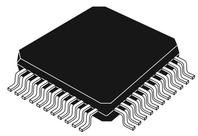
1/4 TO 1/11-DUTY VFD CONTROLLER/DRIVER

- MANY DISPLAY MODES (11 SEGMENTS & 11 DIGITS TO 16 SEGMENTS & 4 DIGITS)
- KEY SCANNING (6 x 4 MATRIX)
- DIMMING CIRCUIT (EIGHT STEPS)
- HIGH-VOLTAGE OUTPUT (V_{DD} – 35V MAX)
- LED PORTS (4 CHS, 20mA MAX)
- GENERAL PURPOSE INPUT PORT (4 bits)
- NO EXTERNAL RESISTOR NECESSARY FOR DRIVER OUTPUT (P-CH OPEN DRAIN + PULL DOWN RESISTOR OUTPUT)
- SERIAL INTERFACE (CLK, STB, D_{IN}, D_{OUT})



PQFP44

DESCRIPTION

The STM86312 is a VFD (Vacuum Fluorescent Display) controller/driver that is driven on a 1/4 to 1/11-duty factor. It consists of 11-segments output lines, 6 grid output lines, 5 segments/grid output drive lines, a display memory, a control circuit, and a key scan circuit. Serial data are input to the STM86312 through a three-line serial interface. This VFD controller/driver is ideal as a peripheral device for a single-chip microcomputer.

ORDERING CODES

Type	Temperature Range	Package	Comments
STM86312	-40 to 85 °C	PQFP44	250 parts per Reel

Figure 1: Block Diagram

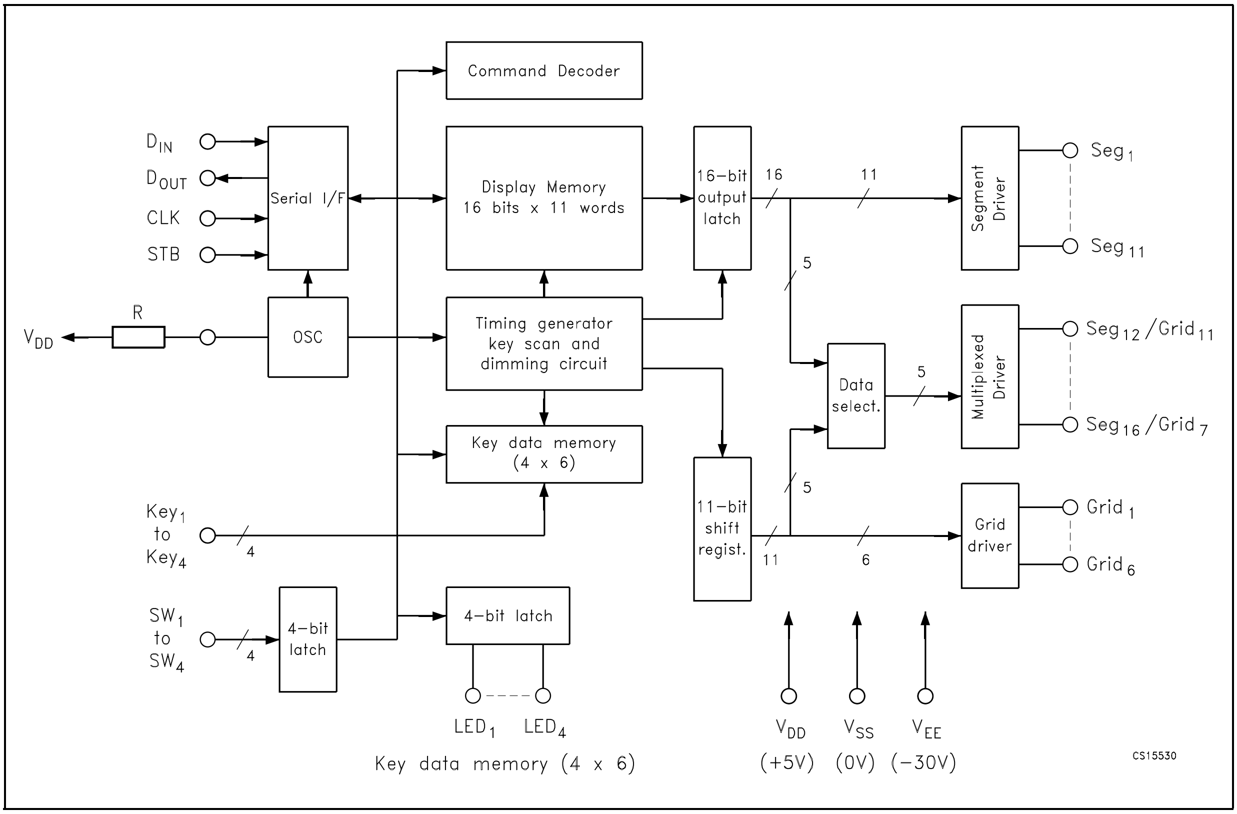


Figure 2: Pin Configuration (TOP VIEW)

