C2X is not needed and CPUMP is tied to VDD.

Max Vout: FB Resistor divider sets maximum Vout for adaptive boost.

Boost Isw Limit: Current limit set by Rsense resistor.

IO Level: Tie to external 3.3V, 1.8v or internal LDO.

I2C/SPI IF: Tie to VDDIO for I2C and GND for SPI.

Vout Discharge: Boost output voltage discharge pin. Leave floating if unused

LED Sinks: Phase Shift updated for detected strings. Unused tied to GND.

I2C Address: Two I2C addresses selectable

LED Current: ISET resistor sets string current.

Dimming Freq: PWM_FSET resistor sets LED output PWM frequency.

Boost Sync / SS: Input for synchronizing boost. When synchronization is not used, connect this pin to ground to disable spread spectrum or to VDDIO to enable spread spectrum.

Fsw Freq: BST_FSET resistor sets the boost switching frequency.

TEXAS INSTRUMENTS

LP8863 Automatic String Detection & Phase Shift

The LP8863-Q1 automatically detects the connected LED strings after VDD POR is released. Unused channels can be tied directly to ground and disabled (do not trigger faults or effect adaptive boost control). The phase shift delay between strings is automatically adjusted for the number of valid strings connected. The following table shows the valid string configurations. Detected string configuration is reported in the AUTO_LED_STRING_CFG[2:0] register.

Configuration	LED0	LED1	LED2	LED3	LED4	LED5	Automatic phase shift
6 channels	150 mA	150 mA	150 mA	150 mA	150 mA	150 mA	60 °
5 channels	150 mA	150 mA	150 mA	150 mA	150 mA	(Tied to GND)	72 °
4 channels	150 mA	150 mA	150 mA	150 mA	(Tied to GND)	(Tied to GND)	90 °
3 channels	150 mA	150 mA	150 mA	(Tied to GND)	(Tied to GND)	(Tied to GND)	120 °
2 channels	150 mA	150 mA	(Tied to GND)	(Tied to GND)	(Tied to GND)	(Tied to GND)	180 °
3 channels, 300 mA /ch (tie LED pins together)	300 mA		300 mA		300 mA		120 °
2 channels, 450 mA /ch (tie LED pins together)	450 mA			450 mA			180 °
1 channel, 900 mA (tied LED pins together)	900 mA						None

LP8863 Fault Reporting w/ I2C & SPI serial interfaces

The LP8863-Q1 uses an interrupt (INT) pin to notify the host of any fault conditions. Interrupts for each fault can be individually enabled or disabled with the I2C/SPI interfaces.

Status bits for each fault are also stored internally. Fault bits are latched even if fault condition no longer exists and device auto recovers to resume normal operation. Fault status bits can be individually cleared.

The following fault interrupt and status are reported:

•VIN UVLO	•Boost OVP (low)
•VIN OVP	•Boost OVP (high)
•VIN OCP	•Boost OCP
•VDD UVLO	•Missing Boost SYNC
•LED Open Fault	•Charge Pump Fault
•LED Short Fault	•Junction Temp (High)
•FSET Fault	•Junction Temp (Low)
•Invalid LED Configuration	•Thermal Shutdown

The LP8863-Q1 also has registers to report detected boost switching frequency, LED PWM dimming frequency and string configuration based on external configuration. Additionally, the brightness path outputs for PWM duty and LED current and adaptive boost target voltage (11-bit) are available to be read by the I2C or SPI interface.

TEXAS INSTRUMENTS

LP8863 Independent Brightness & Current Control

The LP8863-Q1 supports independent 16-bit duty cycle and 12-bit current control for each LED current sink.
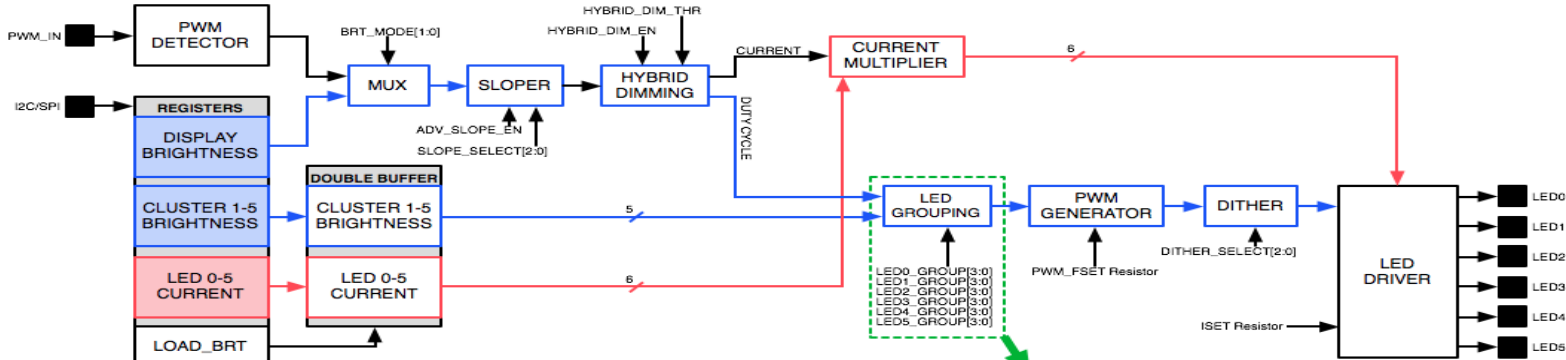
1 The DISPLAY_BRT (or PWM_IN) and five CLUSTERx_BRT registers allow up to six independent 16-bit brightness control inputs.

2 The six individual LEDx_CURRENT registers allow 12-bit adjustment from the maximum LED string current which is set by the ISET resistor value.

3 Any of the six brightness input registers can control any single or group of LED current sinks by programming the six LEDx_GROUP registers.

TEXAS INSTRUMENTS
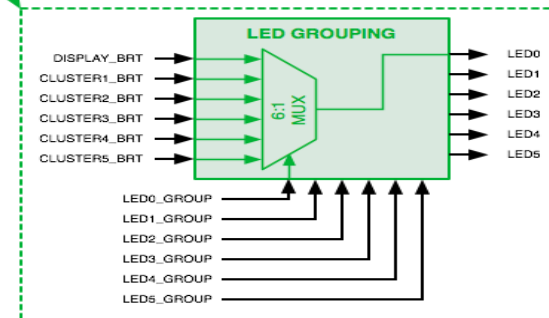
LP8863 Boost Spread Spectrum Functionality

- LP8860 & LP8863 EMI reduction function using optional Spread Specture Function for Boost DC/DC

- Spread spectrum $\pm$3% from central frequency, 1.875kHz modulation frequency

  - For LP8860: Enabled/Disabled with EEPROM bit

  - For LP8863: Enabled when BST_SYNC pin is pulled high

Spread spectrum OFF:
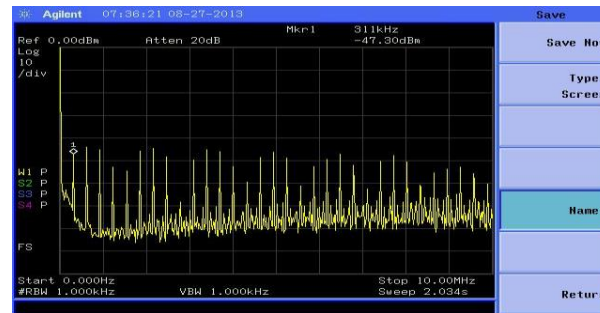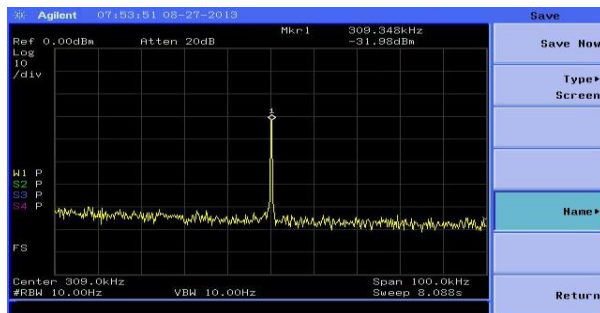
Spread spectrum ON:

TEXAS INSTRUMENTS
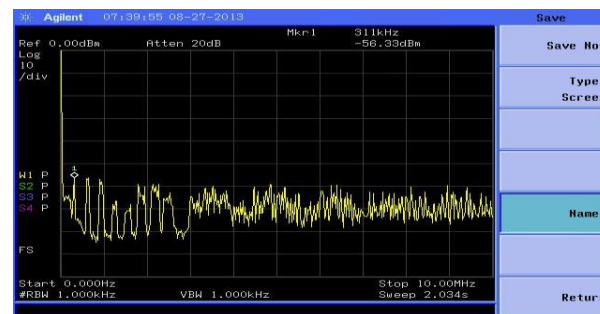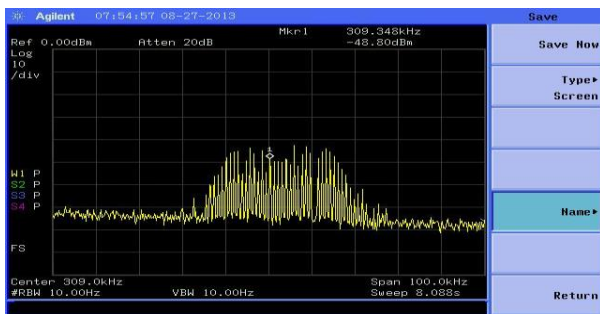
Digital Cluster Block Diagram-LED Tell-Tale

Off-Battery Power
- Pre-Boost
- Wide Vin Buck
- Wide Vin Buck/Boost
- Wide Vin LDO
- Wide Vin Switch
- Reverse Battery Protection
- Over Voltage/Over Current Protection

Cluster System Power
- High-Side Switch
- Mid/Low Vin Boost
- Mid/Low Vin Buck/Boost
- MID/LO Vin LDO
- MID/LO Vin Multi-Rail DC/DC
- MID/LO Vin Buck
- PMIC

System Power

Camera Interface and Driver Monitoring
- Camera Module
- Serializer
- Deserializer
- Video MUX
- Analog Video Decoder
- LVDS
- (IR) LED Driver
- ESD Protection

Engine Monitoring
- OPAMP
- SAR ADC
- Voltage Reference

Applications Processor
- CAN
- RS232 Transceiver
- Ethernet PHY
- Ethernet ESD Protection
- Voltage Translator
- Applications Processor
- FLASH
- DDR
- DDR Termination

Cluster System Control and Monitoring
- CAN Transceiver
- LIN Transceiver
- Voltage Supervisor
- MCU
- Reset
- Supervisor with Watchdog Timer
- RS485 Transceiver
- ESD Protection
- Comparator
- Analog MUX
- Current Sense Amplifer
- Analog Switch
- Temperature Sensor
- IO Expander

