LED Driver IC
for Flexible Numeric Display

MC2701

User's manual

V 1.0

Main features

- **LED driver with 14 outputs (8 segments / 6 digits)**
- **40mA load current capability to each segment**
- **Output pins connected directly to the LEDs or can be open-drain**
- **Key-scanning 8 x 2 matrix**
- **3-wired serial bus interface (CLK, STB, DIN/DOUT)**
- **8-step dimming circuit to control the overall display brightness**
- **Single external resistor for output current set**
- **Inputs with Schmitt trigger give superior noise immunity**
- **A single LED digit output (DIG0_LED) can be used to drive up to 8 discrete LEDs**
- **8-step dimming circuit to control brightness of individual LEDs for LED digit**
- **4.5V~5.5V for Vcc**
- **Drives common-anode LED digits**
- **Built-in power on reset and soft-start circuits**
- **Available in 24SOP package**
- **-40°C to 85°C operating temperature range**
- **Application**
  - Set-top-boxes
  - White goods
  - Home appliances
  - DVD players and VCRs

Revised 17 October, 2014

Revision history

Version	Date	Revision list
0.0	2013.12.25	Initial version
0.1	2014.05.09	Arial characteristic selestion
0.2	2014.05.30	Output pin structure
0.3	2014.06. 25	Operating Voltage 2.5V~5.5V
0.4	2014.08.26	Update Electric Characteristics
0.5	2014.09.17	Update interface packet explaination
0.6	2014.10.17	Update control interface format
0.7	2014.12.16	Internal RC Oscillator frequency is 450kHz typical.
1.0	2014.12.30	Operating Voltage 4.5V~5.5V

Version 0.0

Published by FAE team

1 Overview

1.1. Description

The MC2701 is a compact LED controller and driver that interface microprocessors to LED display throuth a serial 3-wire interface. It drives LED connected in common anode configuration. The MC2701 drives up to 48 discreete LEDs in 8 segment / 6 digit configuration while functioning from a supply voltage 4.5V~5.5V. Additionally it can be used to drive 8 discrete LEDs which form a part of LED digit. The individual LEDs are wired as segment of a digit and brightness of individual LEDs can be controlled digitally. The maximum segment current for the display digits is set through a single external resisteor. Individual digits may be addressed and updated without re-writing the entire display.

Additionally it includes key scanning for an 8 x 2 key matrix which automatically scans a matrix of up to 16 switches. MC2701 supports numeric-type displays and reduces the overall BOM costs through high integration. Also it provides ESD protection of greater than 4KV HBM.

The LED controller /driver is ideal as a peripheral device to interface the display with a singlechip microcomputer.

Device Name	Segment	Grid	Key Scan	Brightness	Package
MC2701D	8	7	16 key matrix	8 steps	24SOP

Table 1.1 Ordering Information of MC2701

1.2 Features

- **Display Capacity**
  - 8 Segment and key-scan pin SEG0/KS0~SEG7/KS7
  - 6 Grid pin DGT0_LED, DGT1~DGT6
  - Customer configurable display capacity
  - Common anode type FND drive
- **Key Scan**
  - 2 Key scan input
  - 8 x 2 Key matrix max.
  - Interrupt signal generation at key detecting
- **Interface**
  - 3-wired serial bus CLK, STB, DIN/DOUT
- **Brightness Control**
  - Ouput current set by external resistor at ISET pin
  - 8 step duty control
  - Each discrete LED and FND brightness control
- **Noise Immunity**
  - Schmitt trigger circuit at 3-wired bus line
- **Built-in Reset**
  - POR (Power-On Reset) 1.2V
  - LVR (Low Voltage Detect Reset) 1.9V
- **Operating Frequency**
  - 450 kHz
- **Operating Voltage**
  - 4.5V ~ 5.5V (CLK speed is limited under 4.5V)
- **Operating Temperature : –40 ~ +85**℃
- **Package Type**
  - 24SOP
  - Pb free package

2 Block diagram

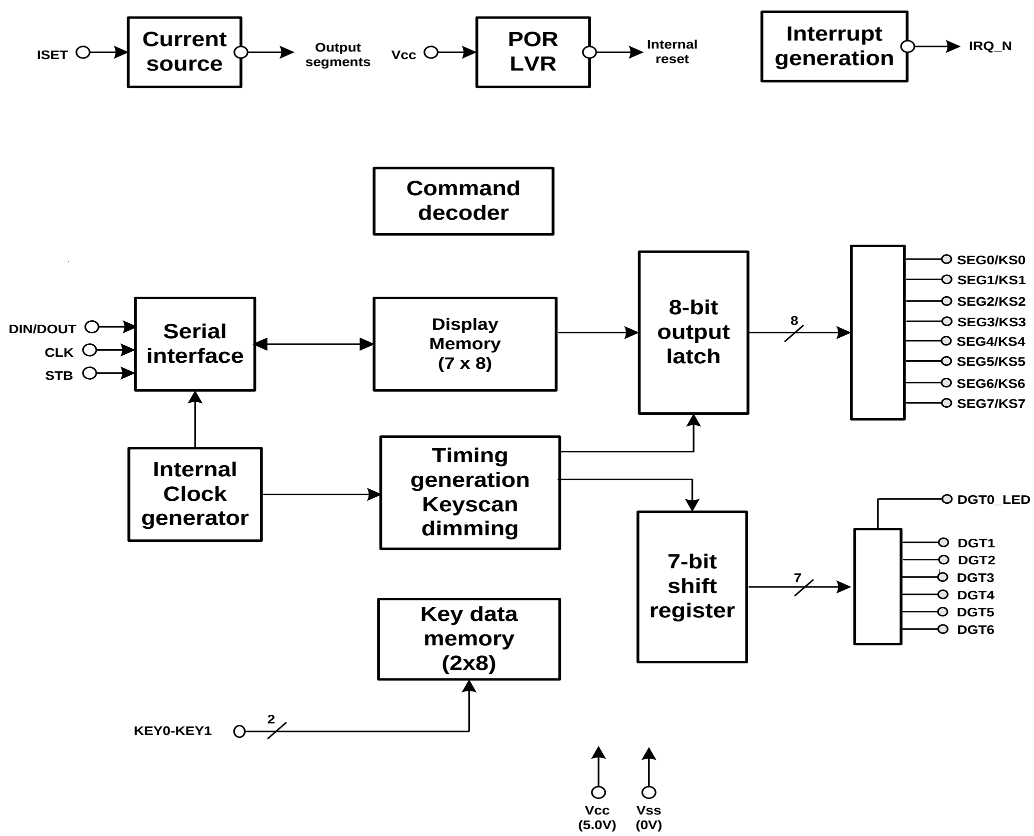
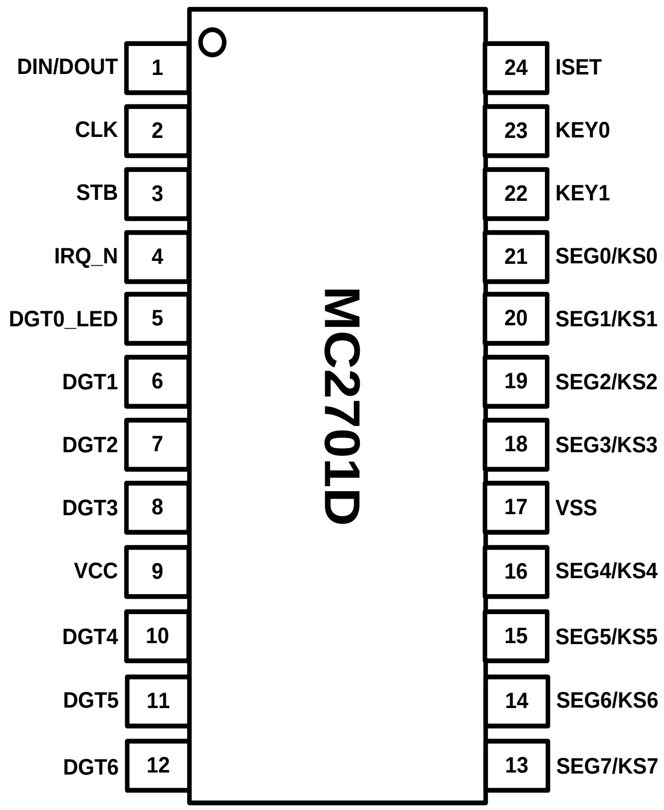


