RCL Semiconductors Ltd.

3½ Digit 5 Function Biplexed LCD Watch With

C1928

Counter-Down and Multiple By 4 Function

GENERAL DESCRIPTION

The C1928 is a poly gate CMOS integrated circuit which provides function as a 3½ digit 5 function biplexed LCD watch with 60 second countdown and 2 digits multiple by 4 function.

The five functions of 3.5 digits watch mode, MONTH, DATE, HOUR, MINUTE and SECOND are derived from a 32768Hz crystal controlled oscillator timebase. All oscillator components except the quartz crystal are built in. The high voltage levels required by the LCD are generated by an on chip voltage doubler using 2 external capacitors. All 3.5-digit 5 function watch display and setting functions are controlled by 2 switches S1 and S2. Counter down or multiple by 4 function are controled by COUNT or MUL keys.

A single battery supply and low current consumption makes it ideal for wrist watch application and many other applications.

FUNCTION

- 5 functions : MONTH, DATE, HOUR, MINUTE and SECOND.
- 12 hour format.
- Alternating HOUR-MINUTE / MONTH-DATE display selectable.
- S1 & S2 control all functions of watch and COUNT or MUL button can change watch to count down or multiple by 4 mode .
- On chip 32768 Hz crystal controlled oscillator with input capacitor.
- Bonding selectable oscillator output capacitor.
- 60 second count-down enable when COUNT button pressed.
- LCD show multiple by 4 result when MUL button pressed after load in 2 digits number.
- It return back to 3.5-digit watch again when RESET button pressed wherever it is original in count down or multiple mode.

FEATURES

- Single battery operation(1.3V-1.8V).
- Single chip CMOS structure.
- Low current consumption (2μA max. @1.5V).
- Drive a 3.5-digit biplexed LCD directly.
- 32768 Hz crystal controlled oscillator with built-in capacitor.
- Bonding selectable oscillator output capacitor.
- Built in voltage doubler.
- S1, S2, COUNT, MUL control buttons and all inputs debounced and pull-down.
- The key matrix have the following keys:
  0, 1, 2, 3, 4, 5, 6, 7, 8, 9, S1, S2, COUNT, MUL, RESET and TDS
- All segments and colon of LCD testing

ABSOLUTE MAXIMUM RATINGS *

Parameter	Value	Unit
Supply voltage V_{DD} - V_{SS} *	- 0.3 ~ + 2.0	V
V_{DD} - V_{EE} *	-0.3 ~ +4.0	V
Voltage at inputs OSCIN1, OSCIN2, S1, S2, COUNT MUL, RESET, TDS and 0 - 9	V_{SS} -0.3 $\leq$ V_{IN} $\leq$ V_{DD} +0.3	V
Voltage at outputs OSCOUT, 512 Hz	V_{SS} $\leq$ V_{OUT1} $\leq$ V_{DD}	–
COM1, COM2, All segments	V_{EE} $\leq$ V_{OUT2} $\leq$ V_{DD}	–
CAP	V_{EE} $\leq$ V_{OUT3} $\leq$ V_{SS}	–
Operating temperature range	-10 ~ +55	°C
Storage temperature range	-25 ~ + 70	°C

Note: These absolute maximum ratings specify condition exceeding which permanent damage to the device may result. They are by no means conditions under which the device may be expected to operate.

ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, V_{DD} = 1.5V, Ta = 25°C, doubler connected with C1 = C2 = 0.1μF, fosc = 32768 Hz. All voltages are referenced to Vss)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition
Supply voltage	V_{DD}	1.30	1.50	1.80	V	−
Supply current	I_{DD}	−	2.0	3.5	μA	V_{DD} = 1.5V, LCD unloaded, all keys disconnected.
Oscillator start voltage	V_{OSC}	1.45	−	−	V	Within 10 seconds.
Oscillator hold voltage	V_{HOLD}	1.30	−	−	V	−
Input low voltage	V_{IL}	-0.30	0	0.3	V	−
Input high voltage	V_{IH}	V_{DD} -0.30	V_{DD}	V_{DD} +0.30	V	V_{DD} = 1.3V to 1.8V