Display Support and Backlight Control
- Display Module
- LCD Panel
- Gamma Buffer
- LCD Bias Supply
- Temperature Sensor
- Ambient Light Sensor
- ESD Protection
- Backlight LED Driver

Driver Notification
- OPAMP
- Tell-Tale Drivers
- Audio DAC
- Class AB or Class D Audio Amplifier

Digital Logic and Voltage Translation
- I2C Level Translator
- Bidirectional Voltage Translation
- Digital Logic
- Non-Inverting Buffer/Driver
- Voltage Translator

TEXAS INSTRUMENTS

Multi-channel LED Indicator Family

New Generation

TLC6C598/12-Q1 ⭐
- Shift Register Power Logic
- 40V Breakdown Voltage
- Vcc = 3 ~ 5.5V
- Cont. <50mA per channel (8/12 ch)
- Thermal Shutdown Protection

TLC6C5816-Q1 ⭐
- Shift Register Power Logic
- 40V Breakdown Voltage
- Vcc = 3 ~ 5.5V
- Cont. <50mA per channel (16 ch)
- 2 PWM Input
- LED Open & Short Diagnostic

TLC6C5712-Q1 ⭐
- Const. Current Sink
- 7V Breakdown Voltage
- Vcc = 3 ~ 5.5V, SPI
- Cont. <75mA/ch (12 ch)
- 8 bit Dot Correction
- 6 Ext. PWM arbitrary mapping
- Full Diagnostic & Protection
- Deactivated LED Fault Detection

TLC6C5716/24-Q1 ⭐
- Const. Current Sink
- 8V Breakdown Voltage
- Vcc = 3 ~ 5.5V, Serial I/F
- Cont. <50mA/ch (24/16 ch)
- 7 bit Dot Correction, 8 bit BC
- 12/10/8 bit Int. Ind. PWM
- Full Diagnostic & Protection

Old Generation

TPIC6C596
- Shift Register Power Logic
- 33V Breakdown Voltage
- Vcc = 4.5 ~ 5.5V
- Cont. <100mA per channel (8 ch)

TPIC2810
- I2C Power Logic
- 40V Breakdown Voltage
- Vcc = 3 ~ 5.5V
- Cont. <100mA per channel (8 ch)

TLC5916/17-Q1 / TLC5926/27-Q1
- Const. Current Sink
- 17V Breakdown Voltage
- Vcc = 3 ~ 5.5V, Serial I/F
- Cont. <120mA/ch (8/16 ch)
- 8 bit Global Dot Correction
- OT, LED Open
- LED Short (7 only)

TLC5941-Q1
- Const. Current Sink
- 17V Breakdown Voltage
- Vcc = 3 ~ 5.5V, Serial I/F
- Cont. <90mA/ch (16 ch)
- 6 bit Ind. Dot Correction
- 12 bit Int. Ind. PWM
- OT, LED Open

TLC59116-Q1
- Const. Current Sink
- 17V Breakdown Voltage
- Vcc = 3 ~ 5.5V, FM+ I2C
- Cont. <120mA/ch (16 ch)
- 8 bit Global Dot Correction
- 8 bit Int. Ind. PWM
- OT, LED Open

Topology

VBAT: 9-18V

MCU
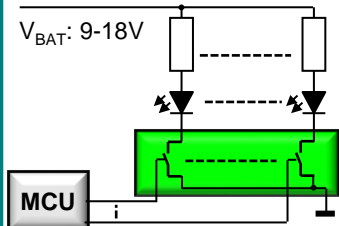
- No Diagnostic
- Simple ON/OFF
- Requires Parallel wires from MCU

VBAT: 9-18V

MCU
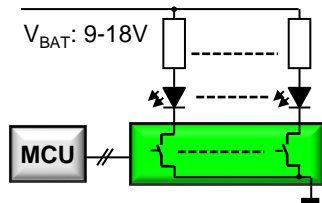
- No Diagnostic or Simple Diagnostic
- Simple ON/OFF
- MCU Serial I/F & Daisy Chain Option

VCC

MCU
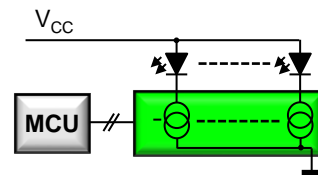
- Diagnostic
- Constant Current w/ Rsense
- MCU Serial I/F & Daisy Chain Option

TEXAS INSTRUMENTS

TLC6C5712-Q1

Features

- **AEC-Q100 Qualified for Automotive Applications**
- **12 Channel Power DMOS Transistor Outputs**
    - Constant current up to 75mA, set via external resistor
    - Breakdown voltage up to 7V
    - Max drop-out voltage: 0.75V @ 50mA/ch, 1.2V @ 75mA/ch
    - Configurable slew rate for optimized EMI performance
- **Precision Constant Current**
    - Channel-Channel difference < ±3%
    - Device-Device difference   < ±3%
    - 8-bit, 256-step linear dot correction for each channel
- **Serial Interface & PWM inputs**
    - 6 PWM Inputs with frequency supervision
    - Programmable PWM mapping capability via SPI interface
- **Diagnostic & Protection**
    - Open-load, Short-to-GND, Shorted-LED detection for both activated and deactivated states
    - LED Weak Supply Detection
    - Adjacent Pin Short Detection
    - Reference Resistor Open/Short Detection & Protection
    - Thermal Prewarning and Shutdown
    - Input PWM Timeout Monitoring
    - Open-drain Error reporting
    - Force Error for SPI Integrity Diagnostics
    - SPI register lock for content protection
- **Small & thermal effective package**
    - 28 HTSSOP (PowerPAD)

Benefits

- Output current high accuracy ensure whole system close to zero deviation in LED Display
- Full Programmable via SPI to offer the flexibility for various applications
- Complete Diagnostic and Protection to meet high functional safety requirements
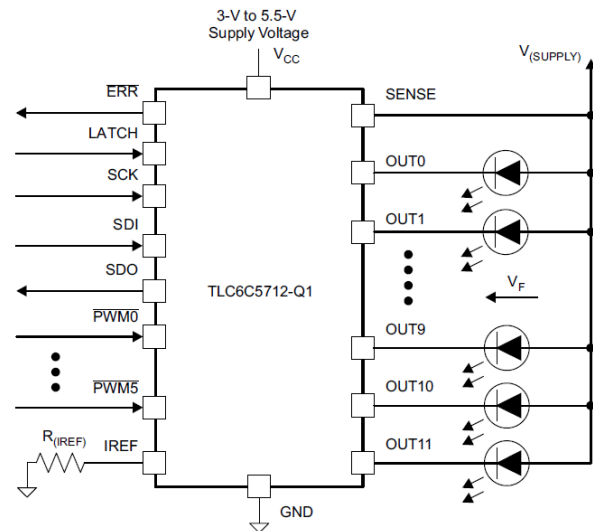
Applications

- Instrumentation Cluster
- HVAC / Head-unit Faceplate, Center Stack HMI, Electronic Gear Shifter
- Local Dimming Display
- RGB Ambient Lighting

Key Parameter Overview

Vcc operating voltage	3 ~ 5.5	V
Output voltage maximum rating	7	V
Full range output current	75	mA
Output current accuracy	±3	%

TEXAS INSTRUMENTS

TLC6C5712-Q1 Functional Block Diagram
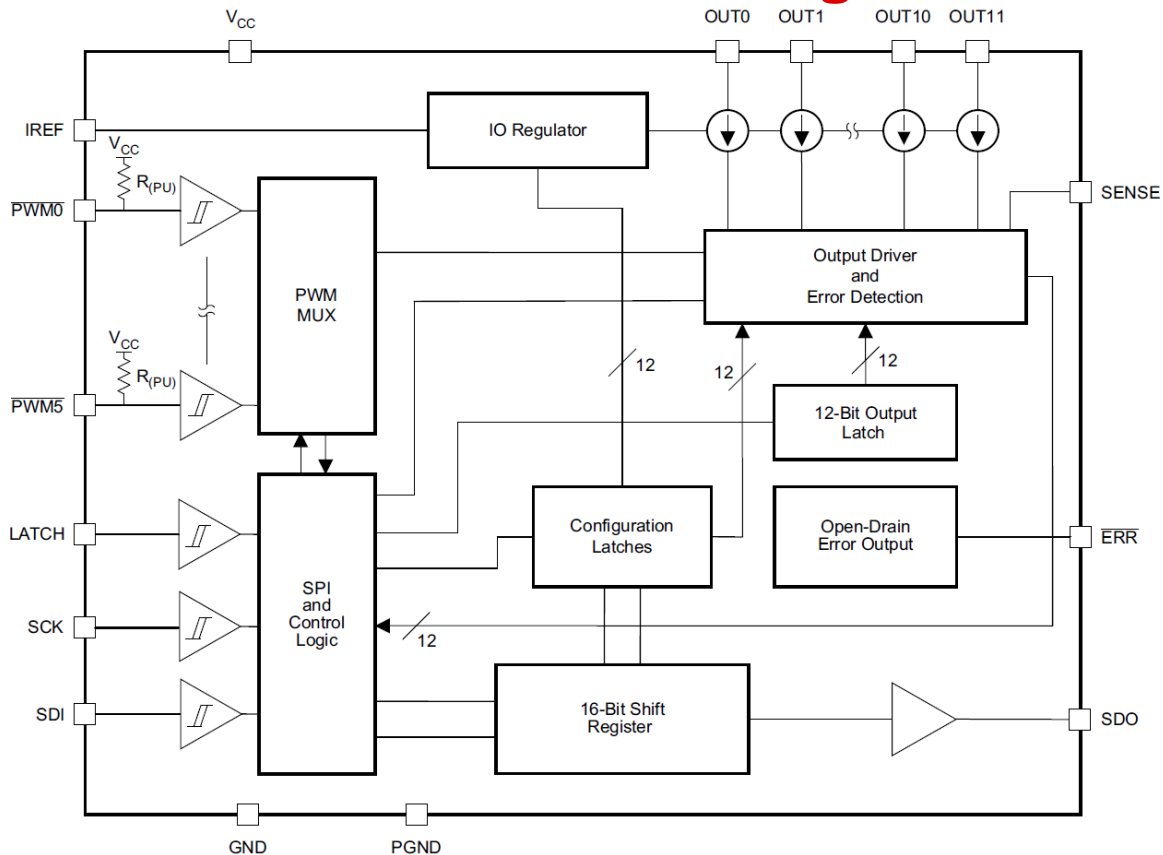
TLC6C5712-Q1 Package and Pin Assignment
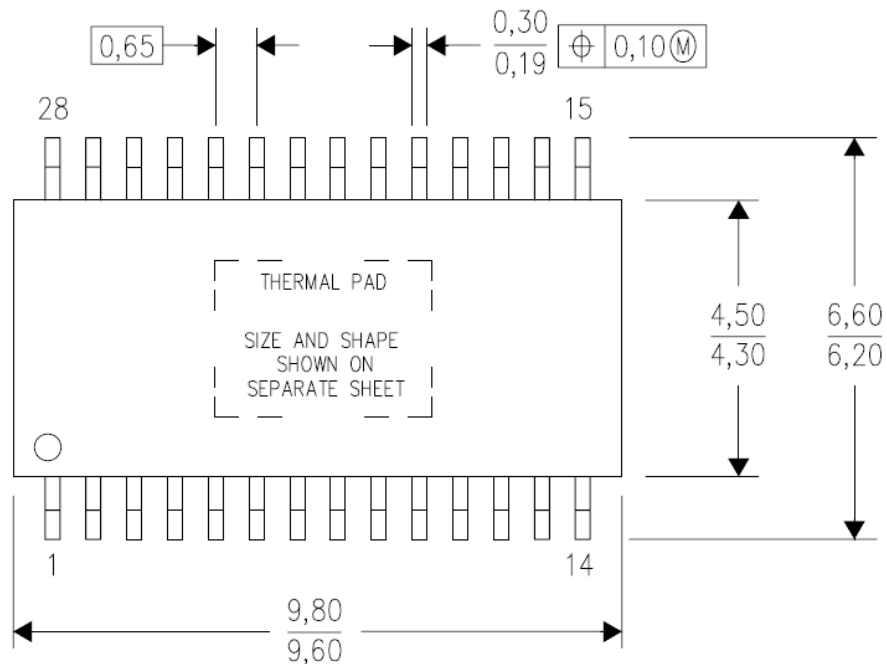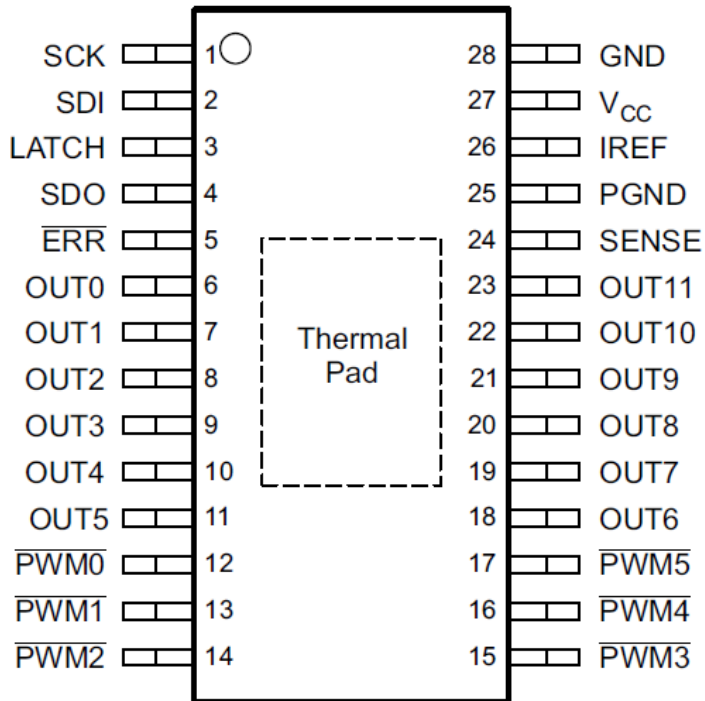
TLC6C5712-Q1 Setting Analog Constant Current Output to 20mA

