# NOVATEK

# NT7603

## *Single-Chip 16Cx2L Dot-Matrix LCD Controller / Driver*

## Features

- Internal LCD drivers
     16 common signal drivers
     80 segment signal drivers
- Maximum display dimensions
     16 characters * 2 lines or
     32 characters * 1 line
- Interfaces with 4-bit or 8-bit MPU
- Versatile display functions provided on chip:
     Display Clear, Cursor Home, Display ON/OFF,
     Cursor ON/OFF, Character Blinking, Cursor
     Shift, and Display Shift
- Three duty factors, selected by PROGRAM:
     1/8, 1/11, and 1/16
- Displays Data RAM (DD RAM): 80 X 8 bits
  (Displays up to 80 characters)
- Character Generator RAM (CG RAM):
     64 X 8 bits for general data,
     8  5 X 8 programmable dot patterns, or
     4  5 X 10 programmable dot patterns
- Low voltage reset
- ITO option for A-type and B-type LCD waveform

- Character Generator ROM (CG ROM):
  2 kinds of CG ROM sizes:
     192 characters:
          160  5 X 8 dot patterns
          32   5 X 10 dot patterns
     240 characters:
          192  5 X 8 dot patterns
          48   5 X 10 dot patterns
  Custom CG ROM is also available
- Built-in power-on reset function
- Logic power supply: single +5V supply
- LCD driver power supply: V1~V5
  ($V_{DD}$+0.3 - $V_{DD}$-7.0) , divided by Built-in LCD power
  division resister.
- Two oscillator operations
     (Freq. = 500KHz - 540KHz):
     • Built-in RC oscillation
     • External clock
- CMOS Process
- Available in COG FORM

## General Description

The NT7603 is a dot matrix LCD controller and driver LSI that can operate with either a 4-bit or an 8-bit microprocessor (MPU). NT7603 receives control character codes from the MPU, stores them in an internal RAM (up to 80 characters), transforms each character code into a 5 X 7, 5 X 8, or 5 X 10 dot matrix character pattern, and then displays the codes on the LCD panel. The built-in Character Generator ROM consists of 256 different character patterns.

The NT7603 also contains Character Generator RAM where the user can store 8 different character patterns at run time. These memory features make character display flexible. NT7603 also provides many display instructions to achieve versatile LCD display functions. The NT7603 is fabricated on a single LSI chip using the CMOS process, resulting in very low power requirements.

Ver 0.5

**Pad Configuration**
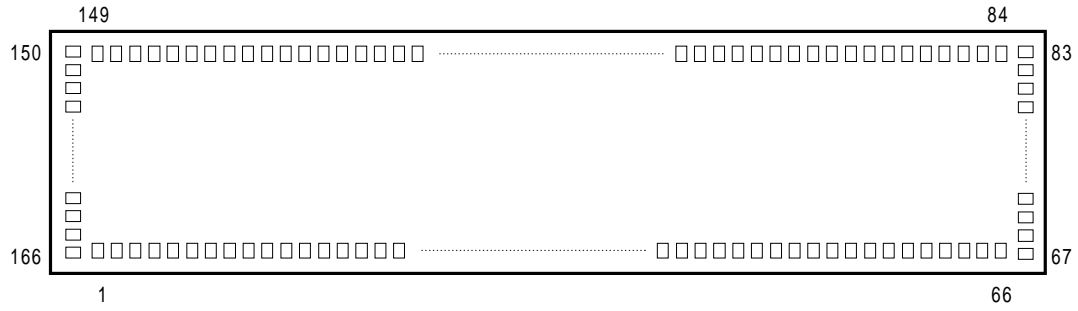


| Item | Pad No. | Size | | Unit |
|------|---------|------|------|------|
| | | X | Y | |
| Chip size | - | 5156 | 1349 | μm |
| Pad pitch | 1– 166 | 70 | | |

