HOLTEK

LCD/LED Display Driver

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HOLTEK SEMICONDUCTOR INC.

# LCD Controller & Driver

▶ Description

Holtek's full range of LCD controllers & drivers support LCD panels of up to 960 pixels. The following table lists the relevant parameters of each series, so that users can select the right IC according to the product application.

HT162x Series — General purpose devices that are suitable for general LCD display products.

HT16C2xA Series — Used in LCD display products that require high noise immunity and high anti-static ability. Among this series, the HT16K23A also provides a key scan function, without requiring key scan circuit design for the main control MCU, therefore simplifying product design.

HT16L2x Series — V_{DD} ranges from 1.8V to 5.5V. This series can be used with a 1.8V low-voltage MCU in LCD products without requiring an external level shifter circuit.

HT16H25 — V_{LCD} is up to 12V. This series can be used in LCD panel products which require a large LCD panel, large COM counts and a high voltage.
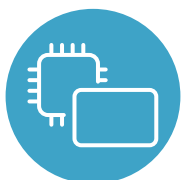
	HT162x Series	HT16C2xA Series	HT16L2x Series	HT16H25
Max. Resolution	32×4 ~ 64×8	20×4 ~ 60×16	32×4 ~ 48×8	60×16
Bias	1/2 ~ 1/4	1/2 ~ 1/5	1/2 ~ 1/4	1/1 ~ 1/5
LCD Driving Waveform	A type (HT1621 only) B type	A type	A type B type	A type B type
LCD Bias Circuit	Internal resistors Charge pump (HT1620 only)	Voltage-follower buffers	Voltage-follower buffers	Internal resistors Charge pump External resistors
Supported LCD Type	TN/STN/HTN	TN/STN/HTN/VATN	TN/STN/HTN/VATN	TN/STN/HTN/VATN

The COM and SEG pin count of the LCD driver IC should be taken into consideration when planning an LCD panel. For example, a 60-pixel LCD panel controlled by a 1/4 duty LCD driver IC supports two designs, 20SEG×3COM and 15SEG×4COM. It is recommended to use the 15SEG×4COM design because there will be no display for one COM scan period for the 20SEG×3COM design, which will result in lower LCD contrast and brightness.

The LCD SEG/COM driving waveforms are analog signals, and the driver will switch between different voltage levels during sequential COM scans to avoid the degradation of display quality and the aging of liquid crystals. The ratio of the lowest analog voltage level to the LCD highest output voltage is called bias. The more COM pins, the shorter the scan time for each COM, which requires a larger bias voltage so as to achieve the same display brightness and contrast.

The conversion formulas between COM and Bias are: $$bias=1/(\sqrt{duty}+1), \quad duty=1/COM$$

If the number of COM pins is 4, the bias should be set to 1/3, so there will be three LCD driving voltage levels: 1/3 V_{LCD}, 2/3 V_{LCD}, 3/3 V_{LCD}.

Due to the characteristics of LCD liquid crystal molecules, applying a DC voltage to the two ends of the liquid crystal molecules for a long time will affect the electrochemical properties of liquid crystals, reduce the display quality, accelerate the aging of liquid crystals and other irreversible damage, so only AC driving can be used. The AC driving method has two types of driving waveform, A type and B type, which are described below and can be used according to the product application.

A Type

- The COM output voltage level changes at each sequential COM scan.
- Faster updates, ideal for fast dynamic picture display applications, more power consumption than B Type.
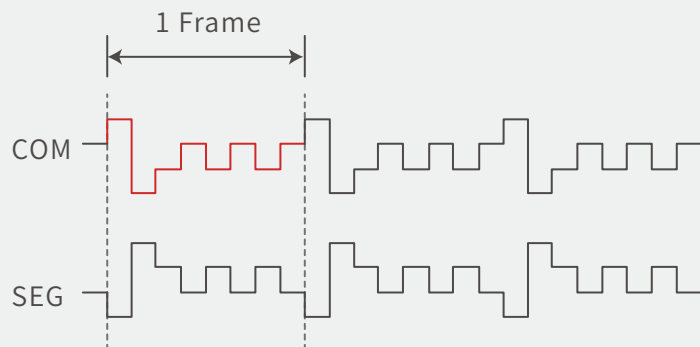

Figure 1. A Type Driving Waveform

B Type

- The COM output voltage level changes at each frame.
- Slower updates, suitable for static image display applications.
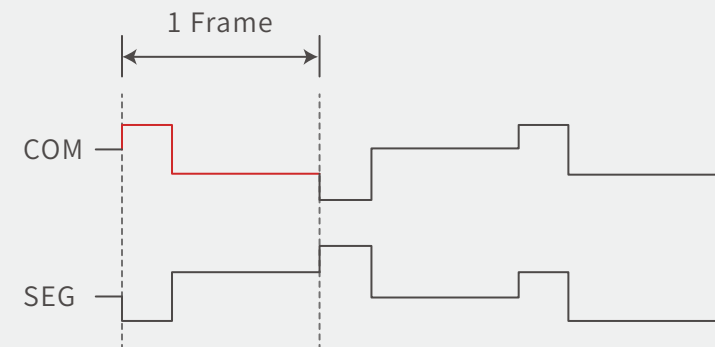

Figure 2. B Type Driving Waveform

The LCD bias circuits are used to generate different voltage levels that drive the LCD, which can be implemented by four architectures: charge pump, voltage-follower buffers, internal resistors and external resistors. The following operation principles are introduced based on a 1/3 bias application.

Charge Pump

The IC internal charge pump circuit generates the LCD bias voltages. The operating current and driving capacity are smaller.

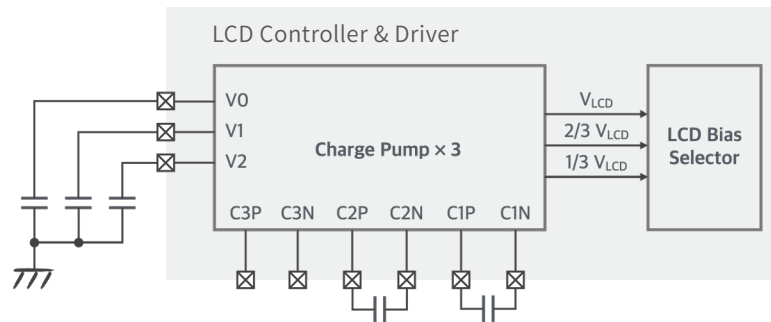For a 1/3 bias, the charge pump is set to generate three LCD driving voltage levels.

Figure 3.

Voltage-follwer Buffers

The IC internal large resistance string (impedance:$M\Omega$) divider voltage is provided to the LCD through the voltage-follower buffers. The operating current and driving capacity are medium.

Figure 4.