- To set 30mA full range current, 20.5kΩ reference resistor can be used. Thus the reference current is 60uA generated by 1.229V reference voltage. (K=500)

$$I_{REF} = \frac{V_{REF}}{R_{REF}} = 60\mu A$$

$$I_{OUT,MAX} = I_{REF} \cdot K = 30mA$$

- By setting 8bit current DAC to 0xAA(170 in Dec), LED current is at 20.04mA during ON state.

$$I_{OUT} = I_{OUT,MAX} \cdot \frac{DC+1}{256} = 20.04mA$$

- PWM could be applied at the same time for group dimming and resolution extension.
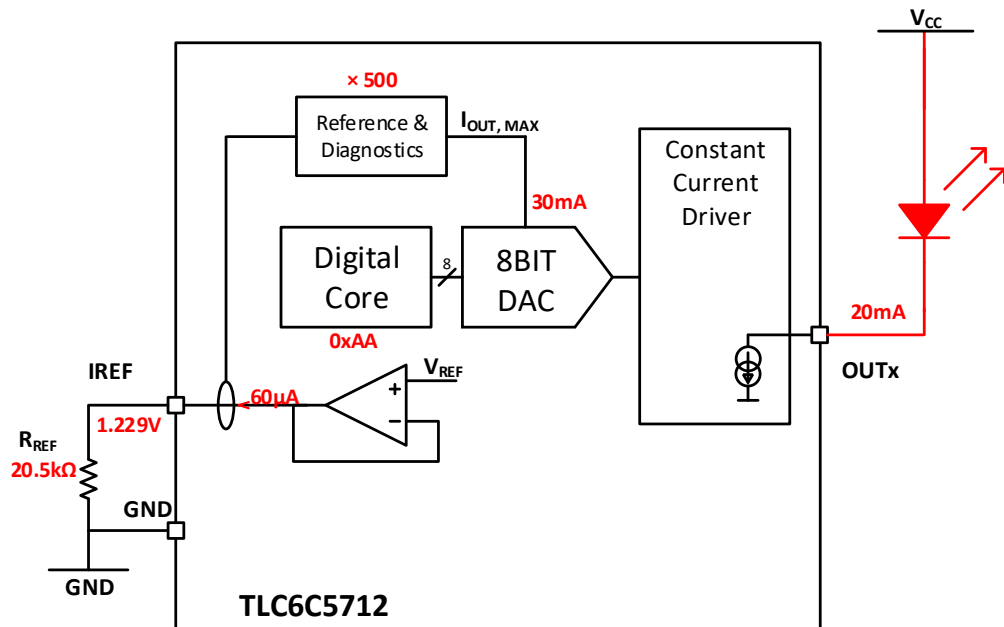
TLC6C5712-Q1 Advanced Full Diagnostics

TLC6C5712 supports full diagnostics features for LED, including:

- Thermal Pre-warning
- Over Temperature Warning & Protection,
- LED Short Detection,
- LED Short to GND Detection,
- LED Open Detection,
- LED Weak Supply Detection,
- Off-state LED Open/Short Detection,
- Adjacent Pin Short Detection,
- Reference Resistor Open/Short Detection & Protection,
- Input PWM Timeout Monitor
- ERR pin programmable to map reported faults
- SPI register lock feature for content protection

TLC6C5712-Q1 $\overline{\text{ERR}}$ Open Drain Output with programmability

- For the ease of software development, open drain $\overline{\text{ERR}}$ output is provided to generate hardware interrupt. So that response time to fault condition could be minimized and MCU resources to routinely check fault status can be saved.

- All diagnostics can be programmed as whether to report to $\overline{\text{ERR}}$ by setting the ERROR Mask register.

- All the faults can be read via READ_STATUS0 register.

WRITE_ERROR_MASK	66h	MASK_R$_{REF}$	POR_MASK	OPEN_MASK	SHORT_MASK	PWM_MASK	WEAK_SUP_MASK	PRE_TSD_MASK	TSD_MASK

READ_STATUS0	A2h	R$_{REF}$_FAULT_FLAG	POR_ERR_FLAG	ANY_OPEN_FLAG	ANY_SHORT_FLAG	ANY_PWM_FAULT_FLAG	WLS_FAULT_FLAG	TSD125_FLAG	TSD150_FLAG

TLC6C5712-Q1 Diagnostics Look Up Table

Fault Name	$\overline{ERR}$ output	Fault Flag	Channel Fault Register	Fault Latch	Supported in ON & OFF state	Channel Independent	Clear by RESET_STATUS	Protection	Comments
Power On Reset	Y	POR_ERR_FLAG	N/A	Y	Y	N	N	Reset all registers	Can only be cleared by RESET_POR
Pre-thermal warning	Y	TSD125_FLAG	N/A	Y	Y	N	Y	No action	
Thermal warning & Protection	Y	TSD150_FLAG	N/A	Y	Y	N	Y	Disable all outputs	Protection cannot be masked for safety
LED Short to Supply	Y	ANY_SHORT_FLAG	SHORT_FAULT_CHx	Y	Y	Y	Y	No action	
LED Open	Y	ANY_OPEN_FLAG	OPEN_FAULT_CHx	Y	Y	Y	Y	No action	
LED Short to GND	Y	ANY_SHORT_FLAG	SG_FAULT_CHx	Y	Y	Y	Y	No action	
Weak LED Supply	Y	WLS_FAULT_FLAG	N/A	Y	Y	N	Y	No action	
Adjacent Pin Short	N	N/A	AD_FLAG_CHx	Y	Manual	Y	Y	No action	Adjacent pin Diagnostics will be initiated via SPI
Reference Resistor Open/Short	Y	R_{REF}_FAULT_FLAG	N/A	Y	Y	N	Y	Set output full range current to default value.	Protection cannot be masked for safety.
Input PWM Timeout	Y	ANY_PWM_FAULT_FLAG	FAULT_PWMx	Y	Y	Y	Y	No action	

TLC6C5712-Q1 Reference Diagnostics & Protection
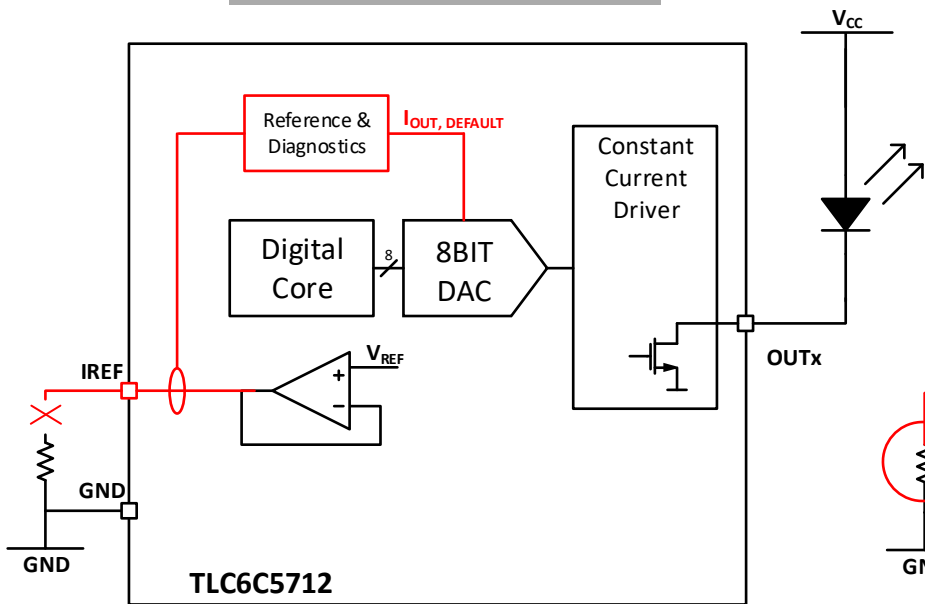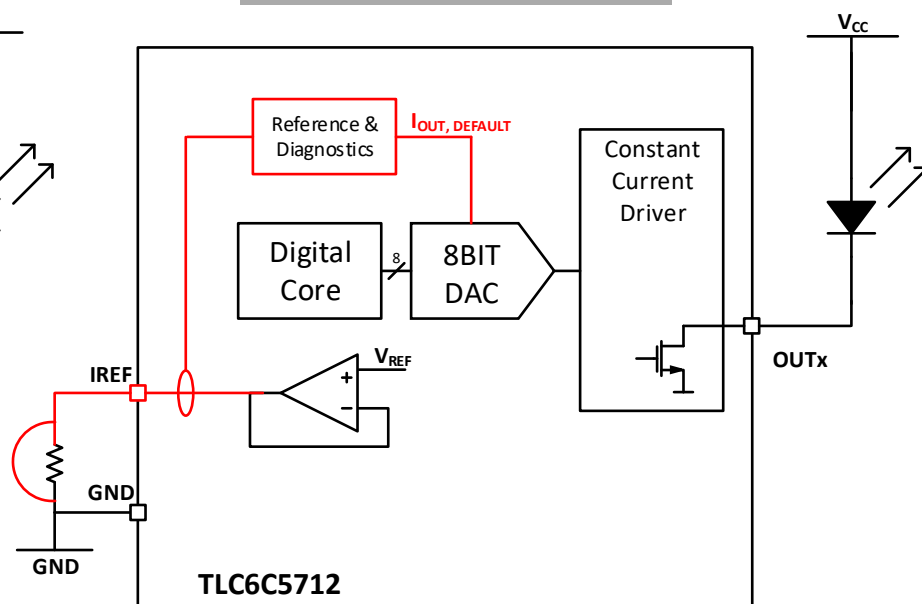
Once reference open/short fault is detected on reference resistor, maximum output current will be switched to default value. The $\overline{\text{ERR}}$ pin will be pulled low with Rref_ Fault_Flag register set.