FUNCTIONAL DESCRIPTION

Oscillator

The oscillator has been designed for a frequency of 32768 Hz. The integrated capacitors C_{IN} and C_{OUT} at the input and output of the OSC provide the capacitive load for the crystal. All components except the crystal are built in. If a precise oscillating frequency is desired, the crystal may be placed between OSCOUT and OSCI1 and the oscillator tuned with a trimming capacitor between OSCI1 and V_{DD}.
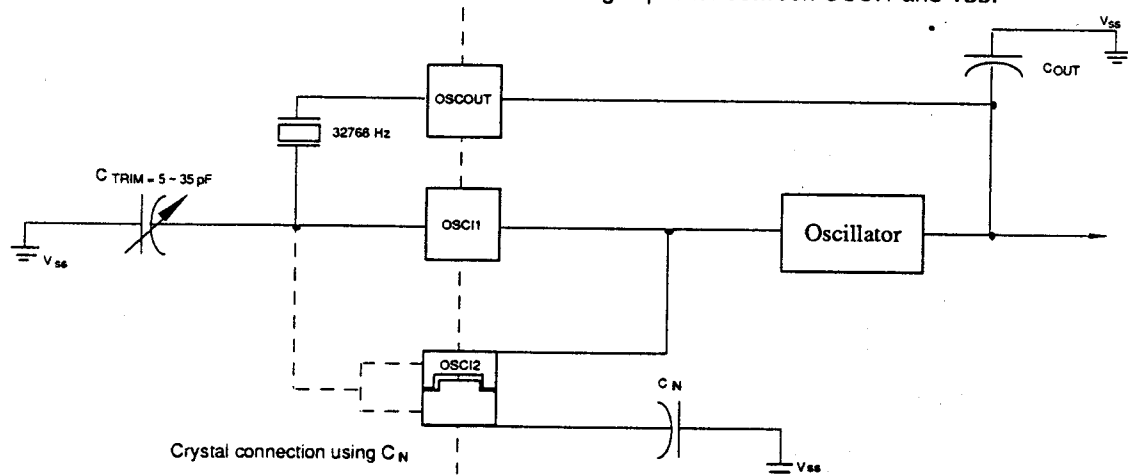

Figure 1. C1928 oscillator circuit

Operation Mode

1. 3.5-Digit Watch Mode:

A 3.5-digit watch with 5 functions: Month, Date, Hour, Minute, Second. It can be set by S1 and S2 buttons and "COUNT"/"MUL" keys are disable during S1&S2 setting. It is either in normal operation mode or alternating mode toggled by S2. During watch mode, "RESET" Key is disable.

2. Count-Down Counter & Multiple By 4 Mode:

When a "COUNT" button is pressed, no matter what is original in HR:MIN or MON DAY or :SEC mode, the watch will become a 60 second count-down counter and LCD display 60 at 2th and 3th digit. When "COUNT" pressed again, It begins to count down from 60s to 0s and stop count when reaches 0. If "RESET" button is pressed when reaches 0, it will change back to watch's original mode again, or if "MUL" button is pressed after 2 digits loaded in from the key matrix, LCD will display multiple by 4 result without colon on, e.g. 99 loaded in, LCD will display 396 when "MUL" button is pressed. The multiple by 4 results should be no more than 3-digits and display on the 1th, 2th and 3th digits of LCD with colon blanked.

3. Reset Mode:

When the "RESET" button is pressed, it will go back to a 3.5-digit watch mode again wherever it is in Count-down mode or Multiple mode. "RESET" is disable when it is in watch mode.

a). During count-down process from 60s to 0s, C1928 will go back to watch HR:MIN mode whenever "RESET" is pressed. When count-down reaches 0 and "RESET" is pressed, it will also go back to watch HR:MIN mode.

b). After count-down reaches 0 and 2 digits are loaded in from the key matrix, it will clear these loaded 2 digits and LCD display 0 whenever "RESET" is pressed, then the correct 2 digits can be re-loaded again from the key matrix; or the correct 2 digits can be directly loaded in from the key matrix to overwrite the original 2 digits.

c). After count-down reaches 0 and 2 digits are loaded in from the key matrix, "MUL" key is pressed and LCD displays multiple by 4 result. At this moment, C1928 will go back to watch mode if "RESET" key is pressed.

