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April 1st, 2010
Renesas Electronics Corporation

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RENESAS

MOS Integrated Circuit

 μ PD17015GS-015**SINGLE-CHIP MICROCONTROLLER INCORPORATING PLL FREQUENCY SYNTHESIZER CONTROLLER FOR TV AND FM/AM RADIO, DESIGNED FOR PORTABLE UNITS**

The μ PD17015GS-015 CMOS microcontroller incorporates a PLL frequency synthesizer controller and LCD controller/driver for receiving broadcasts in the Japanese TV, FM, and AM bands.

The μ PD17015GS-015 is packaged in a 38-pin plastic shrink small outline package (SOP). The device can operate on two dry cells, making it ideal for use in portable units such as radio cassette players. The single chip can be used to configure a digital tuning system.

FEATURES

- Capable of receiving broadcasts on the Japanese TV, FM, and AM bands
- Memory presets for up to five stations in each of the TV, FM, and AM bands (15 stations in total)
- Last channel memory for a single station in each of the TV, FM, and AM bands
- Up/down tuning functions for both auto- and manual tuning (sawtooth wave tuning)
- Internal sleep timer function (control output is automatically turned off 60 or 90 minutes after the timer is turned on)
- Internal automatic power-off function (control output is automatically turned off 60 or 90 minutes after power-on)
- Built-in LCD controller/driver (1/4 duty cycle, 1/2 bias, 3.0-V power (TYP.), 62.5-Hz frame frequency)
- 75-kHz crystal connected
- Supply voltage: While the PLL is operating: $V_{DD} = 1.8$ to 3.6 V ($T_A = -10$ to $+50^\circ\text{C}$)
- Low power consumption: $I_{DD} = 30$ μA max. (in power-off mode)

ORDERING INFORMATION

Part number	Package
μ PD17015GS-015-GJG	38-pin plastic shrink SOP (0.65-mm pitch, 300 mil)

The information in this document is subject to change without notice.

FUNCTION OVERVIEW

Tunable Frequencies, Channel Separation, Reference Frequency, and Intermediate Frequency

(1) BAND_SW = 0, J_WIDE = 0

Band	Tunable frequencies	Channel separation	Reference frequency	Intermediate frequency
FM	76.0-90.0 MHz	100 kHz	25 kHz	-10.7 MHz
AM	522-1629 kHz	9 kHz	3 kHz	450 kHz

(2) BAND_SW = 0, J_WIDE = 1

Band	Tunable frequencies	Channel separation	Reference frequency	Intermediate frequency
FM	76.0-90.0 MHz	100 kHz	25 kHz	-10.7 MHz
AM	522-1629 kHz	9 kHz	3 kHz	450 kHz
VHF _L	1-3 ch	1 ch	25 kHz	-10.7 MHz

(3) BAND_SW = 1, J_WIDE disabled

Band	Tunable frequencies	Channel separation	Reference frequency	Intermediate frequency
FM	76.0-90.0 MHz	100 kHz	25 kHz	-10.7 MHz
AM	522-1629 kHz	9 kHz	3 kHz	450 kHz
VHF _L	1-3 ch	1 ch	25 kHz	-10.7 MHz
VHF _H	4-12 ch	1 ch	25 kHz	-10.7 MHz

TUNING FUNCTIONS**(1) Auto-tuning (sawtooth-wave mode)**

Station search can be performed either up or down through the frequency range. Once a station has been located in fine tuning mode, the corresponding frequency is retained.

(2) Manual tuning

Each time a tuning key is pressed, the frequency increases or decreases by one step. When the key is held down for 0.5 seconds or longer, the frequency increases or decreases in fast-forward mode. This continues until the key is released.

(3) Preset memory call

The frequencies of up to 15 stations, five for each of three bands (FM, AM, and TV), can be stored in memory.

(4) Last channel memory

Last channel memory stores the frequency of one station for each of the three bands.

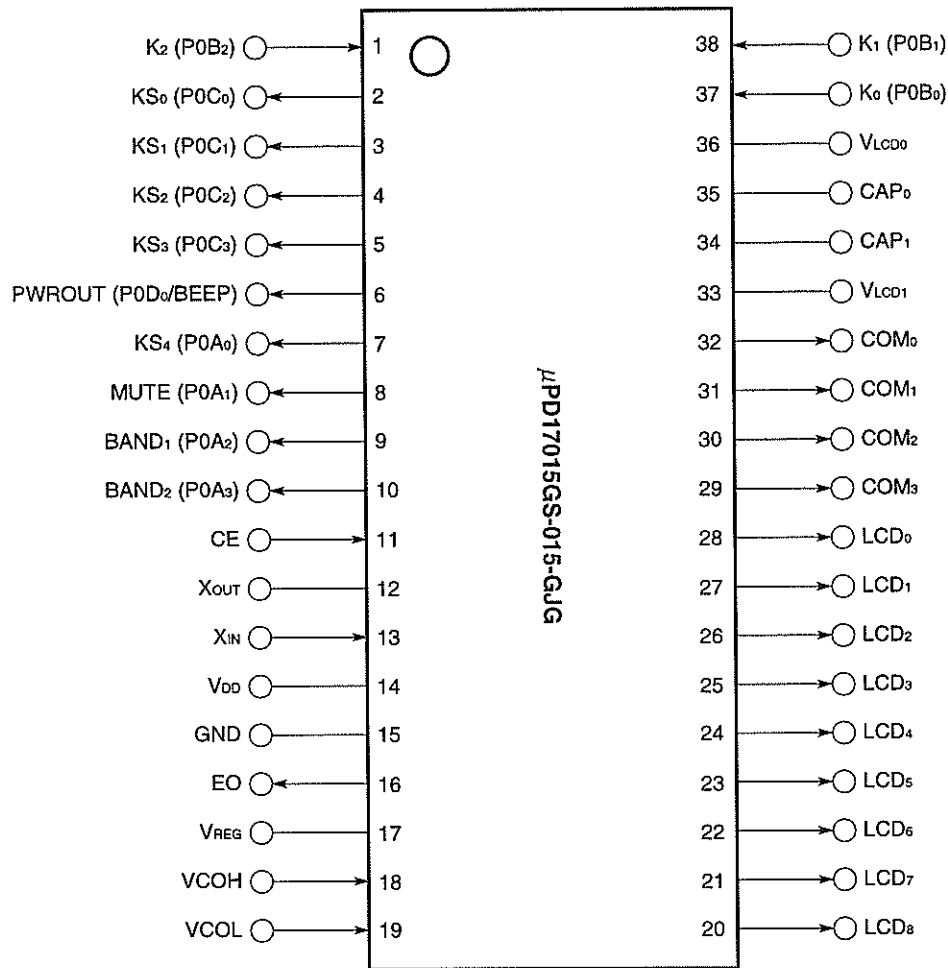
TIMER FUNCTIONS**(1) Sleep timer**

Automatically turns off the control output, thus placing the system in power-off mode, 60 or 90 minutes after the timer is turned on.