Figure 1.1 Block diagram of MC2701

3 Pin assignment



NOTE)

Figure 2.1 MC2701 24SOP pin assignment

4 Package Diagram

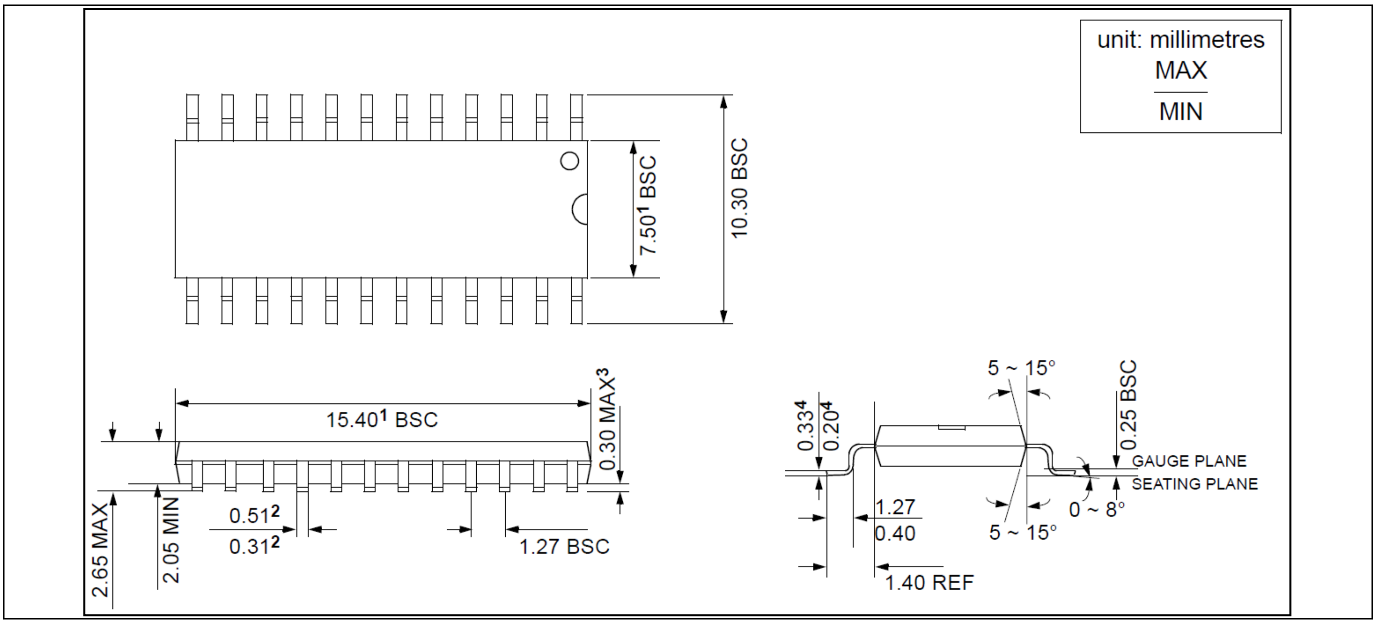


Figure 4.1 24-Pin SOP Package

5 Pin Description

PIN Name	I/O	Function	@RESET	Shared with
DIN/DOUT	I/O	Output serial data at falling edge of shift clock, starting from lower bit. Input serial data is clocked in at rising edge of the shift clock, starting from lower bit.	Input	DOUT
CLK	I	Read serial data at rising edge, and outputs data at falling edge.		
STB	I	Initialize serial interface at rising or falling edge to make MC2701 wait for eception of command. Data input after the falling edge of STB are processed as a command. While command data are processed, current prcessing is stopped, and the serial interface is initialized. While STB is high, instructions are ignored.		
IRQ_N	O	Interupt output (active low) to interrupt MCU when there is a key pressed.		
DGT0_LED	O	Single output LED used together with 8 segments to drive up to 8 discrete LEDs		
DGT1	O	Digit output pins		
DGT2				
DGT3				
DGT4				
DGT5				
DGT6				
Vcc		5.0V Core main supply voltage. Bypass to VSS through a 0.1uF capacitor as close to the pin as possible.		
SEG0/KS0	O	Segment output pns and dual function as key source.		KS0
SEG1/KS1				KS1
SEG2/KS2				KS2
SEG3/KS3				KS3
SEG4/KS4				KS4
SEG5/KS5				KS5
SET6/KS6				KS6
SEG7/KS7				KS7
KEY0	I	Key input pins, Input data to these pins from external keyboard are latched at the end of the display cycle (maximum key matrix is 8 x 2)		
KEY1				
ISET	I	Segment current set. Connected to Vss through a resistor to set peak segment current.		