Internal Resistors

The internal resistance string (impedance:$k\Omega$) generates the bias voltages. The operating current and driving capacity are larger.
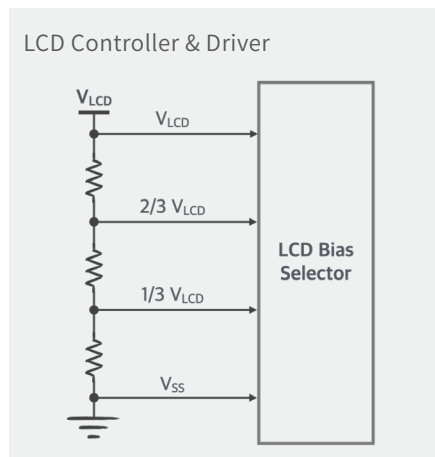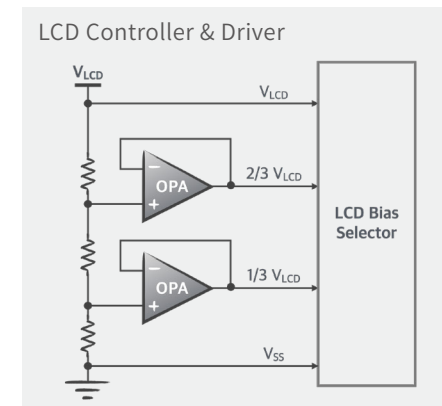

Figure 5.

External Resistors

In general applications, the IC internal LCD bias circuit can meet the most product requirements. When the LCD panel is larger and requires a larger driving capacity, external resistors can be connected.
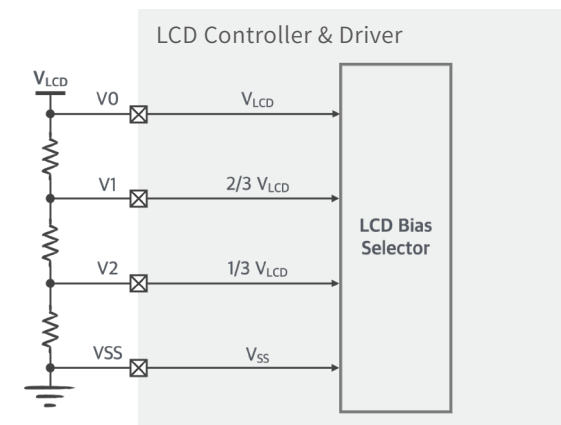

Figure 6.

4

▶ LCD Product Lineup

Refer to Table 1 for the product selection of Holtek LCD Controller/Driver IC series.

| LCD Controller & Driver Series	Supported Maximum Number of LCD Pixels						
	128 Pixels	176 Pixels	256 Pixels	384 Pixels	416 Pixels	512 Pixels	960 Pixels
RAM Mapping (4-Wire)	HT1621 HT1621G 32×4		HT1622 32×8	HT1623 48×8		HT1625 64×8	
	HT1620 32×4 C-Type		HT16220 32×8 Crystal				
High Noise Immunity (I²C)	HT16C21A 20×4 16×8	HT16C22A HT16C22AG 44×4			HT16C23A HT16C23AG 56×4 52×8		HT16C24A HT16C24AG 72×4 68×8 60×16
	HT16K23A 20×4 16×8 20×1Key						
Low Voltage (3-Wire SPI/I²C)	HT16L21 32×4 LED×8			HT16L23 52×4 48×8 LED×8			
High Operating Voltage (3-Wire SPI/I²C)							HT16H25 60×16

Note: G stands for Gold Bump.

Table 1.

▶ Features & Application Circuits

The major features of the LCD Controller & Driver series are described in this section.

HT162x Series RAM Mapping LCD Controller & Driver

Application Circuits
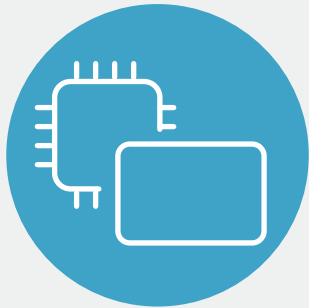
Features

- Supports 32×4 ~ 64×8 LCD display
- 1/2 bias ~ 1/4 bias and 1/2 duty ~ 1/16 duty
- Internal RC oscillator (only HT16220 supports external crystal)
- Integrated LCD display RAM
- VLCD pin to adjust LCD operating voltage
- Frame frequency is 64Hz
- Integrated resistor type bias generator
- Integrated capacitor type charge pump (HT1620 only)
- 8 kinds of timebase/WDT clock sources
- 2 selectable buzzer frequencies: 2kHz/4kHz
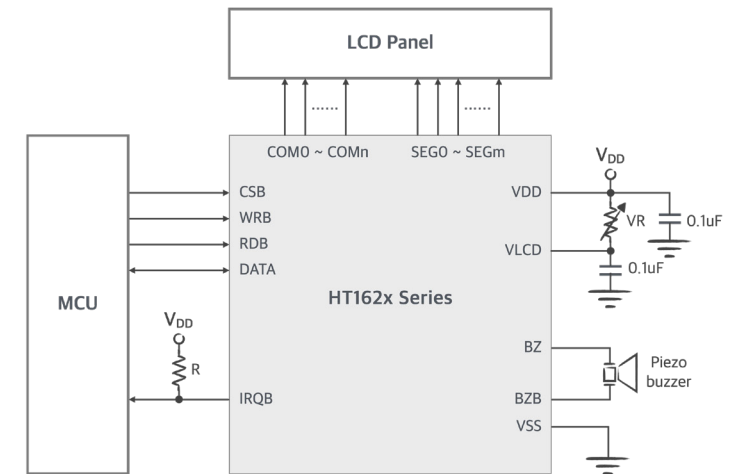- 4-wire interface

▌ HT162x (Internal Resistors) Series

Figure 7.

▌ HT1620 (Charge Pump)

Figure 8.

Application Circuits

HT16C2xA Series
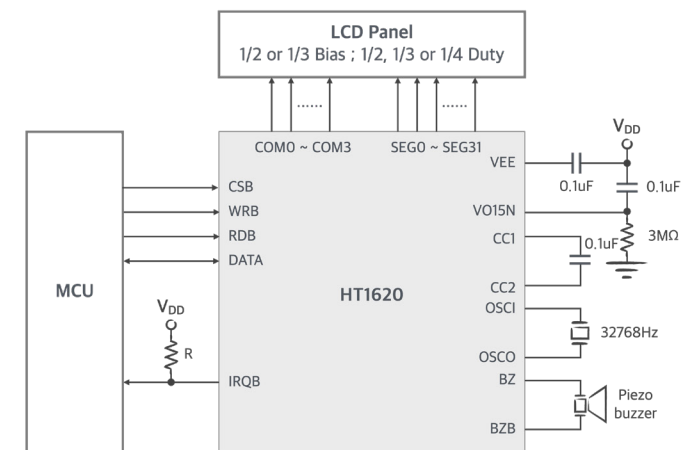

Figure 9.