(2) Automatic power-off

Automatically turns off the control output, thus placing the system in power-off mode, 60 or 90 minutes after power-on.

PIN CONFIGURATION (TOP VIEW)



Remark Pin names for the μPD17015GS-xxx-GJG, where different, are indicated in parentheses.

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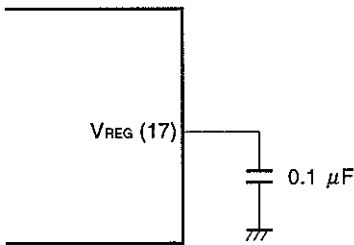
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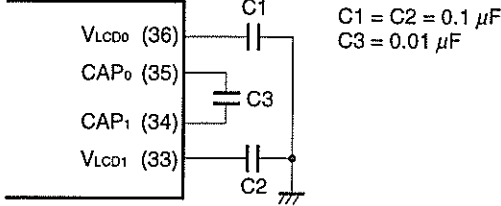
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1. PIN FUNCTIONS

Pin No.	Symbol	Pin name	Description	I/O type												
1 37 38	K ₂ K ₀ K ₁	Key return signal input	Input pin for the key return signal of a key matrix. When the input is high, it is judged that a key is present.	Input with pull-down resistor												
2 1 5 7	KS ₀ 1 KS ₃ KS ₄	Key source signal output	Output pin for the key source signal of a key matrix (active high)	CMOS push-pull output												
6	PWROUT	Power out	Power control output pin Under either of the following conditions, the radio is turned on and the output goes high: (1) While the sleep timer or automatic power-off function is enabled (2) When the radio is turned on by pressing the <input type="checkbox"/> POWER key or setting CE to high	CMOS push-pull output												
8	MUTE	Mute signal output	Output pin for audio mute signal The output (active high) eliminates shock noise when the PLL is unlocked. See Section 4 for details.	CMOS push-pull output												
9 10	BAND ₁ BAND ₀	Band switching signal output	Output pin for band switching signal When the <input type="checkbox"/> BAND key is pressed to switch the band, the output depends on the band as indicated below: <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="text-align: center;">Pin Band</th> <th style="text-align: center;">BAND₁</th> <th style="text-align: center;">BAND₀</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">FM, TV (VL)</td> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> </tr> <tr> <td style="text-align: center;">AM</td> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> </tr> <tr> <td style="text-align: center;">TV (VH)</td> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> </tr> </tbody> </table> <p>(0 = Low, 1: High)</p>	Pin Band	BAND ₁	BAND ₀	FM, TV (VL)	0	0	AM	0	1	TV (VH)	1	0	CMOS push-pull output
Pin Band	BAND ₁	BAND ₀														
FM, TV (VL)	0	0														
AM	0	1														
TV (VH)	1	0														

Pin No.	Symbol	Pin name	Description	I/O type																																		
11	CE	Chip enable	<p>Input pin of operation select signal and reset signal</p> <p>(1) Device operation select signal input The CE pin input determines the device operation as indicated below:</p> <table border="1"> <thead> <tr> <th>Device operation</th> <th>CE = high</th> <th>CE = low</th> </tr> </thead> <tbody> <tr> <td>PLL frequency synthesizer</td> <td>Operation possible</td> <td>Operation inhibited</td> </tr> <tr> <td>Sleep timer</td> <td>Operation possible</td> <td>Operation inhibited (Timer cleared)</td> </tr> <tr> <td>Automatic power-off</td> <td>Operation possible</td> <td>Operation inhibited (Timer cleared)</td> </tr> <tr> <td>Display</td> <td>Mode display</td> <td>No display</td> </tr> <tr> <td>Key operation</td> <td>All key operations possible</td> <td>Only KEYLOCK possible</td> </tr> <tr> <td>Port</td> <td>KS₀-KS₄</td> <td>Key scan for KS₀-KS₄</td> <td>Key scan only for KS₂ and KS₄</td> </tr> <tr> <td></td> <td>PWROUT</td> <td>Programmed output</td> <td>Low level</td> </tr> <tr> <td></td> <td>MUTE</td> <td>Programmed output</td> <td>Low level</td> </tr> <tr> <td></td> <td>BAND₀, BAND₁</td> <td>Programmed output</td> <td>Low level</td> </tr> </tbody> </table> <p>(2) Reset signal input When the level of the CE pin goes from low to high, the device is reset (CE reset) in synchronization with the internal basic timer 0 carry flip-flop. Then, the radio is turned on and is tuned to the station whose frequency is held in the last channel memory.</p> <p>To prevent malfunctions caused by noise, this pin accepts a high or low signal only when it continues for at least 140 μs. Also ensure that any voltage higher than V_{DD} is not applied to this pin at power-up.</p>	Device operation	CE = high	CE = low	PLL frequency synthesizer	Operation possible	Operation inhibited	Sleep timer	Operation possible	Operation inhibited (Timer cleared)	Automatic power-off	Operation possible	Operation inhibited (Timer cleared)	Display	Mode display	No display	Key operation	All key operations possible	Only KEYLOCK possible	Port	KS ₀ -KS ₄	Key scan for KS ₀ -KS ₄	Key scan only for KS ₂ and KS ₄		PWROUT	Programmed output	Low level		MUTE	Programmed output	Low level		BAND ₀ , BAND ₁	Programmed output	Low level	Input
Device operation	CE = high	CE = low																																				
PLL frequency synthesizer	Operation possible	Operation inhibited																																				
Sleep timer	Operation possible	Operation inhibited (Timer cleared)																																				
Automatic power-off	Operation possible	Operation inhibited (Timer cleared)																																				
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Port	KS ₀ -KS ₄	Key scan for KS ₀ -KS ₄	Key scan only for KS ₂ and KS ₄																																			
	PWROUT	Programmed output	Low level																																			
	MUTE	Programmed output	Low level																																			
	BAND ₀ , BAND ₁	Programmed output	Low level																																			
12 13	X _{OUT} X _{IN}	Crystal	<p>Pin used to connect a crystal A 75-kHz crystal is connected.</p>	<p>CMOS push-pull Output (X_{OUT}) Input (X_{IN})</p>																																		