Table 5.1 Normal Pin Description

6 Port Structures

6.1 DGT Pin and SEG/GS pin

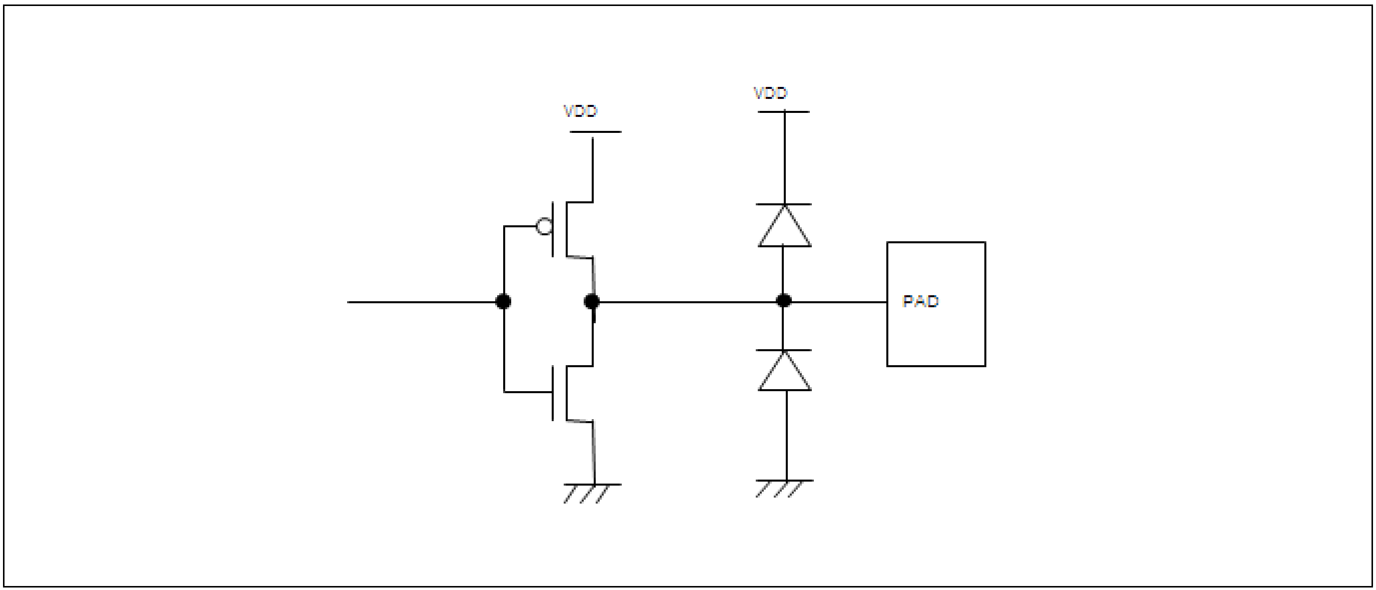


Figure 6.1 DGT pin and SEG/KS pin

6.2 Digital Interface pin (STB/CLK, DIO, IRQ)

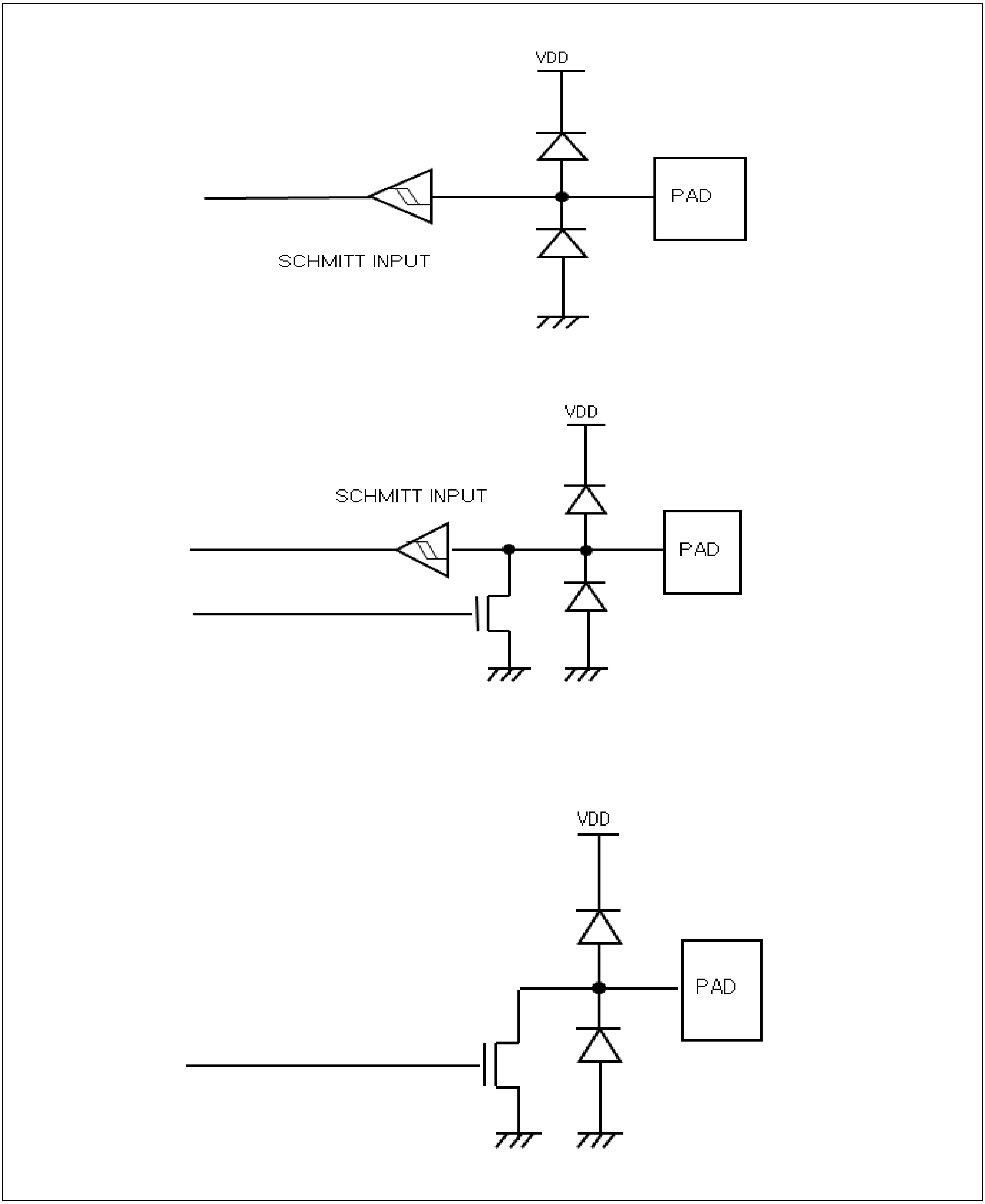


Figure 6.2 3 Wired bus Port and IRQ

6.3 Key In pin (KEY0, KEY1)

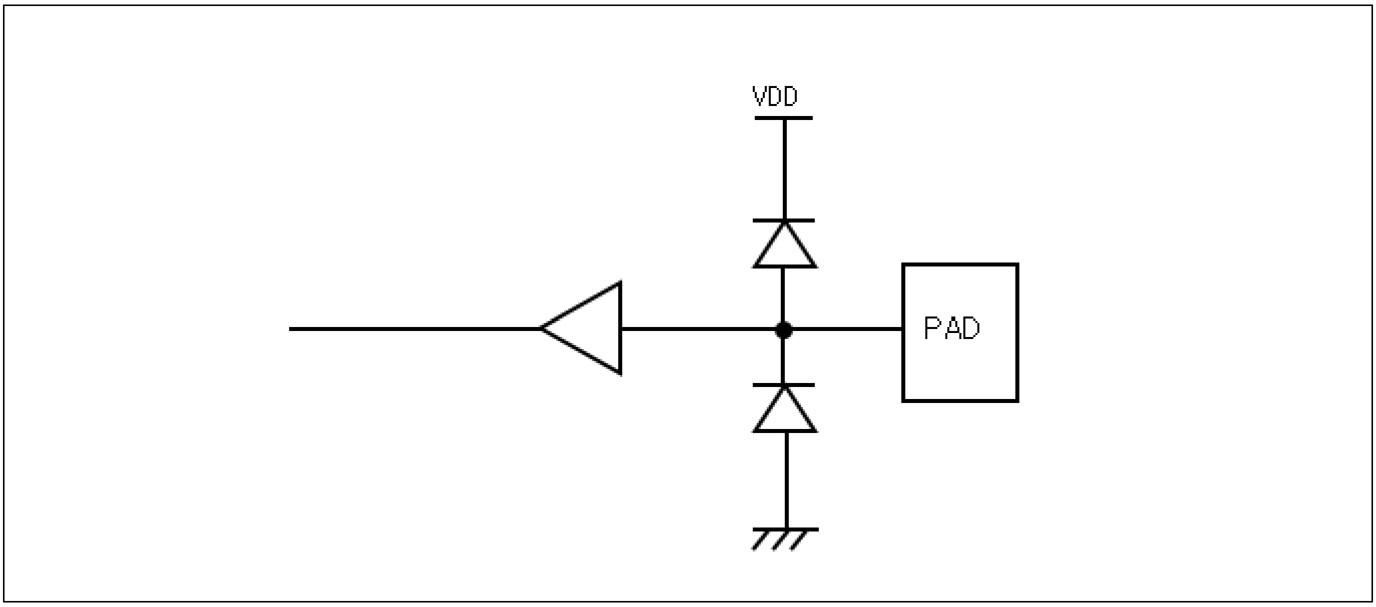


Figure 6.3 KEYIN pin

6.4 ISET pin

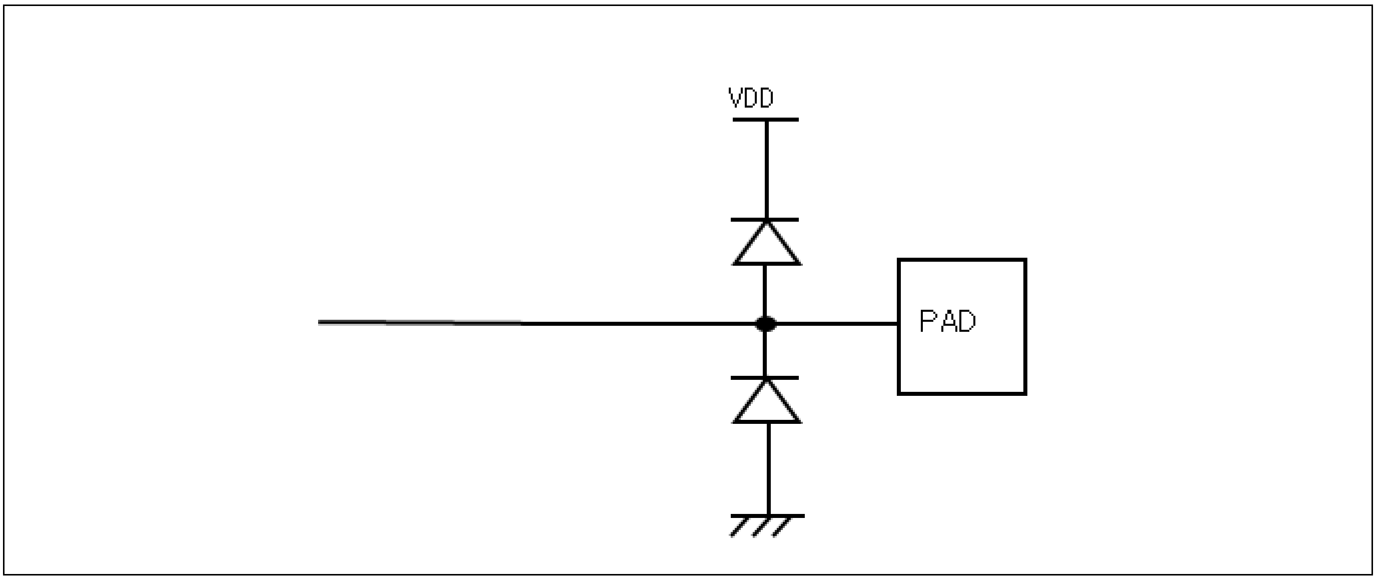


Figure 6.4 ISET pin

7 Electrical Characteristics

7.1 Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Supply Voltage to Vss	Vcc	-0.5 ~ +7.0	V
Logic input voltage	VI	-0.5 ~ Vcc+0.5	V
Power dissipation (1)	P_D	1200	mW
Operating amient temperature	T_A	-40 ~ 85	℃
Junction temperature	T_J	150	℃
Storage temperature	T_{STG}	-65 ~ +150	℃
Lead temperature (10 sec)	T_L	300	℃
Electrostatic discharge voltage on ll pins (2) HBM (Human Body Model)	V_{ESD}	-4 ~ +4	kV

Table 7.1 Absolute Maximum Ratings

NOTE)

1. De-rate at -9.6 mW/℃ at T_A= 25℃
2. In accordance with the JEDEC standard

7.2 DC electrical characteristics

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
Logic supply voltage	V_{CC}		4.5	5.0	5.5	V
High level input voltage	V_{IH}	Digital pin	$0.57V_{CC}$		V_{CC}	℃
Low level input voltage	V_{IL}	Digital pin	-		$0.3\ V_{CC}$	V
Input Current	I_{IH}, I_{IL}	V_{IN}=V_{CC} or V_{SS}	-2		2	uA
Hysteresys voltage (DIN, CLK, STB pins)	V_{HYS}			1.0		V
Low level output voltage	V_{OL}	DOUT, I_{OL2}=4mA			0.4	V
Segment drive LED sink current	I_{SEG}	V_{LED}=2.5V V_{DIGIT}=V_{CC}-1.0V	-30	-40	-50	mA
Digit drive LED source current	I_{DGT}	V_{DIGIT}=V_{CC}-1.0V	240	320	400	mA
Segment drive current matching	I_{TOLSEG}	V_{CC} = 5.0V, T_A=25℃		3		%