HT16K23A with Key Scan Function
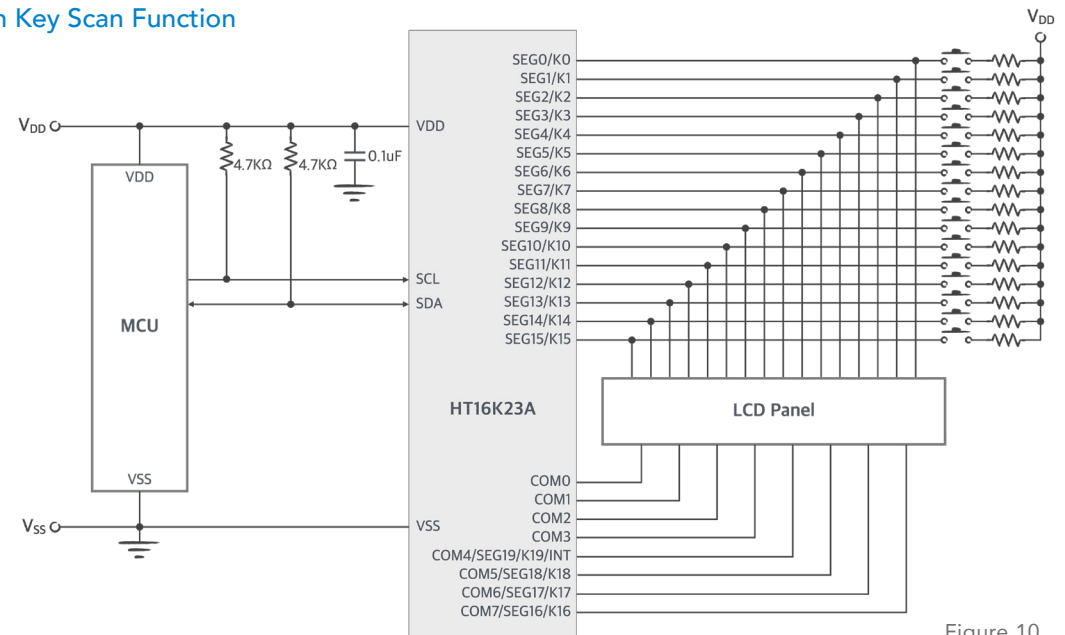
Figure 10.

Features

- Supports 20×4 ~ 60×16 LCD display
- 1/2 bias ~ 1/5 bias and 1/2 duty ~ 1/16 duty
- Operating voltage: 2.4V~5.5V
- Internal 32kHz RC oscillator
- Internal LCD bias generation with voltage-follower buffers
- 2 selectable LCD frame frequencies: 80Hz/160Hz
- Versatile blinking modes
- Internal 16-step LCD operating voltage adjustment
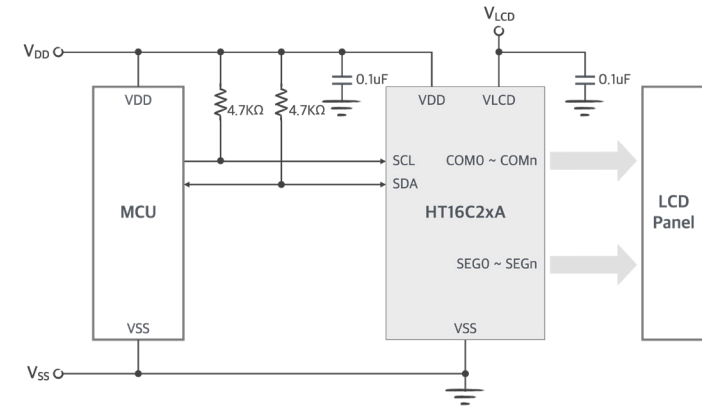- Key scan function (HT16K23A only)
- I^2C interface

Features

- Supports 32×4 ~ 48×8 LCD display
- 1/2 bias ~ 1/4 bias and 1/4 duty ~ 1/8 duty
- Logic operating voltage: 1.8V~5.5V
- LCD operating voltage (V_{LCD}): 2.4V~6.0V
- Internal 32kHz RC oscillator
- Internal LCD bias generation with voltage-follower buffers
- External VLCD pin to supply LCD operating voltage
- Internal regulator to adjust LCD operating voltage: 3.0V/3.2V/3.3V/3.4V/4.4V/4.5V/4.6V/5.0V
- 4 selectable LCD frame frequencies: 64Hz/85.3Hz/128Hz/170.6Hz
- Integrated LED driver
- Versatile blinking modes: Off/0.5Hz/1Hz/2Hz
- I2C or 3-wire interface controlled by IFS pin
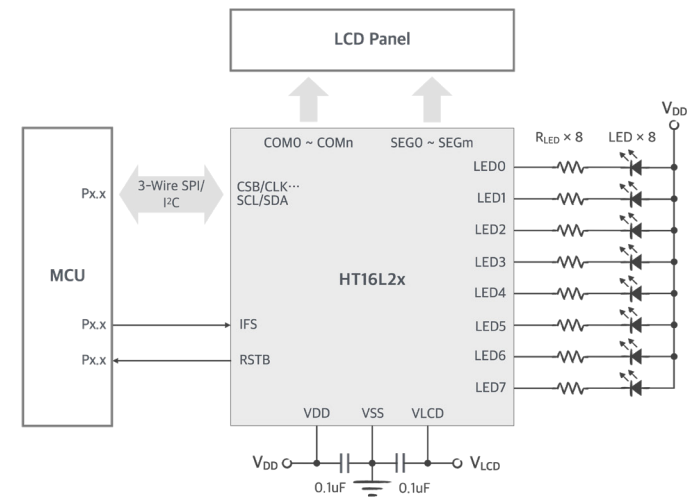
Application Circuits

HT16L2x Series

Figure 11.

Features

- Supports 72×1 ~ 60×16 LCD display
- 1/1 bias ~ 1/5 bias and static ~ 1/8 duty
- Operating voltage: 2.4V~5.5V
- LCD operating voltage (V_{LCD}): 2.5V~12V
- Internal RC oscillator
- Internal LCD bias generated from charge pump or resistor divider
- 4 GPIO ports support binary output or PWM output
- Contrast adjustment function
- Selectable LCD frame frequencies
- 4 selectable blinking frequencies
- Selectable A type or B type LCD driving waveform
- I^2C or 3-wire interface controlled by IFS pin
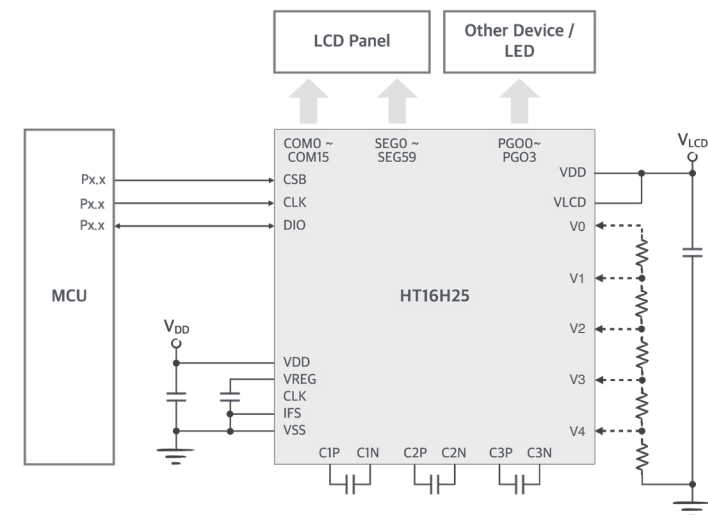
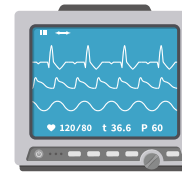## Application Circuits

HT16H25

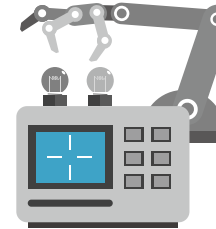Figure 12.

▶ Applications

| Smart Electricity Meters | Audio Products/Home Appliance | Exercise Equipment | Health Care | Industrial Instrument | Other LCD Displays |

▶ Product List

Please refer to the official website for product selection information.