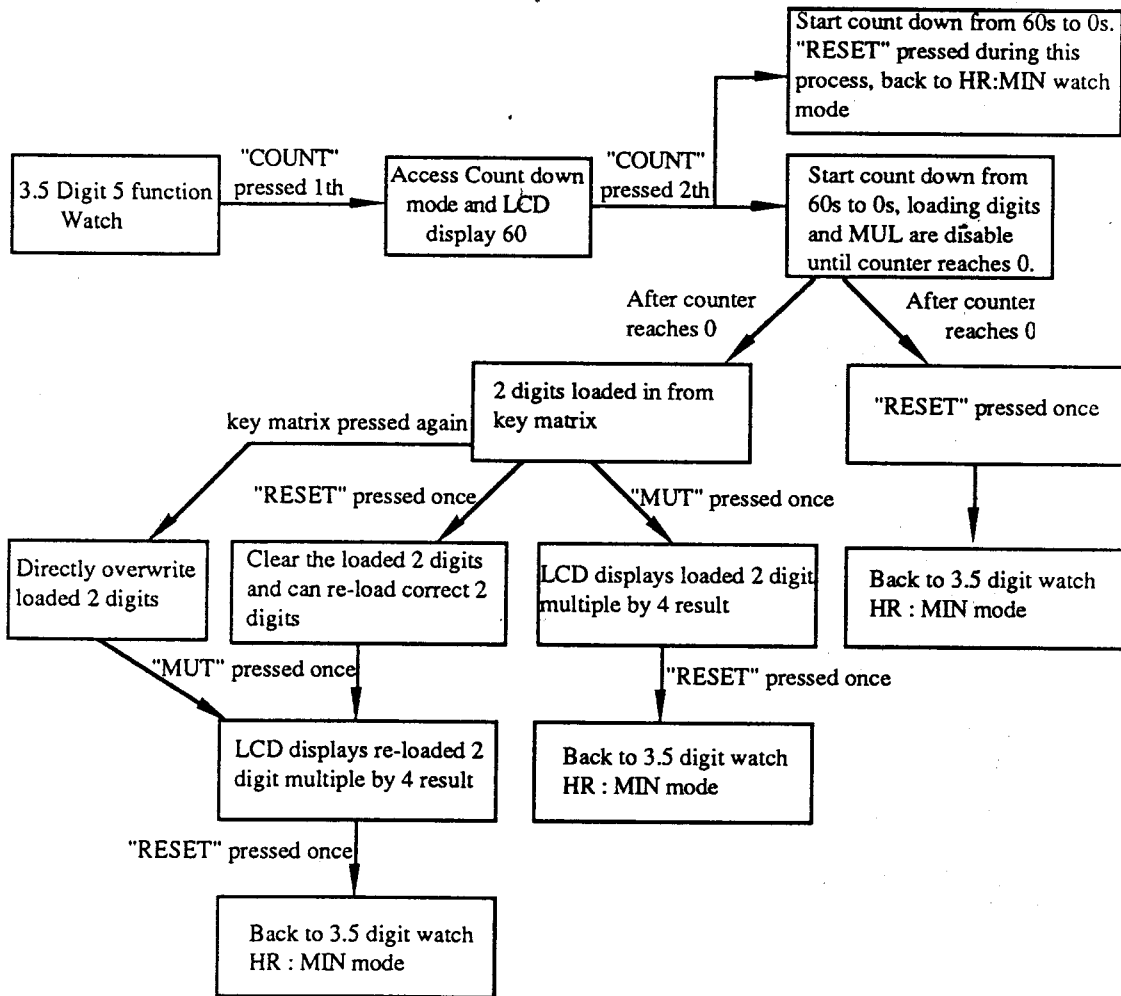The following Fig.2. is "Function Flow Chart" of C1928 :

Figure 2. Function Flow Chart

## Display control in 3.5-Digit Watch Mode

The RCL C1928 has 2 display modes : normal and alternating. The display formats are shown in Fig. 3 for Normal mode and in Fig. 4 for Alternating mode.
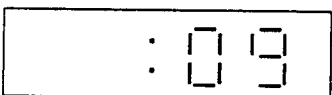
a) Normal mode

