LED Lighting Solutions for Traffic Signals

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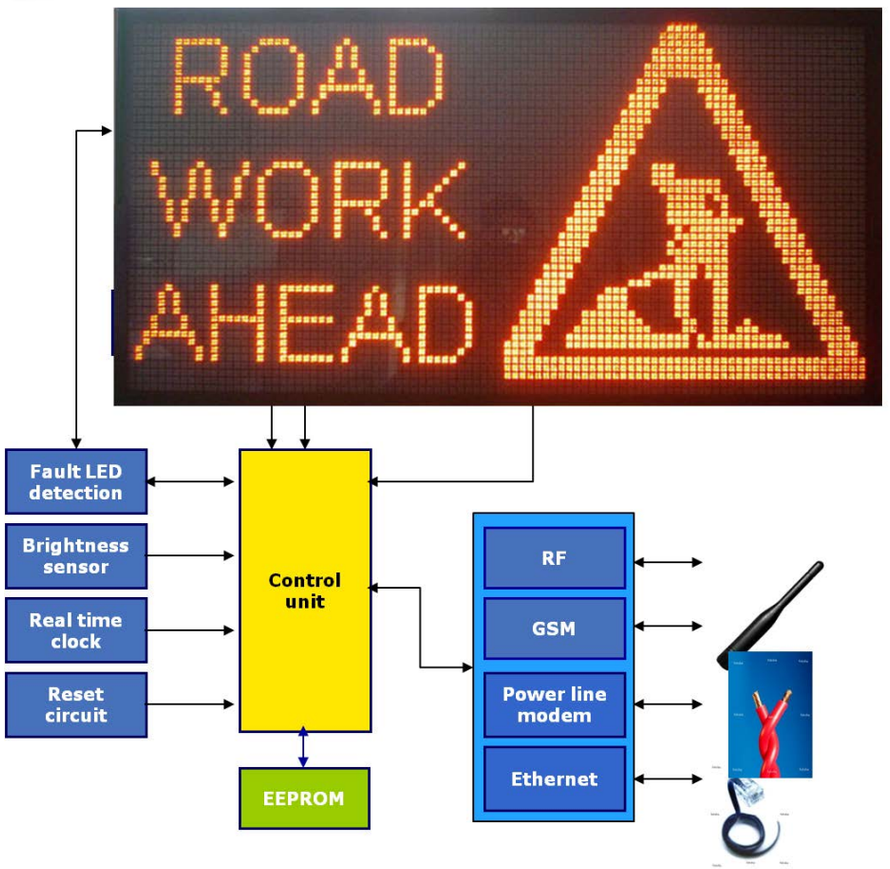

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ST Position:

- #1 in Lighting Segment*
- #2 in Power Management**

ST Expertise:

- System Solutions
- Technology Integration and Innovation
- Excellent Technical Support

*STMicroelectronics, Datapoint and Darnell - 2008
**iSupply - 2010

Content

- LED Lighting Solutions for Traffic Signals
  - LED Array Driver Features/Benefits
    - Error Detection/Diagnostics
    - Auto Power Savings/Shutdown
    - High Precision
    - Balanced Turn-on/off
  - System Evaluation Boards and Tools
    - HB LED driver solution with Diagnostics (32, 40 LEDs)
    - 16 x 32 LED Matrix Display Panel
    - RGB LED driver for Color Displays and Backlighting
    - High Brightness LED Array Dimmer Solution
    - RGB Moving Message Display System
    - LED Driver w/PWM Dimming and Boost Converter Solution

LED Lighting Solutions for Traffic Signals

Main LED applications:
- Traffic Panels/Matrix
- Aviation
- Rail
- Navigation
- Emergency/Police Signals
- Cross Light

STP08DP05, STP16DP*05, STP24DP05 Families, LED7706/7

STPXX Array Drivers
- Constant-current drivers, set by only one external resistor
- Serial data and clock resynchronization
- High current and high precision
- Thermal shutdown
- Error detection and auto power-saving

LED7706/7 DC/DC Converters

LED Array Driver general portfolio

STPXXYY05 Series Features

- Absolute Output Voltage up to 20V
- Output Enable frequency up to 1MHz
- SDI and CLK re-synchronized device by device w/o use of CLK falling edge
- Analog Thermal Shutdown protection
- Clock frequency over 30MHz,
- TSSOP package with exposed pad

Extended Junction Temperature range of – 40° to125 C

C= Constant current

P= Precision

PP = Precision and lower output current range (3-40mA output current)

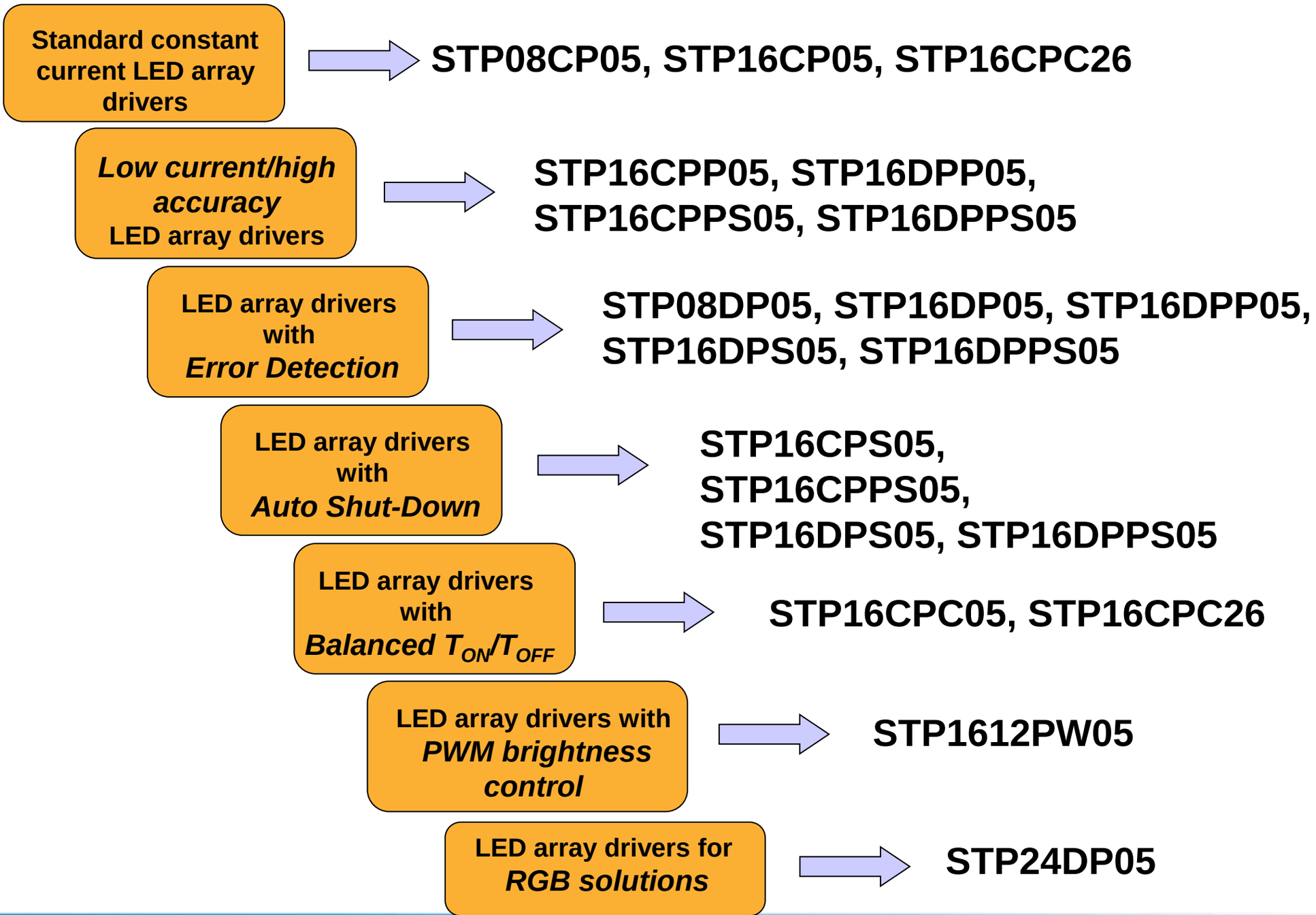
D= Error Detection/Diagnostic

S = Auto-Shutdown

Part Number	Description	Iout	Bit Prec.	Chip Prec.	Evaluation Board
STP08CP05	8-bit C.C. LED driver	5-100mA	+/-1%	+/-3%	**STEVAL-ILL009V5**
STP08DP05	8-bit C.C. LED driver w/Diagnostics	5–100mA	+/-1.5%	+/-5%	**STEVAL-ILL002V3** **STEVAL-ILL002V4**
STP16CP(P)(S)05*	16-bit w/AutoPower-Saving	5–100mA	+/-1.5%	+/-5%	**STEVAL-ILL003V2**
STP16DP(P)(S)05	16-bit with Diagnostics	5–100mA	+/-1.5%	+/-5%	**STEVAL-ILL025V1**
STP1612PW05	16-bit w/12/16 bit e-PWM	3–80mA	+/-1.5%	+/-6%	**STEVAL-ILL028V1**
STP24DP05	24-bit with Diagnostics	3–80mA	+/-3%	+/-8%	**STEVAL-ILL015V1**