LCD Controller & Driver (I²C)

Part No.	VDD	Segment × Common	LCD Voltage	Bias	Built-in OSC.	Key-scan	Interface	Package
HT16C21A	2.4V~5.5V	20×4, 16×8	≤ V_{DD}	1/3, 1/4	√	—	I²C	24SSOP, 28SSOP
HT16C22A	2.4V~5.5V	44×4	≤ V_{DD}	1/2, 1/3	√	—	I²C	48LQFP, 52LQFP
HT16C22AG								Gold Bump
HT16C23A	2.4V~5.5V	56×4, 52×8	2.4V~5.5V	1/3, 1/4	√	—	I²C	48LQFP, 64LQFP
HT16C23AG								Gold Bump
HT16C24A	2.4V~5.5V	72×4, 68×8, 60×16	2.4V~5.5V	1/3, 1/4, 1/5	√	—	I²C	64LQFP, 80LQFP
HT16C24AG								Gold Bump
HT16K23A	2.4V~5.5V	20×4, 16×8	= V_{DD}	1/3, 1/4	√	20×1	I²C	28SSOP

LCD Controller & Driver (4-Wire)

Part No.	VDD	Segment × Common	LCD Voltage	Bias	Built-in OSC.	Ext. Crystal	Interface	Package
HT1620	2.4V~3.3V	32×2, 32×3, 32×4	3/2×V_{DD}	1/2, 1/3	—	√	4-Wire	64LQFP
HT1621	2.4V~5.2V	32×2, 32×3, 32×4	≤ V_{DD}	1/2, 1/3	√	√	4-Wire	44LQFP, 48SSOP, 48LQFP
HT1621G	2.4V~5.2V							Gold Bump
HT1622	2.7V~5.2V	32×8	≤ V_{DD}	1/4	√	—	4-Wire	44LQFP, 64LQFP
HT16220	2.7V~5.2V	32×8	≤ V_{DD}	1/4	—	√	4-Wire	64LQFP
HT1623	2.7V~5.2V	48×8	≤ V_{DD}	1/4	√	√	4-Wire	100LQFP
HT1625	2.7V~5.2V	64×8	≤ V_{DD}	1/4	√	√	4-Wire	100LQFP

Low Voltage LCD Controller & Driver

Part No.	VDD	Segment × Common	LCD Voltage	Bias	LED Driver	Interface	Package
HT16L21	1.8V~5.5V	32×4	2.4V~6.0V	1/2, 1/3	8×1	3-Wire SPI, I²C	44LQFP
HT16L23	1.8V~5.5V	52×4, 48×8	2.4V~6.0V	1/3, 1/4	8×1	3-Wire SPI, I²C	64LQFP

High Operating Voltage LCD Controller & Driver

Part No.	VDD	Max. Resolution Segment × Common	LCD Voltage	Bias	Duty	Charge Pump	Contrast Adjustment	GPO	Interface	Package
HT16H25	2.4V~5.5V	60×16	2.5V~12V	1/1~1/5	Static, 1/2~1/16	×2, ×3, ×4, ×5	4-bit	4CH	I²C, SPI 3-Wire	80/100LQFP

LED Controller & Driver

▶ **Description**

Holtek's full range of LED controllers & drivers support display capacity of up to 384 LEDs. Customers can select the desired IC according to the product requirements, such as number of LEDs, communication interface and other specifications.

Scan methods: Dot-matrix scan and Cross-plexing scan. Their principles are as follows:

▐ **Dot-matrix scan:** The LED matrix consists of multiple ROWs and multiple COMs, and LEDs are scanned and controlled in sequence.

▐ **Cross-plexing scan:** It is a multiplexing technology which switches to ROW or COM at each scan cycle, requiring a smaller number of pins to drive multiple LEDs. However, the LED arrangement is different from the dot-matrix scan method.

Driving modes: Constant Voltage driving and Constant Current driving. Their principles are as follows:

▐ **Constant Voltage driving (HT163x series):** The driving current is determined by the external resistors and the functional setting is simple. This series is suitable for use in monochrome LED display products, such as body fat scales, washing machines, treadmills, etc. Among this series, the HT16K33A also integrates a key scan function, without requiring key scan circuit design for the main control MCU and therefore simplifying product design.

▐ **Constant Current driving (HT16D3x series):** The LED driving current is set by the program and a variety of display change functions such as breathing light, blinking and scrolling are provided. This series is suitable for use in colorful LED display products, such as gaming products, colorful LED speakers, rhythm lamps, etc.

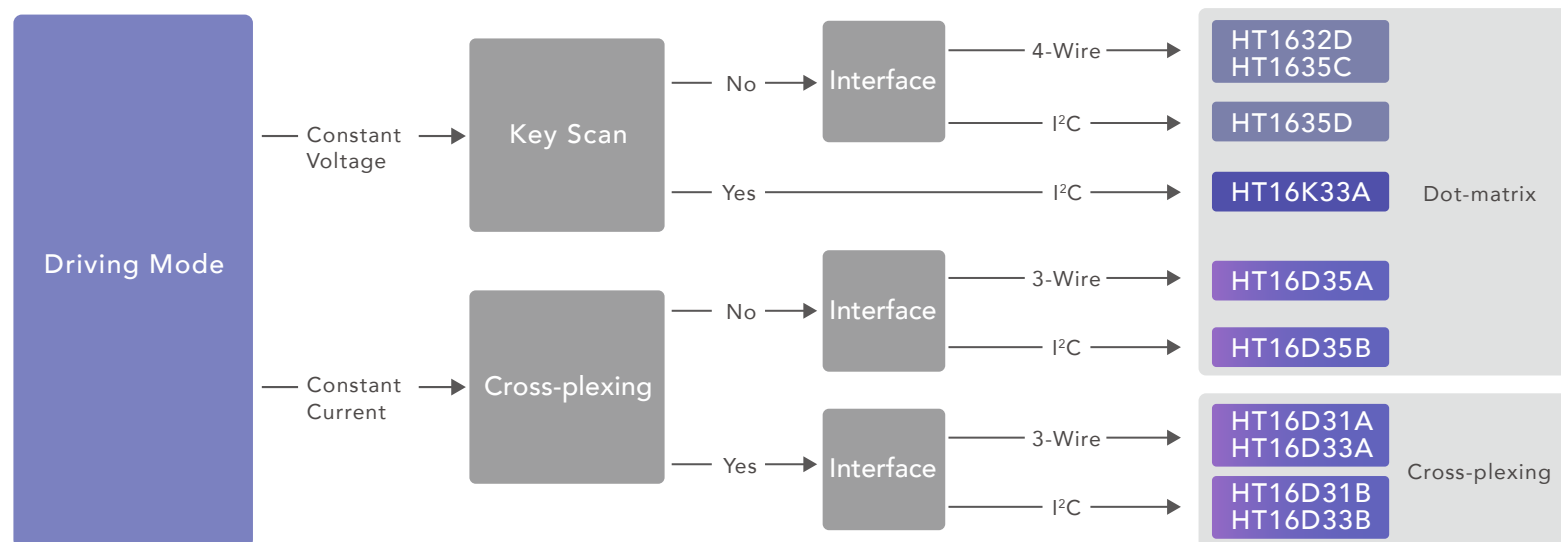Customers can refer to Table 2 to select the desired IC according to the product functions and requirements.

Table 2.

▶ LED Product Lineup

Refer to Table 3 for the product selection of Holtek LED Controller & Driver IC series.