TLC6C5712-Q1 LED Failure modes detection & distinction
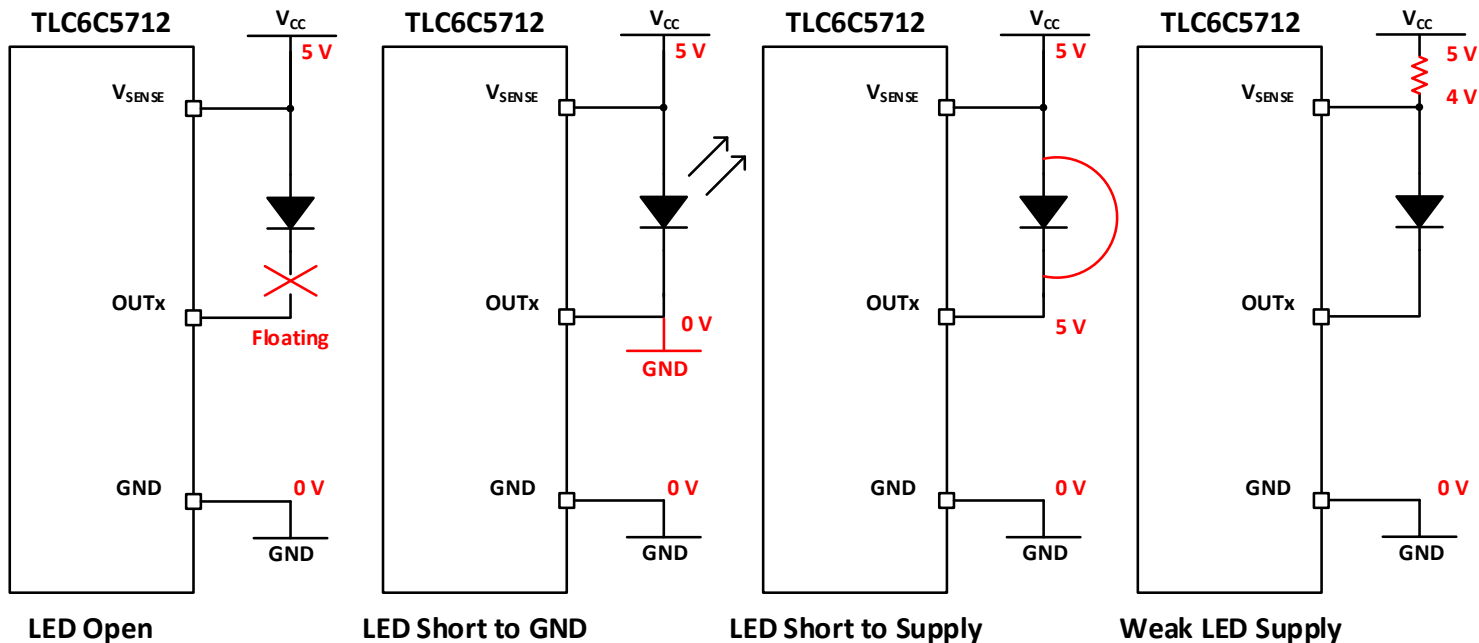
- Common LED faults includes LED Open, LED Short to GND, LED Short to Supply and Weak LED Supply, as depicted above

- All the faults can be detected and distinguished by TLC6C5712 in both ON and OFF state with advanced diagnostics.

TLC6C5712-Q1 Adjacent Pin Short

- TLC6C5712 provides Adjacent pin short diagnostics feature to smart detect any of the adjacent output short condition as shown below.

- Once Adjacent pin short diagnostics routine has been executed via SPI command, the internal state machine will perform automatic diagnostics on the outputs and will report results on the adjacent pin fault registers.
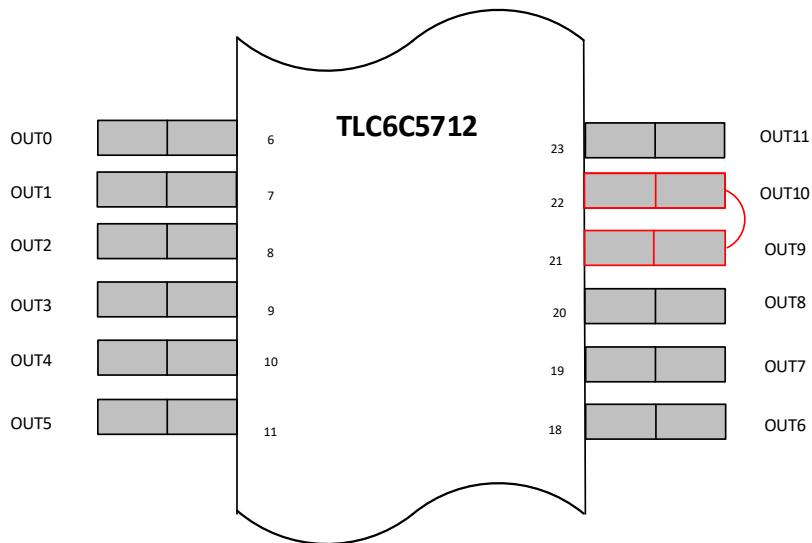
TLC6C5712-Q1 PWM Timeout Monitor

- PWM Timeout monitor counts time interval since last $\overline{\text{PWM}}$ **rising edge** independently for each of the 6 input PWM sources.

- Timer threshold is 20ms.

- It can be individually masked if the channel is not in use.

TEXAS INSTRUMENTS
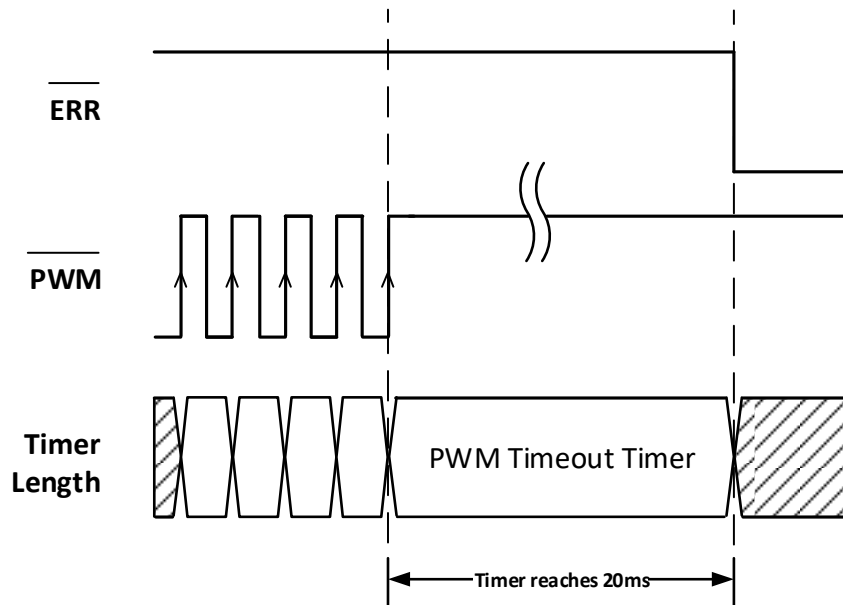
TLC6C5712-Q1 Fault Diagnostic Flow Chart
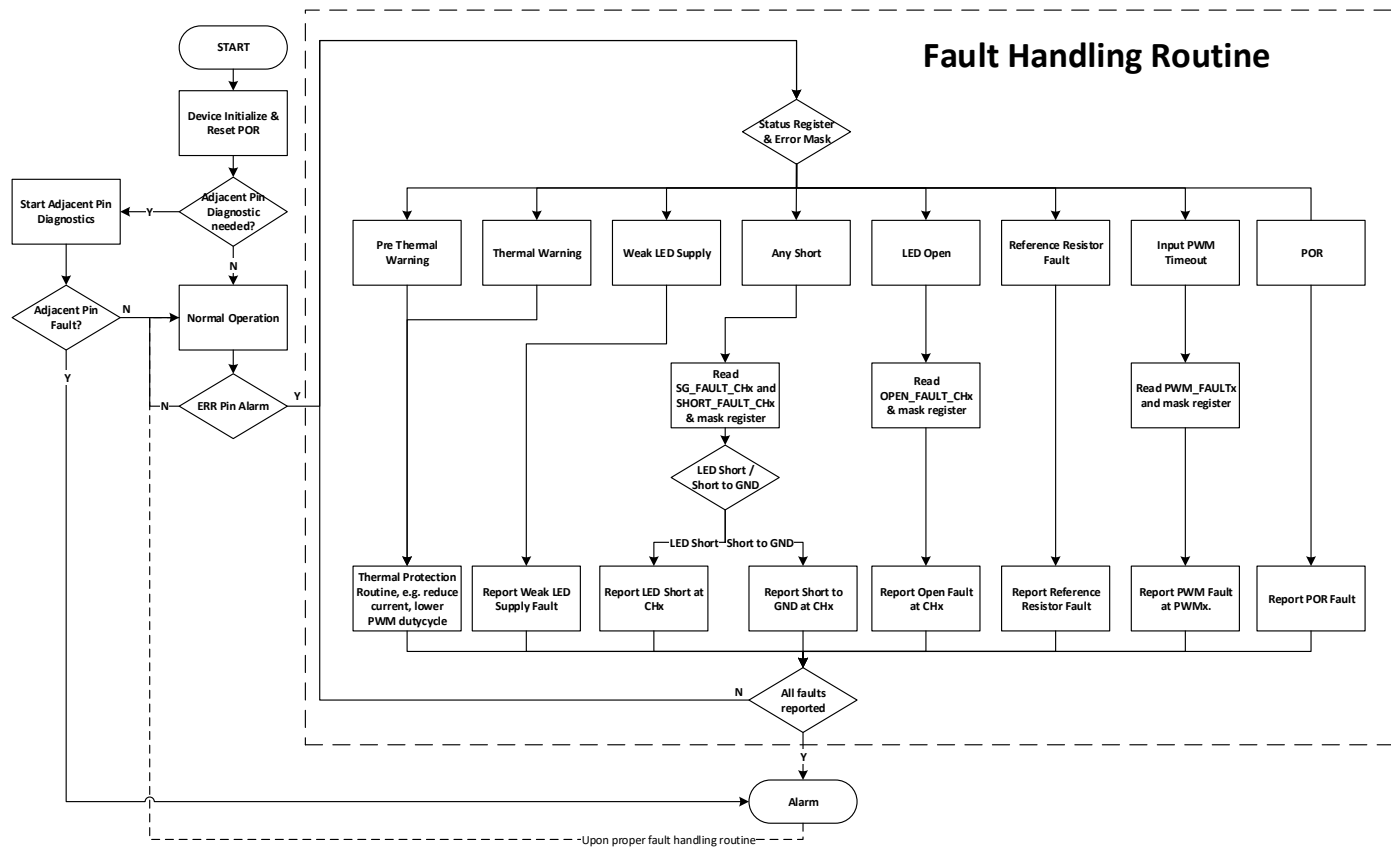
Product Analysis(Const. Current)