External current set reference resistor (precision = ±1% tolerance)	R_{SET}	I_{SEG} = 40mA		360		Ω

Table 7.2 DC electrical characteristics

7.3 Dynamic switching characteristics

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
Internal oscillator frequency	f_{OSC}	TA = 25°C		450		kHz
Clock (CLK) frequency	f_{MAX}	VCC=5V, Duty = 50%	1			MHz
Propagation delay	t_{PLZ}	CLK to DOUT R_L=10KΩ, C_L=15pF			300	ns
	t_{PZL}				100	ns

Table 7.3 Dynamic switchingl characteristic

7.4 Timing characteristics

(TA=-40°C~+85°C, Vcc=5.0V±10%, Typical values are at 25°C)

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
Clock pulse width	PW_{CLK}		400			ns
Strobe pulse width	PW_{STB}		1			us
Data setup time	t_{SETUP}		100			ns
Data hold time	t_{HOLD}		100			ns
Clock strobe time	$t_{CLK-STB}$	CLK rising edge to STB rising edge	1			us

Table 7.4 Timing characteristics

7.5 Power supply characteristics

(TA=-40°C~+85°C)

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit
Quiescent power supply current	I_{STBY}	Vcc = 5.5V, All inputs = Vcc or GND		50	1000	uA
Operating power supply current (display on)	I_{CC}	All segment ON, all digits scanned, intensity set to full, internal oscillator, no display load connected		10	15	mA

Table 7.5 Power supply characteristics

7.6 Typical Characteristics

These graphs and tables provided in this section are for design guidance only and are not tested or guaranteed. In some graphs or tables the data presented are outside specified operating range (e.g. outside specified VDD range). This is for information only and devices are guaranteed to operate properly only within the specified range.