***Also available as STP16CPC05, STP16CPC26 with balanced turn-on/turn-off feature**

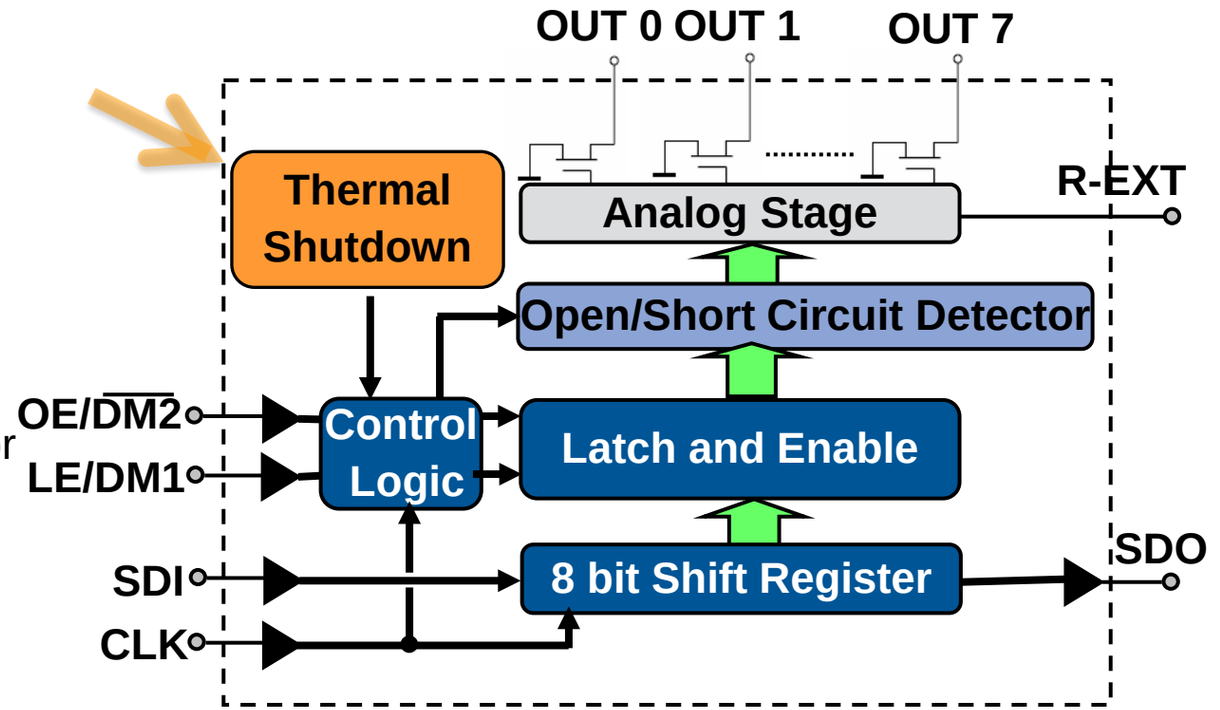
LED Array Drivers Portfolio w/Features

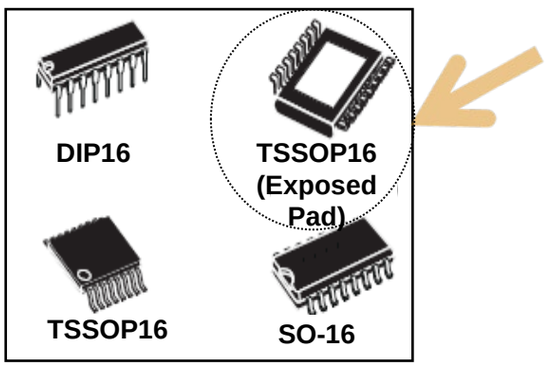


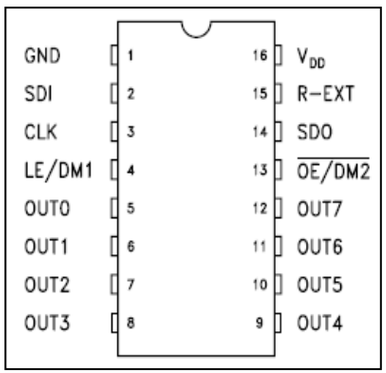
STP08DP05 – 8 ch, 5-100ma Drivers

Key Features:

- **Short and open output error detect**
- Low-voltage power supply (3V – 5.5V)
- 8 constant-current output channels
- 8-bit shift register
- Serial data IN/parallel data OUT
- Output current: 5-100 mA
- Adjustable output current thru ext resistor
- Maximum clock frequency: 30 MHz
- 3.3V microcontroller driver-able
- Current accuracy: +/-1.5% between bits
  - STP08CP05: +/-3% between ICs
  - STP08DP05: +/-5% between ICs
- ESD protection: 2.5 kV HBM, 200V MM
- Extended thermal shut-down and protection features







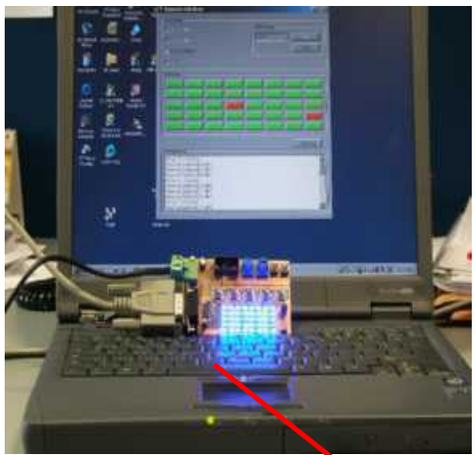
STP08DP05 LED Driver w/Diagnostics

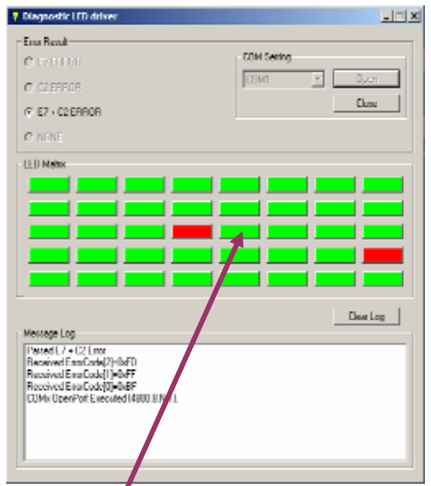
Evaluation Board Solutions

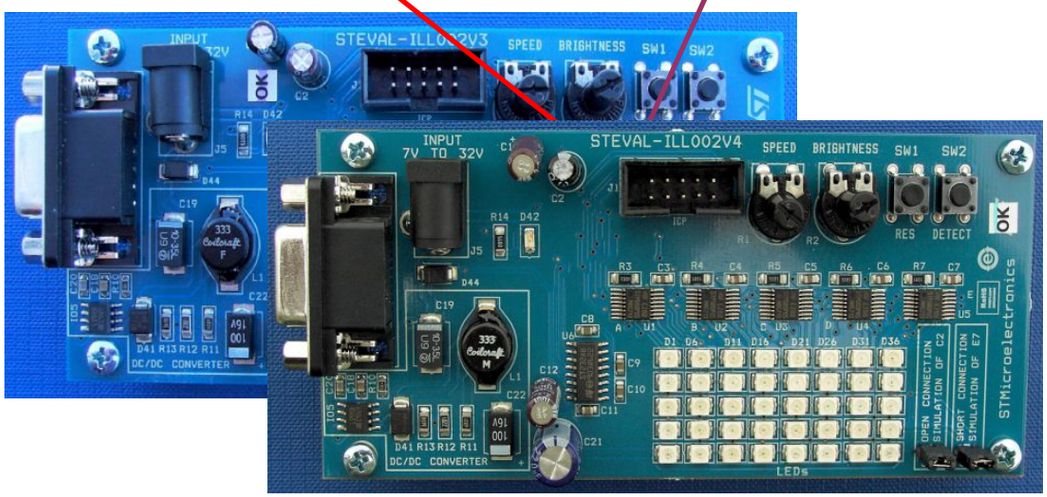
Key Features:

40 LED Matrix with

- **Error detection**
- Current regulation
- Adjustable brightness
- Animated text implemented
- Adjustable blinking speed
- GUI SW for LEDs diagnostic
- Input voltage from 7V to 32V
- DC/DC Converter for high efficiency
- Standard supply connector







Key Products:

- STP08DP05 LED constant current driver
- ST7FLite39 8-bit microcontroller (10-bit ADC, SPI, SCI communication)
- LE50AB Linear voltage regulator
- ST3232C RS-232 Drivers and Receivers
- L5970D DC/DC Converter

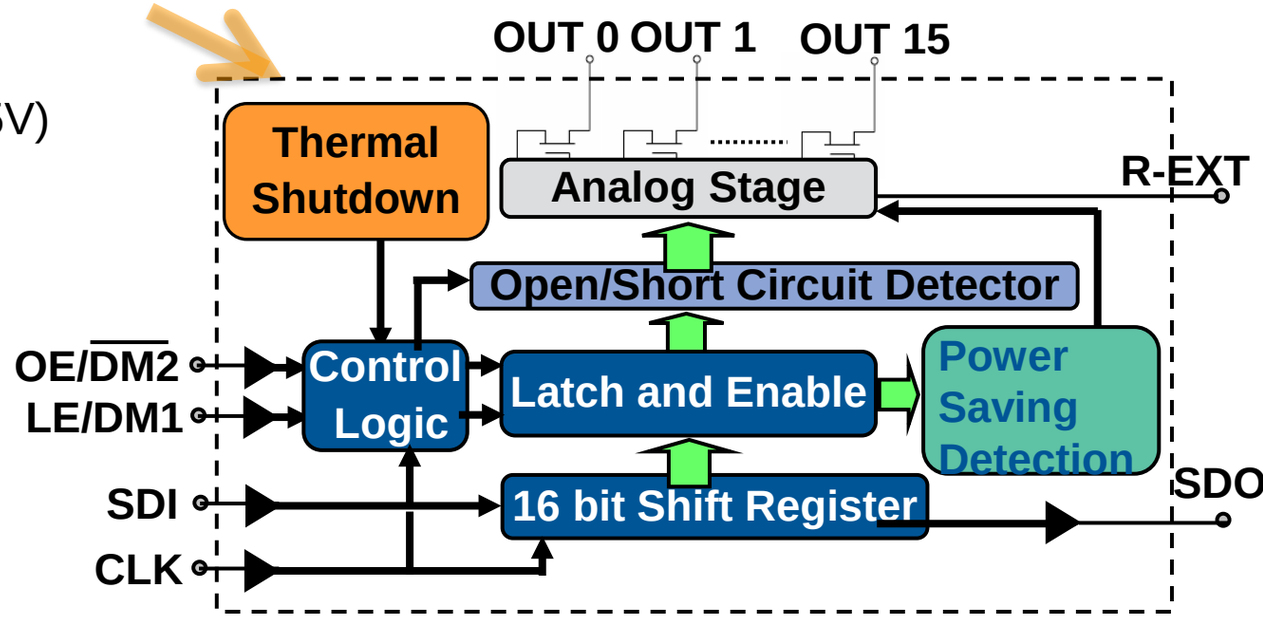
Evaluation board	App note	Description
STEVAL-ILL002V3 (Osram LEDs) **STEVAL-ILL002V4 (Vishay LEDs)**	**AN2478, AN2415**	**High-brightness LED driver with diagnostics (40 LEDs) demonstration board**