LED Controller & Driver Series	Supported Maximum Number of LEDs					
	72 Dots	128 Dots	224 Dots	256 Dots	352 Dots	384 Dots
RAM Mapping		HT16K33A 16×8 13×3 key I²C			HT1635C HT1635D 44×8 4-wire/I²C	HT1632D 32×8 24×16 4-wire
Advanced (3-Wire SPI/I²C)	HT16D31A HT16D31B 8×9 33mA±3% Cross-plexing		HT16D35A HT16D35B 28×8 30mA±3%		HT16D33A HT16D33B 9×10 + 9×10 12×12,16×16 30mA±3% Cross-plexing	

Table 3.
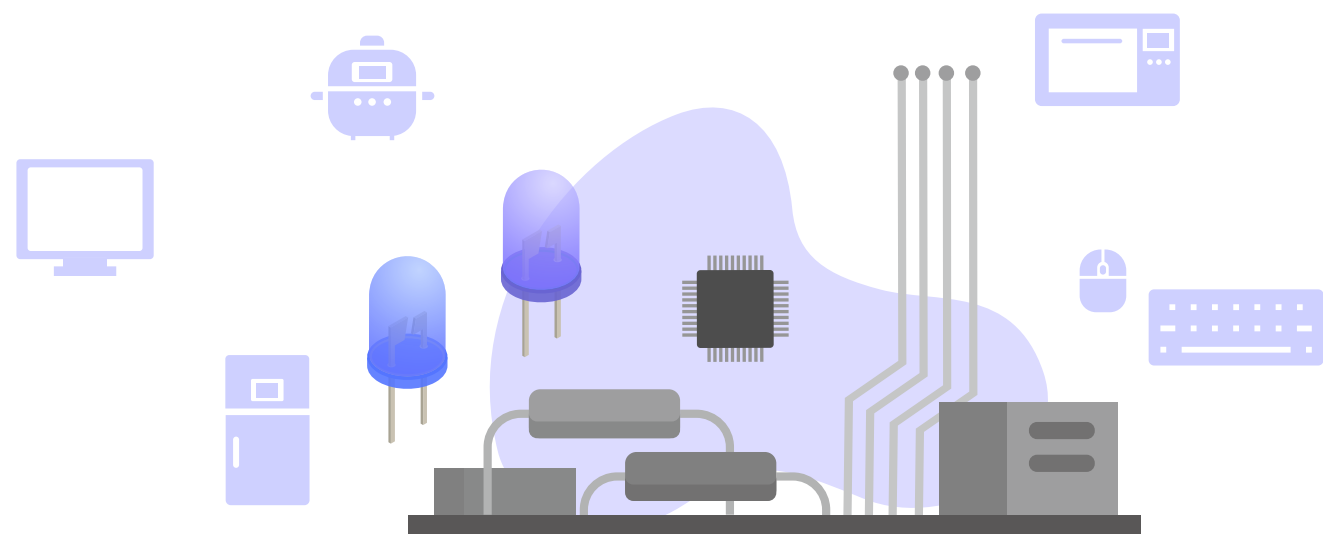
▶ Features & Application Circuits   The major features of the LED Controller & Driver series are described in this section.

HT163x Series   RAM Mapping LED Controller & Driver
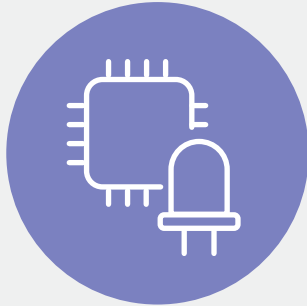
Features

- Supports 16×8 ~ 24×16 LED display
- Internal RC oscillator
- 16-level PWM brightness control
- Cascade function (HT16K33A excluded)
- Max. 13×3 matrix key scan (HT16K33A only)
- Interface:

  HT16K33A/HT1635D: I²C
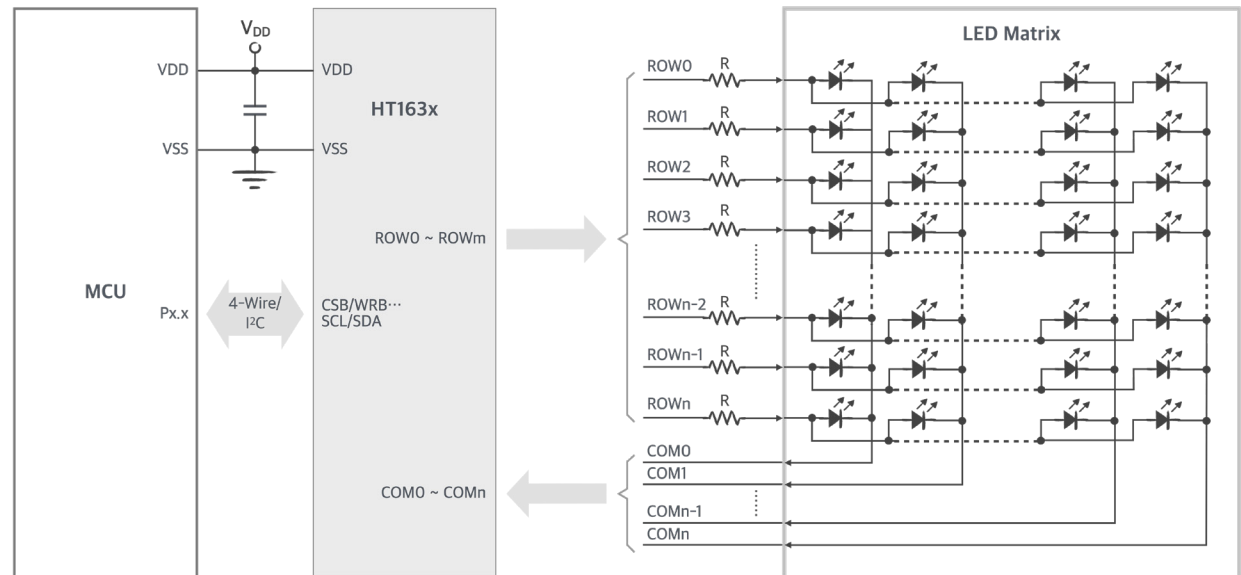
  HT1635C/HT1632D: 4-Wire

Application Circuits

▌ HT163x Series

Figure 13.