The data presented in this section is a statistical summary of data collected on units from different lots over a period of time. “Typical” represents the mean of the distribution while “max” or “min” represents (mean + 3σ) and (mean - 3σ) respectively where σ is standard deviation.

8 Functional description

The MC2701 is a common-anode LED driver controller which can be used to drive red, green or blue LEDs as the current is adjustable through the external resistor. In the common anode configuration, the segment outputs sink the current from the cathodes while the digit outputs source the current to the anodes. The configurable output current can be used to drive LEDs with different current ratings (red, green or blue). The brightness of the whole display can be controlled through the serial interface as described later. The outputs can be connected together in parallel to drive a single LED. In this case, two parallel current sources of equal value drive a single LED. The external resistor value can be set accordingly to determine the desired output current thus controlling the display brightness. Soft-start limits the inrush current during power-up. The display is blanked (LEDs are turned off or in high-Z state) on power-up.

8.1 Low Power mode of operation

Upon initial power up or when not configured or when not used, the MC2701 will be in low power mode of operation wherein the current consumption drops to less than 1mA. During this mode, the data configured is maintained as long as the supply voltage is still present (the contents of the internal RAM need the supply voltage to be present). Port configuration and output levels are restored when the MC2701 resumes normal operation. For minimum supply current in shutdown mode, logic inputs should be at GND or VCC

8.2 Serial Interface

The interface is used to write configuration and display data to the MC2701. The serial interface comprises of a shift register into which DIN is clocked on the rising edge of the CLK when STB is low. When STB is low, falling transitions on CLK clock the data from the device to the microcontroller. The 8-bit data is decoded to determine and execute the command. STB indicates to the device the start of communication when it goes low. DIN/DOUT pin is bi-directional. The data will be validated during positive pulse of the clock in both write/read modes. If the STB signal goes high before completing the data byte write to the device, the preceding data bits are ignored and the previous configuration remains intact.

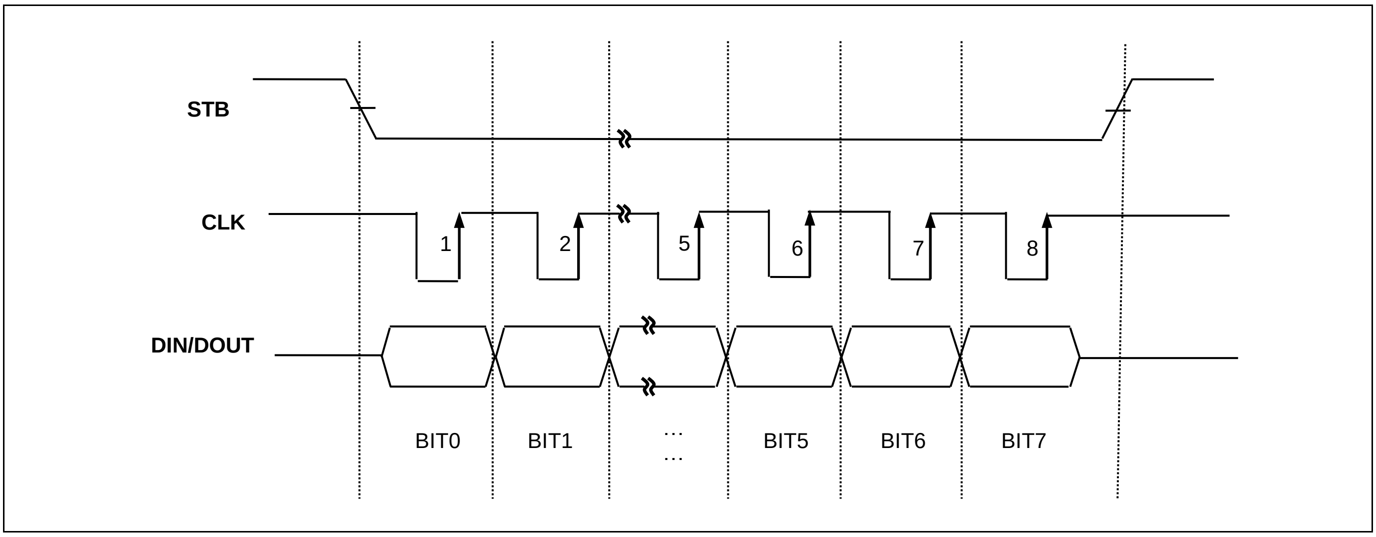


Figure 6.5 3 Wired interface

8.3 Initial power up

On initial power-up, all control registers are reset, the display is blanked and the MC2701 is in the low power mode. All the outputs are in high-impedance state at initial power-up. The DIN/DOUT is pulled high by an external pull-up resistor. The display driver has to be configured before the display can be used.

The device integrates an internal power-on-reset circuit which initializes the digital logic upon power up. The soft-start circuit limits the inrush current and high peak current during power-up. This is done by delaying the input circuit's response to the external applied voltage. During soft-start, the input resistance is higher which lowers the in-rush current when the supply voltage is applied.

8.4 LED drivers

The constant current capability is up to 40 mA per output segment and is set for all the outputs using a single external resistor. When acting as digit drivers, the outputs source current to the display anodes. When acting as segment drivers, the LED outputs sink current from the display cathodes. The outputs are high impedance when not being used as digit or segment drivers. Each port configured as a LED digit driver behaves as a digitally-controlled constant current sink. The LED drivers are suitable for both discrete LEDs and common anode (CA) numeric LED digits. When fully configured as a LED driver, the MC2701 controls up to 8 LED segments in a single digit with 8-step logarithmic brightness control for the digits. A single resistor sets the maximum segment current for all the segments, with a maximum of 40mA per segment. The MC2701 drives any combination of discrete LEDs and CA digits for numeric displays. The recommended value of R_{SET} is the minimum allowed value, since it sets the display driver to the maximum allowed segment current. R_{SET} can be a higher value to set the segment current to a lower maximum value where desired. The user must also ensure that the maximum current specifications of the LEDs connected to the drivers are not exceeded. The brightness of the individual digits in the display panel can be controlled separately.

The MC2701 can be used to drive up to 8 discrete LEDs. The single LED output acts like a digit driver output and can be wired-up with 8 segment outputs to drive up to 8 different discrete LEDs. Physical connections from the LED output as well as the segment outputs must be made to drive the discrete LEDs in the desired manner. The discrete LEDs may be needed to indicate the “Power”, “Standby” status (for example). Also it is possible to separately control the brightness of each single LED.

8.5 Operating the device with 3.3V interface voltage

The device can detect the input voltage levels reference to 3.3 V from the main controller chip as long as the V_{IL} and V_{IH} specifications of the MC2701 are met. If the input voltage to MC2701 is greater than 2.9V, the MC2701 will recognize the signal level as a valid high and if the input voltage is lower than 1.75V, it will be recognized as a valid low level. For the output signals from the device like DOUT and IRQ_N, the signal level depends on the external supply to which the external pull up resistor is connected to. Thus this eliminates the use of any level shifter between the main controller and the MC2701.