Pin No.	Symbol	Pin name	Description	I/O type
14	V _{DD}	Main power supply	<p>Main power supply pin</p> <p>The pin supplies a voltage of 1.8 to 3.6 V to enable all functions. Note that the voltage applied to each of the other pins must not exceed the voltage applied to the V_{DD} pin.</p> <p>At power-up, the following states are established:</p> <ul style="list-style-type: none"> (1) Display : Frequency (2) Tuner : Tuned to the lowest frequency in the AM band (3) Automatic power-off : On (When selected with an initial setting diode) (4) Sleep timer : Off (When selected with an initial setting diode) 	—
15	GND	Ground	Ground pin	—
16	EO	Error out	Output from the charge pump of the PLL frequency synthesizer. If a divided local oscillator (VCO) frequency is higher than the reference frequency, the output of this pin goes high. When the two frequencies match, the output enters the floating state.	CMOS tristate output
17	V _{REG}	Regulator output	<p>Output pin for the PLL voltage regulator.</p> <p>Connect this pin to GND through a 0.1-μF capacitor.</p> <div style="text-align: center;">  <p>The diagram shows a rectangular box representing the VREG (17) pin. A horizontal line extends from the right side of the box to a vertical line. This vertical line is connected to a capacitor symbol, which is then connected to a ground symbol (three parallel lines of decreasing width).</p> </div>	—
18 19	VCOH VCOL	Local oscillator input	Local PLL oscillator frequency input	—
20 28	LCD _s LCD ₀	LCD segment signal output	Output pin for the segment signal of the LCD controller/driver	CMOS push-pull output
29 32	COM ₃ COM ₀	LCD common signal output	Output pin for the common signal of the LCD controller/driver	CMOS tristate output

Pin No.	Symbol	Pin name	Description	I/O type
33 34 35 36	V _{LCD1} CAP ₁ CAP ₀ V _{LCD0}	Pin for connecting a doubling capacitor	<ul style="list-style-type: none"> • V_{LCD1}, V_{LCD0} <p>Power supply pins for driving the LCD</p> <ul style="list-style-type: none"> • CAP₁, CAP₀ <p>Used to connect a doubling capacitor to generate the LCD drive power.</p> <p>To configure a doubler, connect capacitors as indicated below:</p> <div style="text-align: center;">  </div> <p>Caution Note that the LCD drive power, generated by the doubler, depends on the values of C1, C2, and C3.</p>	—

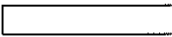
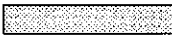
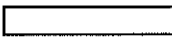
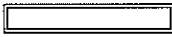
2. KEY MATRIX STRUCTURE

2.1 KEY MATRIX PLACEMENT

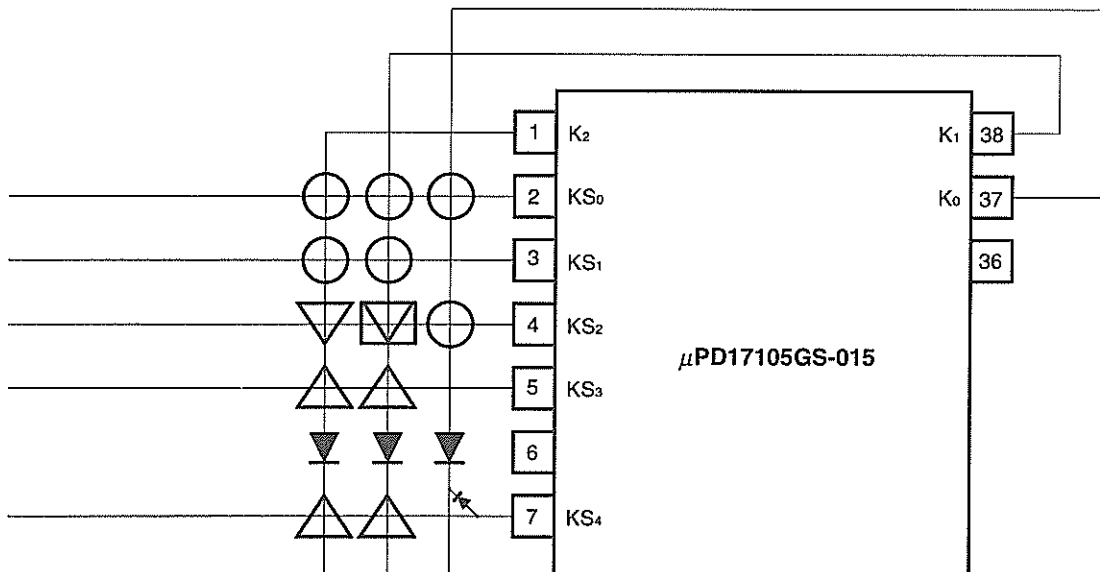
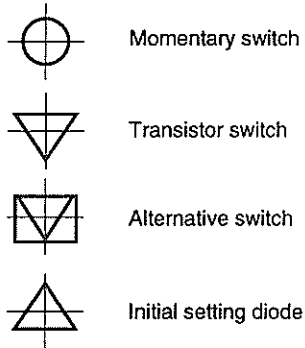
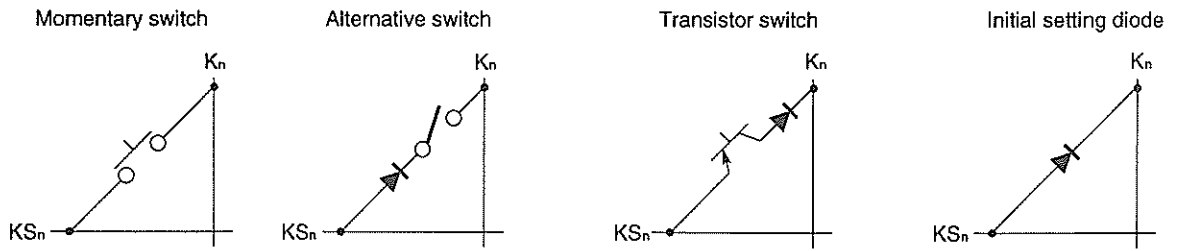
Input pin Output pin	K ₂ (1)	K ₁ (38)	K ₀ (37)
KS ₀ (2)	POWER	T_MODE	BAND
KS ₁ (3)	UP	DOWN	—
KS ₂ (4)	SD	KEYLOCK	SLEEP
KS ₃ (5)	SLEEP_SEL	J_WIDE	—
KS ₄ (7)	BAND_SW	TIMER_SEL	—Note

Note Close using a diode.

Remarks 1. Pin numbers are given in parentheses.

2.  Momentary switch
 Transistor switch
 Alternative switch
 Initial setting diode

2.2 KEY MATRIX CONNECTION



2.3 KEY MATRIXES

2.3.1 Initial Setting Diodes

The μPD17015GS-015 has the following four initial setting diodes:

J_WIDE, **BAND_SW**, **SLEEP_SEL**, **TIMER_SEL**

When V_{DD} is first supplied with power (at a power-on reset), or when the CE pin goes from low to high (at a CE reset), the states of the diodes are read once only. Otherwise, the states are ignored.