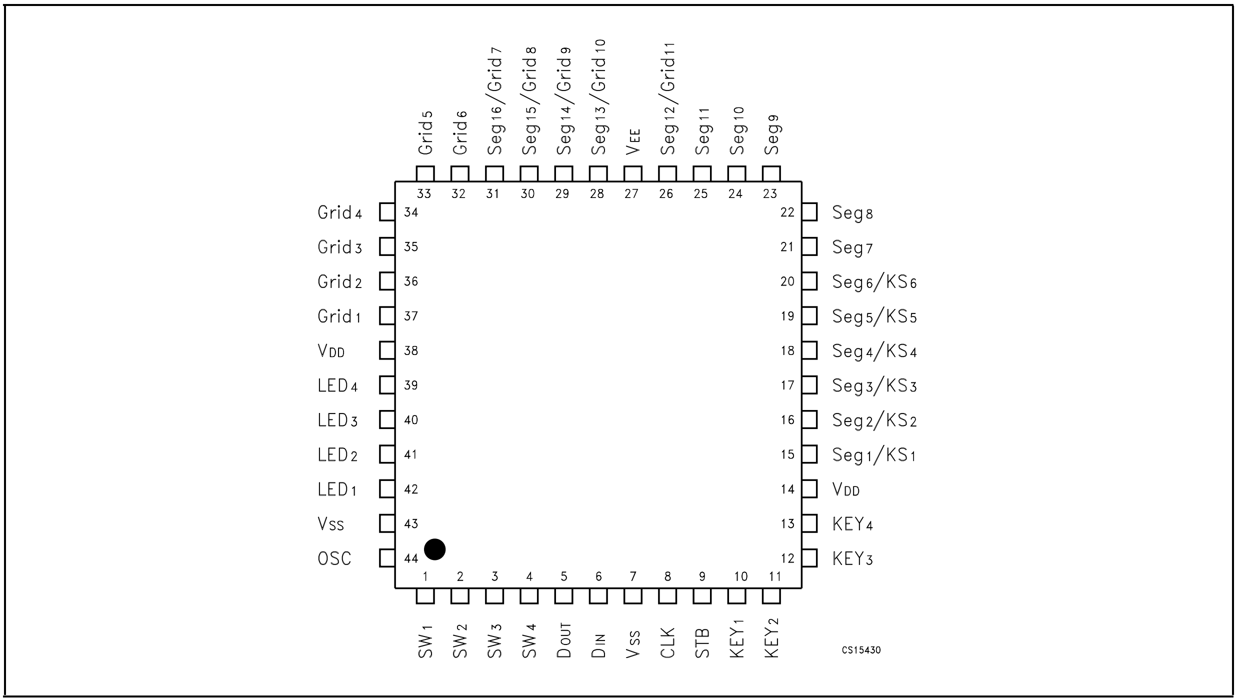


Table 1: Pin Description

PIN N°	SYMBOL	NAME AND FUNCTION
1, 2, 3, 4	SW1, SW2, SW3, SW4	General-purpose switch inputs.
5	D_{OUT}	Output serial data at falling edge of the shift clock, starting from lower bit. This is N-ch open-drain output pin.
6	D_{IN}	Input serial data at rising edge of the shift clock, starting from lower bit.
8	CLK	Reads serial data at rising edge, and outputs data at falling edge.
9	STB	Initializes serial interface at rising or falling edge to make STM86312 waiting for reception of command. Data input after STB has fallen are processed as a command. While command data are processed, current processing is stopped, and the serial interface is initialized. While STB is high, CLK is ignored.
10, 11, 12, 13	KEY1, KEY2, KEY3, KEY4	Input data to these pins are latched at end of the display cycle.
14, 38	V_{DD}	5V ± 10%.
15, 16, 17, 18, 19, 20	SEG1/KS1 to SEG6/KS6	Segment output pins (Dual function as key source).
21, 22, 23, 24, 25	SEG7 to SEG11	Segment output pins.
26, 28, 29, 30, 31	SEG12/GRID11 to SEG16/GRID7	These pins are selectable for segment or grid driving.
32, 33, 34, 35, 36, 37	GRID1 to GRID6	Grid output pins.
39, 40, 41, 42	LED1 to LED4	CMOS outputs. +20 mA max.
7, 43	V_{SS}	Connect this pin to system GND.
27	V_{EE}	Pull-down level. V_{DD} - 35V max.
44	OSC	Connect to an external resistor.

Table 2: Absolute Maximum Ratings (T_A = 25°C, V_{SS} = 0V)

Symbol	Parameter	Value	Unit
V_{DD}	Logic Supply Voltage	-0.5 to 7	V
V_{EE}	Driver Supply Voltage	V_{DD}+0.5 to V_{DD}-40	V
V_I	Logic Input Voltage	-0.5 to V_{DD}+0.5	V
V_{O2}	VFD Driver Output Voltage	V_{EE}-0.5 to V_{DD}+0.5	V
I_{O1}	LED Driver Output Current	25	mA
I_{O2}	VFD Driver Output Current	-40 (Grid)	mA
		-15 (Segment)	
T_A	Operating Ambient Temperature	-40 to 85	°C

Absolute Maximum Ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied.

Table 3: Thermal Data

Symbol	Parameter	Value	Unit
R_{Tj-c}	Thermal Resistance Junction-Case	56	°C/W

Table 4: Recommended Operating Conditions

Symbol	Parameter	Min	TYP	Max	Unit
V_{DD}	Logic Supply Voltage	4.5	5	5.5	V
V_{IH}	High Level Input Voltage	$0.7xV_{DD}$		V_{DD}	V
V_{IL}	Low Level Input Voltage	0		$0.3xV_{DD}$	V
V_{EE}	Driver Supply Voltage	0		V_{DD}-35	V

Maximum power consumption P_{MAX} = VFD driver dissipation + R_L dissipation + LED driver dissipation + dynamic power consumption.
Where segment current = 3 mA, grid current = 15 mA, and LED current = 20 mA,
VFD driver dissipation = number of segments x 6 + number of grids/(number of grids + 1) x 30 (mW)
R_L dissipation = $(V_{DD} - V_{EE})^2$/50 x (segment + 1) (mW)
LED driver dissipation = number of LEDs x 20 (mW)
Dynamic power consumption = V_{DD} x 5 (mW)

Example

Where V_{EE} = -25 V, V_{DD} = 5 V, and in 16-segment and 6-digit modes,
VFD driver dissipation = 16 x 6 + 6/7 x 30 = 122
R_L dissipation = 30^2/50 x 17 = 306
LED driver dissipation = 4 x 20 = 80
Dynamic power consumption = 5 x 5 = 25
Total 553 mW.

Table 5: Electrical Characteristics (V_{DD} = 4.5 to 5.5V, V_{SS} = 0V, V_{EE} = V_{DD} - 35V, T_A = -20 to 70°C, unless otherwise noted. Typical values are at T_A = 25°C)

Symbol	Parameter	Test Conditions	Value			Unit
			Min.	Typ.	Max.	
V_{OH1}	High Level Output Voltage	LED1-LED4, I_{OH1}=-1mA	$0.9V_{DD}$			V
V_{OL1}	Low Level Output Voltage	LED1-LED4, I_{OL1}=20mA			1	V
V_{OL2}	Low Level Output Voltage	D_{OUT}, I_{OL2} = 4mA			0.4	V
I_{OH21}	High Level Output Current	$V_O = V_{DD}$ - 2V, Seg1 to Seg11	-3			mA
I_{OH22}	High Level Output Current	$V_O = V_{DD}$ - 2V, Grid1 to Grid6, Seg12/Grid11 to Seg16/Grid7	-15			mA
I_{OLEAK}	Driver Leakage Current	$V_O = V_{DD}$ - 35V, driver off			-10	µA
R_L	Output Pull-Down Resistor	Driver Output	50	100	150	kΩ
I_I	Input Current	$V_I = V_{DD}$ or V_{SS}			±1	µA
V_{IH}	High Level Input Voltage		$0.7V_{DD}$			V
V_{IL}	Low Level Input Voltage				$0.3V_{DD}$	V
V_{HYS}	Hysteresis Voltage	CLK, D_{IN}, STB		0.35		V
I_{DDdyn}	Dynamic Current Consumption	Under no load, display off			5	mA