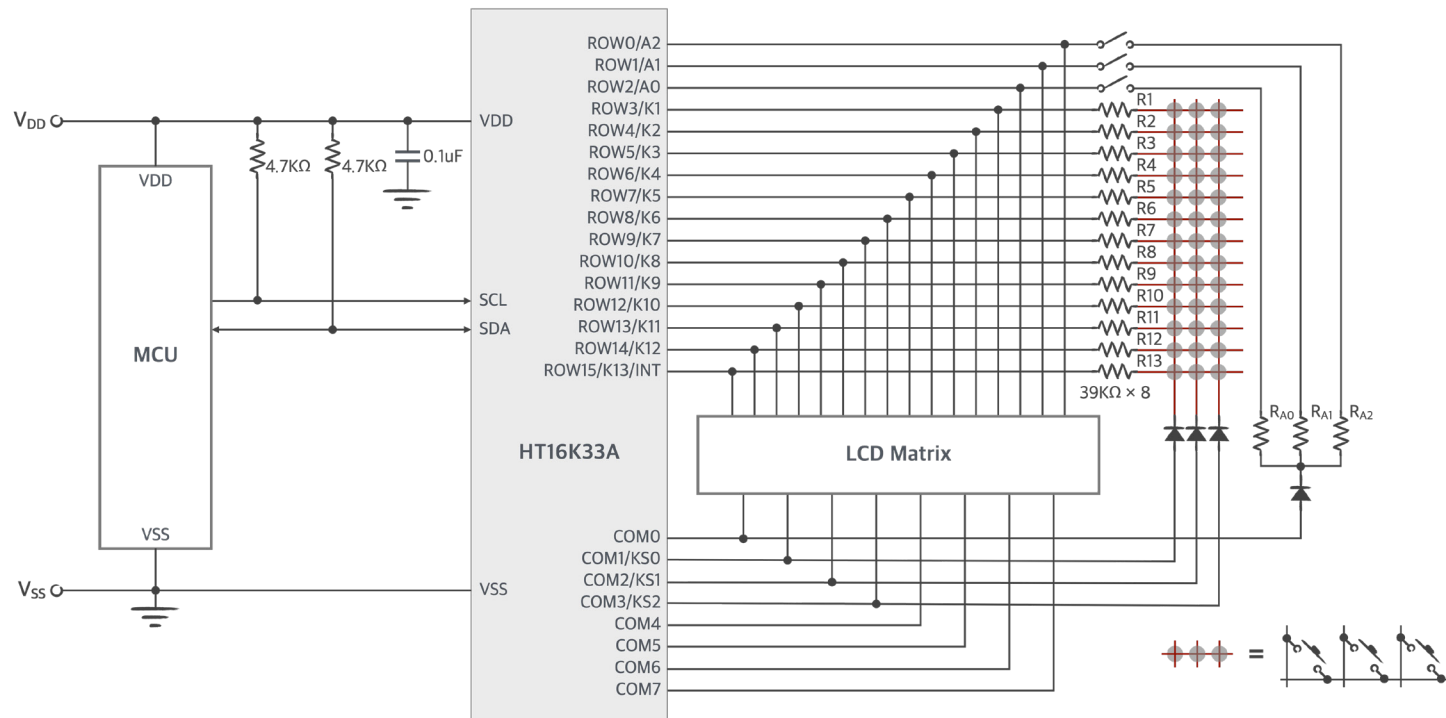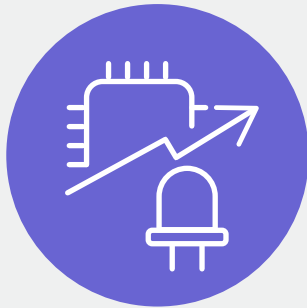## Application Circuits

HT16K33A

Figure 14.

Features

- Supports 8×9 ~ 16×16 LED display
- Logic operating voltage: 2.7V~5.5V
- LED driver operating voltage: 4.5V~5.5V
- Internal RC oscillator
- Current matching to ±3%
- Supports max. 48mA constant sink current (HT16D31x & HT16D33x series only)
- Supports max. 45mA constant sink current (HT16D35x series only)
- Global brightness scale
- Binary scale mode and Gray scale mode
- Global blinking and fade function
- Automatic scroll function
- Over temperature protection circuit
- Open/short circuit protection for each dot (HT16D31x & HT16D33x series only)
- Cascade function
- Interface:
  HT16D31A/HT16D33A/HT16D35A: 3-Wire
  HT16D31B/HT16D33B/HT16D35B: I²C

Application Circuits

HT16D31x/HT16D33x

Due to the cross-plexing architecture, the LED matrix connection varies according to the number of LEDs and color, refer to the relevant datasheet.
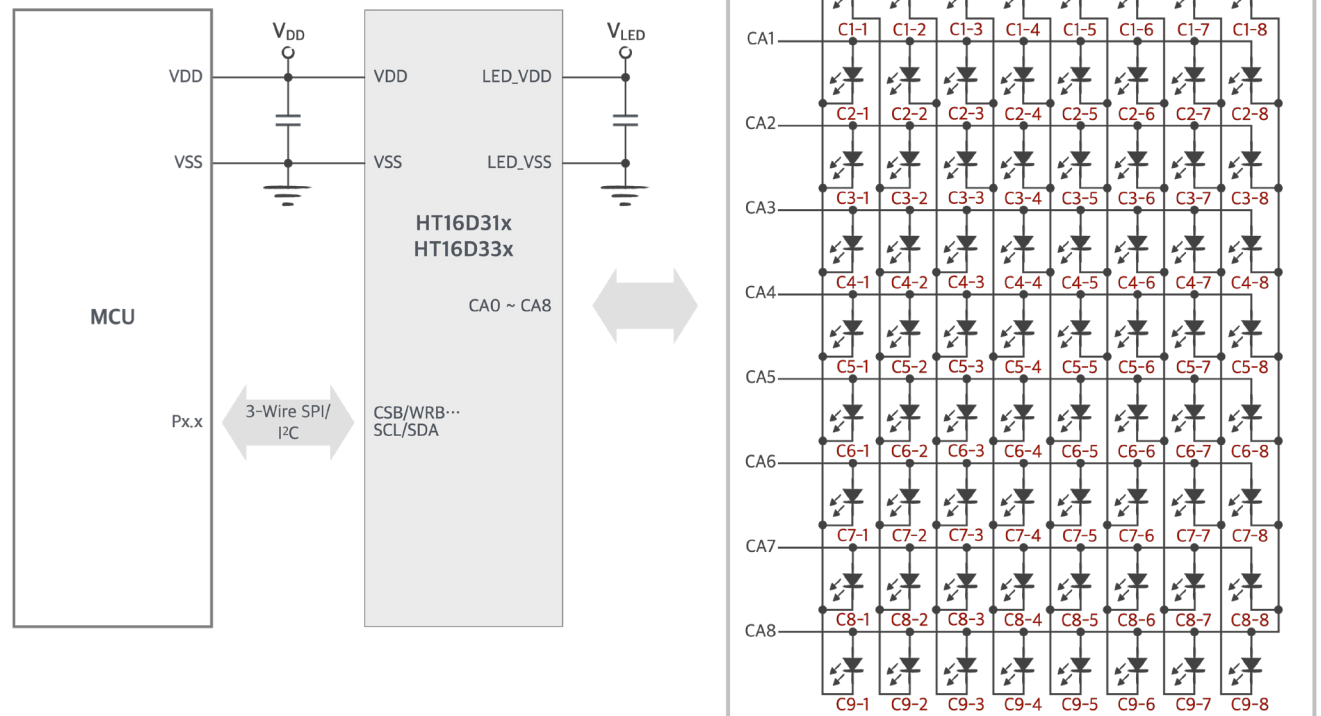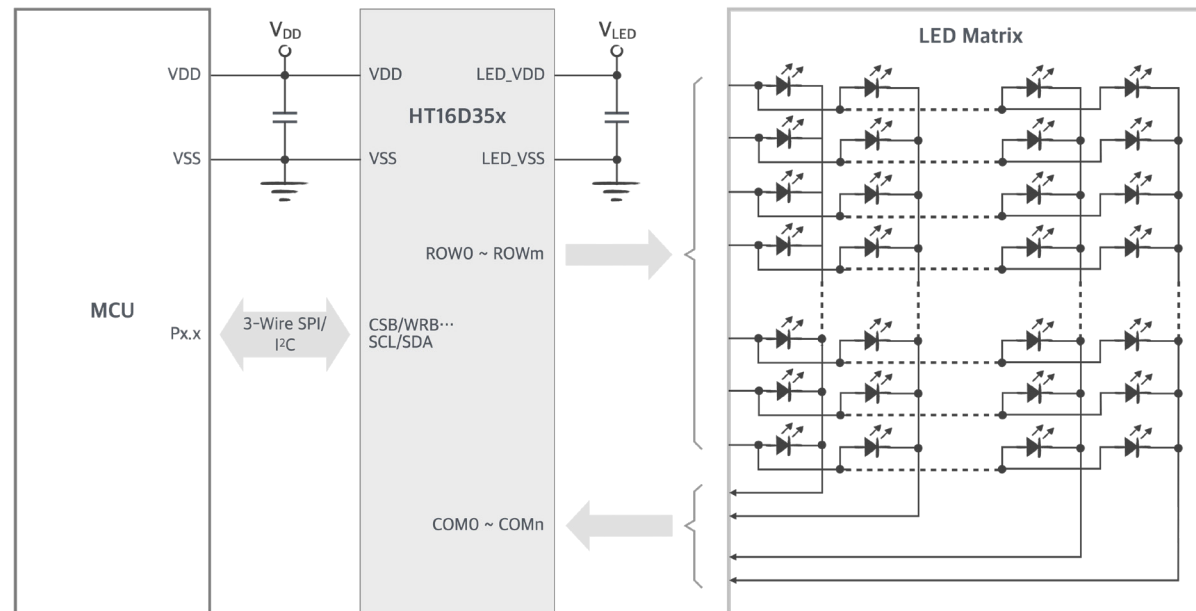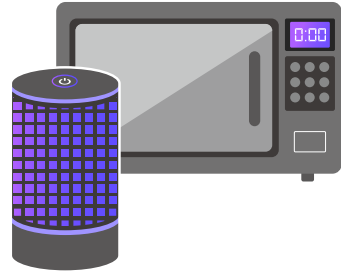