The state of **SLEEP_SEL**, however, is also read at power-on when the **POWER** key is pressed.

The state of an initial setting diode depends on whether the corresponding matrix intersection is closed using the diode, or left open.

The state of an initial setting diode is determined when the same state is read as a result of two 10-ms scans, performed sequentially.

The functions of the initial setting diodes are described below. Using a diode to close a matrix intersection corresponds to 1. Leaving an intersection open corresponds to 0.

Initial setting diode	Description															
<p>J_WIDE</p> <p>BAND_SW</p>	<p>These diodes are used to select the bands. Set the diodes as indicated below:</p> <table border="1"> <thead> <tr> <th>J_WIDE</th> <th>BAND_SW</th> <th>Band</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>AM, FM</td> </tr> <tr> <td>0</td> <td>1</td> <td>AM, FM, TV</td> </tr> <tr> <td>1</td> <td>0</td> <td>AM, FM + 1-3 ch</td> </tr> <tr> <td>1</td> <td>1</td> <td>AM, FM, TV</td> </tr> </tbody> </table>	J_WIDE	BAND_SW	Band	0	0	AM, FM	0	1	AM, FM, TV	1	0	AM, FM + 1-3 ch	1	1	AM, FM, TV
J_WIDE	BAND_SW	Band														
0	0	AM, FM														
0	1	AM, FM, TV														
1	0	AM, FM + 1-3 ch														
1	1	AM, FM, TV														
<p>SLEEP_SEL</p>	<p>This diode is used to select the time that must elapse before the control output is turned off under the control of the sleep timer or automatic power-off function. Set the diode as indicated below:</p> <table border="1"> <thead> <tr> <th>SLEEP_SEL</th> <th>Time</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>60 minutes</td> </tr> <tr> <td>1</td> <td>90 minutes</td> </tr> </tbody> </table>	SLEEP_SEL	Time	0	60 minutes	1	90 minutes									
SLEEP_SEL	Time															
0	60 minutes															
1	90 minutes															
<p>TIMER_SEL</p>	<p>This diode is used to select either the sleep timer or automatic power-off function. Set the diode as indicated below:</p> <table border="1"> <thead> <tr> <th>TIMER_SEL</th> <th>Function</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>The sleep timer function is enabled (the automatic power-off function is disabled).</td> </tr> <tr> <td>1</td> <td>The automatic power-off function is enabled (the sleep timer function is disabled).</td> </tr> </tbody> </table>	TIMER_SEL	Function	0	The sleep timer function is enabled (the automatic power-off function is disabled).	1	The automatic power-off function is enabled (the sleep timer function is disabled).									
TIMER_SEL	Function															
0	The sleep timer function is enabled (the automatic power-off function is disabled).															
1	The automatic power-off function is enabled (the sleep timer function is disabled).															

2.3.2 Transistor Switch

The μPD17015GS-015 has the following transistor switch:

SD

The transistor switch differs from the initial setting diodes in that it can be switched at any time.

The state of the switch is determined when the same state is read as a result of two 1-ms scans, performed sequentially.

Transistor switch	Description						
SD	<p>The switch is used to determine whether the radio is tuned to a station. The presence of a station is judged as indicated below:</p> <table border="1"> <thead> <tr> <th>SD</th> <th>Judgement</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>Station not present</td> </tr> <tr> <td>1</td> <td>Station present</td> </tr> </tbody> </table>	SD	Judgement	0	Station not present	1	Station present
SD	Judgement						
0	Station not present						
1	Station present						

2.3.3 Alternative Switch

The μPD17015GS-015 has the following alternative switch:

KEYLOCK

The alternative switch differs from the initial setting diodes in that it can be switched at any time.

The state of the switch is determined when the same state is read as a result of two 10-ms scans, performed sequentially.

Alternative switch	Description						
KEYLOCK	<p>The switch enables or disables the momentary keys, as indicated below:</p> <table border="1"> <thead> <tr> <th>KEYLOCK</th> <th>Judgement</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>Enabled</td> </tr> <tr> <td>1</td> <td>Disabled</td> </tr> </tbody> </table>	KEYLOCK	Judgement	0	Enabled	1	Disabled
KEYLOCK	Judgement						
0	Enabled						
1	Disabled						

2.3.4 Momentary Switches

The following six keys are classed as momentary switches:

POWER, **T_MODE**, **BAND**, **UP**, **DOWN**, **SLEEP**

The state of a switch is determined when the same state is read as a result of three 10-ms scans, performed sequentially. Subsequent key input is accepted only when no other key is being pressed.

The **UP** and **DOWN** keys can, however, be used as follows: If the **DOWN** key is pressed while the **UP** key is held down, the **DOWN** key is enabled as soon as the **UP** key is released.

Momentary switch	Description
<p>POWER</p>	<p>This key is used to turn on/off the power to the system. It is enabled when the CE pin is set to high.</p> <p>(1) Turning on the radio While the radio is turned off, pressing the POWER key turns it on, after which it may be turned. Simultaneously, the output from the PWROUT pin goes high. When the automatic power-off function is selected (TIMER_SEL = 1), the radio is automatically turned off 60 or 90 minutes after it is turned on.</p> <p>(2) Turning off the radio While the radio is turned on, pressing the POWER key turns it off.</p>
<p>T_MODE</p>	<p>This key is used to select the tuning mode. Each time the T_MODE key is pressed, the mode is switched as indicated below:</p> <div data-bbox="416 966 1289 1306" style="border: 1px solid black; padding: 10px; margin: 10px 0;"> <pre> graph TD Start(()) --> Manual[Manual/auto-tuning mode] Manual -- "Press T_MODE for no more than 2 seconds." --> Call[Preset memory call mode] Manual -- "Hold down T_MODE for at least 2 seconds." --> Write[Preset memory write mode] Call --> Manual Write -- "Press T_MODE." --> WriteFreq[Writes the frequency.] WriteFreq --> Manual </pre> </div> <p>(1) Manual/auto-tuning mode This mode is selected immediately after the radio is turned on by pressing the POWER key. For details of manual and auto-tuning, see the description of the UP and DOWN keys.</p> <p>(2) Preset memory call mode While the radio is turned on, pressing the T_MODE key for no more than two seconds causes MEMORY to blink, thus placing the system in preset memory call mode. For details of preset memory call, see the description of the UP and DOWN keys.</p>