## Block Diagram
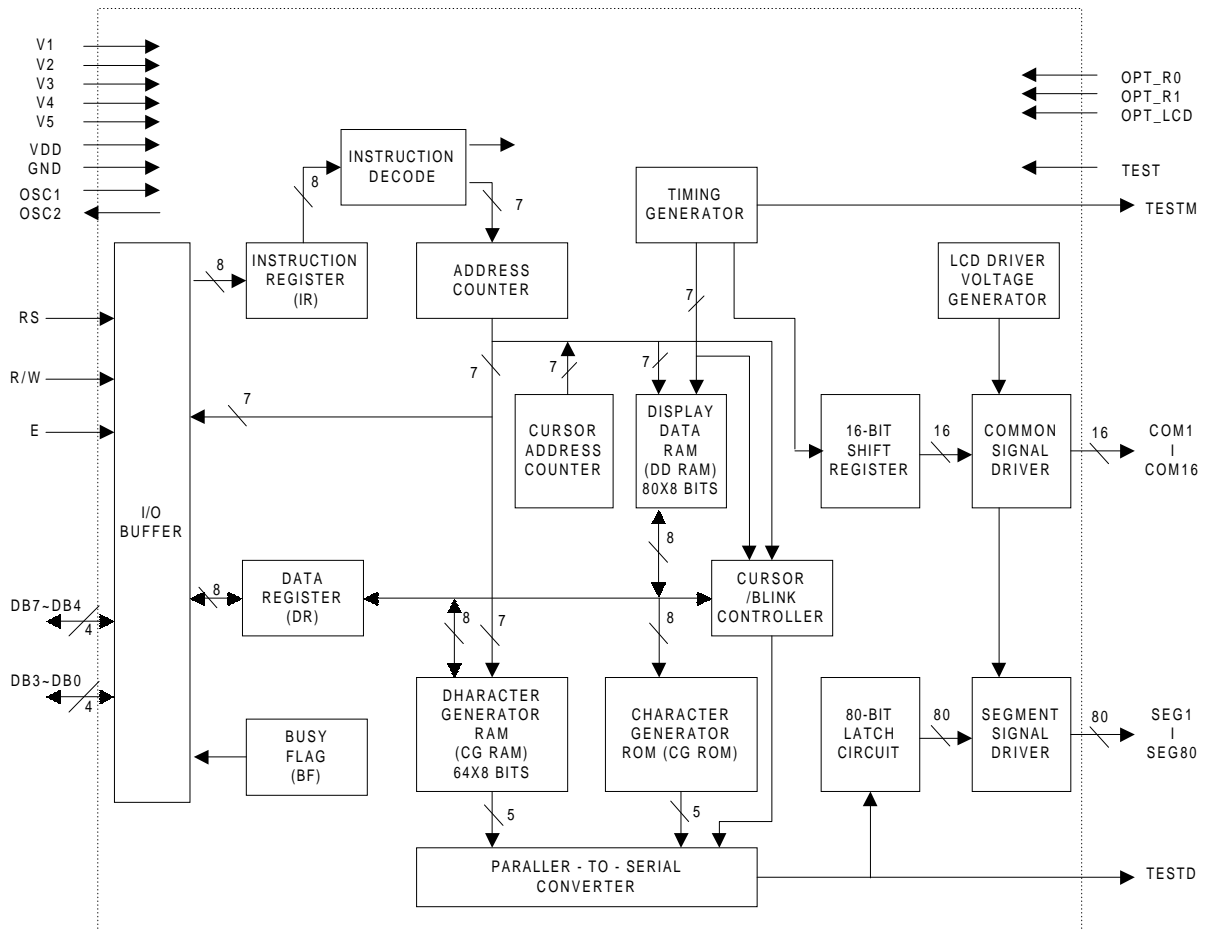
**Pad Description**  (Total 166 pads for COG type.)

| Pad No. | Designation | I/O | External Connection | Description |
|---|---|---|---|---|
| 1 – 15 | GND | P | Power supply | GND: 0V |
| 16 | OSC1 | I | | For external clock operation, clock inputs to OSC1. |
| 17 | OSC2 | O | | Clock output. |
| 18 | V1 | P | Power supply | Power supply for LCD driver. VDD ≥V1 ≥V2 ≥V3 ≥V4 ≥V5 ≥GND |
| 19 | V2 | P | Power supply | Power supply for LCD driver |
| 20 | V3 | P | Power supply | Power supply for LCD driver |
| 21 | V4 | P | Power supply | Power supply for LCD driver |
| 22 – 25 | V5 | P | Power supply | Power supply for LCD driver |
| 26, 28 | OPT_R0, OPT_R1 | I | ITO Option | The built-in bias resister select:<br>OPT_R1, OPT_R0: No ITO=1. ITO on=0<br>1,1:   2.2KΩ;        1,0:   4KΩ;<br>0,1:   6.8KΩ;           0,0:No built-in bias resister: |
| 29 – 43 | VDD | P | Power supply | $V_{DD}$: +5V |
| 44, 45 | RS | I | MPU | Register select signal<br>0: Instruction register (write), Busy flag, address counter (read)<br>1: Data register (write, read) |
| 46, 47 | R/W | I | MPU | Read/Write control signal<br>0: Write      1: Read |
| 48, 49 | E | I | MPU | Read/Write start signal |
| 50, 51 | DB0 | I/O | MPU | Lower 4 tri-state bi-directional data bus for transmitting data between MPU and NT7603. Not used during 4-bit operation. |
| 52, 53 | DB1 | | | |
| 54, 55 | DB2 | | | |
| 56, 57 | DB3 | | | |
| 58, 59 | DB4 | I/O | MPU | Higher 4 tri-state bi-directional data bus for transmitting data between MPU and NT7603. DB7 is also used as busy flag. |
| 60, 61 | DB5 | | | |
| 62, 63 | DB6 | | | |
| 64, 65 | DB7 | | | |
| 66 | OPT_LCD | I | ITO Option | No ITO. (Option =1):  B-Type waveform<br>ITO On. (Option =0):  A-Type waveform |
| 68 | TESTD | O | Test output | Test data output. ( No connect for user) |
| 164 – 157 | COM1 – 8 | O | LCD panel | Common signal output pins, for place on the upper glass (IC face up). |
| 69 – 76, | COM9 – 16 | O | LCD panel | |
| 156 – 77 | SEG1 – 80 | O | LCD panel | Segment signal output pins |
| 165 | TEST | I | Test pin | Test pin internally pull-down. ( No connect for user) |
| 166 | TESTM | O | Test output | LCD driver clock output. ( No connect for user) |
| 67, 27 | GND_OUT | P | | GND output pin, use for pull-down ITO option. |

## Functional Description

The NT7603 is dot-matrix LCD controller and driver LSI. It operates with either a 4-bit or an 8-bit microprocessor (MPU). The NT7603 receives both instructions and data from the MPU. Some instructions set operation modes, such as the function mode, data entry mode, and display mode; as well as some control LCD display functions, such as clear display, restore display, shift display, and cursor. Other instructions include read and write both data and addresses. All instructions allow users convenient and powerful functions to control the LCD dot-matrix displays.

Data is written into and read from the Data Display RAM (DD RAM) or the Character Generator RAM (CG RAM). As display character codes, the data stored in the DD RAM decodes a set of dot-matrix character patterns that are built into the Character Generator ROM (CG ROM). The CG ROM, with many character patterns (up to 256 patterns), defines the character pattern fonts. The NT7603 regularly scans the character patterns through the segment drivers. The CG RAM stores character pattern fonts at run time if users intend to show character patterns that are not defined in the CG ROM. This feature makes character display flexible. Other unused bytes can be used as general-purpose data storage.

The LCD driver circuit consists of 16 common signal drivers and 80 segment signal drivers allowing a variety of application configurations to be implemented.

### Character Generator ROM (CG ROM)

The character generator ROM generates LCD dot character patterns from the 8-bit character pattern codes. The NT7603 provides 2 CG ROM configurations:

### 1. 192 Characters:

The CG ROM contains 160 5 X 8 dot character patterns and 32 5 X 10 dot character patterns, which the relation between the character codes and character patterns is shown in Table 1. The character codes from 00H to 0FH are used to get character patterns from the CG RAM. Character codes from 10H to 1FH and from 80H to 9FH map to full character patterns. Character codes from E0H to FFH are assigned to generate 5 X 10 dot character patterns, and other codes are used to generate 5x8 dot character patterns.

### 2. 240 Characters:

The CG ROM contains 192 5 X 8 dot character patterns and 48 5 X 10 dot character patterns, which the relation between the character codes and character patterns is shown in Table 2. The character codes from 00H to 0FH are used to get character patterns from the CG RAM. Character codes from 10H to 1FH and from E0H to FFH are assigned to generate 5 X 10 dot character patterns, and other codes to generate 5 X 8 dot character patterns. No null character pattern exists in this type. Note that the underlined cursor, displayed on the 8th duty may be obscure if the 8th row of a dot character pattern is coded. We recommend that users display the cursor in the blinking mode if they code 5x8 dot character patterns is their custom CG ROM.

Custom character patterns are available by mask-programming ROM. For convenience of character pattern development, NOVATEK has developed a user-friendly editor program for the NT7603 to help determine the character patterns users prefer. By executing the program on the computer, users can easily create and modify their character patterns. By transferring the resulting files generated by the program through a modem or some other communication method, the user and NOVATEK have established a reliable, fast link for programming the CG ROM.

**Absolute Maximum Ratings***

Power Supply Voltage ($V_{DD}$) . . . . . . . . . . -0.3V to +7.0V
Power Supply Voltage ($V_1$ to $V_5$) . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . GND to $V_{DD}$+0.3V
Input Voltage ($V_I$) . . . . . . . . . . . . . . -0.3V to $V_{DD}$ +0.3V
Operating Temperature ($T_{OPR}$) . . . . . . .-20°C to +70°C
Storage Temperature ($T_{STG}$) . . . . . . . .-55°C to +125°C

■ All voltage values are referenced to GND = 0V
■ $V_1$ to $V_5$, must maintain $V_{DD} \geq V_1 \geq V_2 \geq V_3 \geq V_4 \geq V_5 \geq$ GND.

***Comments**

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to this device. These are stress ratings only. Functional operation of this device at these or any other conditions above those indicated in the operational sections of this specification is not implied or intended. Exposure to the absolute maximum rating conditions for extended periods may affect device reliability.

**DC Electrical Characteristics** ($V_{DD}$ = 5.0V, GND = 0V, $T_A$ = 25°C)

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Conditions | Applicable Pin |
|--------|-----------|------|------|------|------|------------|----------------|
| VDD | Operating Voltage | 4.5 | 5.0 | 5.5 | V | | |
| $V_{IH1}$ | "H" Level Input Voltage (1) | 2.2 | - | $V_{DD}$ | V | | DB0 – DB7, RS, |
| $V_{IL1}$ | "L" Level Input Voltage (1) | -0.3 | - | 0.8 | V | | R/W, E |
| $V_{IH2}$ | "H" Level Input Voltage (2) | $V_{DD}$ -1.0 | - | $V_{DD}$ | V | | OSC1 |
| $V_{IL2}$ | "L" Level Input Voltage (2) | GND | - | 1.0 | V | | |
| $V_{OH1}$ | "H" Level Output Voltage (1) | 2.4 | - | - | V | $I_{OH}$ = -0.25mA | DB0 - DB7 |
| $V_{OL1}$ | "L" Level Output Voltage (1) | - | - | 0.4 | V | $I_{OL}$ = 1.2mA | (TTL) |
| $V_{COM}$ | Driver Voltage Descending (COM) | - | - | 0.3 | V | $I_D$ = 5μA | COM1 - 16 |
| $V_{SEG}$ | Driver Voltage Descending (SEG) | - | - | 0.3 | V | $I_D$ = 5μA | SEG1 - 80 |
| $I_{IL}$ | Input Leakage Current | -1 | - | 1 | μA | $V_{IN}$ = 0 to $V_{DD}$ | Not include OSCI |
| $-I_P$ | Pull-up MOS Current | 50 | 125 | 250 | μA | $V_{DD}$ = 5V | RS, R/W, DB0-DB7 |
| $I_{OP}$ | Power Supply Current | - | 1 | 1.5 | mA | Rf oscillation, from external clock $V_{DD}$ = 5V, $f_{OSC}$ = $f_{CP}$ = 540KHz, include LCD bias current. | $V_{DD}$ |