Part Number	TI TLC5926/27-Q1	TI TLC59116-Q1	TI TLC5941-Q1	TI TLC6C5712-Q1	TI TLC6C5724-Q1
Vout_max	17V	17V	17V	7V	7V
CH #	16	16	16	12	24
Iout_max	120mA	120mA	90mA	75mA	50mA
CH-CH	3%	6%	8%	3%	7%
Dev-Dev	6%	8%	8%	3%	4%
PWM	External, Global by OE pin	Internal, 8-bit	Internal, 12-bit	External, 6 PWM inputs	Internal, 12 bit
Dot Correction	8-bit global DC	8-bit global DC	6bit, channel individual	8-bit individual	7-bit individual DC 8-bit group BC
Slew Rate control	No	No	No	2 options	2 options
Interface	Serial I/F	I2C	Serial I/F	SPI	Serial I/F
Diagnostics	LED Open LED Short Individual CH OTP	LED Open Individual CH OTP	LED Open	LED Open LED Short Short to GND CH Off Diagnostics Adjacent Pin Short Force error	LED Open LED Short Short to GND Adjacent Pin Short
Package	HTSSOP-24	TSSOP-28	HTSSOP-28	HTSSOP-28	HTSSOP-38
Temperature	-40C to 125C	-40C to 105C	-40C to 125C	-40C to 125C	-40C to 125C

Digital Cluster Block Diagram-FPDLink

Off-Battery Power
- Pre-Boost
- Wide Vin Buck
- Wide Vin Buck/Boost
- Wide Vin LDO
- Wide Vin Switch
- Reverse Battery Protection
- Over Voltage/ Over Current Protection

Cluster System Power
- High-Side Switch
- Mid/Low Vin Boost
- Mid/Low Vin Buck/ Boost
- MID/LO Vin LDO
- MID/LO Vin Multi-Rail DC/DC
- MID/LO Vin Buck
- PMIC

System Power

Camera Interface and Driver Monitoring
- Camera Module
- Serializer
- Deserializer
- Video MUX
- Analog Video Decoder
- LVDS
- (IR) LED Driver
- ESD Protection

Engine Monitoring
- OPAMP
- SAR ADC
- Voltage Reference

Applications Processor
- CAN
- RS232 Transceiver
- Ethernet PHY
- Ethernet ESD Protection
- Voltage Translator
- Applications Processor
- FLASH
- DDR
- DDR Termination

Cluster System Control and Monitoring
- CAN Transceiver
- LIN Transceiver
- Voltage Supervisor
- MCU
- Reset
- Supervisor with Watchdog Timer
- RS485 Transceiver
- ESD Protection
- Comparator
- Analog MUX
- Current Sense Amplifer
- Analog Switch
- Temperature Sensor
- IO Expander

Display Support and Backlight Control
- Display Module
- LCD Panel
- Gamma Buffer
- LCD Bias Supply
- Temperature Sensor
- Ambient Light Sensor
- ESD Protection
- Backlight LED Driver

Driver Notification
- OPAMP
- Tell-Tale Drivers
- Audio DAC
- Class AB or Class D Audio Amplifier

Digital Logic and Voltage Translation
- I2C Level Translator
- Bidirectional Voltage Translation
- Digital Logic
- Non-Inverting Buffer/Driver
- Voltage Translator

TEXAS INSTRUMENTS

Digital Cluster with Active Graphics Support
Functional Blocks that Define the System

VBAT

Off-Battery Power
- Input Power Protection
- Non-isolated DC/DC
- Current/Voltage Sense

GPIO

Vehicle Interface Processor
- Digital Processing
- Self-diagnostics/Monitoring
- **Wired Interface**

Vehicle CAN/LIN Bus

Required

Option by OEM

I²C/SPI

Integrated Display
- Wired Interface
- Signal Input/Output Protection
- Input User Interface
- Output User Interface

RGB / OLDI / LVDS

Applications Processor
- Digital Processing
- Clocking
- Non-isolated DC/DC
- Memory
- Wired Interface

Driver Notification
- Power Stage
- Signal Input/Output Protection
- Output User Interface

Monitoring Camera Interface
- Wired Interface
- Input Power Protection
- Signal Input/Output Protection

Analog / YUV / CS-2

Remote HUD Interface
- Wired Interface
- Signal Input/Output Protection
- Power Stage

TEXAS INSTRUMENTS

TI Ethernet & FPD-Link™ Product Line

Infotainment FPD-Link III SerDes

ADAS FPD-Link III SerDes

Automotive 100M & 1G Ethernet
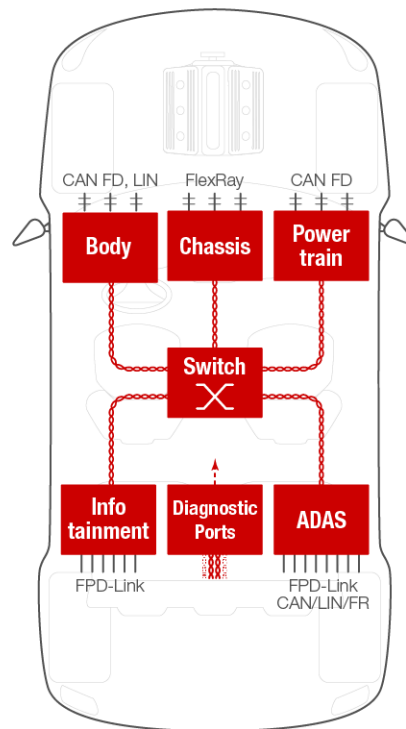
Automotive PCIe Gen 3

TEXAS INSTRUMENTS
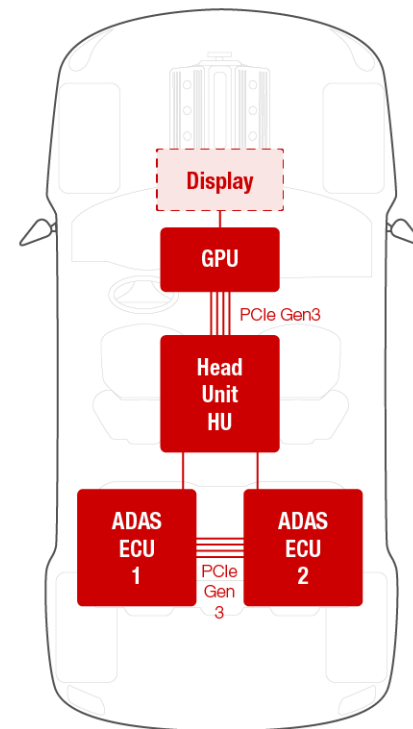
What is FPD-Link™

- What does FPD-Link™ stand for?
  - Short for **F**lat **P**anel **D**isplay **Link**

- What does it do?
  - Transports high-speed data such as video over a twisted pair or coax cable
  - Supports a variety of video interfaces (RGB, OpenLDI (LVDS), MIPI CSI-2 & DSI, HDMI)
  - Aggregates video, audio and clock as well as bi-directional data onto one stream

- What are the use-cases?
  - Automotive Infotainment & Cluster: data transfer between ECU and display
  - Automotive ADAS: data transfer between imagers, radar or other sensors to ECU

FPD-Link™ Learning Center Videos Online

Visit the FPD-Link™ Learning Center!!

Training Subjects:
1. Introduction to FPD-Link SerDes
2. Diagnostic & Data Protection
3. FPD-Link Parameters & Transmission Channel
4. Power over Coax (PoC)
5. Interfaces
6. Tools

Starting an FPD-Link™
design today?