Table 6: Switching Characteristics (V_{DD} = 4.5 to 5.5V, V_{SS} = 0V, V_{EE} = V_{DD} - 35V, T_A = -20 to 70°C, unless otherwise noted. Typical values are at T_A = 25°C)

Symbol	Parameter	Test Conditions		Value			Unit
				Min.	Typ.	Max.	
t_{PLZ}	Propagation Delay	CLK → D_{OUT} R_L = 10 kΩ, C_L = 15 pF				300	ns
t_{PZL}						100	
t_{TZH1}	Rise Time	C_L = 300 pF	Seg1 to Seg11			2	µs
t_{TZH2}			Grid1 to Grid6, Seg12/ Grid11 to Seg16/Grid7			0.5	
t_{THZ}	Fall Time	C_L = 300 pF, Segn, Gridn				120	µs
f_{MAX}	Maximum Clock Frequency	Duty = 50%		1			MHz
C_I	Input Capacitance					15	pF

Table 7: Timing Characteristics (V_{DD} = 4.5 to 5.5V, T_A = -20 to 70°C, unless otherwise noted. Typical values are at T_A = 25°C)

Symbol	Parameter	Test Conditions	Value			Unit
			Min.	Typ.	Max.	
PW_{CLK}	Clock Pulse Width		400			ns
PW_{STB}	Strobe Pulse Width		1			µs
t_{SETUP}	Data Setup Time		100			ns
t_{HOLD}	Data Hold Time		100			ns
$t_{CLK-STB}$	Clock-Strobe Time	CLK ↑→ STB↑	1			µs
t_{WAIT}	Wait Time (Note 1)	CLK ↑→ CLK↓	1			µs

NOTE 1: Refer to page Serial Communication Format.

DISPLAY RAM ADDRESS AND DISPLAY MODE

The display RAM stores the data transmitted from an external device to the STM86312 through the serial interface; addresses are as follows, in 8-bits unit:

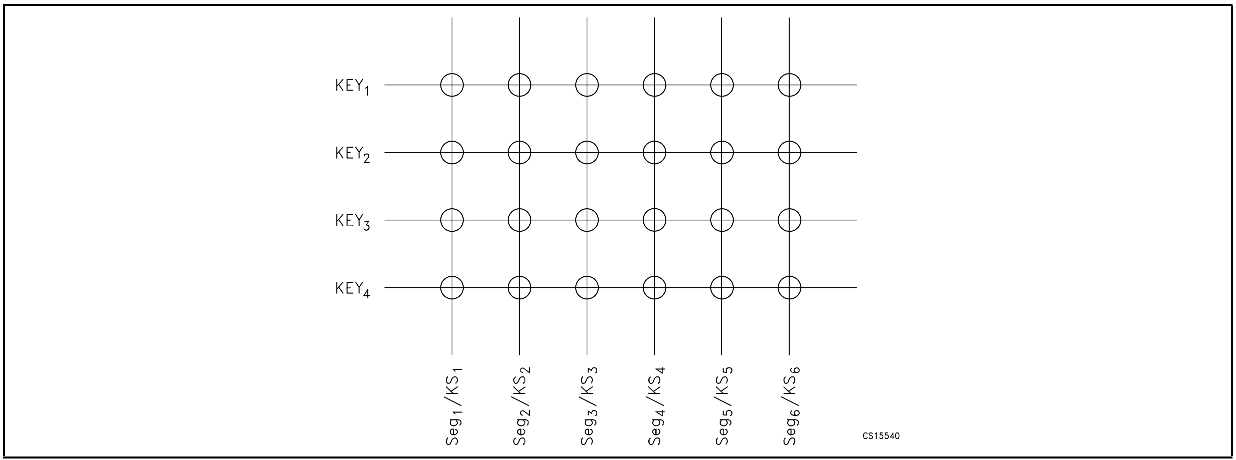
Seg1 … Seg4	… Seg8	… Seg12	… Seg16	
00 H_L	00 H_U	01 H_L	01 H_U	**DIG1**
02 H_L	02 H_U	03 H_L	03 H_U	**DIG2**
04 H_L	04 H_U	05 H_L	05 H_U	**DIG3**
06 H_L	06 H_U	07 H_L	07 H_U	**DIG4**
08 H_L	08 H_U	09 H_L	09 H_U	**DIG5**
0A H_L	0A H_U	0B H_L	0B H_U	**DIG6**
0C H_L	0C H_U	0D H_L	0D H_U	**DIG7**
0E H_L	0E H_U	0F H_L	0F H_U	**DIG8**
10 H_L	10 H_U	11 H_L	11 H_U	**DIG9**
12 H_L	12 H_U	13 H_L	13 H_U	**DIG10**
14 H_L	14 H_U	15 H_L	15 H_U	**DIG11**

b0 … b3	b4 … b7
XX H_L	XX H_U

"0" in memory means V_{EE} on output; "1" in memory means V_{DD} on output.

Figure 3: Key Matrix And Key-input Data Storage Ram

The key matrix is of 6 x 4 configuration, as shown below



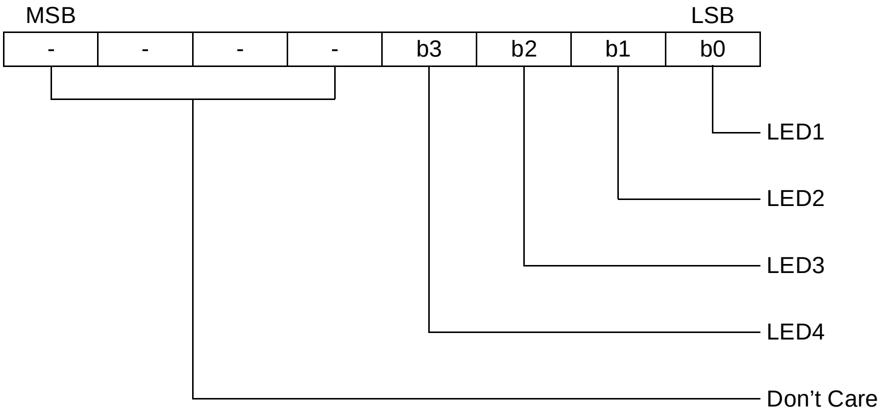
The data of each key are stored as illustrated below, and are read by the appropriate read command, starting from the least significant bit