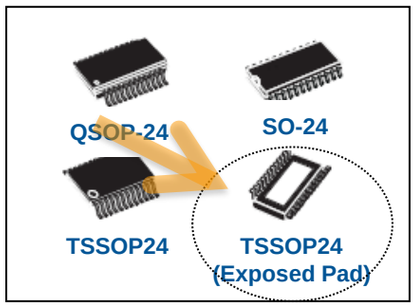
STP16CP(S)05 or STP16DP(S)05

16 channel, 5-100mA LED Array Drivers

Key Features:

- Low-voltage power supply: (3V to 5.5V)
- 16 constant-current output channels
- 16-bit shift register
- Output current:
  - 5 to 100mA for STP16*P05 series
- Adj output current - ext resistor
- 3.3 V microcontroller drivable
- Maximum clock frequency: 30 MHz
- Current accuracy:
  - +/-1.5% between bits
  - +/-3% between ICs
- ESD protection: 2.5 kV HBM, 200V MM
- Extended thermal range and protection features
- **Short and open output ERROR DETECT:**
  - **STP16DP05 and STP16DPS05**
- **Auto Shut-Down:**
  - **STP16CPS05 and STP16DPS05**
- **Bal output rise/fall time, typ 100ns:**
  - **STP16CPC05**



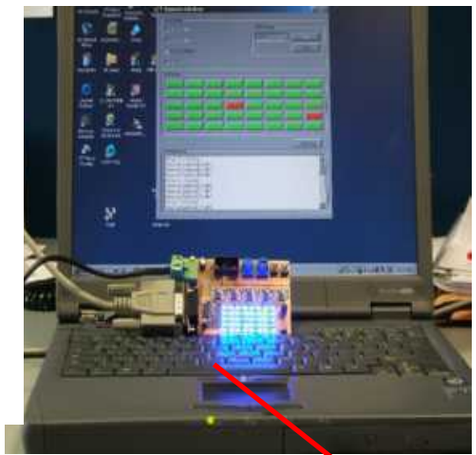


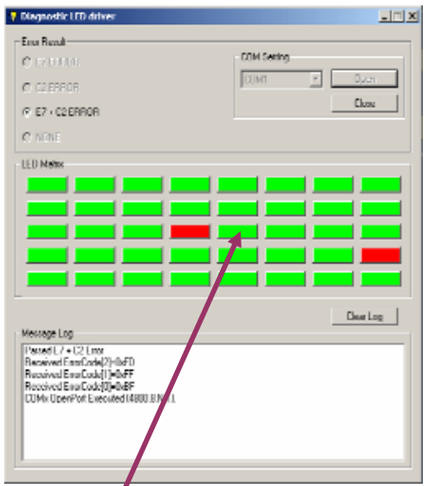
STP16CP/DP05 LED Driver Eval Board

Key Features:

32 LED Matrix with

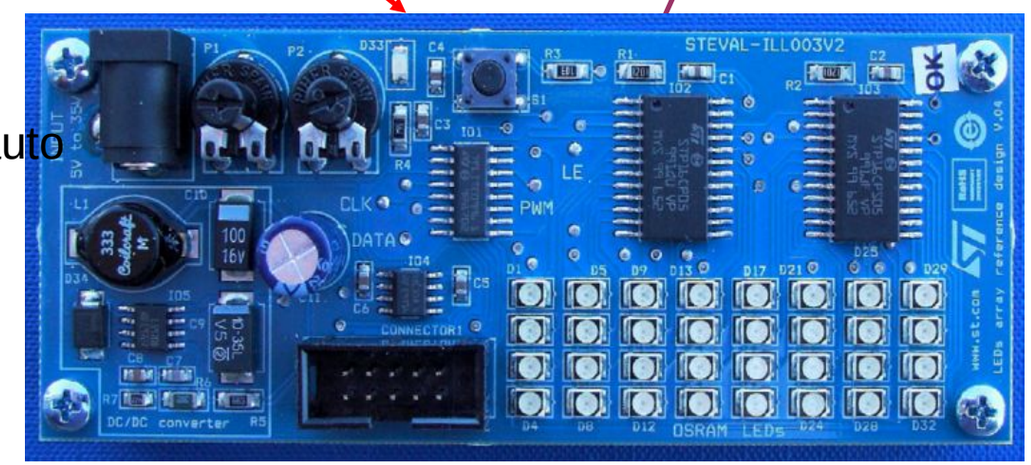
- Current regulation
- Adjustable brightness
- Animated text capability
- Adjustable blinking speed
- GUI SW for LEDs diagnostic
- Input voltage from 5V to 35V
- DC/DC Converter for high efficiency





Key Products:

- STP16CP05 LED constant current driver
- STP16CPS05 LED constant current driver w/auto power saving/shut down
- ST7FLite09 8-bit microcontroller
- L78L33AC Voltage regulator
- STPS340U Schottky diode
- L5970D DC/DC converter



Evaluation board	Application note	Description
STEVAL-ILL003V2	**AN2141**	**High-brightness 32-LED evaluation board without diagnostic based on the STP16CP05 LED driver**

STP16DP05 LED Driver w/Diagnostics

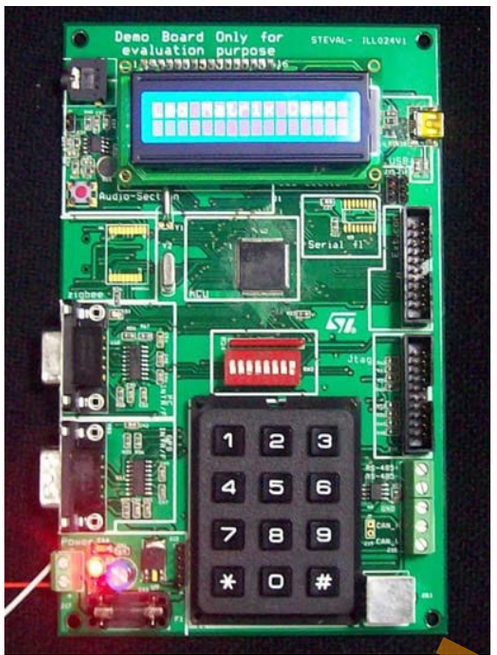
Evaluation Board Solution

Key Features:

- 16 x 32 LED Matrix display with STP16DP05
- Mother/slave board for LED display based on STM32 uCtlr
- Supports up to 8 add'l display units in series
- Controlled by a single control unit supporting up to 254 display units
- Configurable through Windows HyperTerminal via serial interface and thru PS2 keyboard
- GPS Interface
- Audio Output -Playback of Pre-recorded .wav files

Key Products:

- STP16DP05 LED display driver
- STM32F103 32-bit ARM-based microcontroller
- STM1001 Reset IC
- ESDALC6V1W Quad Transil



STEVAL-ILL024V1
LED Matrix Control Unit based upon STM32F103VB

STEVAL-ILL025V1
Shows Capability of STP16DP05 in driving Matrix LED Display panel

Evaluation boards	User Manual	Description
STEVAL-ILL025V1/STEVAL-ILL024V1 LED matrix control unit	**UM0767**	**Demonstration boards based on the STP16DP05 LED matrix driver and the STM32F103VB**

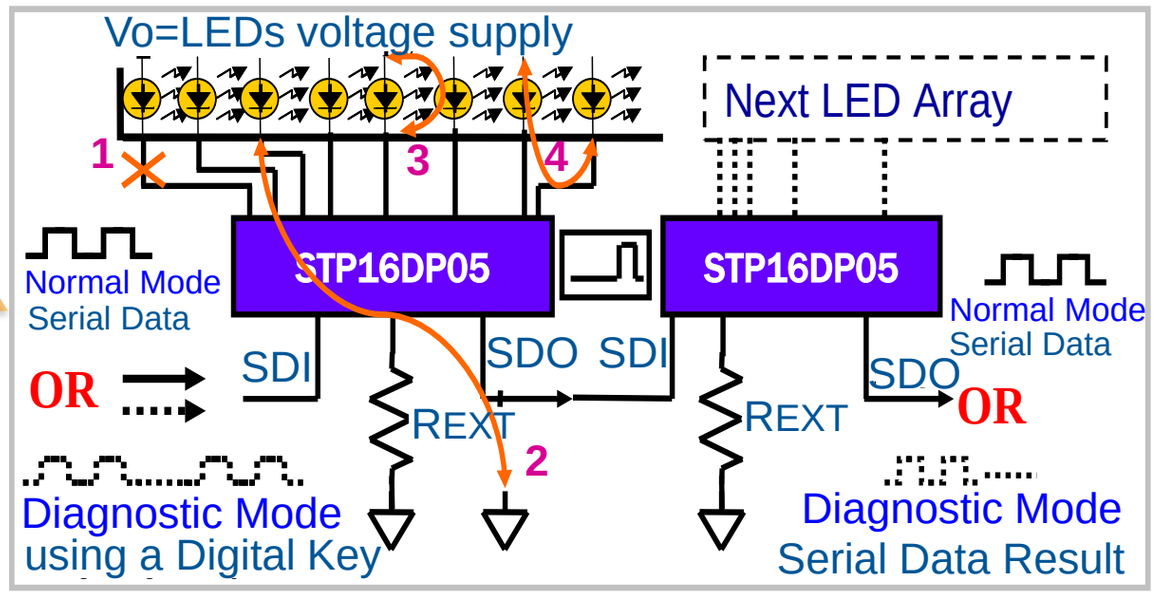
Error Detection/Diagnostic Mode

ERROR DETECTION → ***Detects Open and Shorts LED on the Output***

NORMAL MODE
Device works like a Constant Current LED Driver

DIAGNOSTIC MODE
The LED Driver enters the Diagnostic mode by using a *Digital Key* input to the SERIAL DATA IN

Detection conditions	Detection results
$I_{ODEC} \leq 0.5 \times I_O$	*OPEN LINE (1) or OUTPUT SHORT TO GND (2) detected*
$I_{ODEC} \geq 0.5 \times I_O$	NO ERROR DETECTED
$V_O \geq 2.4V$	*SHORT ON LED (3) or SHORT TO V_O (4)*
$V_O \leq 2.2V$	NO ERROR DETECTED



Error Detection availability: ***STP08DP05 ,STP16DP05, STP16DPS05, STP16DPP05, STP16DPPS05, and STP24DP05, STP24GPL05, and STP1612PW05***