## DC Electrical Character (continued)

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Conditions | Applicable Pin |
|--------|-----------|------|------|------|------|------------|----------------|
| External Clock Operation | | | | | | | |
| $f_{CP}$ | External Clock Operating Frequency | 250 | 540 | 700 | KHz | | |
| $t_{DUTY}$ | External Clock Duty Cycle | 45 | 50 | 55 | % | | |
| $t_{RCP}$ | External Clock Rise Time | 0.1 | - | 0.5 | μs | | |
| $t_{FCP}$ | External Clock Fall Time | 0.1 | - | 0.5 | μs | | |
| Internal Clock Operation (Built-in RC Oscillator) | | | | | | | |
| $f_{OSC}$ | Oscillator Frequency | 380 | 540 | 700 | KHz | Rf = 50KΩ (reference only) | |
| $V_{LCD1}$ $V_{LCD2}$ | LCD Driving Voltage | 3.0 | - | $V_{DD}$ | V | $V_{DD} - V_5$ | |

## AC Characteristics

Read Cycle  ($V_{DD}$ = 5.0V, GND = 0V, $T_A$ = 25°C)

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Conditions |
|--------|-----------|------|------|------|------|------------|
| $t_{CYCE}$ | Enable Cycle Time | 500 | - | - | ns | Figure 1 |
| $t_{WHE}$ | Enable "H" Level Pulse Width | 300 | - | - | ns | Figure 1 |
| $t_{RE}$, $t_{FE}$ | Enable Rise/Fall Time | - | - | 25 | ns | Figure 1 |
| $t_{AS}$ | RS, R/W Setup Time | 60[1] 100[2] | - | - | ns | Figure 1 |
| $t_{AH}$ | RS, R/W Address Hold Time | 10 | - | - | ns | Figure 1 |
| $t_{RD}$ | Read Data Output Delay | - | - | 190 | ns | Figure 1 |
| $t_{DHR}$ | Read Data Hold Time | 20 | - | - | ns | Figure 1 |

## AC Characteristics   (continued)

Write Cycle  ($V_{DD}$ = 5.0V, GND = 0V, $T_A$ = 25°C)

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Conditions |
|--------|-----------|------|------|------|------|------------|
| $t_{CYCE}$ | Enable Cycle Time | 500 | - | - | ns | Figure 2 |
| $t_{WHE}$ | Enable "H" Level Pulse Width | 300 | - | - | ns | Figure 2 |
| $t_{RE}$, $t_{FE}$ | Enable Rise/Fall Time | - | - | 25 | ns | Figure 2 |
| $t_{AS}$ | RS, R/W Setup Time | $60^1$ / $100^2$ | - | - | ns | Figure 2 |
| $t_{AH}$ | RS, R/W Address Hold Time | 10 | - | - | ns | Figure 2 |
| $t_{DS}$ | Data Output Delay | 100 | - | - | ns | Figure 2 |
| $t_{DHR}$ | Data Hold Time | 10 | - | - | ns | Figure 2 |

Notes: 1: 8-bit operation mode
        2: 4-bit operation mode

## Power Supply Conditions Using Internal Reset Circuit

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Conditions |
|--------|-----------|------|------|------|------|------------|
| $t_{RON}$ | Power Supply Rise Time | 0.1 | - | 10 | ms | Figure 3 |
| $t_{OFF}$ | Power Supply OFF Time | 1 | - | - | ms | Figure 3 |

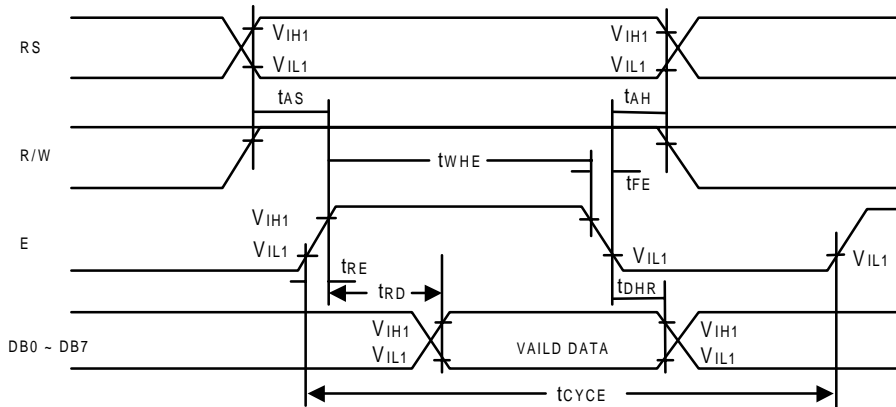**Timing Waveforms**

**Read Operation**



Figure 1. Bus Read Operation Sequence
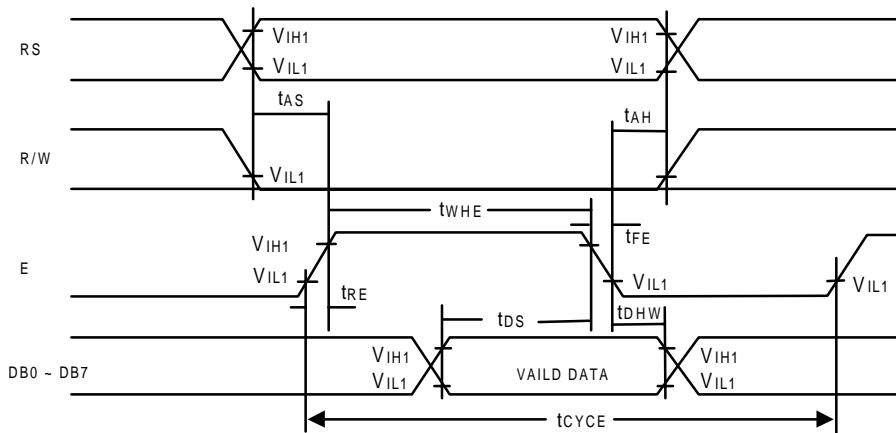(Reading out data from NT7603 to MPU)

**Write Operation**



Figure 2. Bus Write Operation Sequence
(Writing out data from NT7603 to MPU)
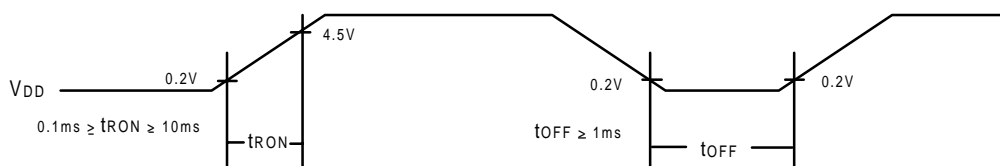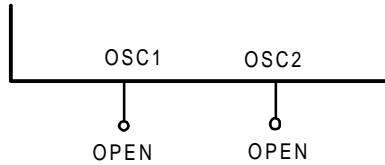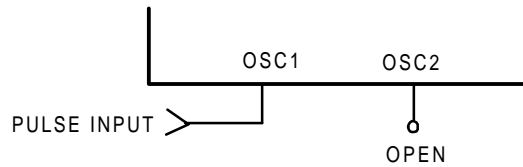
**Interface Signals with Segment Driver LSI**



Figure 3. $t_{OFF}$ stipulates the time of power ODD for instantaneous
Power supply to or when power supply repeats ON and OFF.