KEY1 … KEY4	KEY1 … KEY4
Seg1/KS1	Seg2/KS2
Seg3/KS3	Seg4KS4
Seg5/KS5	Seg6/KS6
b0 … b3	b4 … b7

↓

LED PORT

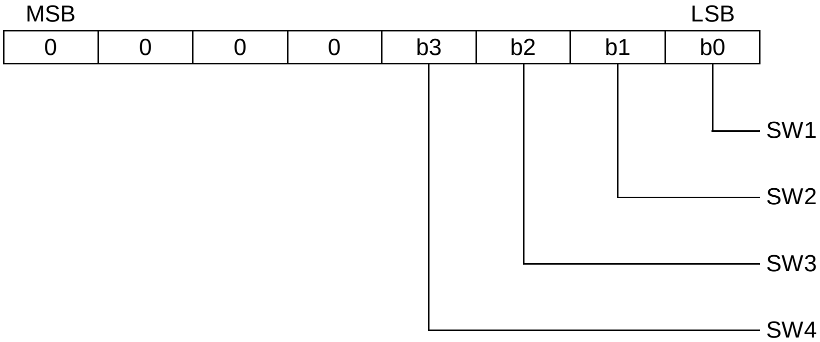
Data are written to the LED port by a write command, starting from the least significant bit of the port. When a bit of this port is 0, the corresponding LED lights; when the bit is 1, the LED goes off. The data of bits 5 through 8 are ignored.



On power application, all the LEDs remain dark.

SW DATA

The SW data are read by the appropriate read command, starting from the least significant bit. Bits 5 through 8 of the SW data are 0.



COMMANDS

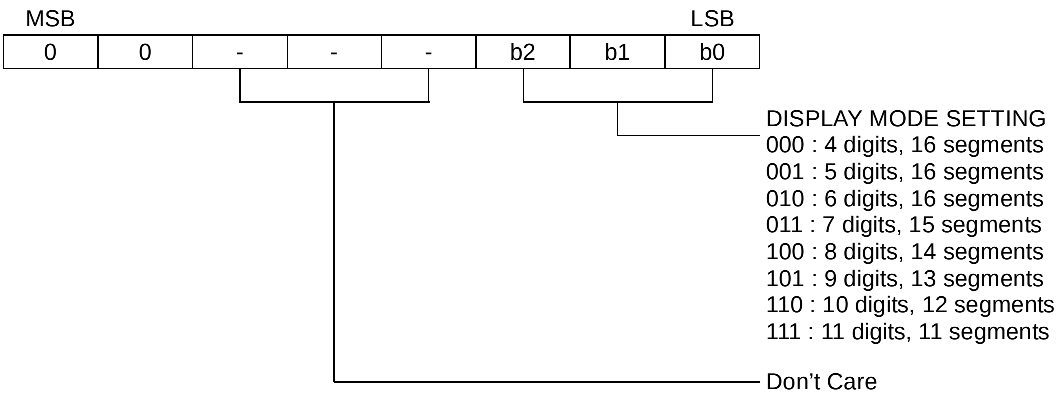
A command sets the display mode and status of the VFD driver.

The first 1 byte input to the STM86312 through the D_{IN} pin after the STB pin has fallen 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).

(1) DISPLAY MODE SETTING COMMAND

This command initializes the STM86312 and selects the number of segments and number of grids (1/4 to 1/11 duty, 11 segments to 16 segments).

When this command is executed, display is forcibly turned off, and key scanning is also stopped. To resume display, the display ON command must be executed. If the same mode is selected, however, nothing is performed.



On power application, the 11-digit 11-segment mode is selected.

(2) DATA SETTING COMMAND

This command sets data write and data read modes.

MSB							LSB
0	1	-	-	0	b2	b1	b0

b1, b0: DATA WRITE AND READ MODE SETTING
00 : Write data to display memory
01 : Write data to LED port
10 : Read key data
11 : Read SW data

b2: ADDRESS INCREMENT MODE SETTING
(DISPLAY MEMORY)
0= Increments address after data has been written
1= Fixed address

- -: Don't Care

On power application, the normal operation mode and address increment mode are set.
Do not use STM86312 in test mode.

(3) ADDRESS SETTING COMMAND

This command sets an address of the display memory

MSB							LSB
1	1	-	b4	b3	b2	b1	b0

b4 - b0: Address (00H-15H)

-: Don't Care

If address 16H or higher is set, the data are ignored, until a correct address is set.
On power application, the address is set to 00H.

(4) DISPLAY CONTROL COMMAND

MSB							LSB
1	0	-	-	b3	b2	b1	b0

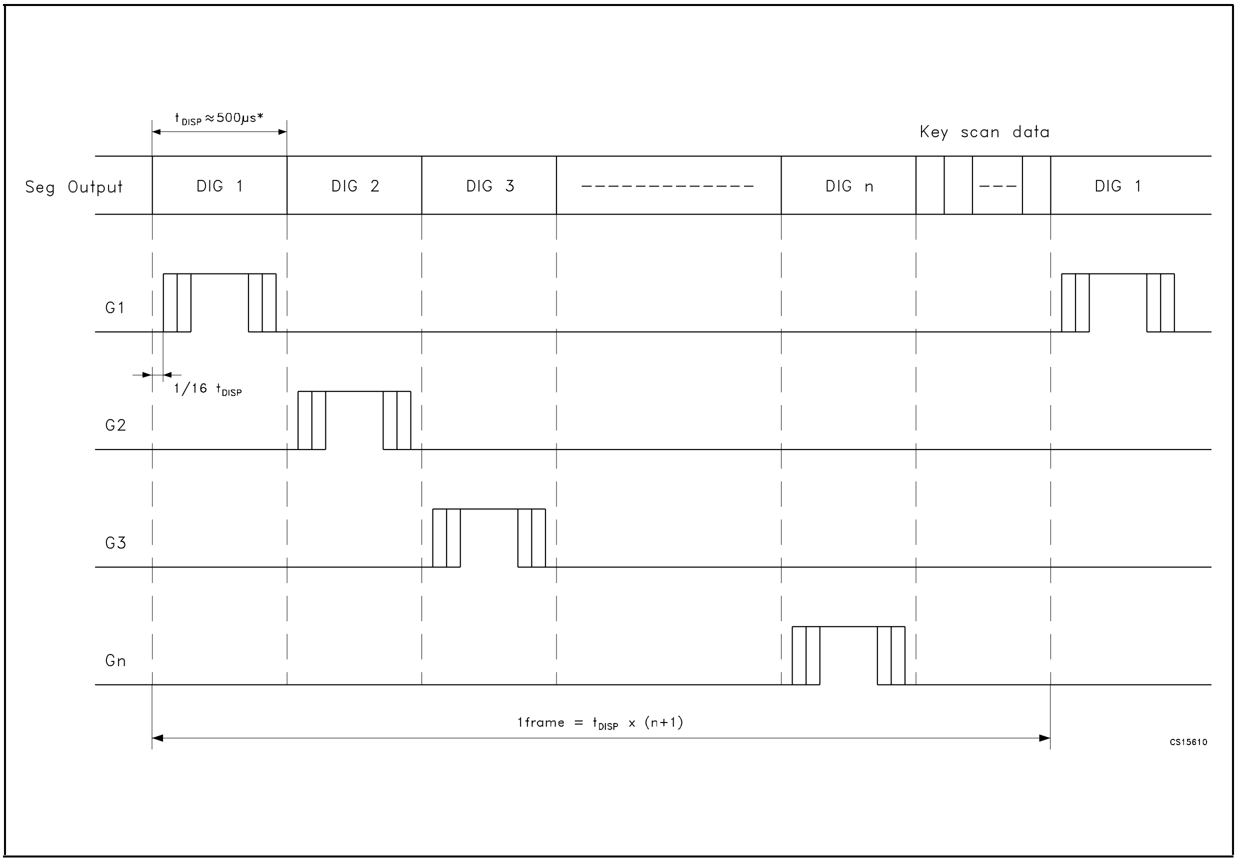
b2 - b0: DISPLAY MODE SETTING
000 : Set Pulse Width to 1/16
001 : Set Pulse Width to 2/16
010 : Set Pulse Width to 4/16
011 : Set Pulse Width to 10/16
100 : Set Pulse Width to 11/16
101 : Set Pulse Width to 12/16
110 : Set Pulse Width to 13/16
111 : Set Pulse Width to 14/16