AutoPower Saving/ShutDown Mode

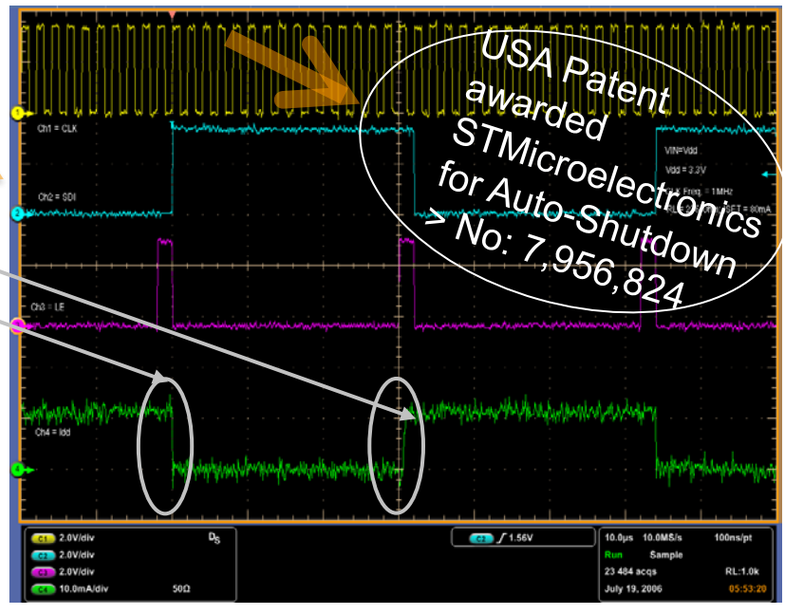
NO Active Data Latched → ***Automatically Shuts Down***

First Active Data Latched → ***Automatically Powers Up***

At Io = 80mA,

- **Active: $I_{DD\ (ON)}$ = 11.7mA (typ)**
- **Not Active: $I_{DD\ (Shut\text{-}down)}$ = 100uA (typ)**

$I_{DD(SHUT\text{-}DOWN)}$ is 117 times less than $I_{DD(ON)}$



EXAMPLE

- LED panel size: 10m x 5m
- Estimated number of LED Drivers: 10,000 pcs
- LED drivers active at any one time : ~ 20%

❖ Using std LED driver ➔ All 10,000 will consume high current (approx 117 A)

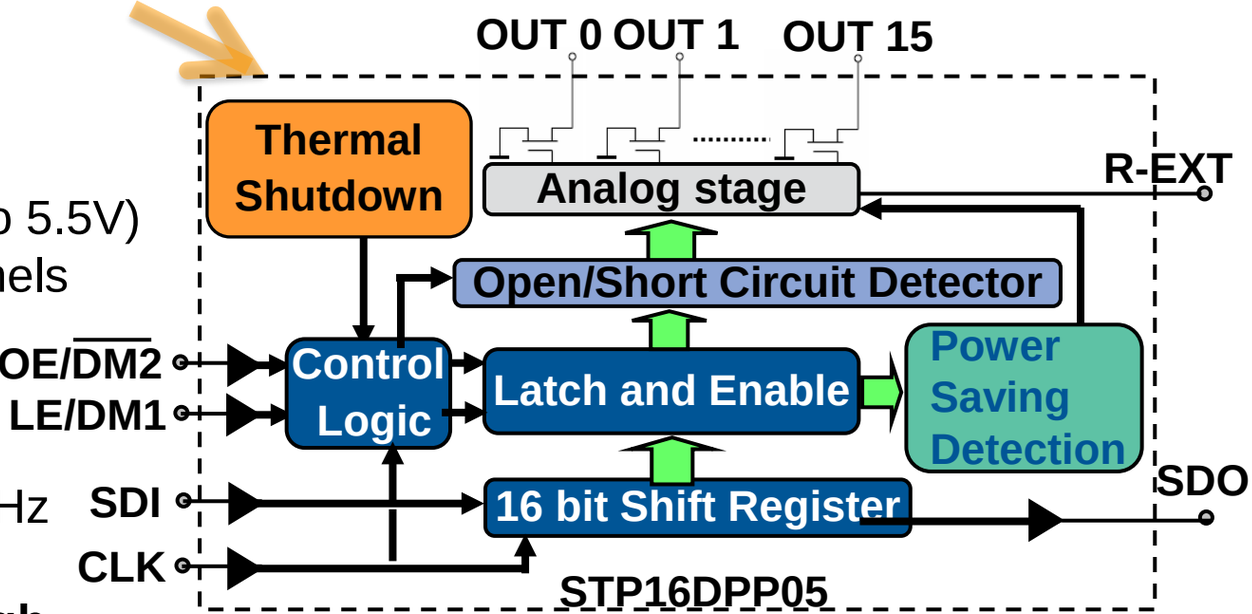
❖ Using STP16DPS05 ➔ Only 2,000 will consumer high current (approx 23 A)

Power savings using STP16CPS05 is ~ 80 %

Auto Shut-Down available in ***STP16CPS05, STP16DPS05, STP16CPPS05, STP16DPPS05***

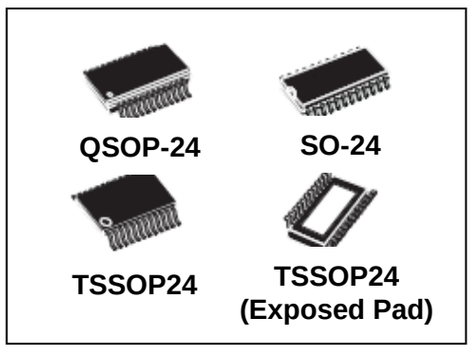
STP16CPP/DPP05 - 16 ch, 3-40mA

High Accuracy LED drivers



Key Features:

- Low-voltage power supply: (3V to 5.5V)
- 16 constant-current output channels
- 16-bit shift register
- Serial data in/parallel data out
- 3.3V microcontroller driver-able
- Maximum clock frequency: 30 MHz
- **Output current:**
  - **3 to 40mA (adjustable through external resistor)**
- **Current accuracy:**
  - **+/-0.5% @ 20mA**
  - **+/-2% @ 3mA**
- ESD protection: 2.5 kV HBM, 200 V MM
- Extended thermal range and protection features
- **Auto Shut-Down available:**
  STP16CPPS05 and STP16DPPS05



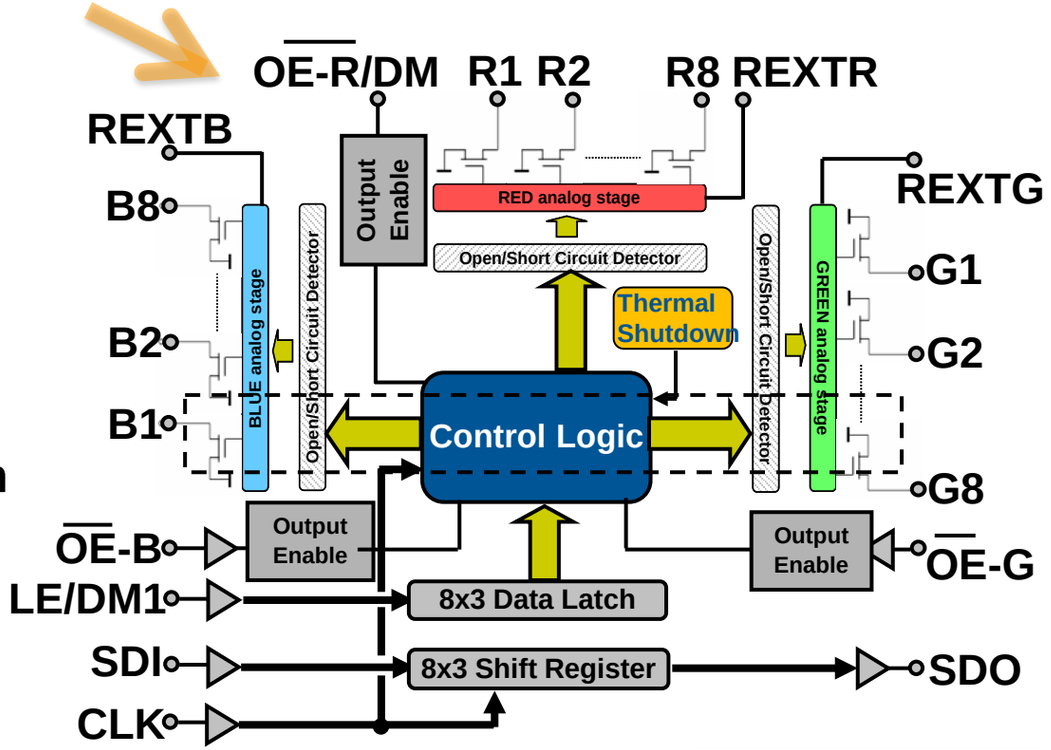
STP24DP05 – 24 channel, 5-80mA

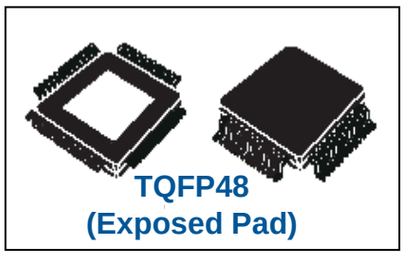
Key Features:

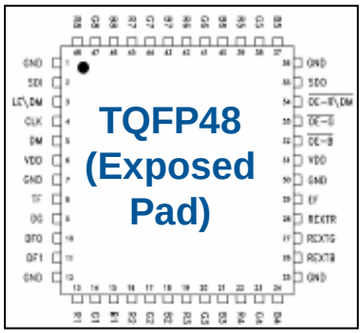
- Low-voltage power supply: from 3V-5.5V
- 24-bit shift registers
- Serial data in/parallel data out
- 3 groups (RGB) of 8 constant-current output channels from 5-80mA
- Short and Open output error detection
- Adjustable output current through external resistor for each group of 8-channel
- Gradual output delay (30ns for each group RGB)
- 3.3 V microcontroller driveable
- Maximum clock frequency: 25 MHz
- ESD protection: 2.5 kV HBM, 200 V MM
- Thermal Shutdown with flag pin