Momentary switch	Description				
<div style="border: 1px solid black; padding: 2px; display: inline-block;">T_MODE</div>	<p>(3) Preset memory write mode</p> <p>While the radio is turned on, holding down the <div style="border: 1px solid black; padding: 2px; display: inline-block;">T_MODE</div> key for two seconds or longer causes MEMORY to blink, thus placing the system in preset memory write mode. For details of preset memory write, see the description of the <div style="border: 1px solid black; padding: 2px; display: inline-block;">UP</div> and <div style="border: 1px solid black; padding: 2px; display: inline-block;">DOWN</div> keys.</p>				
<div style="border: 1px solid black; padding: 2px; display: inline-block;">BAND</div>	<p>Pressing this key switches the reception band.</p> <p>Each time the <div style="border: 1px solid black; padding: 2px; display: inline-block;">BAND</div> key is pressed, the band is switched sequentially as indicated below:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th data-bbox="587 429 927 472">BAND_SW = 1</th> <th data-bbox="927 429 1262 472">BAND_SW = 0</th> </tr> </thead> <tbody> <tr> <td data-bbox="587 472 927 570" style="text-align: center;"> <div style="border: 1px solid black; padding: 5px; display: inline-block;">→ AM → FM → TV →</div> </td> <td data-bbox="927 472 1262 570" style="text-align: center;"> <div style="border: 1px solid black; padding: 5px; display: inline-block;">→ AM → FM →</div> </td> </tr> </tbody> </table> <p>When the power is first turned on (V_{DD} start-up), the lowest frequency in the AM band is called.</p>	BAND_SW = 1	BAND_SW = 0	<div style="border: 1px solid black; padding: 5px; display: inline-block;">→ AM → FM → TV →</div>	<div style="border: 1px solid black; padding: 5px; display: inline-block;">→ AM → FM →</div>
BAND_SW = 1	BAND_SW = 0				
<div style="border: 1px solid black; padding: 5px; display: inline-block;">→ AM → FM → TV →</div>	<div style="border: 1px solid black; padding: 5px; display: inline-block;">→ AM → FM →</div>				
<div style="border: 1px solid black; padding: 2px; display: inline-block; margin-bottom: 5px;">UP</div> <div style="border: 1px solid black; padding: 2px; display: inline-block;">DOWN</div>	<p>These keys are used for manual or auto-tuning (seek), as well as preset memory call or write.</p> <p>(1) Manual or auto-tuning (seek)</p> <p>Momentarily pressing the <div style="border: 1px solid black; padding: 2px; display: inline-block;">UP</div> or <div style="border: 1px solid black; padding: 2px; display: inline-block;">DOWN</div> key increments or decrements the frequency by one step (single channel separation).</p> <p>Holding down the key for 0.5 seconds or longer causes the frequency to be continuously increased or decreased. In this state, releasing the key starts tuning seek.</p> <p>When, during auto-tuning, it is judged that the radio is tuned to a station, fine tuning starts. If, during fine tuning, several stations are detected one after another, SD checks up to five stations, selects the center station, and retains its frequency.</p> <ul style="list-style-type: none"> • While auto-tuning is being performed, the following key is disabled: <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-left: 20px;">SLEEP</div> • Pressing one of the following keys during auto-tuning stops auto-tuning at the current frequency and enables the operation assigned to that key. <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-left: 20px;">T_MODE</div>, <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-left: 10px;">BAND</div>, <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-left: 10px;">POWER</div>, <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-left: 10px;">KEYLOCK</div> <small>Note</small> • Pressing one of the following keys during auto-tuning stops auto-tuning at the current frequency. <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-left: 20px;">UP</div>, <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-left: 10px;">DOWN</div> <p>Note The <div style="border: 1px solid black; padding: 2px; display: inline-block;">KEYLOCK</div> key is an alternative switch.</p>				

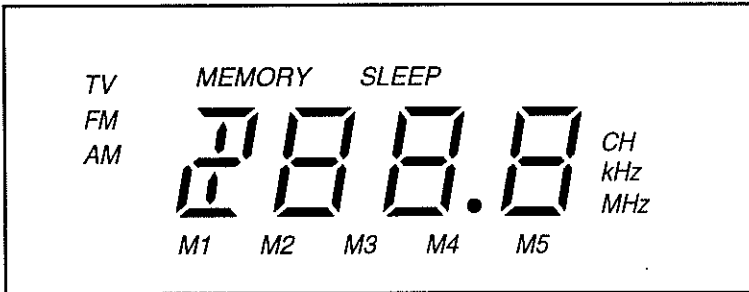
Momentary switch	Description																														
<div style="border: 1px solid black; padding: 2px; margin-bottom: 5px; width: fit-content;">UP</div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px; width: fit-content;">DOWN</div>	<p>(2) Preset memory call</p> <p>Once preset memory call mode has been selected by pressing the T_MODE key, the UP and DOWN keys can be used to select the number corresponding to the preset memory (M1 to M5) to be called.</p> <div style="text-align: center; margin: 20px 0;"> <pre> graph LR M1[M1] -- UP --> M2[M2] M2 -- UP --> M3[M3] M3 -- UP --> M4[M4] M4 -- UP --> M5[M5] M5 -- DOWN --> M4 M4 -- DOWN --> M3 M3 -- DOWN --> M2 M2 -- DOWN --> M1 M1 -- DOWN --> M5 M5 -- UP --> M1 </pre> </div> <p>Upon power-on, the following frequencies are written to preset memory M1 to M5, to facilitate adjustment of the system:</p> <table border="1" style="margin: 20px auto; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="border: none;">Preset memory number</th> <th>M1</th> <th>M2</th> <th>M3</th> <th>M4</th> <th>M5</th> </tr> </thead> <tbody> <tr> <th style="border: none;">Band</th> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td style="border: none;">FM (MHz)</td> <td>76.0</td> <td>79.5</td> <td>83.0</td> <td>86.5</td> <td>90.0</td> </tr> <tr> <td style="border: none;">AM (kHz)</td> <td>522</td> <td>801</td> <td>999</td> <td>1341</td> <td>1629</td> </tr> <tr> <td style="border: none;">TV (ch)</td> <td>1</td> <td>3</td> <td>6</td> <td>10</td> <td>12</td> </tr> </tbody> </table> <p>(3) Preset memory write</p> <p>To write a frequency to a preset memory, follow the procedure below.</p> <ol style="list-style-type: none"> ① Select the frequency to be stored, either by manual or auto-tuning. ② Select preset memory write mode by pressing the T_MODE key. MEMORY blinks, together with the number of the currently selected preset memory. ③ Select the number of the preset memory (M1 to M5) to which the frequency will be written, using the UP or DOWN key. ④ After selecting the preset memory number, press the T_MODE key. The current frequency is thus written to the selected preset memory. Preset memory write mode is canceled if the T_MODE key is not pressed within approximately 12 seconds of the preset memory number being selected. 	Preset memory number	M1	M2	M3	M4	M5	Band						FM (MHz)	76.0	79.5	83.0	86.5	90.0	AM (kHz)	522	801	999	1341	1629	TV (ch)	1	3	6	10	12
Preset memory number	M1	M2	M3	M4	M5																										
Band																															
FM (MHz)	76.0	79.5	83.0	86.5	90.0																										
AM (kHz)	522	801	999	1341	1629																										
TV (ch)	1	3	6	10	12																										