In the normal mode, the HOUR and MINUTE are displayed with the colon flashing once every second. MONTH and DATE are called up by pressing S1 once. The colon is blanked. Leading zero is not suppressed for date. In this state, if S1 is pressed again, the first digit will be blanked and the SECOND displayed at the second and third digits, the colon will be on continuously. Activating S1 again will put the display back to HOUR-MINUTE. When MONTH and DATE are being displayed, an automatic time-out facility will return the display to HOUR-MINUTE 0.5 to 1.5 second after releasing S1.
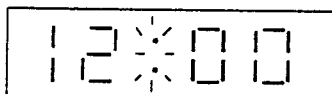
HOUR-MINUTE Display
Time = 12 o'clock
Colon flashes at 1 Hz rate
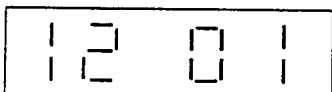
MONTH-DATE Display
Date = 1th December
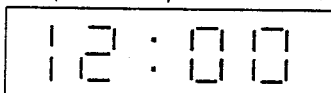Colon blanked and leading zero is not suppressed

SECOND Display
Solid,colon and leading zero is not suppressed
Display increments once per second

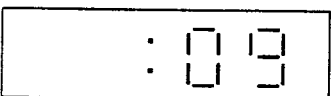Figure 3. Normal mode display format

b) Alternating mode

This mode is entered by pressing S2 once in normal mode. In this mode, the display switches between HOUR-MINUTE and MONTH-DATE once every second. The two states are distinguished by the colon being on continuously in the HOUR-MINUTE display and off in the MONTH-DATE display. SECOND is displayed by pressing S1. The colon is on continuously. The SECOND increments once every second. The alternating display is re-entered by activating S1 again. Return to normal mode requires completion of the setting sequence.

HOUR-MINUTE Display
Time = 12 o'clock
Colon is on continuously

MONTH-DATE Display
Date = 1th December
Colon blanked and leading zero is suppressed

SECOND Display
Solid colon and leading zero is not suppressed
Display increments once per second

Figure 4. Alternating mode display format

c) Setting

There are four setting modes. They are, in order of appearance : MONTH, DATE, HOUR and MINUTE. From the alternating mode, each setting mode is entered in succession by pressing S2. In each mode, only the information which may be changed is displayed. MONTH is displayed at the first digit with everything else blanked. DATE is displayed at the second and third digits without leading zero suppression. The first digit and colon are also blanked. HOUR occupies the first digit. The colon is on. The second digit is blanked. The third digit displays an A for AM or a P for PM. Lastly, MINUTE is displayed at the second and third digits. The colon is on and the first digit is off. S1 is used for adjustment in each setting mode. Momentary closure of S1 increments the displayed item once. If S1 is held down, the display will advance twice every second after a delay of 0.75 ~ 1.75 second.If S1 is pressed in the MINUTE setting mode, not only will the MINUTE display advance, the internal SECOND counter will also be reset to 00. Upon return to normal display mode by activating S2, the colon will be stationary. Time keeping resumes after S1 is pressed. This may be used to synchronize the timepiece with a standard timing signal if desired.

During S1 and S2 setting, "COUNT" and "MUL" function keys are disable.