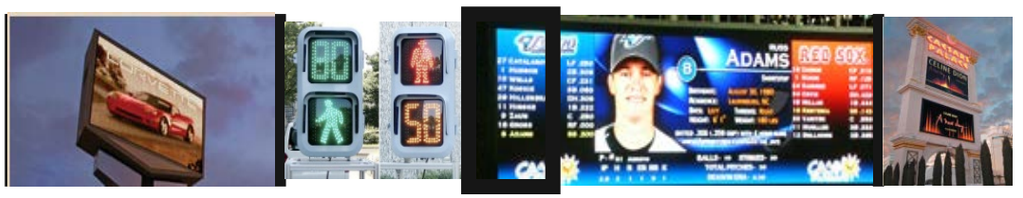
Applications:

- Full color high resolution LED panel displays
- Colored traffic signs







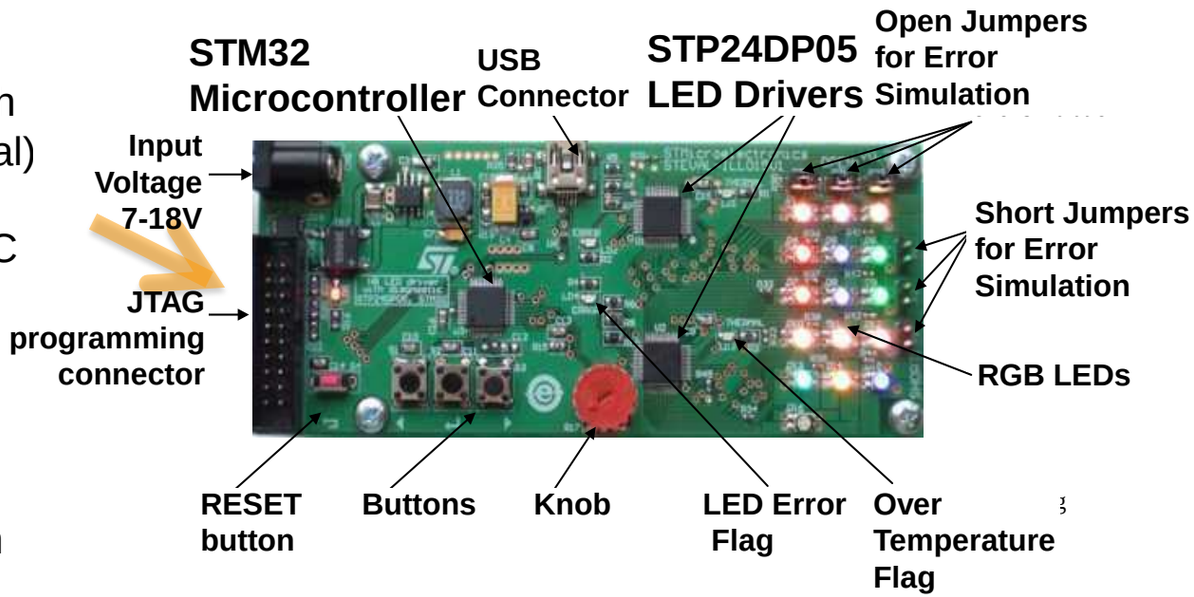


HB RGB Dimmer Evaluation Board

Based on STP24DP05 and STM32F103C6

Key Features:

- Two STP24DP05 (TQFP48) w/16 RGB high brightness LEDs connected (48 LEDs in total)
- STM32 with cost-effective internal HS osc
- High efficient switching power supply DC/DC ST1S10 with input voltage range of 7,5V - 18V, current 0.7A.
- Error Detection Feature/Over-Temp Flag
- Adjustable Brightness
- .JTAG interface for C firmware updates
- Mini USB connector for PC GUI connection
- Imp signal test points for lab evaluation
- Buttons and a knob to control the board.
- 3 jumpers each for simulating disconnection and simulating shortage of 3 LEDs



Key Products:

- STP24DP05
- STM32F103
- ST1S10

Demo Kit Support:

- STEVAL-ILL015V1with OSRAM LEDs
- CD with User Manual, Application Note, Datasheets
- C Library for dimming control of every single LED
- Demo Firmware and PC Software:
- Stand alone: A game, color dimming effects, Error Detection
- USB demo: Error Detection over USB

Evaluation board	App Notes /User Manuals	Description
STEVAL-ILL015V1	**AN2841, UM0574, UM0588**	**High Brightness RGB LED Array dimmer demo board based on the STP24DP05 and STM32**

Multicolor LED Display Panel Eval Board

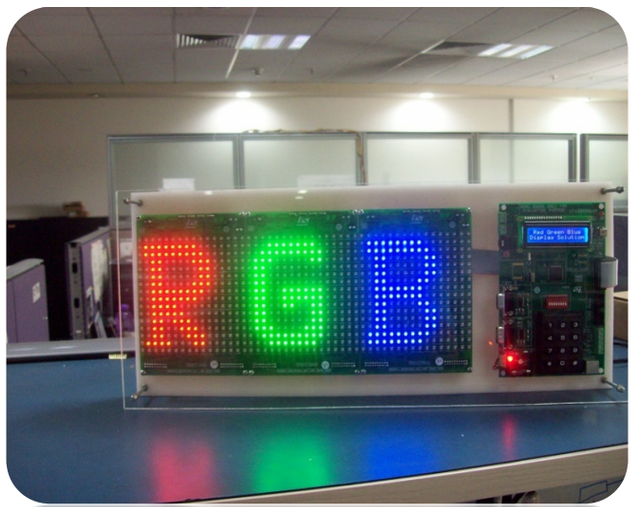
RGB Moving Message Display System with STP24DP05 and STM32F103

Key Features:

- Control unit with PS2 keyboard interface for data entry
- LCD on control unit for showing the display text and background color options
- 4xSTP24DP05 for each display panel
- 8 panels can be cascaded in series through flat ribbon cable
- System configuration in typing data mode or in audio playback mode or in demo mode

Key Products:

- STP24DP05 LED Display Driver
- STM32F103 32-bit microcontroller on control board
- STM1001 Reset IC
- STPS3L60 Schottky Diode
- ST3232C 3V RS232 com interface



STEVAL-ILL032V1

STEVAL-ILL033V1

Support:

- Full color Display Panels
- Airport and Railway information system
- Bank currency conversion rate boards

Evaluation board	User Manuals	Description
STEVAL-ILL032V1, STEVAL-ILL033V1	UM1449	STM32-based RGB LED Matrix Display Demo

LED Array Driver Feature Summary

Part Number	#ch	I_{LED} (mA)	ΔI_{LED}		Error detection	Auto Power Saving	Balanced Turn ON/OFF	Gray-scale Brightness control	Current Gain Adjustment	Staggered output delay
			Channel to channel (MAX)	IC to IC (MAX)						
STP08CP05	8	5 - 100	3% (20 100mA)	6%						
STP08DP05	8	5 – 100	3% (20 100mA)	6%	✓					
STP16CP05	16	5 - 100	3% (20 100mA)	5%						
STP16CPS05	16	5 - 100	3% (20 100mA)	5%		✓				
STP16DP05	16	5 - 100	3% (20 100mA)	5%	✓					
STP16DPS05	16	5 - 100	3% (20 100mA)	5%	✓	✓				
STP16CPP05	16	3 - 40	3% (20 40mA)	5%						
STP16CPPS05	16	3 - 40	3% (20 40mA)	5%		✓				
STP16DPP05	16	3 - 40	3% (20 40mA)	5%	✓					
STP16DPPS05	16	3 - 40	3% (20 40mA)	5%	✓	✓				
STP16CPC05	16	5 - 100	3% (20 100mA)	5%			✓			
STP16CPC26	16	5 - 90	3%	6%			✓			
STP24DP05	24	5 - 80	6% (5 15mA) 3% (15 80mA)	6%	✓					✓
STP1612PW05	16	3 - 60	1.5% (3 60mA)	6%	✓			✓	✓	✓

Array Driver Eval Boards Summary

Part Number	Order Code	Description	Feature	App Notes	Power Supply
STP16CP05 **STP16CPS05**	**STEVAL-ILL003V2**	32 LEDs Array Reference Board	- Adjustable Brightness, Blinking Speed - Animated Text - GUI SW for LEDs diagnostics	**AN2241**	Std Supply Connector
STP16DP05	**STEVAL-ILL024V1** **STEVAL-ILL025V1**	Mother/slave board for LED display based on STM32 16x32 LED matrix	- Animated Text - Adjustable Blinking Speed - GPS Interface	**UM0767**	5V, 0.5A 3.5V-5V, 3A
STP1612PW05	**STEVAL-ILL028V1**	RGB LED Driver w/Indep PWM for Color Display via STM32 SPI	-Adjustable Color - JTAG interface for C firmware update	**UM0882** **UM0885**	Std Supply Connector
STP08DP05	**STEVAL-ILL002V3**	40 LEDs Diagnostic Reference Board Using OSRAM Blue LEDs	- Adjustable Brightness, Blinking Speed - Animated Text - Error Detection Feature	**AN2415** **AN2478**	Std Supply Connector
STP08DP05	**STEVAL-ILL002V4**	40 LEDs Diagnostic Reference Board Using Vishay Green LEDs	-Adjustable Brightness, Blinking Speed - Animated Text - Error Detection Feature	**AN2415** **AN2478**	Std Supply Connector
STP24DP05	**STEVAL-ILL015V1**	16 RGB LED Array based on STP24DP05 and STM32F103C6	- Adjustable Brightness - JTAG interface for C firmware update - Mini USB connector for PC GUI - Error Detection Feature	**UM0574**	Std Supply Connector
STP24DP05	**STEVAL-ILL032V1** **STEVAL-ILL033V1**	STM32-based RGB LED Matrix Display Demo	- Adjustable text color and speed - Adjustable background color - Audio Playback Mode	**UM1449**	Std Supply Connector

Using DC-DC Switching Regulators

In Driving LEDs

Monolithic solutions offer high efficiency and compactness, wide input voltage range, high current capability for a variety of applications, and high dimming performance for superior brightness uniformity.