Momentary switch	Description
<p data-bbox="277 195 406 229"><input type="button" value="SLEEP"/></p>	<p data-bbox="464 195 852 223">This key turns the sleep timer on or off.</p> <p data-bbox="464 229 1283 257">The <input type="button" value="SLEEP"/> key is enabled when initial setting diode TIMER_SEL is set to 0.</p> <p data-bbox="464 263 1153 291">The <input type="button" value="SLEEP"/> key is recognized only while the radio is turned on.</p> <p data-bbox="464 325 983 353">(1) While SLEEP is not displayed on the LCD panel</p> <p data-bbox="464 359 1453 453">Pressing the <input type="button" value="SLEEP"/> key turns on the sleep timer, causing the SLEEP display to appear. The output to the PWROUT pin is held high for 60 or 90 minutes. Once the set time (60 or 90 minutes) has elapsed, the system is automatically placed in power-off mode.</p> <p data-bbox="464 487 943 514">(2) While SLEEP is displayed on the LCD panel</p> <p data-bbox="464 521 1433 549">Pressing the <input type="button" value="SLEEP"/> key turns off the sleep timer, causing the SLEEP display to be cleared.</p>

3. DISPLAY

3.1 LCD PANEL

The figure below shows the LCD panel display when BAND_SW is set to 1.



When both BAND_SW and J_WIDE are set to 0, "TV" and "CH" are disabled.

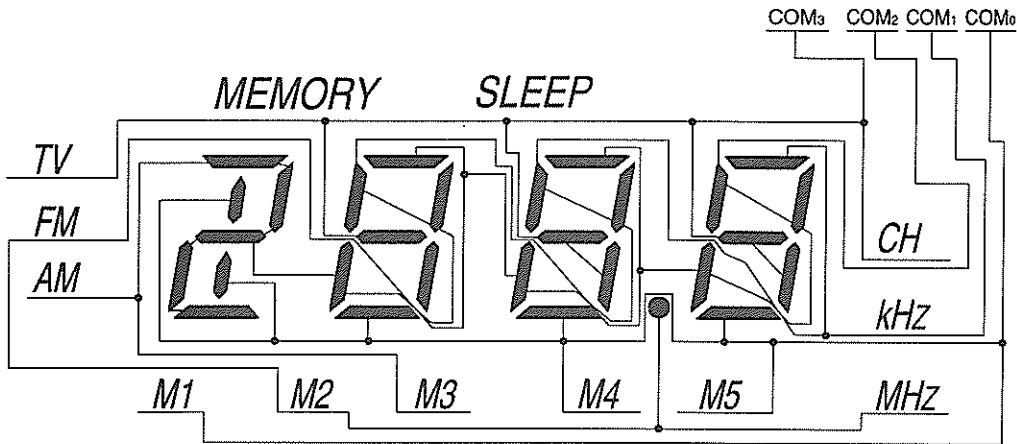
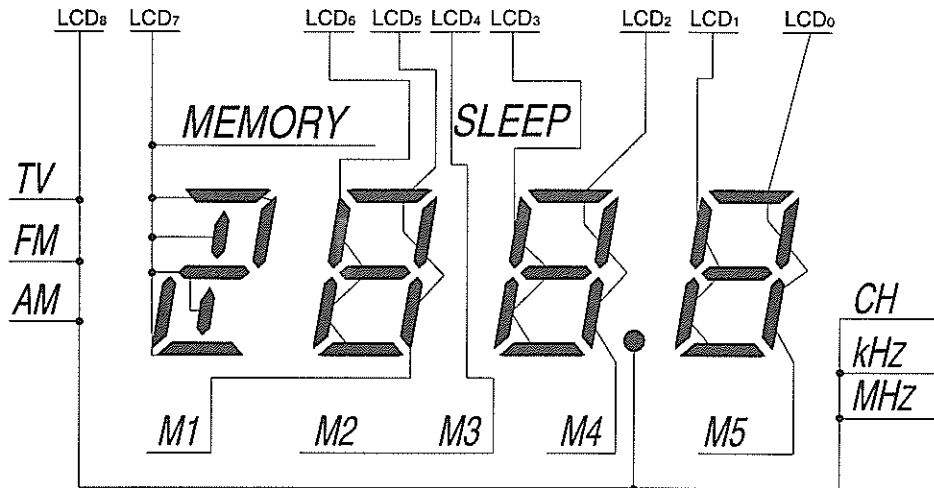
The following parts share a segment:

- "TV" - "CH"
- "FM" - "." - "MHz"
- "AM" - "kHz"

3.2 CHARACTER STYLE



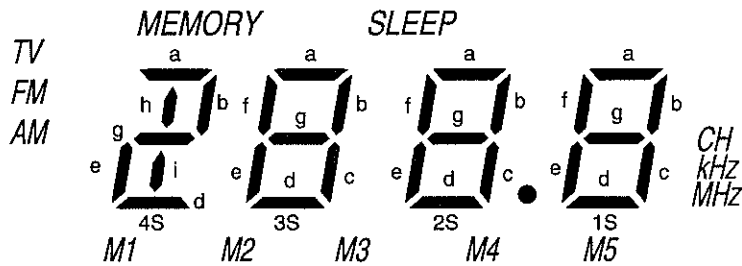
3.3 LCD ASSIGNMENT



3.4 LCD ASSIGNMENT

The table below indicates the display pattern when BAND_SW is set to 1.