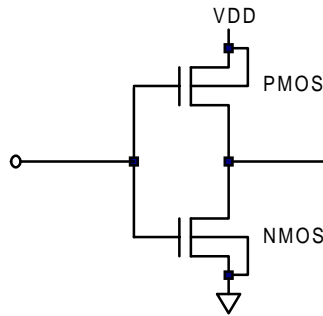**Note 1:** The NT7603 has two clock options:

**A. Internal Oscillator (Built-in RC)**
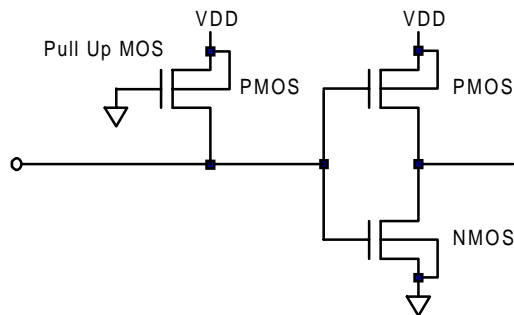


**B. External Clock Operation**



**Note 2:** Input/Output Terminals:

**A. Input Terminal**
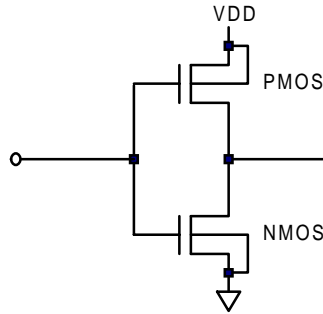   Applicable Terminal: E (No Pull Up MOS)



   Applicable Terminal: RS, R/W (with Pull Up MOS)
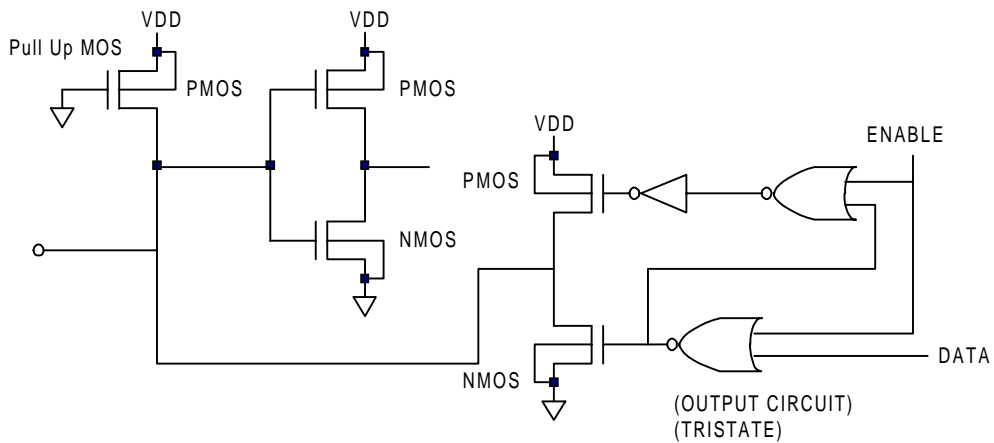
**B. Output Terminal**

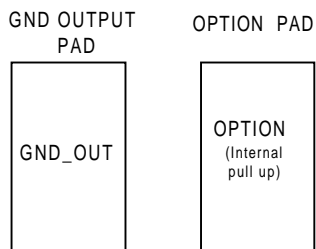Applicable Terminal: TESTM



**C. I/O Terminal**

Applicable Terminal: DB0 to DB7



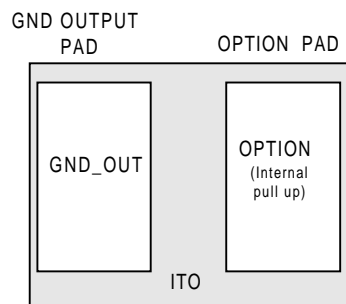**Note 3:** ITO Options:

Set Option=0: Place ITO on the Option Pad.
Set Option=1: No ITO on the Option Pad.

**Table 1. NT7603-01 Correspondence between Character Codes and Character Patterns (NOVATEK Standard 192 Character CG ROM)**

The table below shows the correspondence between character codes and character patterns. The columns represent the Higher 4-bit (D4 to D7) of the Character Code (Hexadecimal), ranging from 0 to F. The rows represent the Lower 4-bit (D0 to D3) of the Character Code (Hexadecimal), ranging from 0 to F. The first data column is labeled with "CG RAM" entries as follows:

| Lower 4-bit (D0 to D3) | CG RAM | Character Pattern |
|---|---|---|
| 0 | CG RAM (1) | (dot-matrix character glyphs) |
| 1 | CG RAM (2) | (dot-matrix character glyphs) |
| 2 | CG RAM (3) | (dot-matrix character glyphs) |
| 3 | CG RAM (4) | (dot-matrix character glyphs) |
| 4 | CG RAM (5) | (dot-matrix character glyphs) |
| 5 | CG RAM (6) | (dot-matrix character glyphs) |
| 6 | CG RAM (7) | (dot-matrix character glyphs) |
| 7 | CG RAM (8) | (dot-matrix character glyphs) |
| 8 | CG RAM (1) | (dot-matrix character glyphs) |
| 9 | CG RAM (2) | (dot-matrix character glyphs) |
| A | CG RAM (3) | (dot-matrix character glyphs) |
| B | CG RAM (4) | (dot-matrix character glyphs) |
| C | CG RAM (5) | (dot-matrix character glyphs) |
| D | CG RAM (6) | (dot-matrix character glyphs) |
| E | CG RAM (7) | (dot-matrix character glyphs) |
| F | CG RAM (8) | (dot-matrix character glyphs) |

## Table 2. Example of 240 Character CG ROM

Higher 4-bit (D4 to D7) of Character Code (Hexadecimal)

Lower 4 bit (D0 to D3) of Character Code (Hexadecimal)

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | CG RAM (1) | | | | | | | | | | | | | | | |
| 1 | CG RAM (2) | | | | | | | | | | | | | | | |
| 2 | CG RAM (3) | | | | | | | | | | | | | | | |
| 3 | CG RAM (4) | | | | | | | | | | | | | | | |
| 4 | CG RAM (5) | | | | | | | | | | | | | | | |
| 5 | CG RAM (6) | | | | | | | | | | | | | | | |
| 6 | CG RAM (7) | | | | | | | | | | | | | | | |
| 7 | CG RAM (8) | | | | | | | | | | | | | | | |
| 8 | CG RAM (1) | | | | | | | | | | | | | | | |
| 9 | CG RAM (2) | | | | | | | | | | | | | | | |
| A | CG RAM (3) | | | | | | | | | | | | | | | |
| B | CG RAM (4) | | | | | | | | | | | | | | | |
| C | CG RAM (5) | | | | | | | | | | | | | | | |
| D | CG RAM (6) | | | | | | | | | | | | | | | |
| E | CG RAM (7) | | | | | | | | | | | | | | | |
| F | CG RAM (8) | | | | | | | | | | | | | | | |

## Instruction Set

| Instruction | Code | | | | | | | | | | Function | Execution time (max) (f$_{osc}$ = 250KHz) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | | |
| Display Clear | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | Clear entire display area. | 1.64ms |
| Display/ Cursor Home | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | * | Restore display from shift and load address counter with DD RAM address 00H. | 1.64ms |
| Entry Mode Set | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | I/D | S | Specify direction of cursor movement and display shift mode. This operation takes place after each data transfer (read/write). | 40μs |
| Display ON/OFF | 0 | 0 | 0 | 0 | 0 | 0 | 1 | D | C | B | Specify activation of display (D) cursor (C) and blinking of character at cursor position (B). | 40μs |
| Display/ Cursor Shift | 0 | 0 | 0 | 0 | 0 | 1 | S/C | R/L | * | * | Shift display or move cursor. | 40μs |
| Function Set | 0 | 0 | 0 | 0 | 1 | DL | N | F | * | * | Set interface data length (DL), number of display line (N), and character font (F). | 40μs |
| RAM Address Set | 0 | 0 | 0 | 1 | ACG | | | | | | Load the address counter with a CG RAM address. Subsequent data access is for CG RAM data. | 40μs |
| DD RAM Address Set | 0 | 0 | 1 | ADD | | | | | | | Load the address counter with a DD RAM address. Subsequent data access is for DD RAM data. | 40μs |
| Busy Flag/ Address Counter Read | 0 | 1 | AC | | | | | | | | Read Busy Flag (BF) and contents of Address Counter (AC). | 40μs |
| CG RAM/ DD RAM Data Write | 1 | 0 | Write data | | | | | | | | Write data to CG RAM or DD RAM. | 40μs |
| CG RAM/ DD RAM Data Read | 1 | 1 | Read data | | | | | | | | Read data from CG RAM or DD RAM. | 40μs |
| | I/D = 1 : Increment       I/D = 0 : Decrement<br>S = 1 : Display Shift On<br>D = 1 : Display On<br>C = 1 : Cursor Display On<br>B = 1 : Cursor Blink On<br>S/C = 1 : Shift Display       S/C = 0 : Move Cursor<br>R/L = 1 : Shift Right       R/L = 0 : Shift Left<br>DL = 1 : 8-Bit       DL = 0 : 4-Bit<br>N = 1 : Dual Line       N = 0 : Signal Line<br>F = 1 : 5x10 dots       F = 0 : 5x8 dots<br>BF = 1 : Internal Operation<br>BF = 0 : Ready for Instruction | | | | | | | | | | DD RAM : Display Data RAM<br><br>CG RAM : Character Generator RAM<br>ACG :       Character Generator RAM Address<br>ADD :       Display Data RAM Address<br>AC :       Address Counter | |