8.6 Power consumption estimation

Each port of the MC2701 can sink a maximum current of 40 mA into an LED with a 4.4 V forward voltage drop when operated from a supply voltage of 5.0 V. The minimum voltage drop across the internal LED drivers is thus 5.0 - 4.4 = 0.6 V. The MC2701can sink 8 x 40 = 320 mA when all outputs are operating as LED segment drivers at full current.

On a 5.0 V supply, a MC2701 dissipates (5.0 V - 4.4 V) x 320 mA = 192 mW when driving 8 of these 4.4 V forward voltage drop LEDs at full current. If the application requires high drive current, consider adding a series resistor to each LED to drop excessive drive voltage off-chip. If the forward voltage of the LED is lesser than 4.4 V (say 2.4 V), then the maximum power dissipation of MC2701 when all segments are turned on will be (5 - 2.4) V x 320 mA = 832 mW. To lower the power dissipation, consider adding a small series resistor in the supply. Another alternative is to increase the value of the R_{SET} to lower the current of the LEDs from 40 mA to say 30 or 20 mA. The efficiency will be the power consumption in the LEDs divided by the input power consumed.

Efficiency = V_{diode} x I_{diode} / V_{CC} x I_{CC}

As an example, consider LED with forward voltage of V_F = 2.4V, I_{peak} = 40 mA, $V_{CC\ (max)}$ = 5.5 V, N = number of segments = 8 (max), D = duty cycle = 15/16, Power dissipation, $P_{D\ (max)}$ = 5 mA x 5.5 V + (5.5 - 2.4) V x (15/16) x 40 mA x 8 = 27.5 + 780 = 807.5 mW. To lower this value, add a series resistor with the supply

9 Key scan and display cycle

The display RAM stores the data transmitted from an external device to the MC2701 through the serial interface. The grid and segment outputs are controlled by the display output module. The entire grid will be turned off on channel 1/16 and 16/16 meaning that the first channel and last channel are off. This is referred to as blanking time. During the keyscan time (first cycle from timing generator), the entire grid is turned off and only the segments are enabled one by one (seg0 to seg7). The segment on time is 64 µs. During the LED discrete time (second cycle), the data present on the internal LED buffer is checked. If the data is present, then the brightness setting of each LED in the brightness control register is checked. Then each segment will be enabled or disabled based on the register value. In this duration, the grids 1 to 6 are turned off. The grid corresponding to LED digit is turned on. The LED on duty cycle is 14/16. If the LED/seg1 brightness is 12/16, it means that the segment1 OFF time is 12/16 and on time is 2/16. During 7-segment display time (3rd cycle to 8th cycle), the display status is checked whether it is ON or OFF. If display is ON, then the dimming settings are checked from the configuration register for the grid (it may be common dimming setting or individual dimming setting for each digit). The minimum turn on time is 1/16 and maximum turn on time is 14/16. The blanking time is valid before the turning on and turning off of the grid. The blanking interval is 32 µs. This will continue until the maximum number of digits configured in the register. Once the full cycle is complete, the keyscan cycle will start again. If the display is not turned on, then the timing generation will immediately go to the key scan mode.

Initial:

All the segments and grids are turned off.

During operation:

1. Turn on segment (keyscan) one by one. On time duration is 64 us.
2. Check the data present in LED register. If data is present, turn on the respective LED grid and segments.
3. Check the display on. If display is turned on, then enable the grid one by one from grid 1 to grid 6 (maximum) and turn on segments.

9.1 Key matrix and key-in data storage RAM

During the key scan cycle all the grids are turned off. The first segments turn on is 64 us. The key1 and key2 signals will be sampled after 60 us. The two signals latch into the internal key buffer. The same applies for other segments. This key buffer compares the data with the previous key status. If any changes are seen in the buffer values, then the IRQ_N is asserted. The IRQ_N signal is active low (level). This IRQ_N signal will be cleared at the end of reading the key buffer (end of byte transfer). The key buffer must be completely read before the IRQ_N is cleared. The key matrix is of 8 x 2 configuration, as shown below:

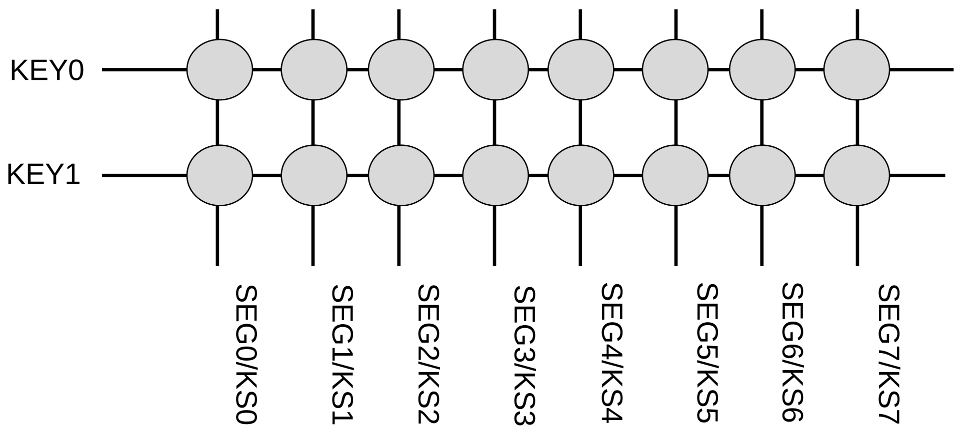


Figure 6.6 Key matrix

The data of each key are stored as illustrated below, and are read by the appropriate read command, starting from the least significant bit.

	KEY	KS0	KS1	KS2	KS3	KS4	KS5	KS6	KS7
1st byte	00h	0	0	0	0	0	0	0	0
2nd byte	00h	0	0	0	0	0	0	0	0

The initial key buffer value is “00”. During operation, the buffer values will change depending upon the values of the key-press, and IRQ is low. When key data is read by host, IRQ is high again..

10 Command

Command sets the display mode and the status of the LED driver. The first byte input to the MC2701 through the DIN input after the STB goes low is regarded as a command. If STB is set high while commands/data are transmitted, serial communication is initialized, and the commands/data being transmitted are invalid (however, the commands / data already transmitted remain valid).

10.1 Write command

7	6	5	4	3	2	1	0
-	READ	AUTOINC	BANK1	BANK0	ADDR2	ADDR1	ADDR0
-	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Initial value : 00H

READ	Read or write command define	
	0	Write command (default)
	1	Read command
AUTOINC	Auto increment address	
	0	Auto increase address (default)
	1	Fixed address
BANK[1:0]	Memory bank	
	00	7-segment font memory
	01	LED Display
	10	7-segment brightness set
	11	LED brightness set
ADDR[2:0]	Memory address	
	000	Memory address 0
	…..	
	101	Memory address 5

The following bytes are either configuration data or display data. During the write command, the control flag display on and auto increment address are latched into the internal control flag register. The default value is ‘0’ for display on control register implying that the display is off. The user must turn on the display to view the display memory. Similarly the auto increment address mode is enabled by default. If the user desires to read from a particular address location, the user can fix the address pointer.