Texas Instruments FPD-Link™
Learning Center can help light the way

● Learn more

TEXAS INSTRUMENTS

HDMI、(e)DP、MIPI（CSI& DSI）

HDMI

(e)DP

MIPI

TEXAS INSTRUMENTS
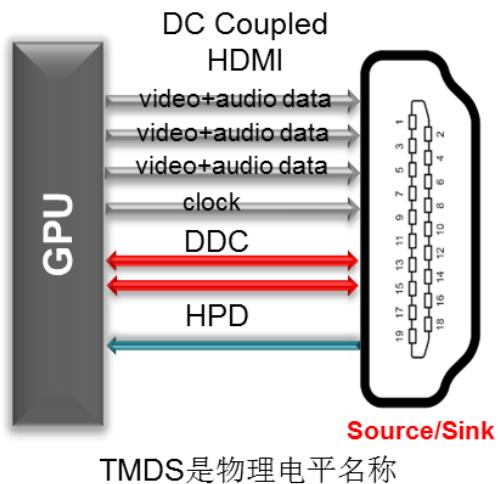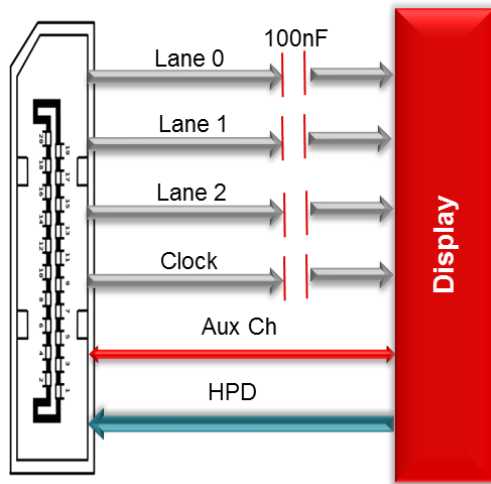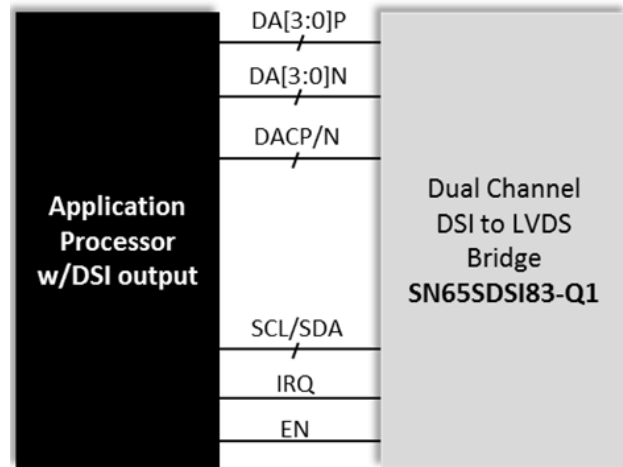
RGB ribbon cable – short Vs 10m distance

TEXAS INSTRUMENTS

The Challenge – Our Solution

HOST **LCD**

FPD-Link LVDS Interface
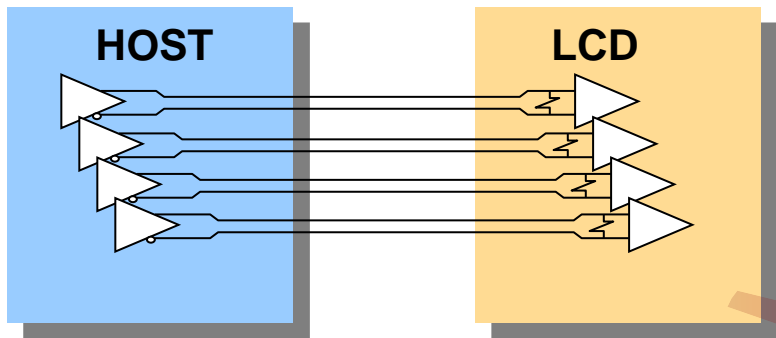
- *3 Data + 1 Clock = 8 wires = More Co$t*
- *DC Direct Connection*
- *No DC Balance Support*
- *No AC Coupling Support*
- *Cable Length: ~1 (2) Meter*

- *2 Wires*
- *AC Coupled Interface*
- *DC Balance Support*
- *Pre-Emphasis & Double Vod*
- *Cable Length ≥ 10 Meter*

FPD-Link Interface

HOST **LCD**

TEXAS INSTRUMENTS
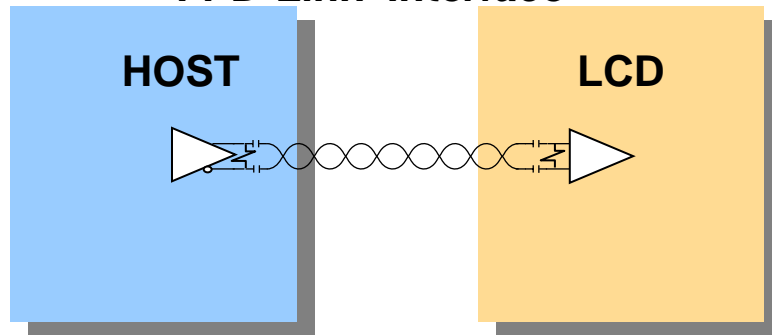
FPD-Link™ Legacy

FPD-Link I	FPD-Link II	FPD-Link III
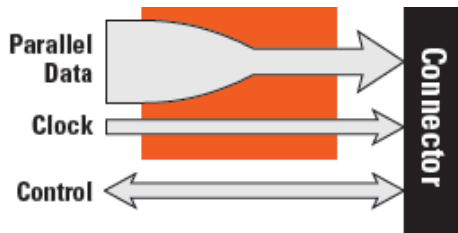
Parallel Clock

Many to Less

- 3/4 Data + 1 Clock = 8 wires
- Cable length ~ 3 meter
- Lower EMI
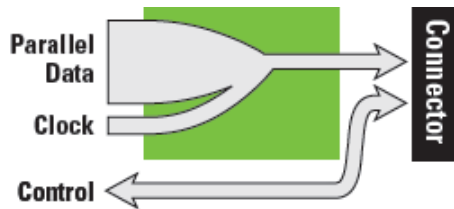
Embedded Clock

Many to One

- 2 wires (plus control)
- Up to 1.8 Gbps
- Cable length ≥ 10 meter
- Reduced weight
- No ground currents on cable
- AEC-Q100, ISO 10605

Embedded Clock and Control

Do More (on One)

- 2 wires only
- Up to 3 Gbps
- HDCP content protection (optional)
- Embedded control channel
- Adaptive equalization
- Built-in Diagnostics
- AEC-Q100, ISO 10605
- Great variety of video interfaces: RGB, OpenLDI (LVDS), MIPI CSI-2 & DSI, HDMI

...plus power transfer (PoC)!

TEXAS INSTRUMENTS

Continuous, Low-Latency Backchannel

Forward Channel Driver

Video →

Forward Channel Receiver

Control ↔

Back Channel Receiver

Back Channel Driver
No reference clock
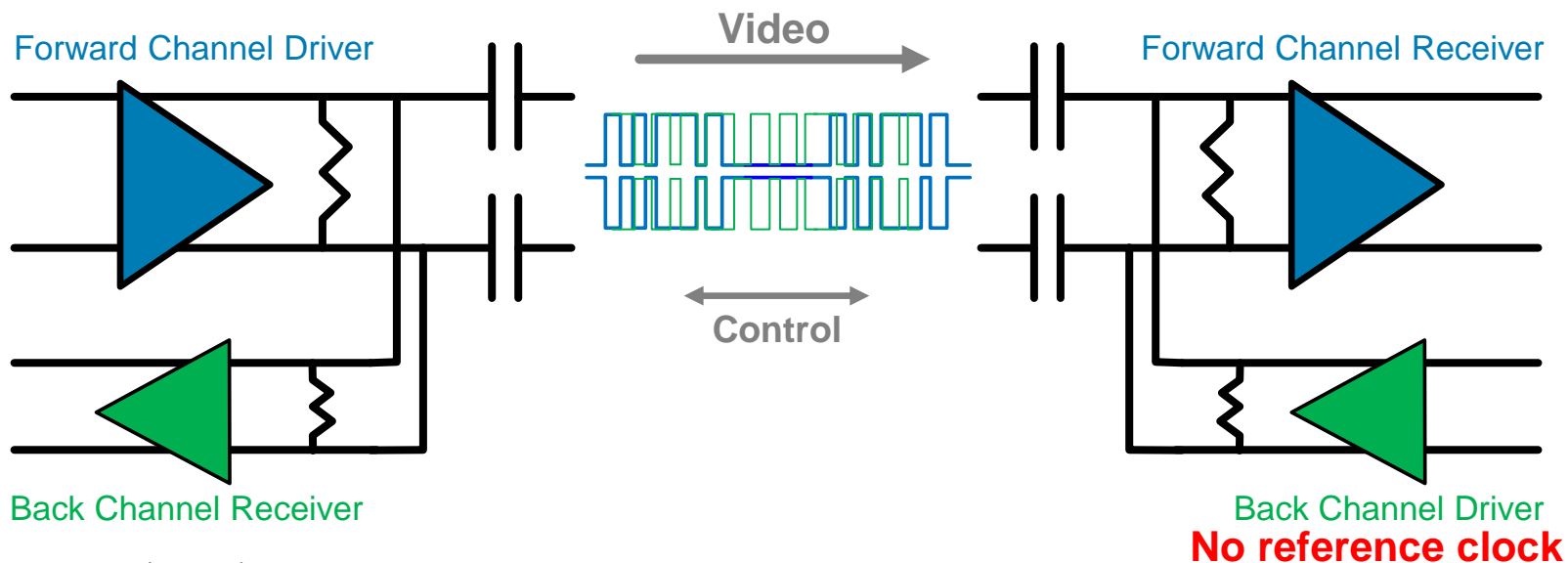
- Ultra-low (<15µs) latency
  - **Ideal for remote ISP & camera sync control**
- EMI friendly
  - No common mode modulation
  - No pre-emphasis or tuning

- No waiting for video blanking
  - **Backchannel sent continuously**
- Single pair
  - Works over coax & STP

TEXAS INSTRUMENTS

Common Automotive Video Links
with FPD-Link™

Video

Power *

Bidirectional Control

101010

Coaxial cable

Shielded Twisted Pair (STP) or Star Quad cable (STQ)

IVI
SoC
Sensor
ADAS

Video
Audio**
Clock***
Control/ GPIO

Ser

Des

Video
Audio**
Clock***
Control/ GPIO

IVI
Display
ECU
ADAS
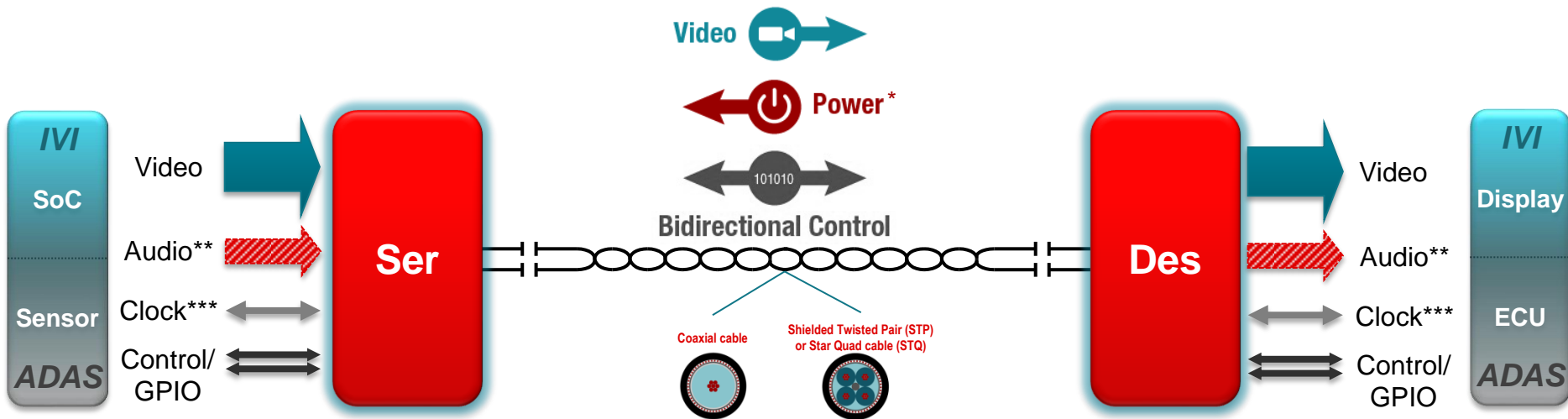
*: optional for ADAS devices (Power over Coax [PoC])
**: optional on certain IVI devices
***: SER → DES for IVI devices | DES → SER for ADAS devices