Note 1: Symbol "*" signifies an insignificant bit (disregard).
Note 2: Correct input value for "N" is predetermined for each model.

**Interface to LCD**

**(1) Character Font and Number of Lines**

The NT7603 provide a 5 X 7 dot character font 1-line mode, a 5 X 10 dot character font 1-line mode and a 5 X 7 dot character font 2-line mode, as shown in the table below.

Three types of common signals are available as displayed in the table. The number of lines and the font type can be selected by the program.

| Number of Lines | Character Font | Number of Common Signals | Duty Factor | Bias |
|:---:|:---:|:---:|:---:|:---:|
| 1 | 5 X 7 dots + Cursor (or 5x8 dots) | 8 | 1/8 | 1/4 |
| 1 | 5 X 10 dots + Cursor | 11 | 1/11 | 1/4 |
| 2 | 5 X 7 dots + Cursor (or 5x8 dots) | 16 | 1/16 | 1/5 |

**(2) Connection to LCD**

The following 4 LCD connection examples show the various combinations between characters and lines. NT7603 can directly drive the following combinations:

(a) 5 X 8 Font - 16 character X 1 line (1/8 duty cycle, 1/4 bias)
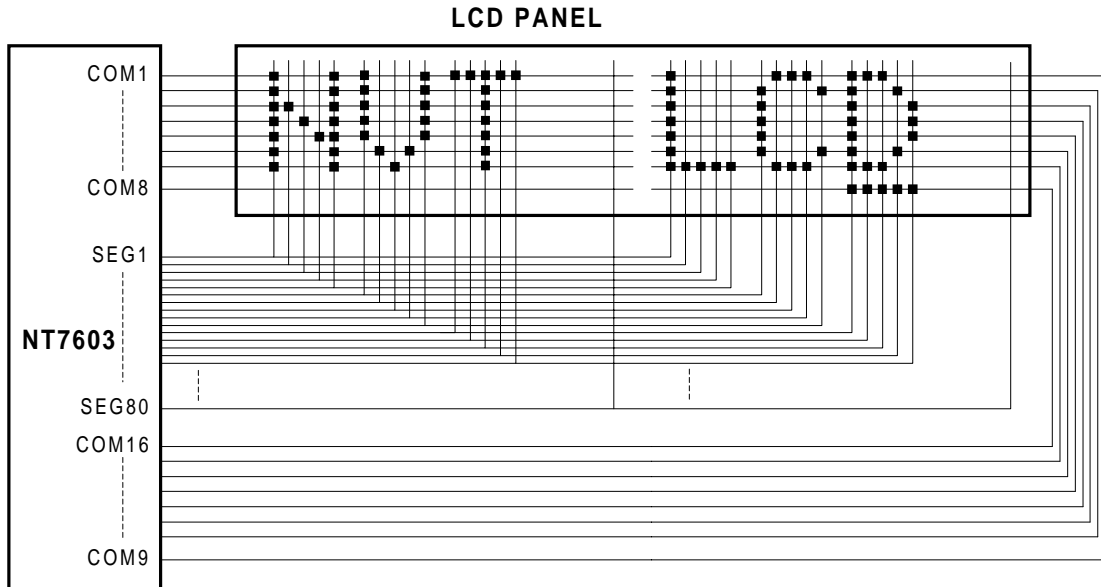
**LCD PANEL**
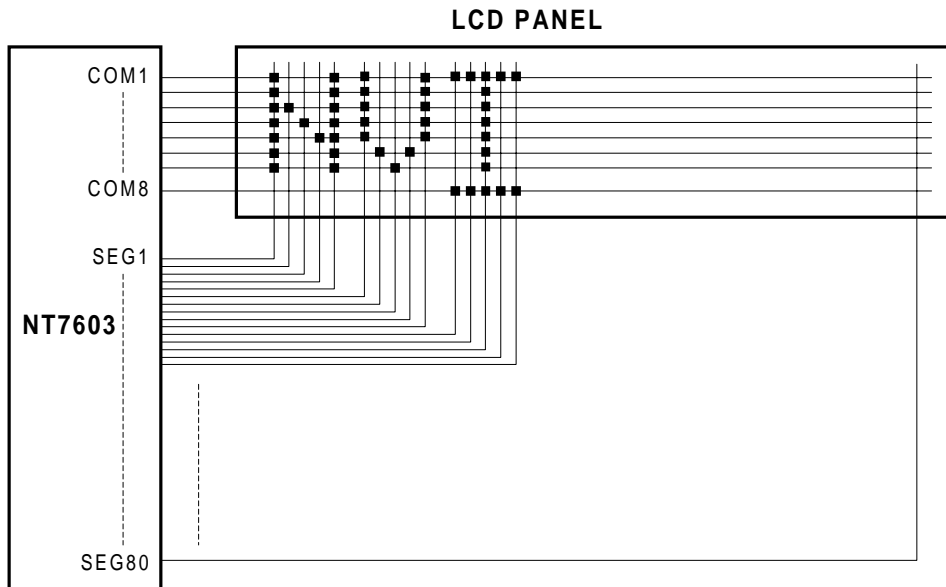
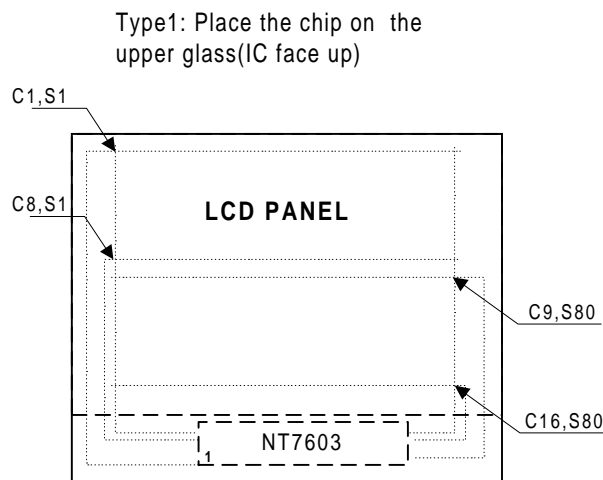(b) 5 X 10 Font - 16 character X 1 line (1/11 duty cycle, 1/4 bias)