Display on: command 0x0D

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
x	0	x	0	1	1	0	1

Display off: command 0x0E

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
x	0	x	0	1	1	1	0

Use these two commands to turn the display ‘ON’ and ‘OFF’.

10.2 Read command

7	6	5	4	3	2	1	0
-	READ	AUTOINC	BANK1	BANK0	ADDR2	ADDR1	ADDR0
-	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Initial value : 00H

READ	Read or write command define	
	0	Write command (default)
	1	Read command
AUTOINC	Auto increment address	
	0	Auto increase address (default)
	1	Fixed address
BANK[1:0]	Memory bank	
	00	7-segment memory
	01	LED Display and Key Data
	10	7-segment brightness set
	11	LED brightness set
ADDR[2:0]	Memory address	
	000	Memory address 0
	…..	
	101	Memory address 5

Use the page 0x01 to read the LED data and key data.

Address	Function
00	LED data (optional)
01	Key data 0
02	Key data 1

Set flag for key1 and key2 to ensure that the user reads from the particular key. When reading the key data from the memory, the IRQ_N will be automatically cleared signifying that the end of the 8th bit was transmitted correctly. If the IRQ_N is asserted by the last eight keys, then the user reads the key data (one byte only by reading the first byte). In this case, the IRQ_N will remain active until the second byte is read. When the user uses the read key to read the LED and key data, first the user must choose the address (default address location is 0x00) after which the address will increment only by 3 addresses (maximum).

10.3 Device configuration

This section describes how to program and read the configuration of the device. Configuration data comprises of the display setting, dimming setting, display on/off and fixed address/auto increment. The address pointer will indicate the configuration location and write signal writes the configuration data into the respective location. The memory block is split into two page locations. One is for the 7-segment brightness configuration memory and the other is for the LED (discrete) configuration memory. The configuration memory address starts from 0x00 to 0x07. The configuration page address is “10” and “11”.

Initial Value:

Memory page	Address	Value
10	00	0xFB
10	01	0x00
10	02	0x00
10	03	0x00
11	00	0x00
11	01	0x00
11	02	0x00
11	03	0x00

Table 13. Memory page mapping

Description: Address 0x00; page 0x10

7	6	5	4	3	2	1	0
VALUE2	VALUE1	VALUE0	LED_BRIT	DGT_BRIT	DIGIT2	DIGIT1	DIGIT0
R/W	R/W -	R/W	R/W	R/W	R/W	R/W	R/W

Initial value : FBH

VALUE[2:0] Constant brightness control value for all including the LED (discrete)
- 000 Pulse width is 1/16, Minimum brightness value (default)
- 001 Pulse width is 2/16
- 010 Pulse width is 4/16
- 011 Pulse width is 10/16
- 100 Pulse width is 11/16
- 101 Pulse width is 12/16
- 110 Pulse width is 13/16
- 111 Pulse width is 14/16, Maximum brightness value

LED_BRIT LED Brightness control mode
- 0 Variable brightness control for LED
- 1 Constant brightness control for LED

DGT_BRIT Digit brightness control mode
- 0 Variable brightness control for 7 segment display
- 1 Constant brightness control for 7 segment display

DIGIT[2:0] Configure the maximum display digits
- 000 1 digit display
- 001 2 digits display
- 010 3 digits display
- 011 4 digits display
- 100 5 digits display
- 101 6 digits display

MSB 5 – 7 indicates constant brightness control value for all including the LED (discrete) Default is constant brightness control with 14/16 pulse width (for maximum brightness).

Page 0x10 - address 0x01 to 0x03 is for the variable brightness control value for 7 segments: Default is constant brightness control with 14/16 pulse width. Each brightness control duty value is selected from 0000(1/16) to 0111(14/16).

Description: Address 0x01~0x03; page 0x10

Address	MSB	LDB
0x01	Digit 2	Digit 1
0x02	Digit 4	Digit 3
0x03	Digit 6	Digit 5

Table 14. Digit variable brightness control

Page0x11 - address 0x00 to 0x03 is for the variable brightness control value for LED (discrete). Default is constant brightness control with 14/16 pulse width. During normal operation, the user defined value will be stored in the respective location. Each brightness control duty value is selected from 0000(1/16) to 0111(14/16).

Description: Address 0x00~0x03; page 0x11

Address	MSB	LDB
0x00	LED/SEG1	LED/SEG0
0x01	LED/SEG3	LED/SEG2
0x02	LED/SEG5	LED/SEG4
0x03	LED/SEG7	LED/SEG6

Table 15. LED variable brightness control

10.4 Display memory

The display memory stores the display data and sends to the LED when the display is on. The address pointer, memory page and write signal indicates to this block the location to write the data. This block will manage the address pointer. When the user writes a first byte, the address increments by one if in auto-increment mode, else the address pointer remains in the same location. The initial address is latched during the write/read command into the address pointer. The display memory (7-segment/LED) is directly mapped into the display segments. The user can access only one bank at a time in both the read and write modes. The memory block is split into 4 pages.

Memory page address

Page 1 7-segment memory	Page 2 LED display	Page 3 7 segment brightness set	Page 4 LED brightness set
Address 0x00~0x05 (40bits)	Address 0x00 (8 bits)	Address 0x00~0x03 (32 bits)	Address 0x00~0x03 (32 bits)

7-segment display (FND) memory page 0x00:

Address	Data
0x00	0x00
0x01	0x00
0x02	0x00
0x03	0x00
0x04	0x00
0x05	0x00

Table 17. 7-segment display address

LED display memory page 0x01:

Address	Data
0x00	0x00

Table 18. LED display address

Initial memory:

Default memory value is “00” in all locations.

During operation:

User defined value in these locations. When the user wants to read the data from a particular location, the user sends the address page through read command and chooses the mode of the address pointer (fixed or auto). In this case, the user can access the whole memory area in that particular page (maximum 0 x 05). The display RAM stores the data transmitted from an external device to the MC2701 through the serial interface; addresses are as follows, in 8-bits unit:

	SEG7	SEG6	SEG5	SEG4	SEG3	SEG2	SEG1	SEG0
DGT1	0	0	0	0	0	0	0	0
DGT2	0	0	0	0	0	0	0	0
DGT3	0	0	0	0	0	0	0	0
DGT4	0	0	0	0	0	0	0	0
DGT5	0	0	0	0	0	0	0	0
DGT6	0	0	0	0	0	0	0	0

“0” in memory means GND on output; “1” in memory means V_{CC} on output

11 Key-scanning and display interface timing

During the first cycle, the 16 channels are used for the keyscan. The keyscan duration is made up of 64 us. The second cycle is used for the display of the LED (discrete). The maximum time is 512 us and the 3rd-8th cycles are used for the 7-segment display. The number of cycles will increase or decrease depending upon the user configuration.
By default, the configuration is made up of 4 cycles. If any data is written to the discrete LED, only then the 2nd cycle is valid. Otherwise the 7-segment moves from 2nd-7th cycle. This is a continuous operation. During the normal operation, the user cannot control or stop the timing generation. One cycle of key scanning consists of one frame, and data of 8 x 2 matrices are stored in the RAM.