TEXAS INSTRUMENTS

FPD-Link™ Applications

Infotainment Displays

FPD-Link

**Automotive Cable
Point-to-Point**

FPD-Link

- 3D Surround View
- Rear View Camera
- Rear Cross Traffic
- Blind Spot Detection
- Lane Departure Warning
- Intelligent Headlamp Control
- Traffic Sign Recognition
- Forward Collision Warning
- Intelligent Speed Control
- Pedestrian Detection
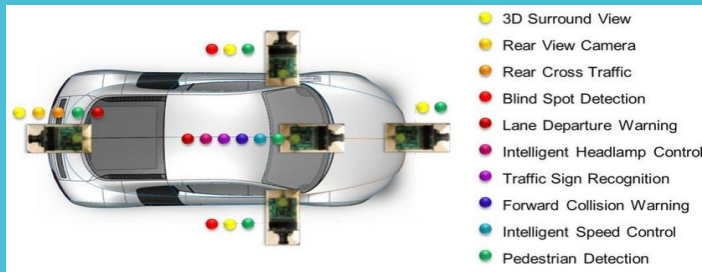
ADAS Surround View Cameras & Sensors

FPD-Link

**Automotive Cable
Point-to-Point**

FPD-Link

**Head-Unit
With ECU**

Aggregation of video, audio, GPIO, control (I^2C, I^2S) over one link and backward control

TEXAS INSTRUMENTS

ADAS and IVI

TEXAS INSTRUMENTS
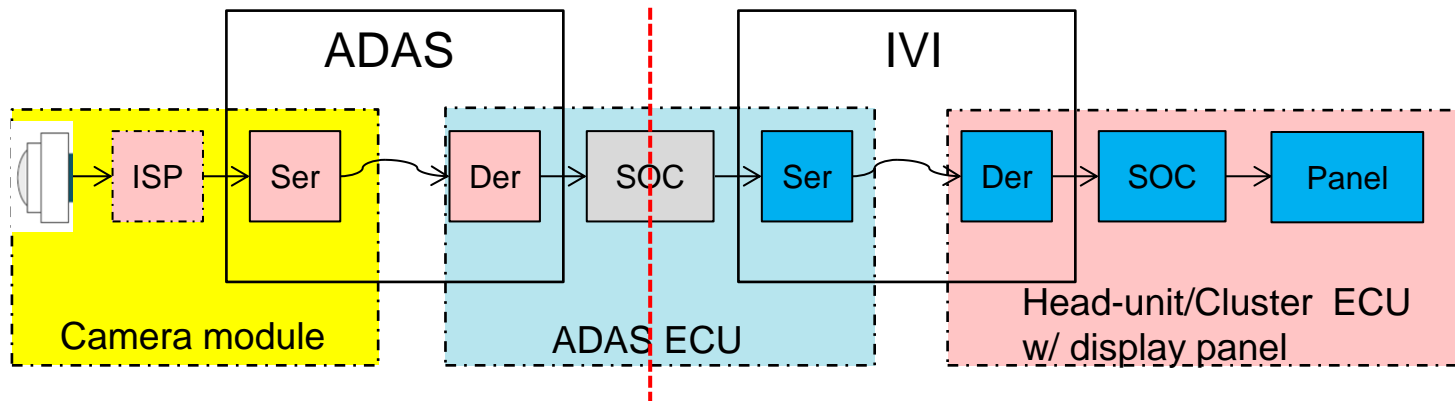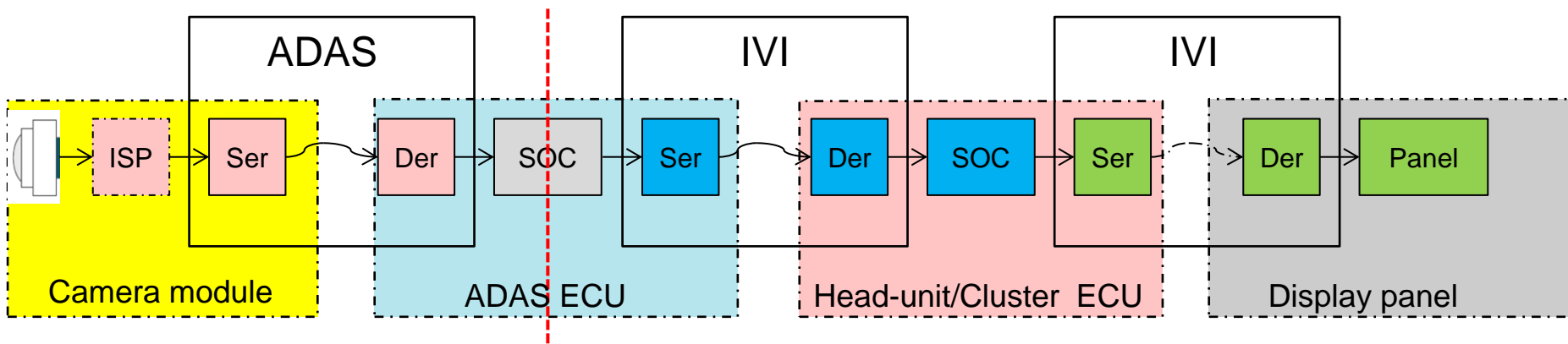
FPD-Link – IVI Portfolio
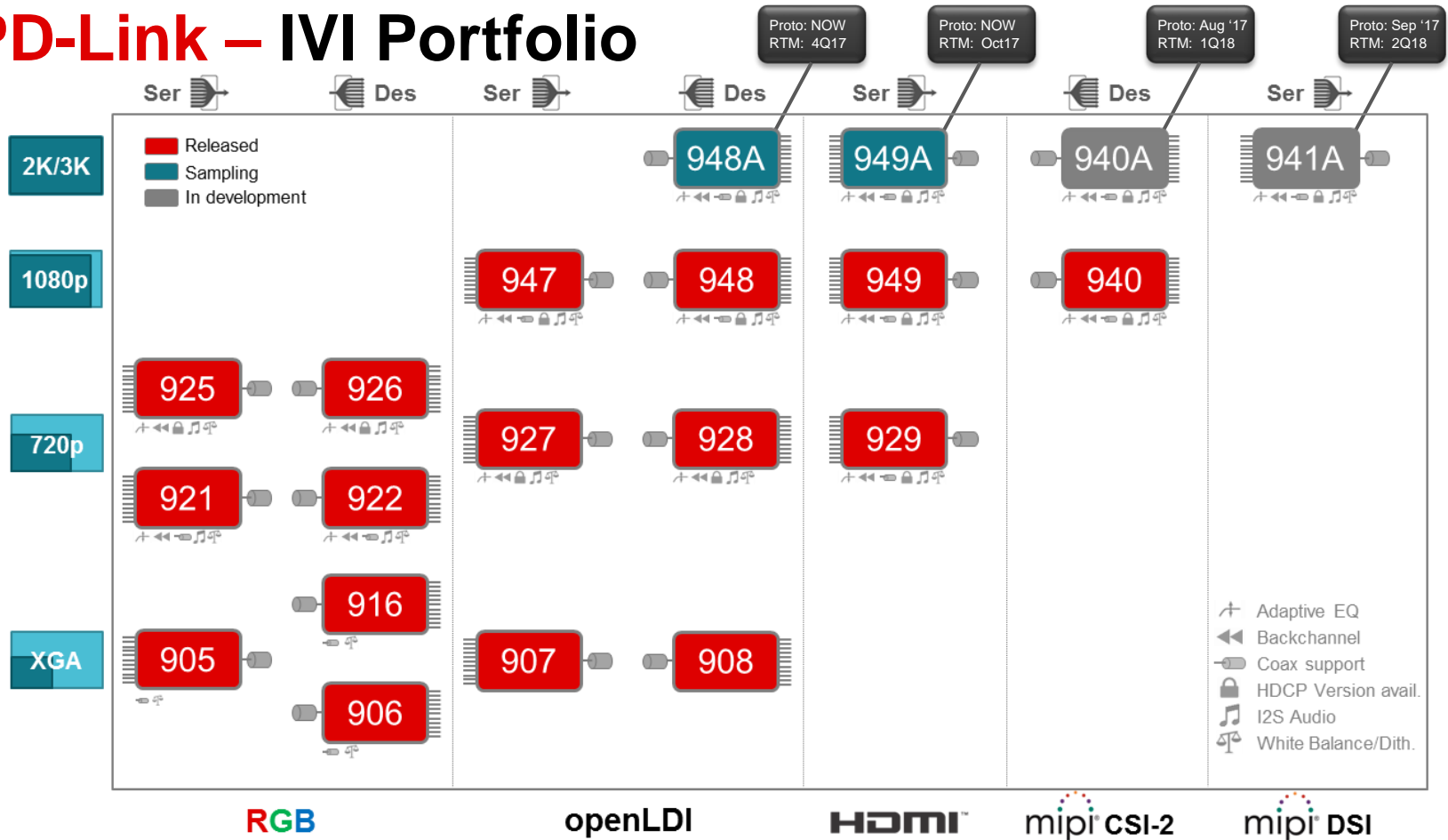
Advanced Adaptive Equalization

At Transmitter

After 10m Cable

After Adaptive EQ
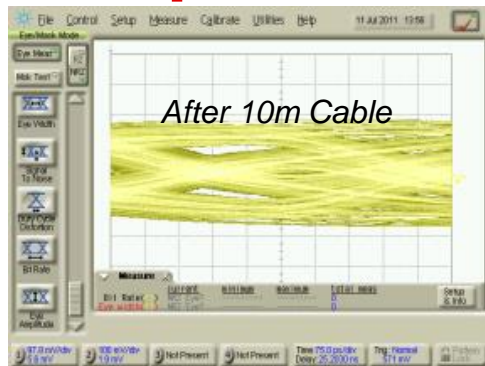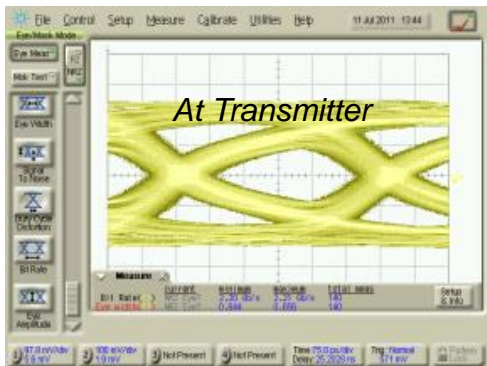
- Automatic algorithm
  - **No adjustment** – compensates for cable type, length, connectors, etc
  - **Adapts during power up**
- **Compensates** for cable ageing effects
- No EMI impact
- Diagnostic function
  - Read out EQ level to monitor cable health
- Supports future data rates over low cost cables