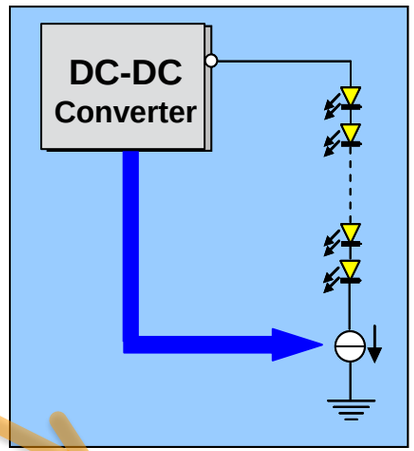
LED770x

Boost for multi-rows applications

DC BUS powered applications

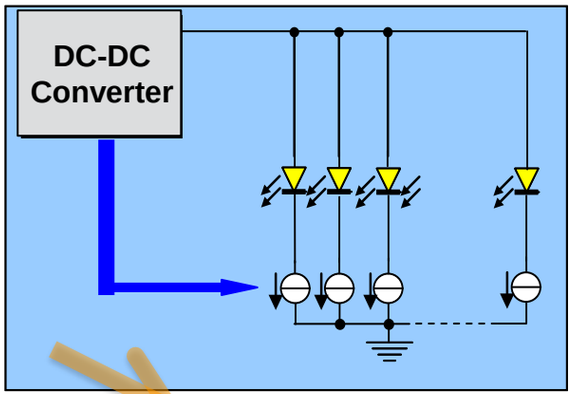
Optimized LED driving solution

LED7706 and LED7707



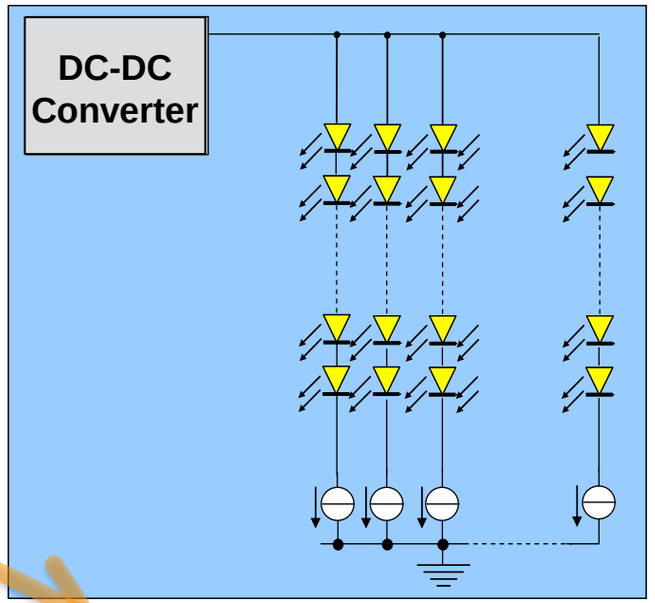
Serial

- simpler architecture
- brightness uniformity
- high voltage to manage



Parallel

- low voltage
- high complexity due to current matching
- high power dissipation on current generators



Multiple channel

LED770x Trade-off based on:

- technology availability (rated voltage)
- efficiency
- LED current regulation

- Typical input bus available → 24V
- LEDs to drive → up to 10
  (e.g. considering 40V technology)

NEED FOR BOOST CONVERSION

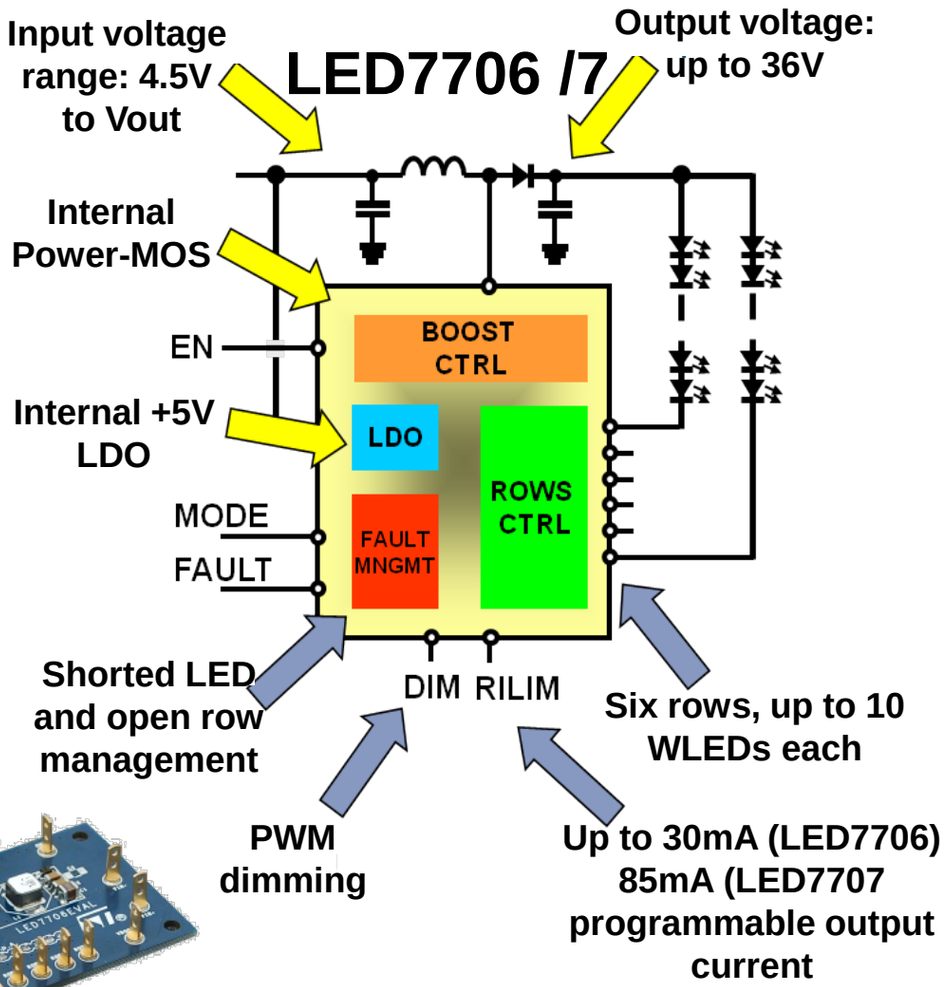
LED7706/7: LED Controllers

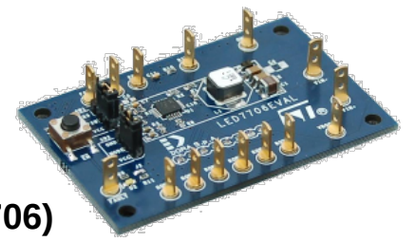
BOOST SECTION

- 4.5V to 36V Input Voltage range
- Internal +5V LDO
- Internal Power-MOSFET
- Up to 93% Efficiency
- Up to 36V Output Voltage
- 200kHz to 1MHz Switching Frequency
- Fixed F_{SW} Peak Current Mode control
- Programmable Soft-Start Duration
- Programmable OV and OC Protections
- Single Ceramic Output Capacitor
- External sync for multi-device application

BACKLIGHT DRIVER SECTION

- Six ROWs capable of driving multiple LEDs in series (e.g. up to ten WLEDs per ROW)
- Programmable Output Current per ROW
  - Up to 30mA (LED7706)
  - Up to 85mA (LED7707)
- PWM Dimming
  - 500ns minimum dimming ON time (LED7706)
  - 10uS minimum dimming ON time (LED7707)
- 2% Current Matching between ROWs
- Shorted LED Fault Detection
- Open ROW Fault Detection
- Capability to Disconnect Unused ROWs



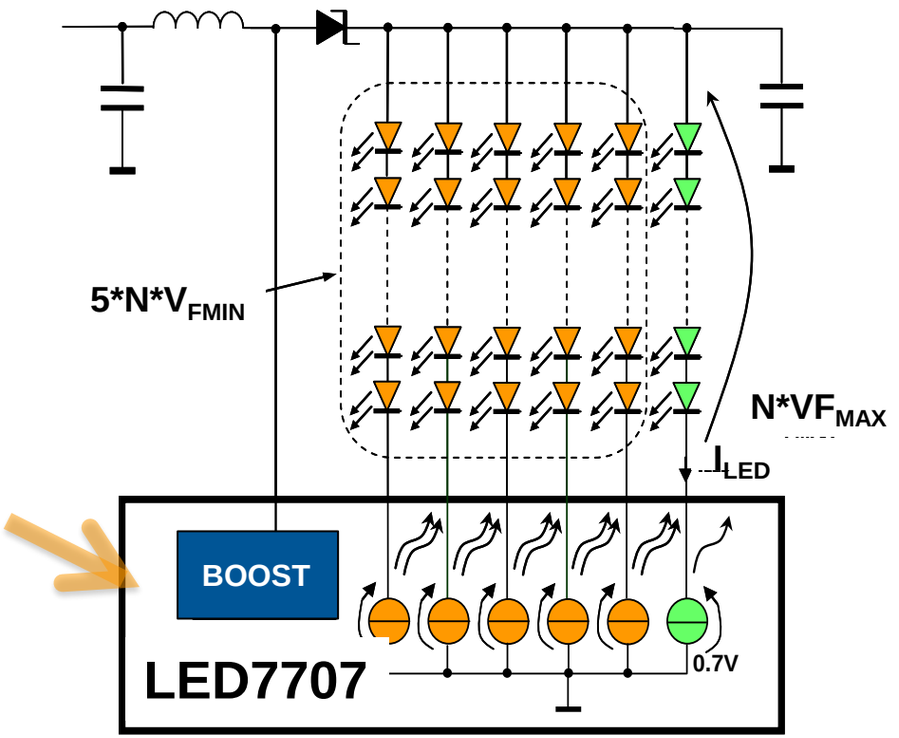


Ideal for:
Industrial: traffic signals, lighting, and displays
Industrial: mid to large size LCD TV, MNT
Automotive: navigation displays and dash board

LED7706/7: Adaptive Output Voltage

Fixed output voltage → V_F spread → **Higher power dissipation**

Adaptive output voltage → Output voltage depends on the active LED string with highest V_F → **Minimization of the power dissipation on the current generators**