Figure 15.

Application Circuits

▌ HT16D35x

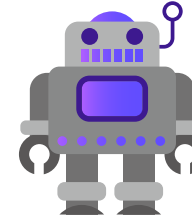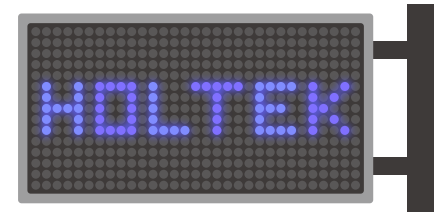Figure 16.

▶ Applications

| Gaming Products | Audio Products/Home Appliance | Health Care | Toys | LED Billboards |

▶ Product List

Please refer to the official website for product selection information.

	Part No.	VDD	Row × Common	Row Source Current	Row Sink Current	Com Source Current	Com Sink Current	PWM Gray	Key-scan	Interface	Package
LED Controller & Driver	HT1632D	4.5V~ 5.5V	32×8, 24×16	50mA	12mA	45mA	250mA	16 Level for Global	—	4-Wire	48LQFP, 52LQFP
	HT1632D-2		28×8								48LQFP
	HT1635C	4.5V~ 5.5V	44×8	50mA	10mA	45mA	250mA	16 Level for Global	—	4-Wire	64LQFP
	HT1635D									I²C	
	HT16K33A	4.5V~ 5.5V	16×8, 12×8	20mA±5%	6mA	20mA	160mA	16 Level for Global	13×3, 10×3	I²C	24SSOP, 28SSOP

|	Part No.	VDD	Row × Common	Com Source Current	Com Sink Current	Constant Current	PWM Gray	Fade	Auto Scrolling	Over Temp. Detection	Open/Short Detection	Interface	Package
Advanced LED Controller & Driver	HT16D31A	2.7V~ 5.5V	8×9	270mA	—	33mA±3% Max. 48mA	256 Level for each dot	√	√	√	√	3-Wire SPI	16NSOP-EP 16QFN
	HT16D31B											I²C	
	HT16D33A	2.7V~ 5.5V	9×10 + 9×10 12×12, 16×16	315mA	—	33mA±3% Max. 48mA	256 Level for each dot	√	√	√	√	3-Wire SPI	28SSOP 32QFN
	HT16D33B											I²C	
	HT16D35A	2.7V~ 5.5V	28×8	250mA	45mA	30mA±3% Max. 45mA	64 Level for each dot	√	√	√	—	3-Wire SPI	48LQFP-EP
	HT16D35B											I²C	

▶ HT16D3x LED Product Development Platform

The HT16D3x LED product development platform includes the HT16D3x LED Workshop, LED Editor and development boards, and supports these four devices: HT16D31B/HT16D33A/HT16D35A/HT16D35B.

▌**HT16D3x LED Workshop：** This software helps users simplify the program development of LED products. The project development is divided into three steps: screen design, display effect design and automatic code generation for the MCU.

🔗 (Official website link： https://www.holtek.com/page/detail/dev_plat/HT16D3X_LED_Workshop)

▌**LED Editor:** It is a user-friendly software tool that allows users to edit patterns and colors, set commands such as scroll and breathing lights, then view the emulated display effect on the computer screen. Through the HT16D3x LED Workshop, the edited graphics and commands are converted into program code for Holtek MCUs and then programmed to the MCU.

▌**Development Boards:** The development boards help users easily experience the development platform and evaluate the HT16D31B/HT16D33A/HT16D35A/HT16D35B devices. These boards include a general MCU control board and seven LED EV boards. Users can select the LED EV board according to the product requirements. For a list of part numbers and the purchase links for the boards, refer to the "HT16D3x Development Boards" section.
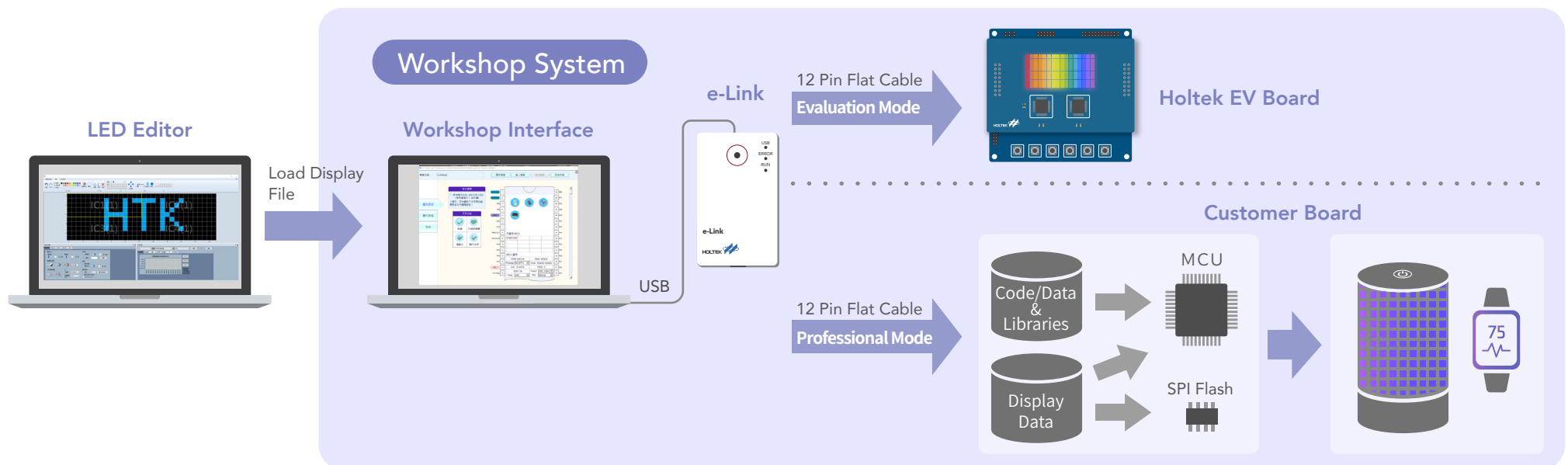
▶ HT16D3x Development Boards