TEXAS INSTRUMENTS

FPD-Link Highlights

General

- Video, Bidirectional Control (I²C, SPI), GPIO and Power
  - Over single twisted pair or coaxial cable assemblies
- Adaptive equalization compensates for cable type, length, age and condition
- Multiple interface options: RGB, YUV, OpenLDI (LVDS), MIPI CSI-2 & DSI, HDMI

Infotainment

- Support for 720p, 1080p & 2K/3K
- Easy-to-use HDCP content protection
- Dithering, White Balance, and Test Patterns
- I²S audio plus I²S clock cleaning

ADAS

- Support for 1 and 2 Megapixel image sensors
- Very low latency
- Synchronized sensors with system clock → no oscillator on sensor side
- Easy frame synchronization using GPIO
- Deserializers with 2:1 input mux
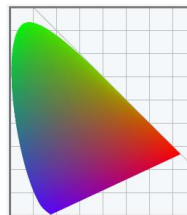
White balance
FRC Dithering

High-bandwidth
Digital Content Protection
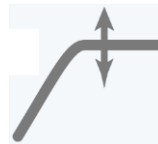
Adaptive Equalization   2:1 camera mux

TEXAS INSTRUMENTS

Link Diagnostics: Layered Protection

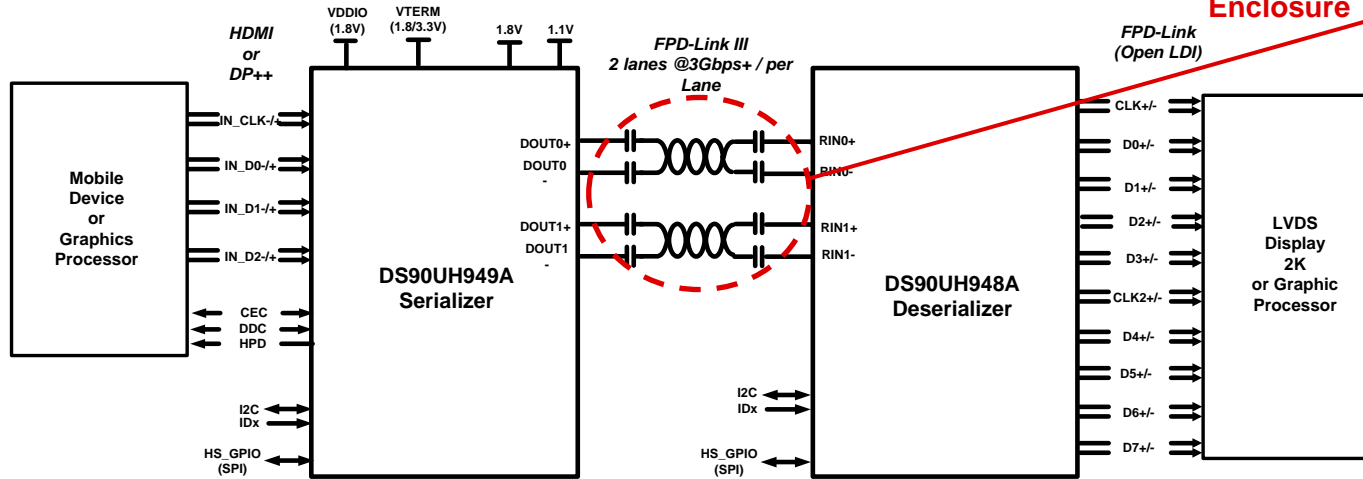|			
12	Pattern Generation	Generates video patterns for test	test mode
11	BIST	Bit error rate test	test mode
10	Prog. Interrupt	Programmable open drain interrupt pin flags errors to processor	always active
9	Prog. Alarm Bit *	Programmable alarm signal provides module health monitoring	always active
8	Voltage/Temp Meas *	Monitors up to 2 voltages as well as internal temperature	always active
7	Frame Count	Verifies no frozen frames (note: frame count is sent by imager)	always active
6	I2C Write Protect *	Protects sensor module misconfiguration if I2C has bit errors	always active
6	CSI-2 CRC *	Verifies end-to-end link integrity and bit error rate	always active
5	SerDes CRC	Verifies SerDes link integrity and bit error rate	always active
4	CSI-2 Input Check *	Checks for data integrity from sensor data at input to 953	always active
3	Lock Detect	Verifies link established	always active
4	Internal Oscillator	Internal serializer oscillator establishes link even without clock	always active
2	Adaptive EQ Level	Read relative cable quality via I2C (7 levels)	set at power up
1	Link Fault Detect	Cable open, + to - short, short to ground, short to battery, incorrect link	always active

*: 953/954 for ADAS only

☐ test mode   ☐ normal operation

TEXAS INSTRUMENTS

Display & Camera Resolutions – today

FPD-Link III

800 x 480 — **WVGA**

1280 x 720 — **720p HD**

1280 x 960

1920 x 1080 | 2048 x 1080 — **2K 1080p HD**

1920 x 1200

1.0   1.2 1.3   2.0   2.3 **Megapixels**

TEXAS INSTRUMENTS
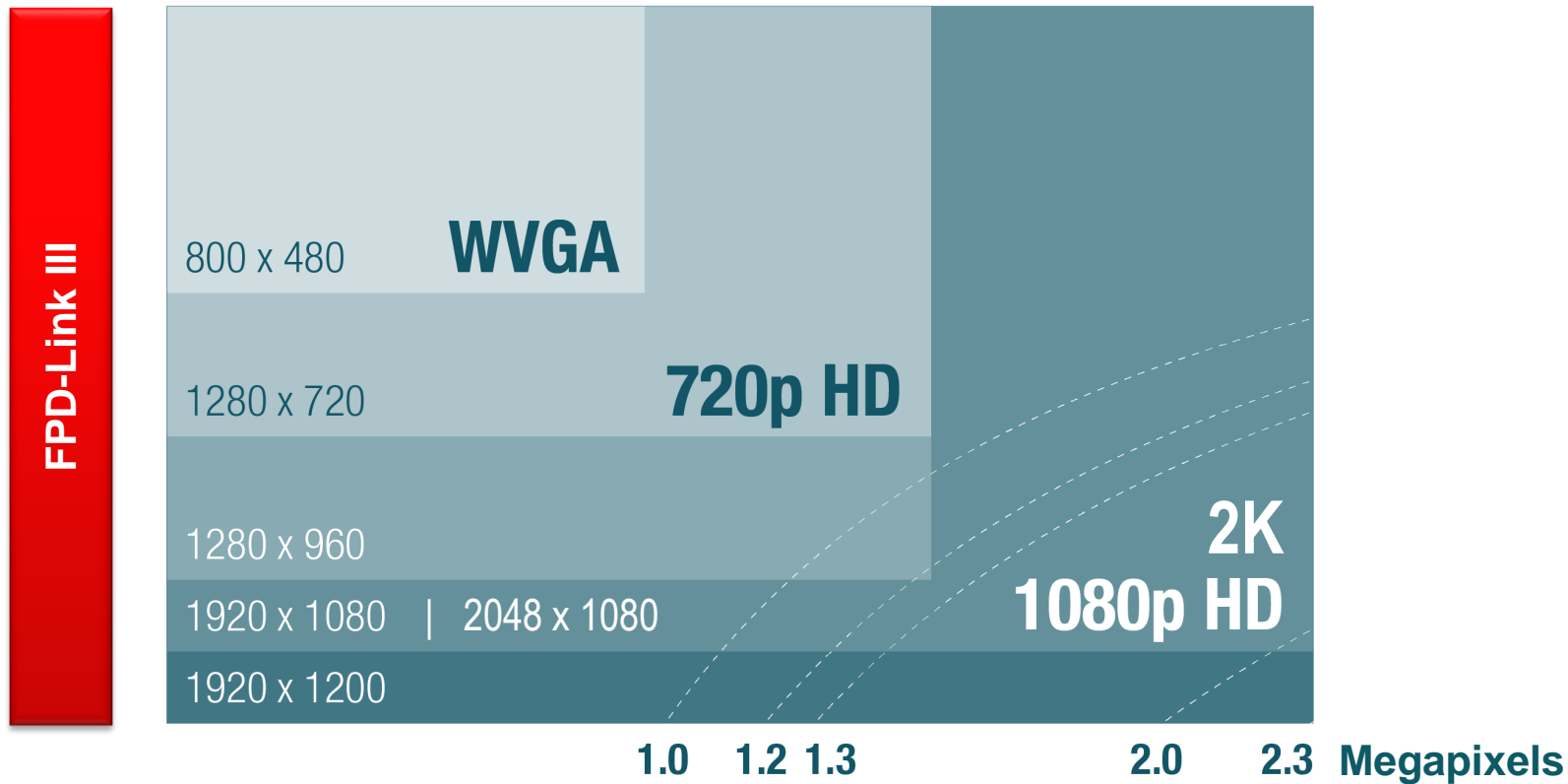
DS90Ux94xA
for 2K/3K Applications
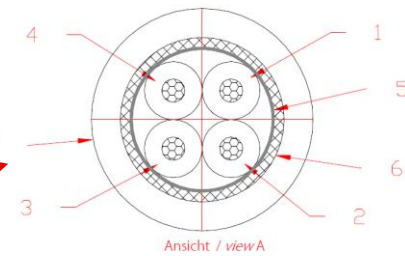
STQ cable

- Supports Pixel Clock up to **210MHz** for 2K resolution

- **2880 x 1080 @60fps**

- Dual lane FPD-Link III

- **Backward compatible** to 720p generation (DS90Ux92x)

- High Speed **Bidirectional GPIOs** up to 2.5MHz in the back channel, OR

- SPI control interface up to 3.3Mbps via the backchannel

- I²C Control Interface up to 1MHz

TEXAS INSTRUMENTS

FPD-Link Value Proposition

- Most comprehensive Infotainment SerDes product portfolio in the industry
  - RGB, OpenLDI, CSI-2 MIPI, HDMI, DSI interfaces, …and adding more
  - QVGA, WVGA, 720p, 1080p and 2K/3K display support, …and beyond
- Benefits from forward and backward compatibility between existing 92x & 94x product families – it applies to future families as well
- Migration path to 1080p and 2K/3K displays
  - 1st in the Industry
- Adaptive cable equalization
  - 1st in the industry
- On-chip HDCP memory
  - 1st in the industry

TEXAS INSTRUMENTS

Summary

Digital Cluster Application Key Part:

- Wide Vin DCDC: LMR33630/20-Q1 LM73605/6-Q1

- High Performance Backlighting: LP8863

- Diagnostic LED Tell-Tale: TLC6C5712-Q1

- Automotive Connectivity Solution: FPDLINK Brief

TEXAS INSTRUMENTS

Thanks

TEXAS INSTRUMENTS