Example

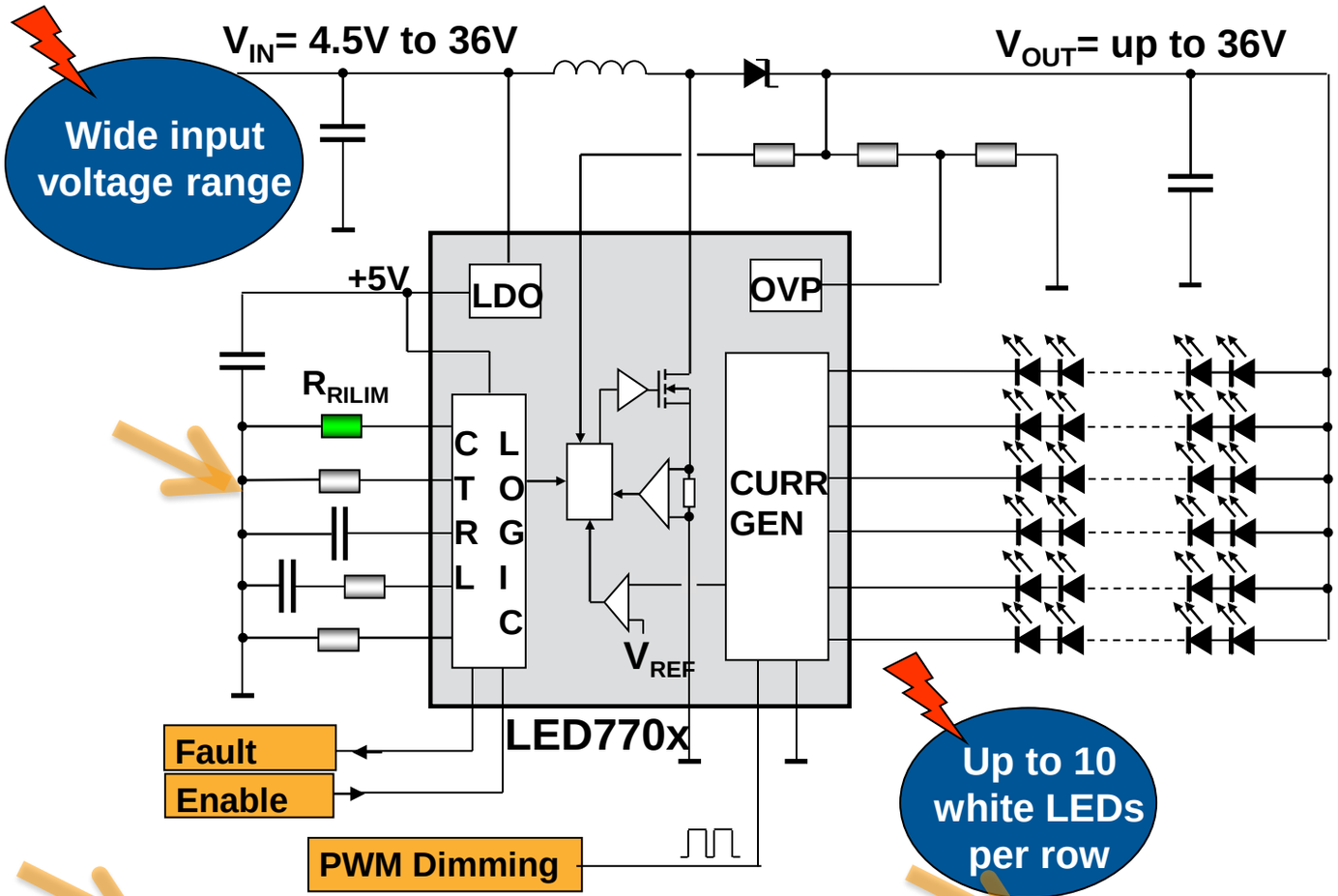
- V_{IN} = 12V
- 6 strings of 8 LEDs
- $V_{F,LED}$ = 3.5 0.2V
- f_{SW} = 600kHz
- I_{ROW} = 75mA

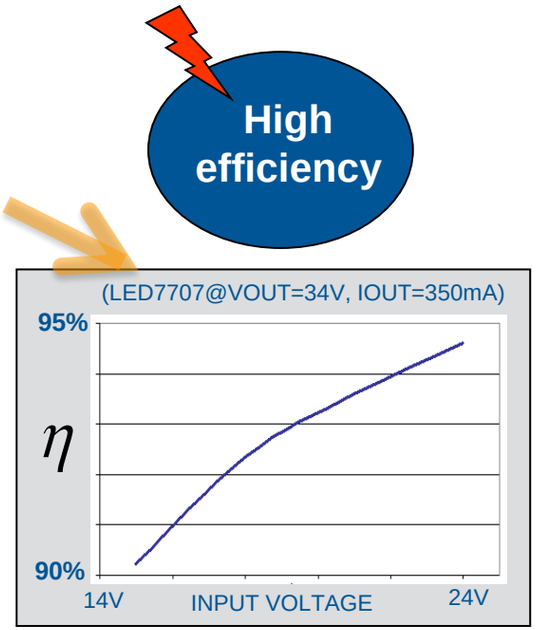
η = 84.2% (fixed V_{OUT} approach)

η = 87.3%* (adaptive V_{OUT} approach)

***0.5% lower every 100mV of increase of the voltage across the master generators**

LED7706/7: Boost topology





Input voltage: 4.5V to 36V

Maximum RMS switch current: 2.5A

Parallelable channels for higher current (LED7707)

$$I_{LED} = \frac{K_R}{R_{RILIM}}$$

LED current:
up to 85mA/ch (LED7707)

Channel to channel current mismatch: ±2%

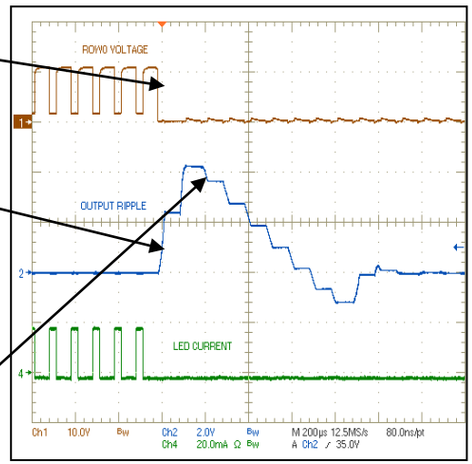
Up to 20kHz PWM dimming (1%-100%, LED7706)

LED Faults & Dimming Waveforms

1) ROW0 Opens

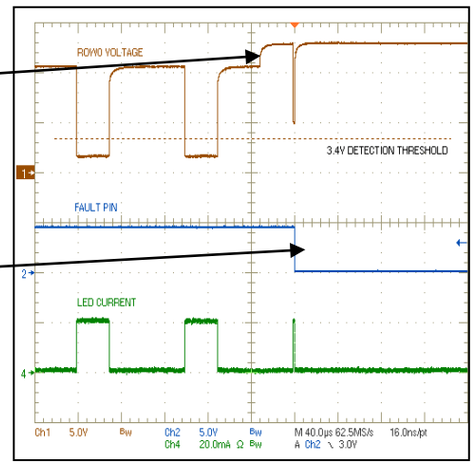
2) The output voltage increases

3) If 95% is crossed, the faulty ROW is disconnected



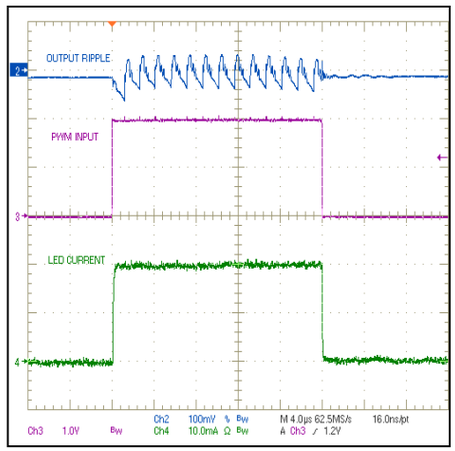
1) LED Short Circuit: the ROW0 Voltage Increases

2) If the 3.4V threshold is crossed, the device is turned off (MODE=0)