General MCU Control Board (ESK-LED-100)

Monochrome LED EV Board ×3 (ESK-16D3xx-M00)
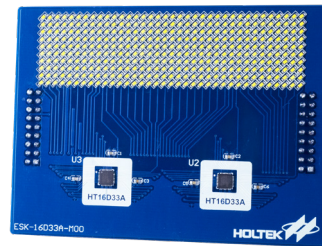
Colorful LED EV Board ×4 (ESK-16D3xx-C00)

Monochrome EV Boards

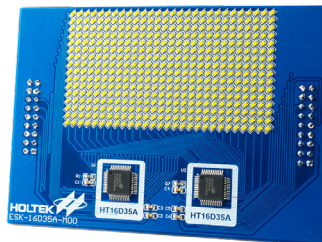|	
Name	**HT16D33A Monochrome LED EV Board**
Part No.	**ESK-16D33A-M00**
Description	Integrated HT16D33A driver ICs, 360 white LEDs (10×36 matrix).

🛒 Purchase Link

Name	**HT16D35A Monochrome LED EV Board**
Part No.	**ESK-16D35A-M00**
Description	Integrated HT16D35A driver ICs, 448 white LEDs (16×28 matrix).

🛒 Purchase Link

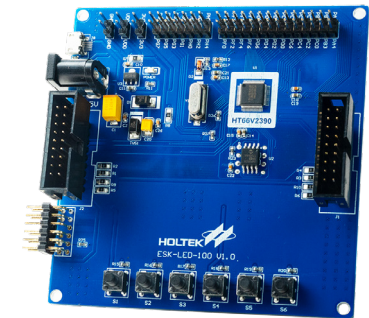## Control Board

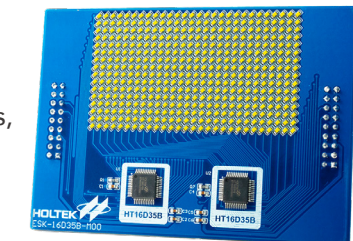|	
Name	**General MCU Control Board**
Part No.	**ESK-LED-100**
Description	Integrated HT66V2390 MCU, used with LED EV boards. (ESK-16Dxx-xxx)

🛒 Purchase Link

Monochrome EV Boards

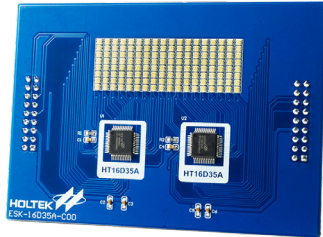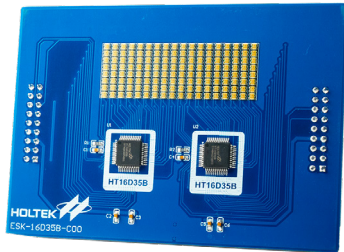|	
Name	**HT16D35B Monochrome LED EV Board**
Part No.	**ESK-16D35B-M00**
Description	Integrated HT16D35B driver ICs, 448 white LEDs (16×28 matrix).
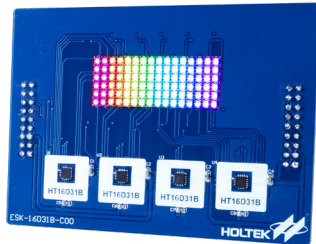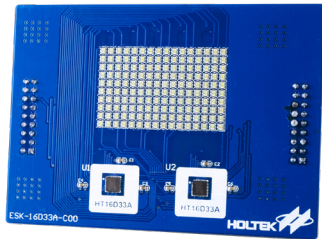
🛒 Purchase Link

Colorful EV Boards

Name	**HT16D31B Colorful LED EV Board**
Part No.	**ESK-16D31B-C00**
Description	Integrated HT16D31B driver ICs, 96 RGB LEDs (6×16 matrix).

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Name	**HT16D33A Colorful LED EV Board**
Part No.	**ESK-16D33A-C00**
Description	Integrated HT16D33A driver ICs, 160 RGB LEDs (10×16 matrix).

🛒 Purchase Link

Name	**HT16D35A Colorful LED EV Board**
Part No.	**ESK-16D35A-C00**
Description	Integrated HT16D35A driver ICs, 144 RGB LEDs (8×18 matrix).

🛒 Purchase Link

Name	**HT16D35B Colorful LED EV Board**
Part No.	**ESK-16D35B-C00**
Description	Integrated HT16D35B driver ICs, 144 RGB LEDs (8×18 matrix).

🛒 Purchase Link

LCD/LED Controller & Driver Application Notes

▶ Application Notes

HT16D33A/B and HT16D31A/B LED Driver Application Guidelines：

This application note will introduce the Ghost effect, which is derived from this series of LED Driver applications which use common cathode or common anode RGB LED Matrix displays. This effect can be processed by using the device internal functions and a mode for arraying common cathode or common anode RGB LEDs.

🔗 Note Website：https://www.holtek.com/page/applicationNotes/AN0568

HT16H25 Treadmill Display Application Guideline：

Using a master MCU to communicate with the HT16H25 through the I²C interface, this application note will simulate a treadmill LCD display and provide users with a means to better understand the HT16H25 features and applications.

🔗 Note Website：https://www.holtek.com/page/applicationNotes/AN0505

HT16L21 BD Player Panel Application：

This application note will introduce how to use the HT16L21 to drive Blue-ray Display LCD panels with a master MCU using the I²C interface, with the aim of increasing user's understanding of the HT16L21 features and applications.

🔗 Note Website：https://www.holtek.com/page/applicationNotes/AN0478

HT1629G Emulated Vehicle Instrument Information Display Application：

Using a master MCU to communicate with the HT1629G via the SPI interface, this application note will emulate a vehicle instrument LCD display and provide users with a means to better understand its features and applications.

🔗 Note Website：https://www.holtek.com/page/applicationNotes/AN0477

HT162x Application Guidelines：

This guideline will first introduce the operation principles of the HT162x series LCD drivers and then introduce some application methods and notes.

🔗 Note Website：https://www.holtek.com/page/applicationNotes/AN0468

Using the HT16K33A in DVD Player Panel Applications：

Using a master MCU to communicate with the HT16K33A via the I²C interface, this application note will simulate a DVD player panel display and provide users with a means to better understand HT16K33A features and applications.

🔗 Note Website：https://www.holtek.com/page/applicationNotes/AN0363

Using the HT16C2xA I²C Interface for LCD Driving and Control：

Using a master MCU to communicate with the HT16C23A via the I²C interface, this application note will simulate a three-phase electricity meter display and provide users with a means to better understand HT16C2xA features and applications.

🔗 Note Website：https://www.holtek.com/page/applicationNotes/AN0280

Electricity Meter Applications Using the HT16C22A：

This application note describes the related setup and application methods for a 4×40 LCD electricity meter driven by the HT16C22A.

🔗 Note Website：https://www.holtek.com/page/applicationNotes/AN0255

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Sharing Success Through Excellence

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