b3: TURNS ON/OFF DISPLAY
0= Display OFF (Key Scan Continues *)
1= Display ON

- -: Don't Care

On power application, the 1/16-pulse width is set and the display is turned off.
*: On power application, key scanning is stopped.

Figure 4: Key Scanning And Display Timing



* The value can be modified by trimmering R_{OSC}.

One cycle of key scanning consists of one frame, and data of 6 x 4 matrices are stored in RAM.

SERIAL COMMUNICATION FORMAT

Figure 5: Reception (command/data write)

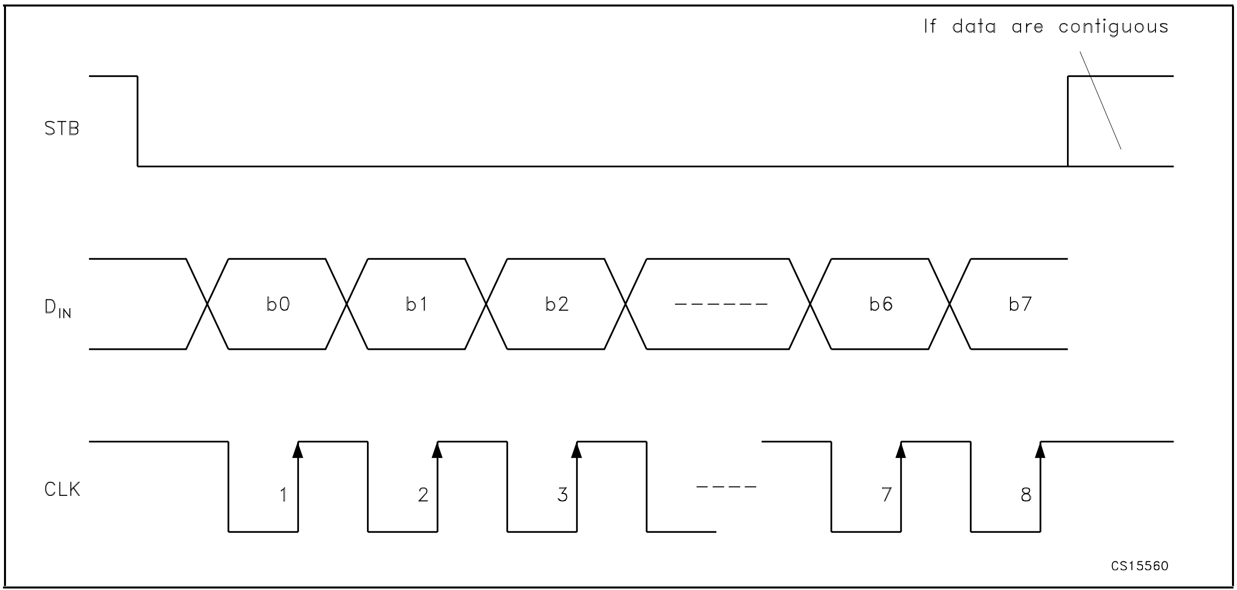
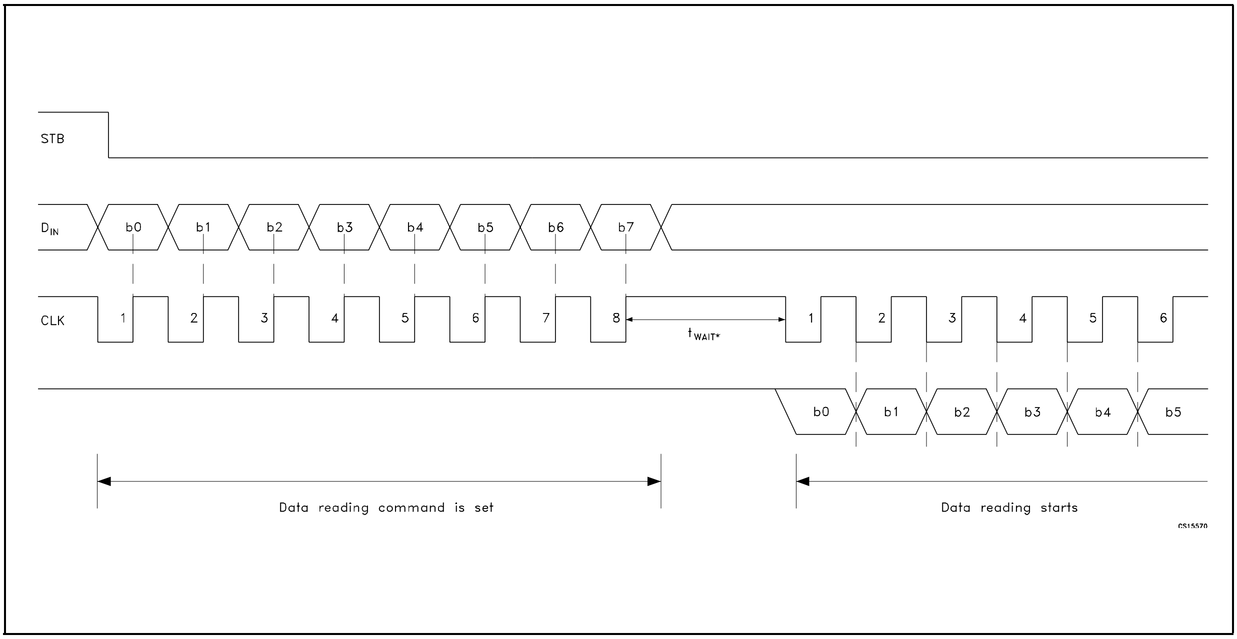