Common Segment	COM ₃ (29)	COM ₂ (30)	COM ₁ (31)	COM ₀ (32)
LCD ₀ (28)	1s c	1s b	1s a	M5
LCD ₁ (27)	1s g	1s f	1s e	1s d
LCD ₂ (26)	2s c	2s b	2s a	M4
LCD ₃ (25)	2s g	2s f	2s e	2s d
LCD ₄ (24)	SLEEP	M2	M3	
LCD ₅ (23)	3s c	3s b	3s a	M1
LCD ₆ (22)	3s g	3s f	3s e	3s d
LCD ₇ (21)	MEMORY		4s abged	4s hi
LCD ₈ (20)	TV, CH	FM, MHz, "."	AM, kHz	



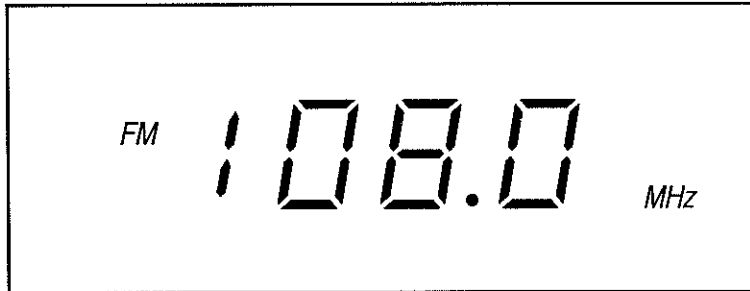
3.5 DISPLAY

3.5.1 Display

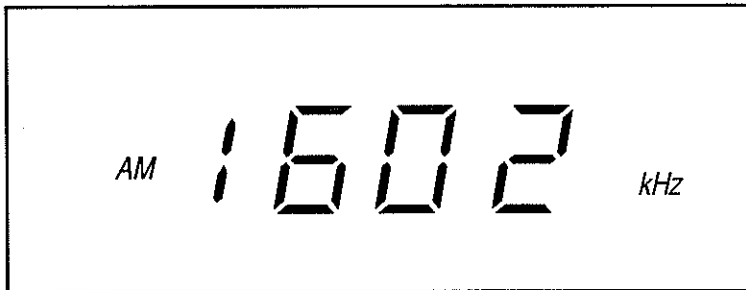
Display	Description
TV FM AM CH MHz kHz	Indicates the band. Displayed only when the frequency display is selected.
M1 M2 M3 M4 M5	Indicates the preset memory numbers. The number of the currently selected preset memory is displayed. This display is cleared when the frequency is changed in other than preset memory call or write mode.
7-segment	Indicates the frequency. The 7-segment displays are turned off for 500 ms while writing the frequency to a preset memory.
. (decimal point)	Indicates a decimal point. This uses the same segment as that used for the FM indication.
MEMORY	Displayed in preset memory call or write mode.
SLEEP	Displayed while the sleep timer is on.

3.5.2 Sample Displays

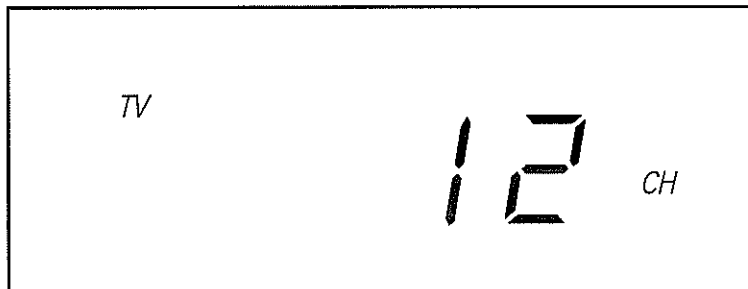
(1) Frequency display (FM)



(2) Frequency display (AM)



(3) Frequency display (TV)



4. MUTE OUTPUT TIMING DIAGRAMS

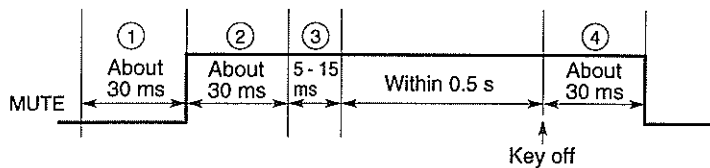
Circled numbers ① to ⑥ in the following timing diagrams represent the following:

- ① Key-on chattering protection
- ② Preceding mute
- ③ Updating of the frequency division ratio setting and indication
- ④ Following mute
- ⑤ Seek time
- ⑥ Waiting for PLL locking

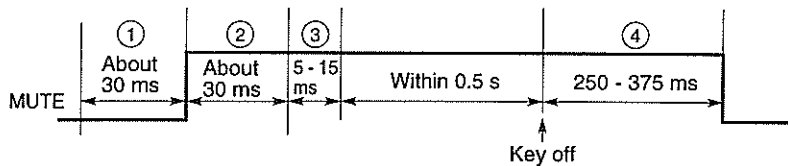
4.1 MANUAL UP/DOWN

This section provides the timing diagrams for manual operation.

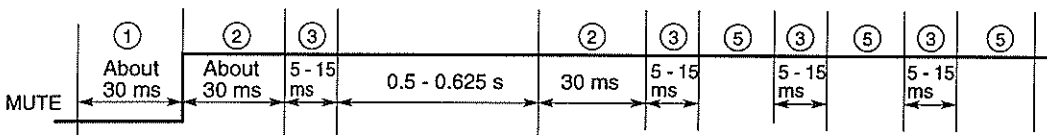
(1) When a key is momentarily pressed (other than at a band edge)



(2) When a key is momentarily pressed (at a band edge: highest frequency ↔ lowest frequency)



(3) When a key is held down for 0.5 seconds or longer



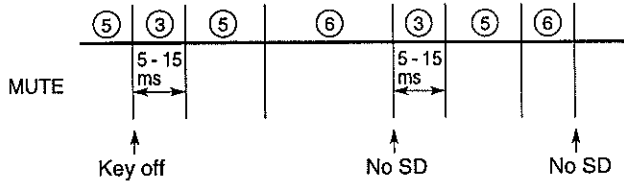
The seek time of ⑤ depends on the reception band, as described below. When a band edge (highest frequency ↔ lowest frequency) is encountered, the time becomes 250 to 375 ms.

- FM : 21 to 27 ms
- AM : 47 to 54 ms
- TV : 125 to 250 ms

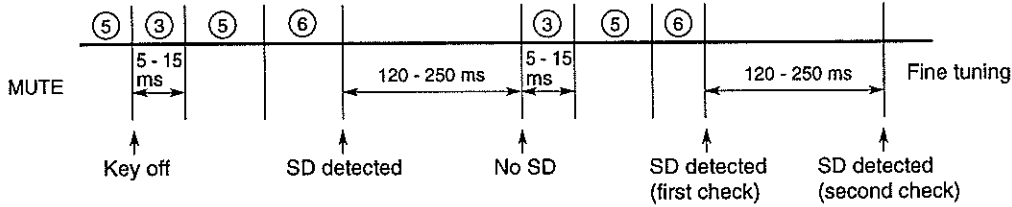
4.2 AUTO-TUNING

This section provides timing diagrams for auto-tuning operations.