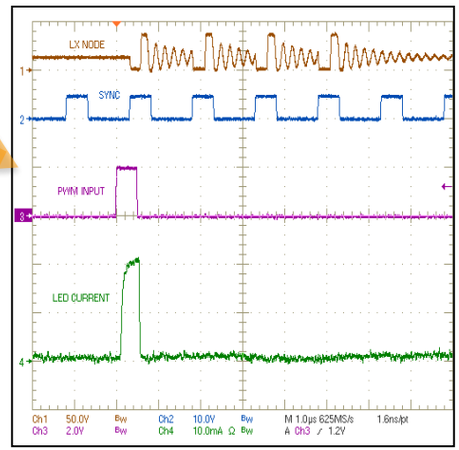


Detecting and Managing Faults in LED7706/7

20µs Dimming On-Time



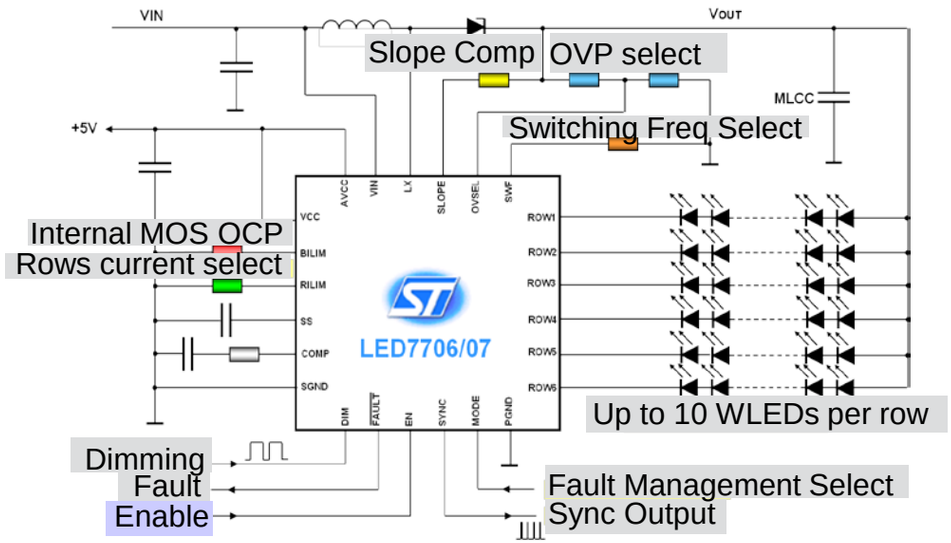
500ns Dimming On-Time



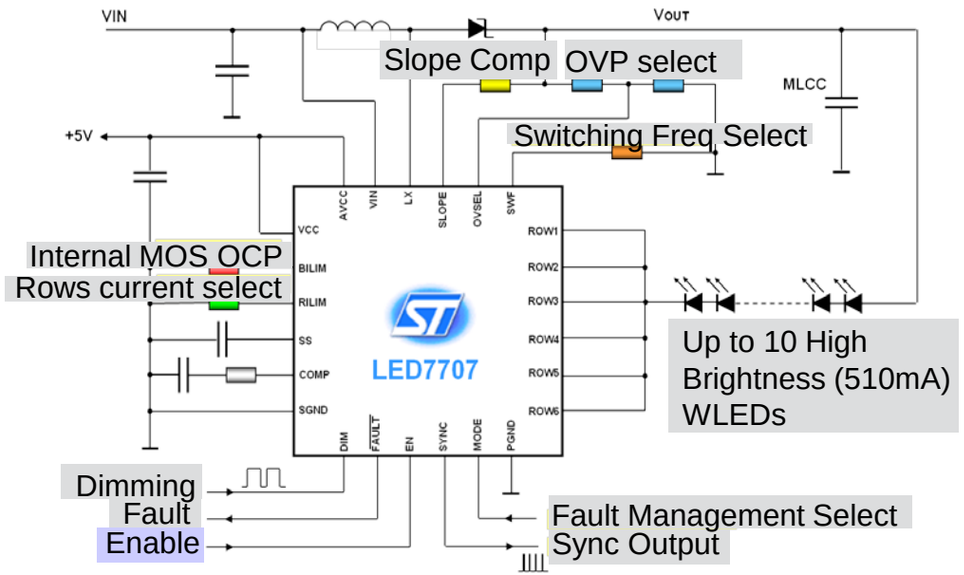
(f_{DIM}=10kHz, D_{DIM}=20%, f_{SW}=630kHz, LED current=20mA)

Managing Dimming Waveforms in LED7706/7

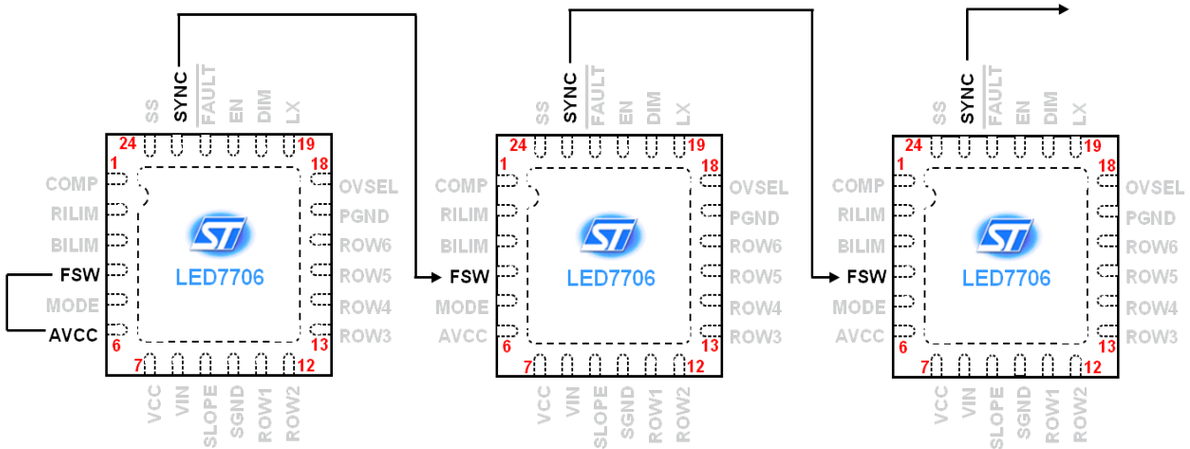
LED7706/7 LED Driver Application Examples



Typical application schematic



High-Brightness LED driving solution



Multi-device applications with external Synchronization

LED Driver w/Boost Converter Solution

Based on the LED7706 and LED7707

STEVAL-ILL020V1

STEVAL-ILL021V1

Key Features:

Boost section

- 4.5 V to 36 V input voltage range
- Internal power MOSFET
- Internal +5 V LDO for device supply
- Up to 36 V output voltage
- Constant frequency peak current-mode control
- 200/250 kHz to 1 MHz adjustable switching frequency (LED7706/7)
- External sync for multi-device application
- Pulse-skip power saving mode at light load
- Programmable soft-start
- Programmable OVP protection
- Single ceramic output capacitor
- Non-latched thermal shutdown

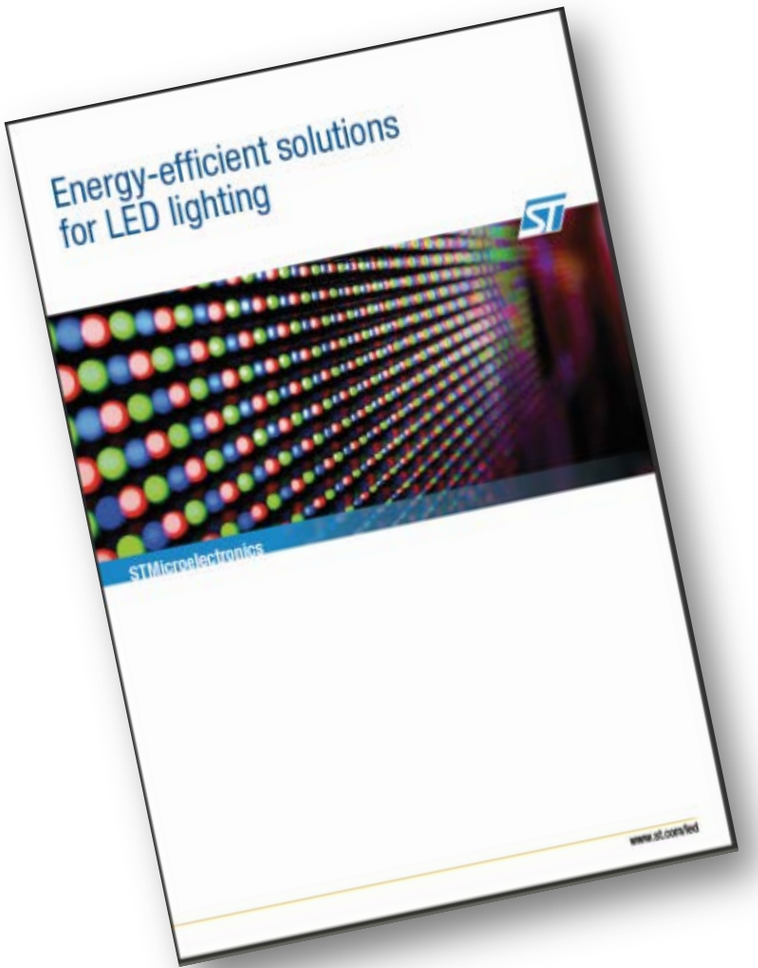
LED driver section

- Six rows with 30/85 mA maximum current capability (adjustable) LED7706 /7
- Up to 10 white LEDs per row
- Rows disable option
- Less than 500 ns minimum dimming time (1% minimum dimming duty-cycle at 20 kHz dimming frequency - LED7706,
- Less than 10 µs minimum dimming time at 1kHz dimming frequency - LED7707
- 2.0% current matching between rows
- LED failure (open and short circuit) detection

Part #	Evaluation Board	Vin	Ioutmax	Description	App Notes
LED7706	**STEVAL-ILL020V1**	4.5V to 36V	20mA per channel	LEDs Driver with Boost Converter for LCD Panels Backlight	**AN2809**
LED7707	**STEVAL-ILL021V1**	4.5V to 36V	60mA per channel	LEDs Driver with Boost Converter for LCD Panels Backlight	**AN2810**

Energy-Efficient Solutions for Traffic Signals on st.com

LED Lighting Brochure

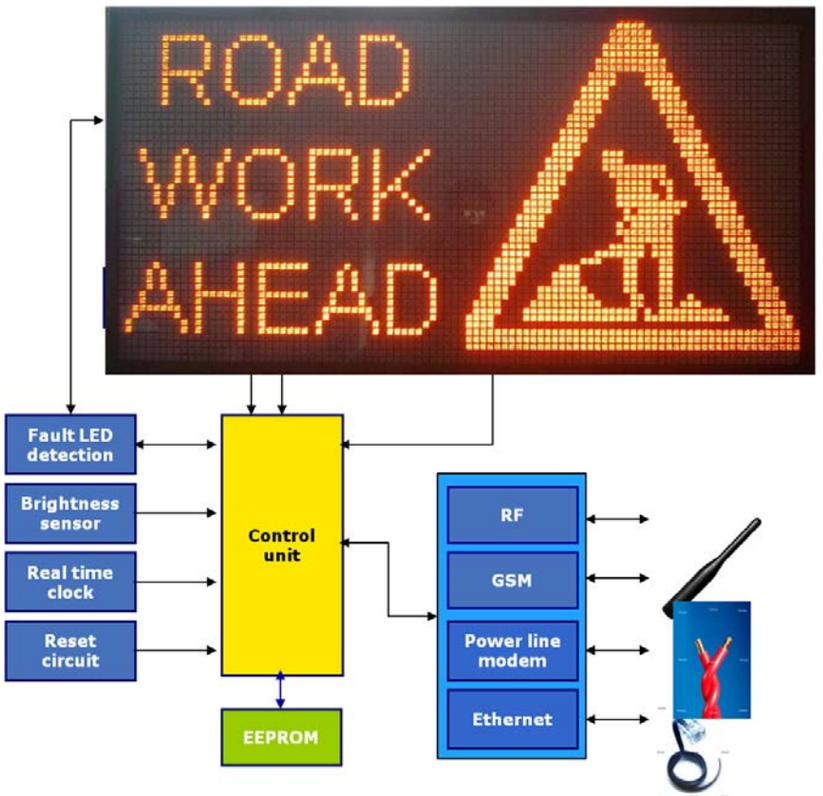


http://www.st.com/internet/com/SALES_AND_MARKETING_RESOURCES/MARKETING_COMMUNICATION/MARKETING_BROCHURE/brlighting.pdf

LED Application web pages

Lighting
ST's lighting solutions are split into five main categories: dimmer, fluorescent, halogen, HID and LED.

http://www.st.com/internet/com/appli_scope/392.jsp



ST LED Lighting Solutions

For more information, visit:

www.st.com > home > support > tools & resources
www.st.com > LED Drivers for Traffic Signals

Thank you