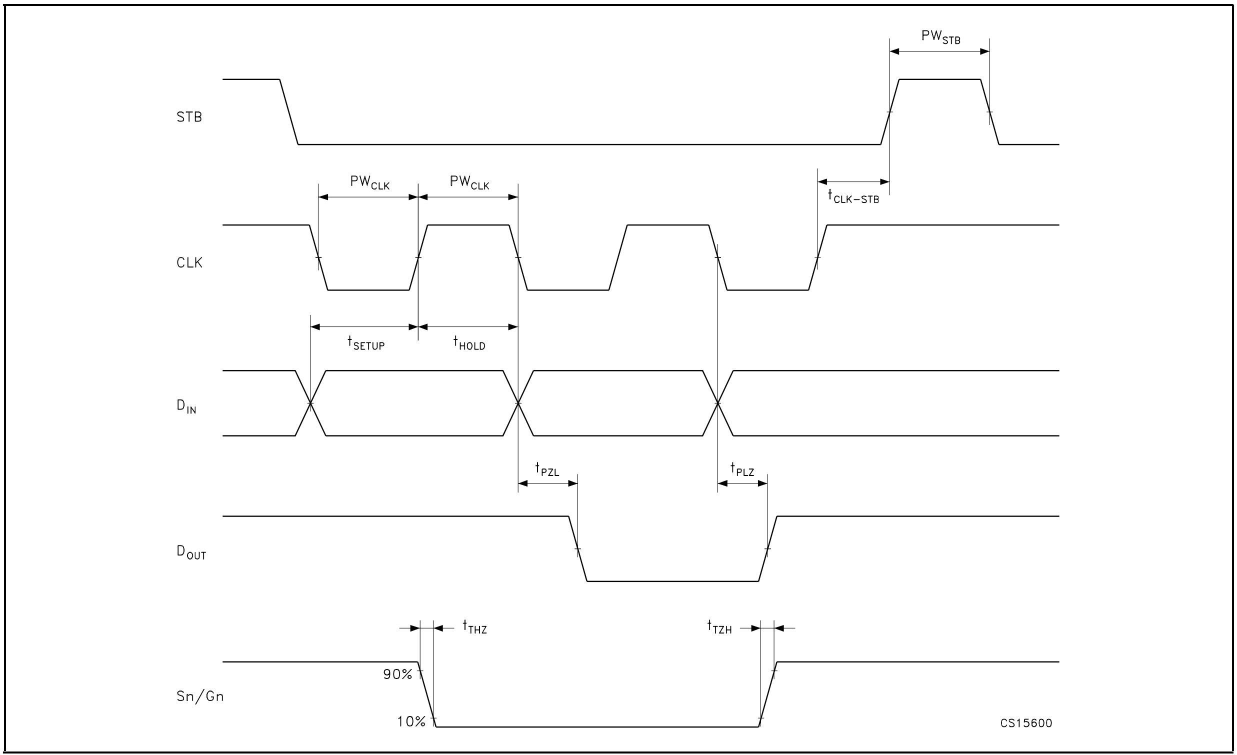
Figure 6: Transmission (data read)



Because the D_{OUT} pin is an N-ch open-drain output pin, be sure to connect an external pull-up resistor to this pin (1 kΩ to 10 kΩ).

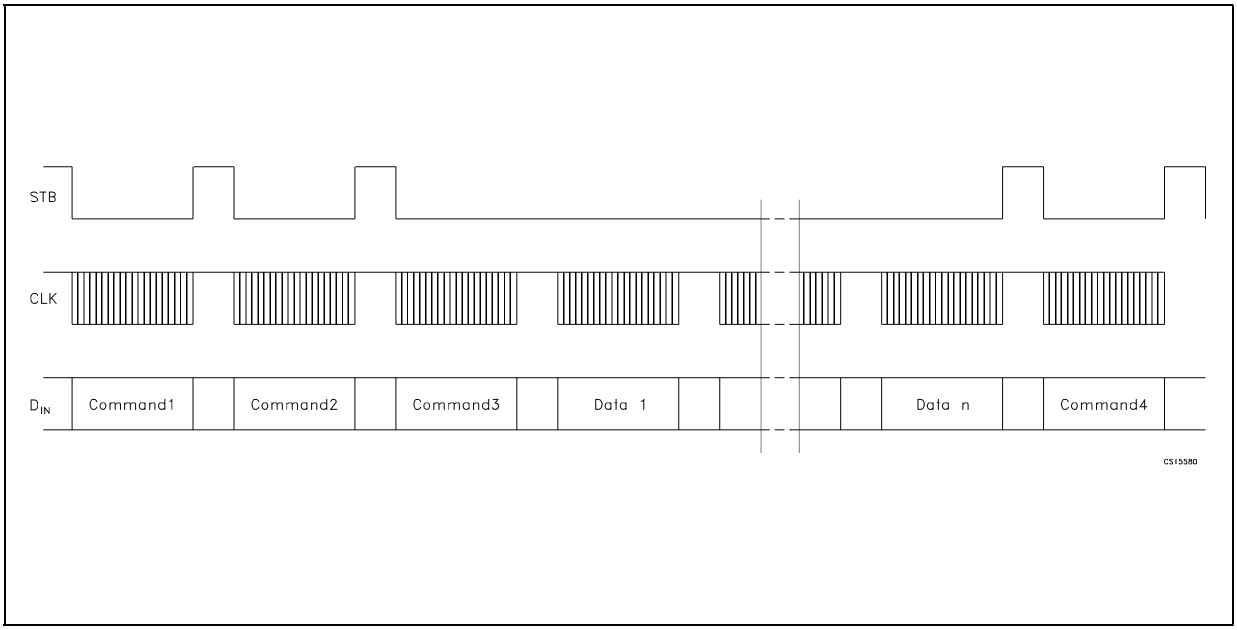
*: When data are read, a wait time t_{WAIT} of 1µs is necessary within the rising edge of the eighth clock that has set the command and the falling one of the first clock that has read the data.