**LCD PANEL**
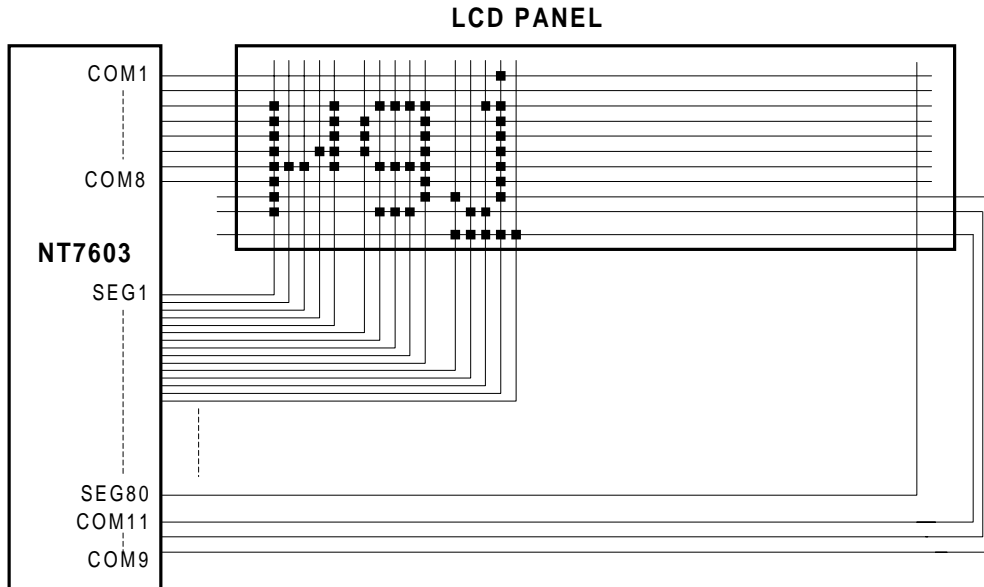


(c) 5 X 8 Font - 16 character X 2 line (1/16 duty cycle, 1/5 bias)

**LCD PANEL**
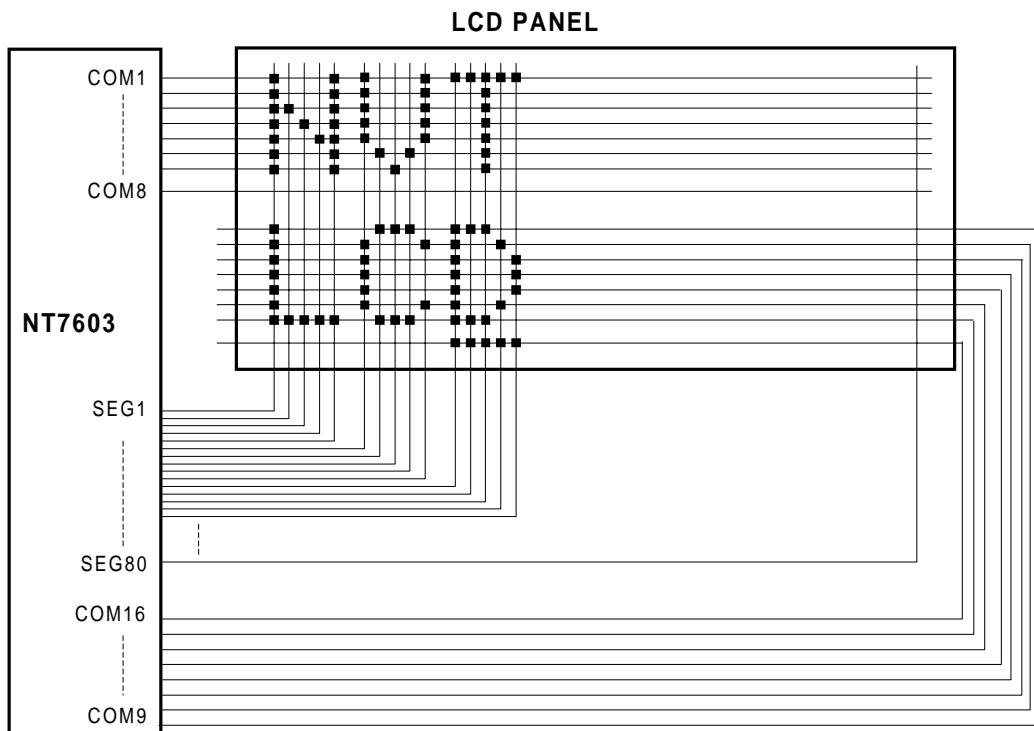
(d) 5 X 8 Font - 32 character X 1 line (1/16 duty cycle, 1/5bias)

**LCD PANEL**



**(3)Orientation type of NT7603:**

Type1: Place the chip on the upper glass(IC face up)

**(3) Bias Power Connection**

NT7603 provides 1/4 or 1/5 bias for various duty cycle applications. The built-in power division resister divide voltage is described in the following table. The division resister is The connection of NT7603, power supply, and resistors are also shown as follows:

| Power Division | 1/8, 1/11 Duty Cycle - 1/4 Bias | 1/16 Duty Cycle - 1/5 Bias |
|---|---|---|
| $V_1$ | $V_{DD} - 1/4\ V_{LCD}$ | $V_{DD} - 1/5\ V_{LCD}$ |
| $V_2$ | $V_{DD} - 1/2\ V_{LCD}$ | $V_{DD} - 2/5\ V_{LCD}$ |
| $V_3$ | $V_{DD} - 1/2\ V_{LCD}$ | $V_{DD} - 3/5\ V_{LCD}$ |
| $V_4$ | $V_{DD} - 3/4\ V_{LCD}$ | $V_{DD} - 4/5\ V_{LCD}$ |
| $V_5$ | $V_{DD} - V_{LCD}$ | $V_{DD} - V_{LCD}$ |

The bias is auto selected by duty cycle. When LCD is set to 1/16 duty, the bias is set to 1/5. Otherwise, the bias is set to 1/4.

The ITO Option can select the division resister value:

| OPT_R1 | OPT_R0 | Division Resister |
|---|---|---|
| No ITO (1) | No ITO (1) | 2.2K$\Omega$ |
| No ITO (1) | ITO On (0) | 4K$\Omega$ |
| ITO On (0) | No ITO (1) | 6.8K$\Omega$ |
| ITO On (0) | No ITO (0) | No built-in resister (external input) |
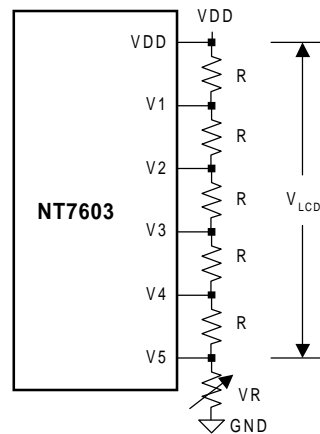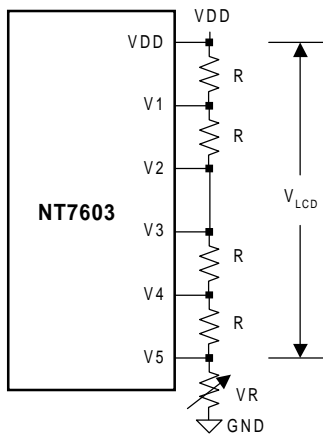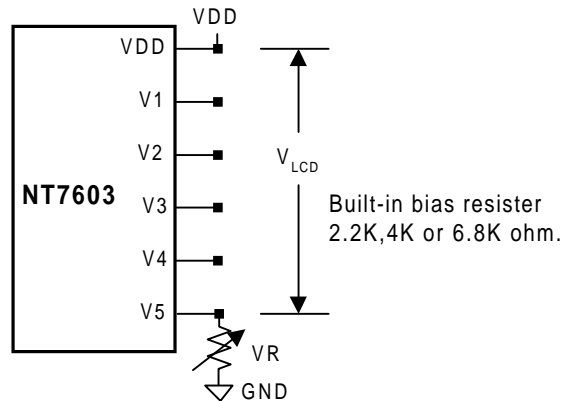
Exit Power division. (The resistance value depends on the LCD panel size.)