11.1 Serial communication format (reception)

The figure below shows the “reception” by MC2701 for command/data write sequence. The STB must be low for 1 us before the first and last clock rise. The minimum time the STB must remain low is 9 us. The maximum clock frequency is 1 MHz with a duty cycle of 50%. Data set-up and hold time must be 100 ns.

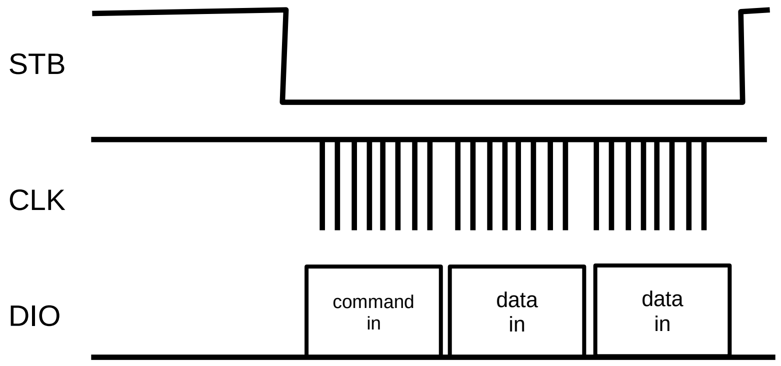


Figure 5. Serial communication format (reception)

11.2 Serial communication format (transmission)

The figure below shows the “transmission” from MC2701 for data read sequence.

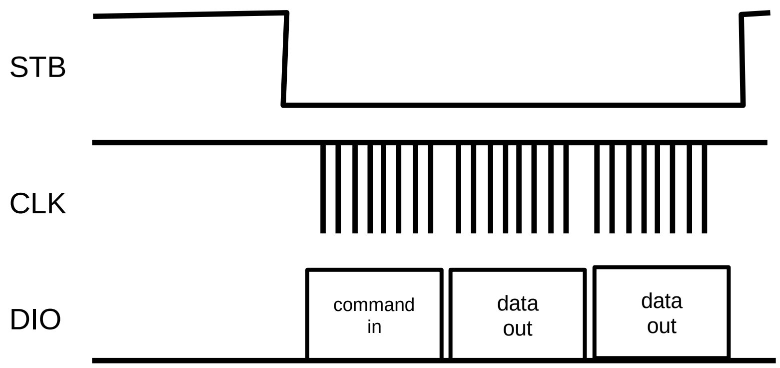


Figure 6. Serial communication format (transmission)

Because the DIN/DOUT pin is a bi-directional pin, it is recommended to connect an external pull-up resistor to this pin (1 KΩ to 10 KΩ). No minimum wait time is needed to read the data from the device. The MC2701 will output the data about 250 ns after the 8th clock pulse's falling edge. It is therefore suggested that the host must release the bus within 100ns after clocking the last bit on the 8th clock pulse. The MC2701 is able to clock out the valid data on the immediate falling edge of the CLK without missing any clock cycle.

The communication packet is active on STB low state. A packet compirses command only or command plus multi data. Most of MC2701 controls are combined by command only packet and command plus multi data packet . But the display ON and OFF control packet are command only.

12 Application diagram

12.1 Recommend Application Circuit

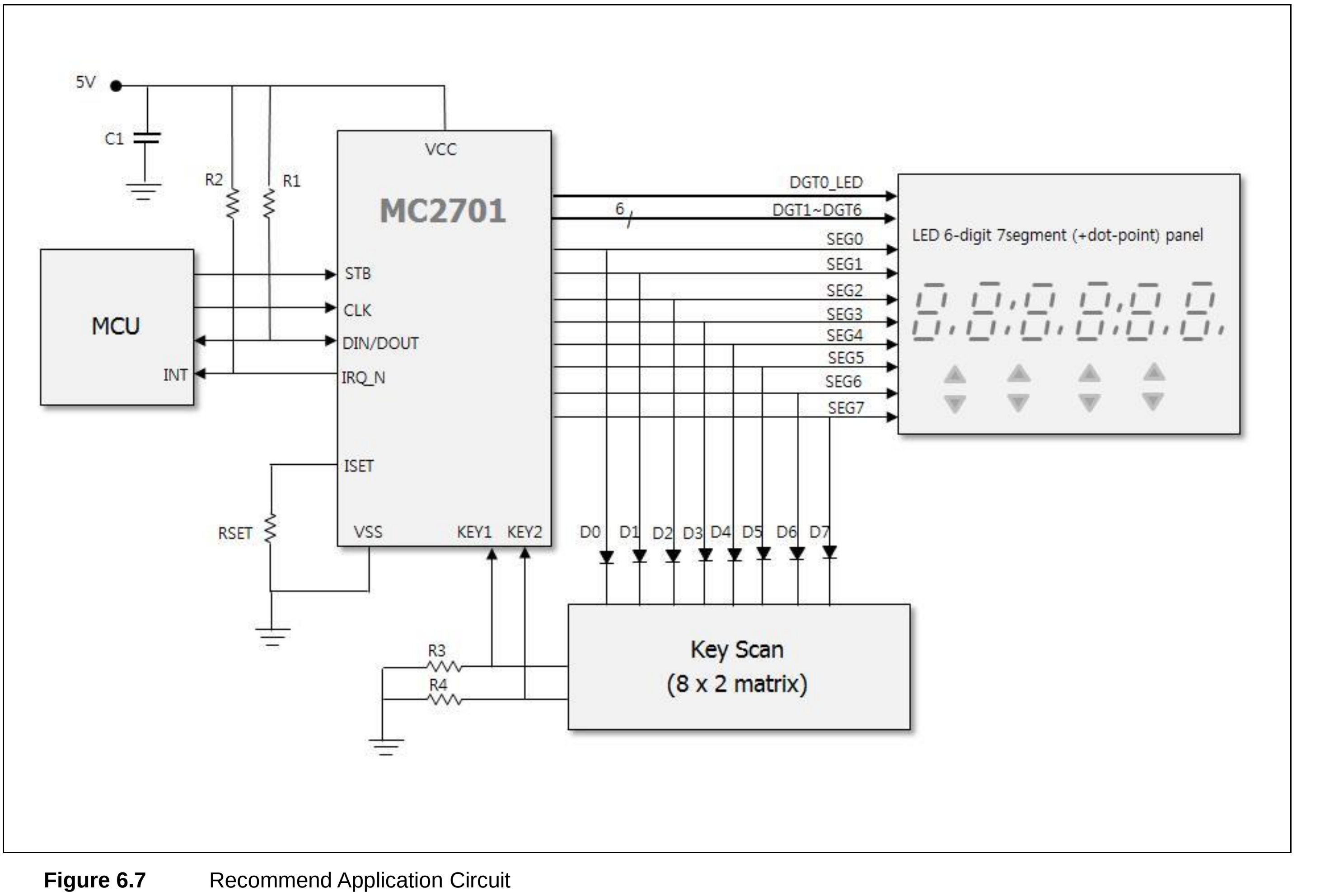


Figure 6.7 Recommend Application Circuit

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