Figure 7: Switching Characteristics Waveform



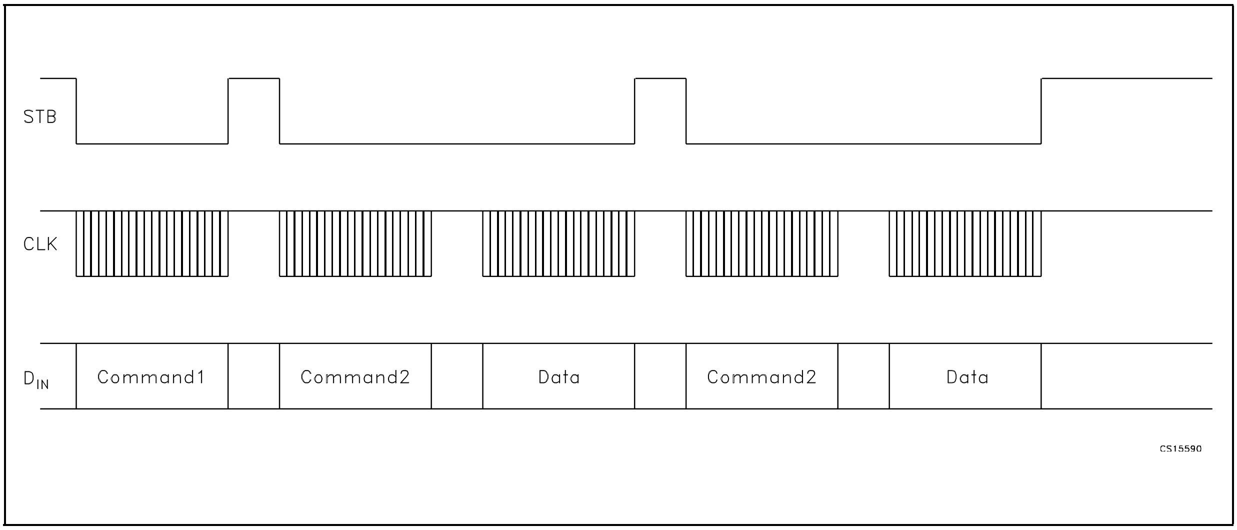
APPLICATION

Figure 8: Updating display memory by incrementing address



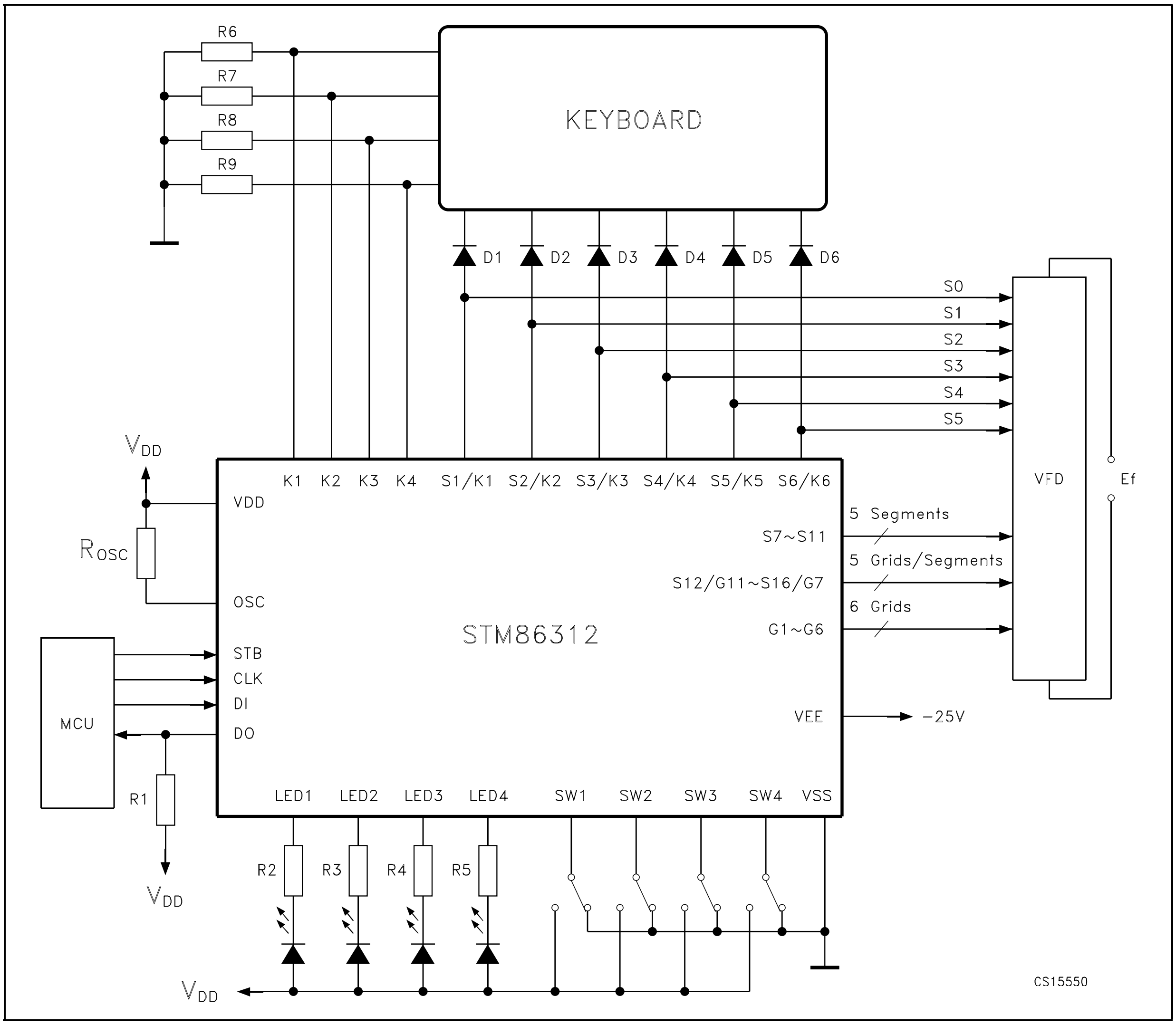
Command 1: sets display mode
Command 2: sets data
Command 3: sets address
Data 1 to n: transfers display data (22 bytes max.)
Command 4: controls display