## (4) LCD Waveform

A-type, 1/8 Duty Cycle, 1/4 Bias



$$1 \text{ Frame} = \frac{1\text{sec}}{270K} \times 400 \times 8 = 11.9\text{ms}$$

$$\text{Frame Frequency} = \frac{1}{11.9\text{ms}} = 84.3\text{Hz}$$

A-type, 1/11 Duty Cycle, 1/4 Bias



$$1 \text{ Frame} = \frac{1\text{sec}}{\phantom{xxx}} \times 400 \times 11 = 16.3\text{ms}$$

$$\text{Frame Frequency} = \frac{1}{\phantom{xxx}} = 61.4\text{Hz}$$

A-type, 1/16 Duty Cycle, 1/5 Bias



$$1 \text{ Frame} = \frac{1\text{sec}}{\phantom{xxx}} \times 200 \times 16 = 11.9\text{ms}$$

$$\text{Frame Frequency} = \frac{1}{\phantom{xxx}} = 84.3\text{Hz}$$

### B-type, 1/8 Duty Cycle, 1/4 Bias



200 CLOCKS

COM1  1  2  3  4  5  6  7  8  9 ... 16  1  2

VDD, V1, V2 (V3), V4, V5

1 Frame

$$1 \text{ Frame} = \frac{1sec}{270K} \times 200 \times 16 = 11.9ms$$

$$\text{Frame Frequency} = \frac{1}{11.9ms} = 84.3Hz$$

### B-type, 1/11 Duty Cycle, 1/4 Bias



200 CLOCKS

COM1  1  2  3  4  5  6  7  8  9  10  11  12 ... 21  22  1  2

VDD, V1, V2 (V3), V4, V5

1 Frame

$$1 \text{ Frame} = \frac{1sec}{270K} \times 200 \times 22 = 16.3ms$$

$$\text{Frame Frequency} = \frac{1}{16.3ms} = 61.4Hz$$

### B-type, 1/16 Duty Cycle, 1/5 Bias



100 CLOCKS

COM1  1  2  3  4  5 · · · · 13  14  15  16  17 ... 31  32  1  2

VDD, V1, V2, V3, V4, V5

1 Frame

$$1 \text{ Frame} = \frac{1sec}{270K} \times 100 \times 32 = 11.9ms$$

$$\text{Frame Frequency} = \frac{1}{11.9ms} = 84.3Hz$$

**Application Circuit** (for reference only)
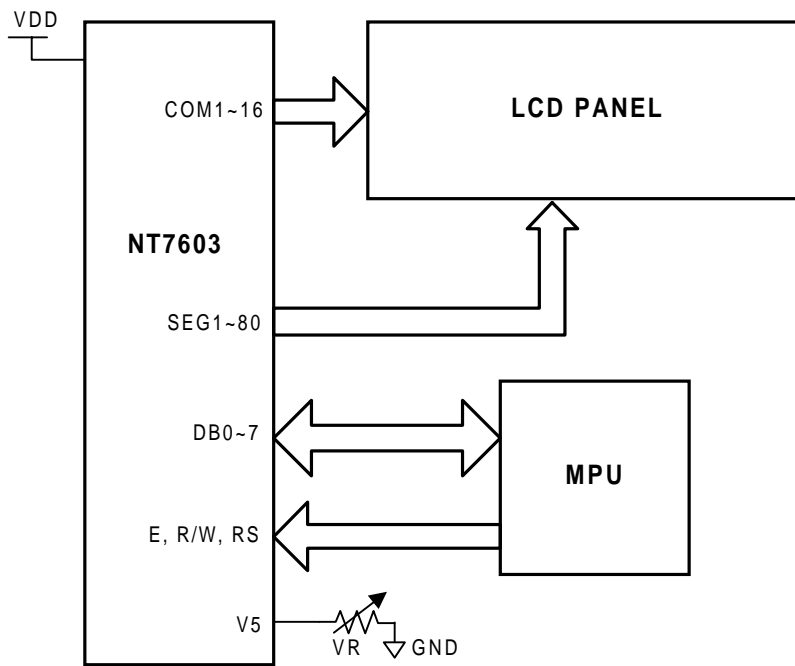
**Ordering Information**

| Part No. | CG ROM | Package | Shipment Style |
|---|---|---|---|
| **NT7603BDB-01** | 192 CGROM (ref P12) | COG CHIP FORM | Bumped Die on Blue tape |
| **NT7603BDT-01** | 192 CGROM (ref P12) | COG CHIP FORM | Bumped Die on chip Tray |
| **NT7603BDW-01** | 192 CGROM (ref P12) | COG CHIP FORM | Bumped Die on Wafer |

# NT7603

## Pad Configuration of NT7603

Unit: μm
Chip Window: 1220 × 5010 μm$^2$
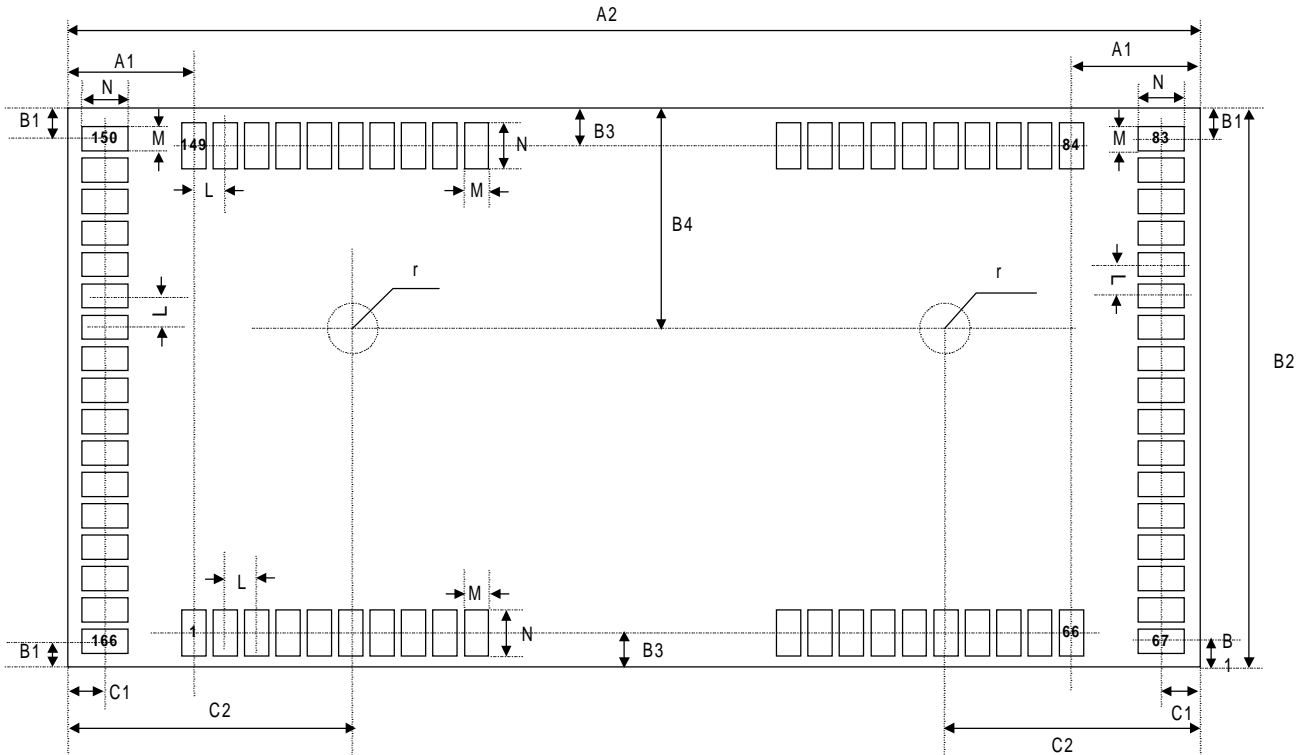


| A1 | 230 | C1 | 66 |
|----|-----|----|-----|
| A2 | 5010 | C2 | 511.55 |
| B1 | 50 | r | 35 |
| B2 | 1220 | M | 42 |
| B3 | 70 | N | 90 |
| B4 | 500.2 | L | 70 |