Setting And Display Sequence In Watch Operation Mode
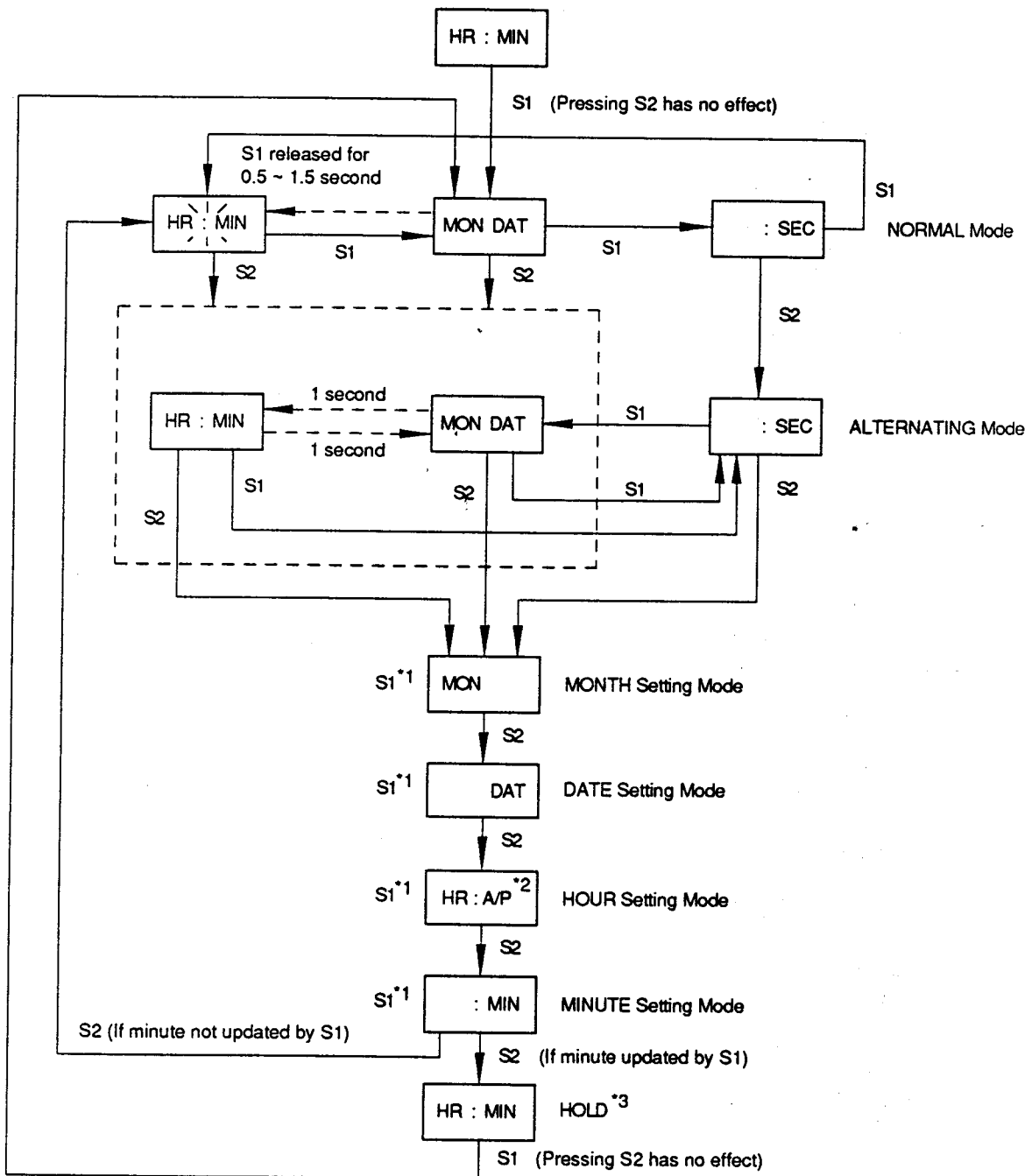
Keys: :   Colon is on continuously.

         :   Colon flashes at 1 Hz rate

Note: *1   Connecting S1 to VDD increments displayed item by 1. Continuous contact to VDD initiates 2 Hz auto advancement 0.75 ~ 1.75 second after first increment.

      *2   12 hour format. A is displayed for AM and P for PM at the third digit. The second digit is blanked.

   *3   If minute has been updated, seconds are reset to 00. Time keeping resumes after closing S1.

"TDS" For LCD Testing

When "TDS" button is pressed, all the segments and colon of LCD will be on until this button is released.