Figure 9: Updating specific address



Command 1: sets data
Command 2: sets address
Data: display data

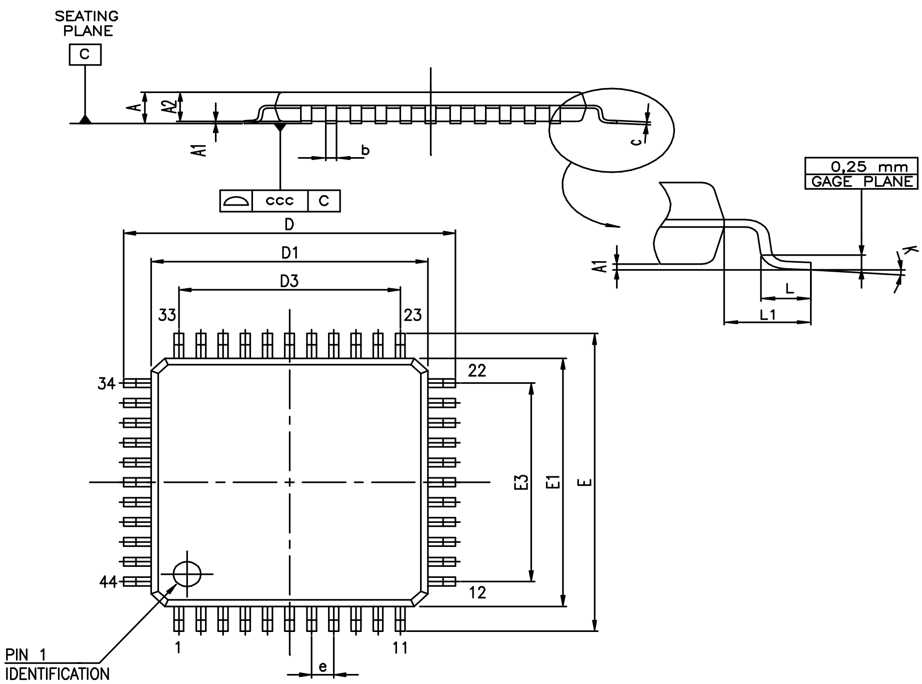
Figure 10: Application Circuit



Note: R_{OSC} = 47kΩ for oscillator resistor
R1=1~10 kΩ for external pull-high resistor
R2~R5 = 750Ω~1.2 kΩ
R6~R9 = 10kΩ for external pull-low resistor
D1~D6 = 1N4001
Ef = Filament voltage for VFD.

PQFP44 MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			2.45			0.096
A1			0.25			0.010
A2	1.80	2.00	2.20	0.071	0.079	0.087
b	0.29		0.45	0.011		0.018
c	0.11		0.23	0.004		0.009
D		13.2			0.520	
D1		10.00			0.394	
D3		8.00			0.315	
E		13.2			0.520	
E1		10.00			0.394	
E3		8.00			0.315	
e		0.80			0.031	
L	0.73	0.88	1.03	0.029	0.035	0.041
L1		1.6			0.063	
K	0°	3.5°	7°	0°	3.5°	7°



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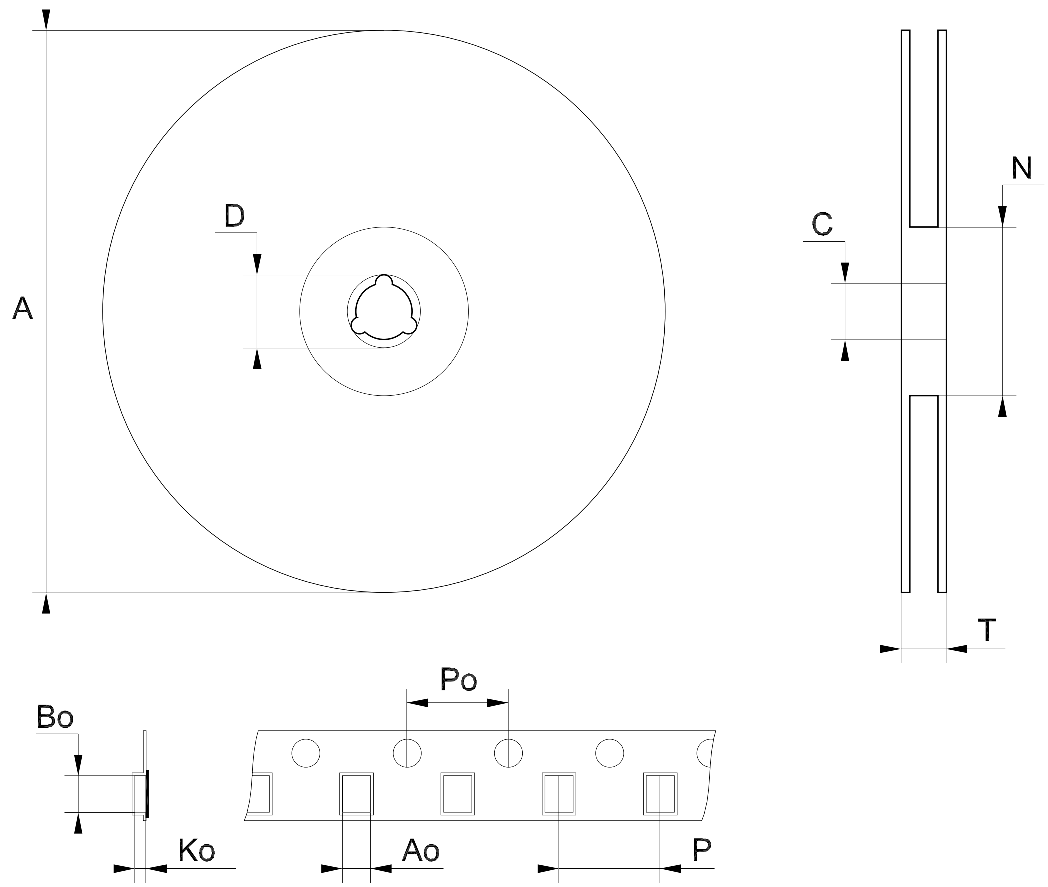
Tape & Reel PQFP44 MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			330			12.992
C	12.8		13.2	0.504		0.519
D	20.2			0.795		
N	60			2.362		
T			30.4			1.196
Ao	12.25		12.45	0482		0.490
Bo	12.25		12.45	0482		0.490
Ko	2.1		2.3	0.083		0.091
Po	3.9		4.1	0.153		0.161
P	15.9		16.1	0.626		0.639



Note: Drawing not in scale

Table 8: Revision History

Date	Revision	Description of Changes
27-May-2004	1	First Release

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