### PAD Location

| NO. | PAD NAME | X | Y | NO. | PAD NAME | X | Y |
|-----|----------|------|------|-----|----------|------|------|
| 1 | GND | -2275 | -540 | 13 | GND | -1435 | -540 |
| 2 | GND | -2205 | -540 | 14 | GND | -1365 | -540 |
| 3 | GND | -2135 | -540 | 15 | GND | -1295 | -540 |
| 4 | GND | -2065 | -540 | 16 | OSC1 | -1225 | -540 |
| 5 | GND | -1995 | -540 | 17 | OSC2 | -1155 | -540 |
| 6 | GND | -1925 | -540 | 18 | V1 | -1085 | -540 |
| 7 | GND | -1855 | -540 | 19 | V2 | -1015 | -540 |
| 8 | GND | -1785 | -540 | 20 | V3 | -945 | -540 |
| 9 | GND | -1715 | -540 | 21 | V4 | -875 | -540 |
| 10 | GND | -1645 | -540 | 22 | V5 | -805 | -540 |
| 11 | GND | -1575 | -540 | 23 | V5 | -735 | -540 |
| 12 | GND | -1505 | -540 | 24 | V5 | -665 | -540 |

| NO. | PAD NAME | X | Y | NO. | PAD NAME | X | Y |
|-----|----------|------|------|-----|----------|------|------|
| 25 | V5 | -595 | -540 | 74 | COM[14] | 2439 | -70 |
| 26 | OPT_R0 | -525 | -540 | 75 | COM[15] | 2439 | 0 |
| 27 | GND | -455 | -540 | 76 | COM[16] | 2439 | 70 |
| 28 | OPT_R1 | -385 | -540 | 77 | SEG[80] | 2439 | 140 |
| 29 | VDD | -315 | -540 | 78 | SEG[79] | 2439 | 210 |
| 30 | VDD | -245 | -540 | 79 | SEG[78] | 2439 | 280 |
| 31 | VDD | -175 | -540 | 80 | SEG[77] | 2439 | 350 |
| 32 | VDD | -105 | -540 | 81 | SEG[76] | 2439 | 420 |
| 33 | VDD | -35 | -540 | 82 | SEG[75] | 2439 | 490 |
| 34 | VDD | 35 | -540 | 83 | SEG[74] | 2439 | 560 |
| 35 | VDD | 105 | -540 | 84 | SEG[73] | 2275 | 540 |
| 36 | VDD | 175 | -540 | 85 | SEG[72] | 2205 | 540 |
| 37 | VDD | 245 | -540 | 86 | SEG[71] | 2135 | 540 |
| 38 | VDD | 315 | -540 | 87 | SEG[70] | 2065 | 540 |
| 39 | VDD | 385 | -540 | 88 | SEG[69] | 1995 | 540 |
| 40 | VDD | 455 | -540 | 89 | SEG[68] | 1925 | 540 |
| 41 | VDD | 525 | -540 | 90 | SEG[67] | 1855 | 540 |
| 42 | VDD | 595 | -540 | 91 | SEG[66] | 1785 | 540 |
| 43 | VDD | 665 | -540 | 92 | SEG[65] | 1715 | 540 |
| 44 | RS | 735 | -540 | 93 | SEG[64] | 1645 | 540 |
| 45 | RS | 805 | -540 | 94 | SEG[63] | 1575 | 540 |
| 46 | RW | 875 | -540 | 95 | SEG[62] | 1505 | 540 |
| 47 | RW | 945 | -540 | 96 | SEG[61] | 1435 | 540 |
| 48 | E | 1015 | -540 | 97 | SEG[60] | 1365 | 540 |
| 49 | E | 1085 | -540 | 98 | SEG[59] | 1295 | 540 |
| 50 | DB[0] | 1155 | -540 | 99 | SEG[58] | 1225 | 540 |
| 51 | DB[0] | 1225 | -540 | 100 | SEG[57] | 1155 | 540 |
| 52 | DB[1] | 1295 | -540 | 101 | SEG[56] | 1085 | 540 |
| 53 | DB[1] | 1365 | -540 | 102 | SEG[55] | 1015 | 540 |
| 54 | DB[2] | 1435 | -540 | 103 | SEG[54] | 945 | 540 |
| 55 | DB[2] | 1505 | -540 | 104 | SEG[53] | 875 | 540 |
| 56 | DB[3] | 1575 | -540 | 105 | SEG[52] | 805 | 540 |
| 57 | DB[3] | 1645 | -540 | 106 | SEG[51] | 735 | 540 |
| 58 | DB[4] | 1715 | -540 | 107 | SEG[50] | 665 | 540 |
| 59 | DB[4] | 1785 | -540 | 108 | SEG[49] | 595 | 540 |
| 60 | DB[5] | 1855 | -540 | 109 | SEG[48] | 525 | 540 |
| 61 | DB[5] | 1925 | -540 | 110 | SEG[47] | 455 | 540 |
| 62 | DB[6] | 1995 | -540 | 111 | SEG[46] | 385 | 540 |
| 63 | DB[6] | 2065 | -540 | 112 | SEG[45] | 315 | 540 |
| 64 | DB[7] | 2135 | -540 | 113 | SEG[44] | 245 | 540 |
| 65 | DB[7] | 2205 | -540 | 114 | SEG[43] | 175 | 540 |
| 66 | OPT_LCD | 2275 | -540 | 115 | SEG[42] | 105 | 540 |
| 67 | GND | 2439 | -560 | 116 | SEG[41] | 35 | 540 |
| 68 | TESTD | 2439 | -490 | 117 | SEG[40] | -35 | 540 |
| 69 | COM[9] | 2439 | -420 | 118 | SEG[39] | -105 | 540 |
| 70 | COM[10] | 2439 | -350 | 119 | SEG[38] | -175 | 540 |
| 71 | COM[11] | 2439 | -280 | 120 | SEG[37] | -245 | 540 |
| 72 | COM[12] | 2439 | -210 | 121 | SEG[36] | -315 | 540 |
| 73 | COM[13] | 2439 | -140 | 122 | SEG[35] | -385 | 540 |

| NO. | PAD NAME | X | Y | NO. | PAD NAME | X | Y |
|-----|----------|-----|-----|-----|----------|---------|-------|
| 123 | SEG[34] | -455 | 540 | 146 | SEG[11] | -2065 | 540 |
| 124 | SEG[33] | -525 | 540 | 147 | SEG[10] | -2135 | 540 |
| 125 | SEG[32] | -595 | 540 | 148 | SEG[9] | -2205 | 540 |
| 126 | SEG[31] | -665 | 540 | 149 | SEG[8] | -2275 | 540 |
| 127 | SEG[30] | -735 | 540 | 150 | SEG[7] | -2439 | 560 |
| 128 | SEG[29] | -805 | 540 | 151 | SEG[6] | -2439 | 490 |
| 129 | SEG[28] | -875 | 540 | 152 | SEG[5] | -2439 | 420 |
| 130 | SEG[27] | -945 | 540 | 153 | SEG[4] | -2439 | 350 |
| 131 | SEG[26] | -1015 | 540 | 154 | SEG[3] | -2439 | 280 |
| 132 | SEG[25] | -1085 | 540 | 155 | SEG[2] | -2439 | 210 |
| 133 | SEG[24] | -1155 | 540 | 156 | SEG[1] | -2439 | 140 |
| 134 | SEG[23] | -1225 | 540 | 157 | COM[8] | -2439 | 70 |
| 135 | SEG[22] | -1295 | 540 | 158 | COM[7] | -2439 | 0 |
| 136 | SEG[21] | -1365 | 540 | 159 | COM[6] | -2439 | -70 |
| 137 | SEG[20] | -1435 | 540 | 160 | COM[5] | -2439 | -140 |
| 138 | SEG[19] | -1505 | 540 | 161 | COM[4] | -2439 | -210 |
| 139 | SEG[18] | -1575 | 540 | 162 | COM[3] | -2439 | -280 |
| 140 | SEG[17] | -1645 | 540 | 163 | COM[2] | -2439 | -350 |
| 141 | SEG[16] | -1715 | 540 | 164 | COM[1] | -2439 | -420 |
| 142 | SEG[15] | -1785 | 540 | 165 | TEST | -2439 | -490 |
| 143 | SEG[14] | -1855 | 540 | 166 | TESTM | -2439 | -560 |
| 144 | SEG[13] | -1925 | 540 | | ALK_L | -1993.45 | 109.8 |
| 145 | SEG[12] | -1995 | 540 | | ALK_R | 1993.45 | 109.8 |