"MREST" for system reset

During the probe testing, the whole chip can be reset by "MREST" pull high. It is for the testing only. It is unnecessary to ponding this pad out to PCB..
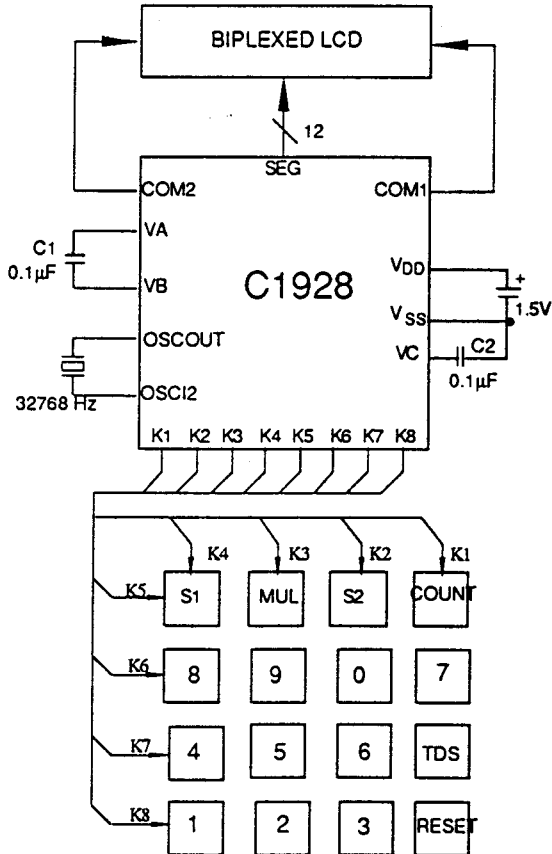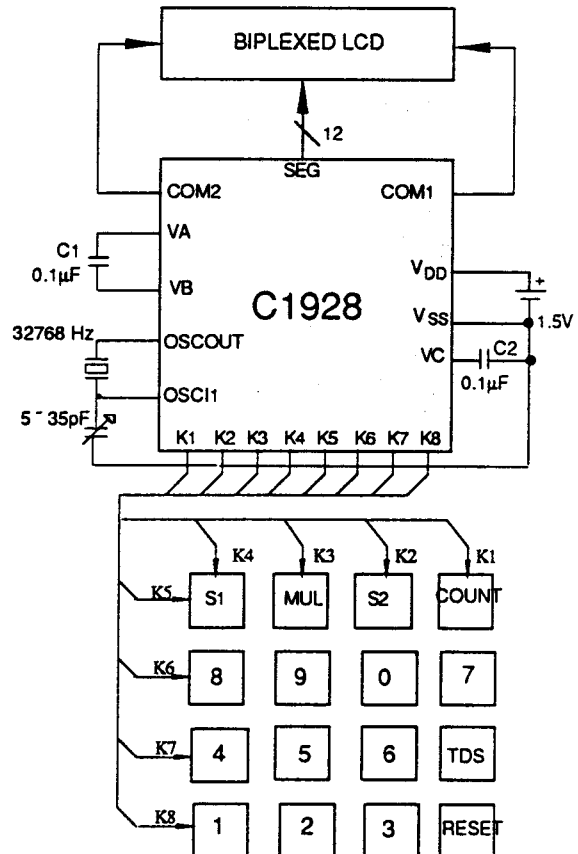
MULTIPLEXED LCD FORMAT
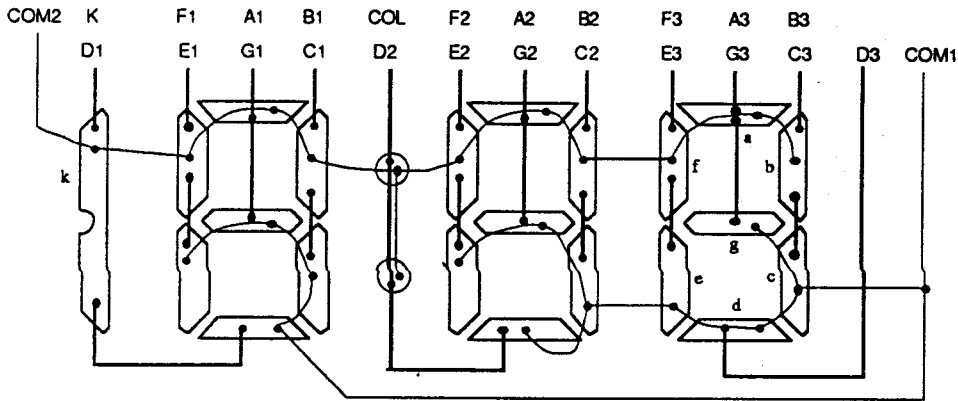
Pin	1	2	3	4	5	6	7	8	9	10	11	12	13	14
COM1		G1	E1	D1	C1	G2	E2	D2	C2	E3	D3	C3	G3	COM1
COM2	COM2	A1	F1	K	B1	A2	F2	COL	B2	F3		B3	A3	

TYPICAL APPLICATION CIRCUIT (Substrate is connected to GND)

Without Trimmer   With Trimmer

PAD DIAGRAM

A3/G3　B3/C3　　D3　F3/E3　B2/C2　COL/D2　F2/E2　A2/G2　B1/C1　K/D1　　F1/E1　A1/G1　　　COM2

COM1

VC

VA

C1928

Die Size = 123 mil X 104 mil
Pad Size = 86 um X 86 um

VB

OSCO

VDD

OSCI1

OSCI2

TEST1　　　　K1　　　　K2　K3　　　　K4　K5　　　K6　K7　　　K8　VSS　MREST