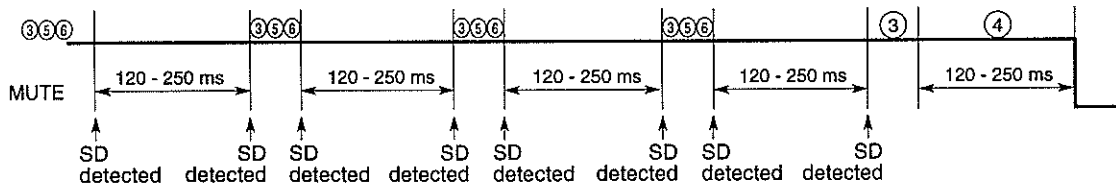
(1) When no stations are detected



(2) When a station is detected



(3) Fine tuning



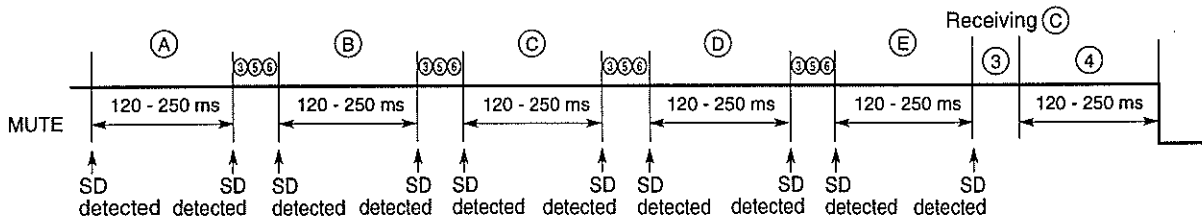
When several stations are detected one after another, the SD checks up to five stations, selects the center station, and tunes to its frequency. When the first station is encountered by SD, fine tuning stops. The center station is displayed when fine tuning is terminated.

The seek time of (5) depends on the reception band, as described below. If a band edge (highest frequency ↔ lowest frequency) is encountered, the time becomes 250 to 375 ms.

- FM : 21 to 27 ms
- AM : 47 to 54 ms
- TV : 125 to 250 ms

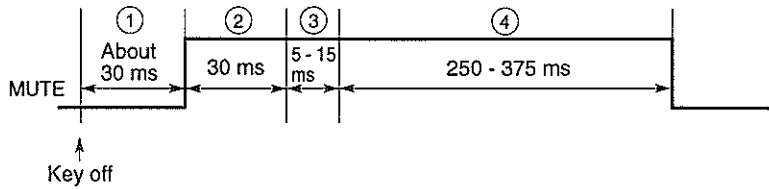
Remark When no station is detected in (B) to (D), the following occurs:

- When no station is detected in (E), broadcast (B) is selected.
- When no station is detected in (D), broadcast (B) is selected.
- When no station is detected in (C), broadcast (A) is selected.
- When no station is detected in (B), broadcast (A) is selected.
- When stations are detected in (A) to (E), broadcast (C) is selected.



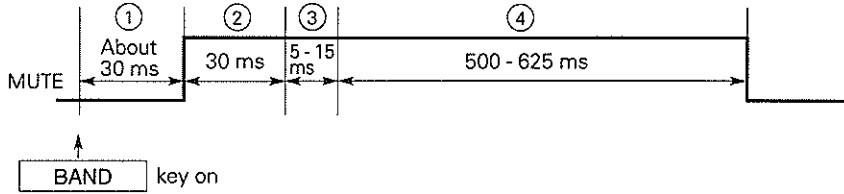
4.3 PRESET MEMORY CALL

This section provides the timing diagram for preset memory call.



4.4 BAND SWITCHING

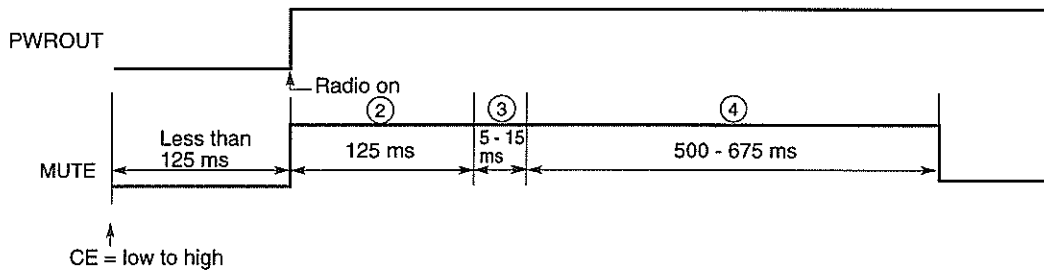
This section provides the timing diagram for band switching.



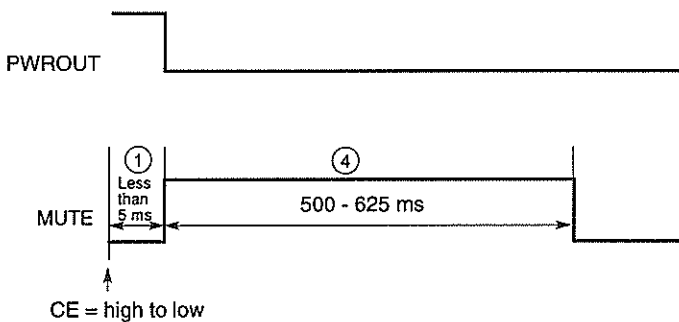
4.5 CE PIN

This section provides timing diagrams for mute output when the level of the input to the CE pin changes.

(1) When the input goes from low to high

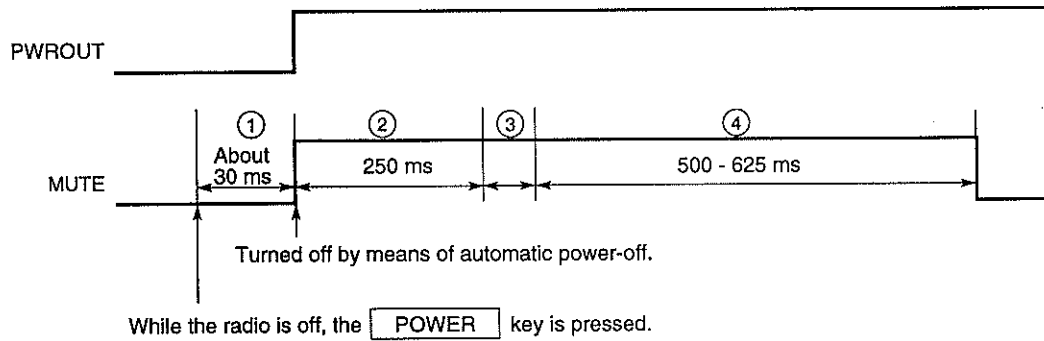


(2) When the input goes from high to low

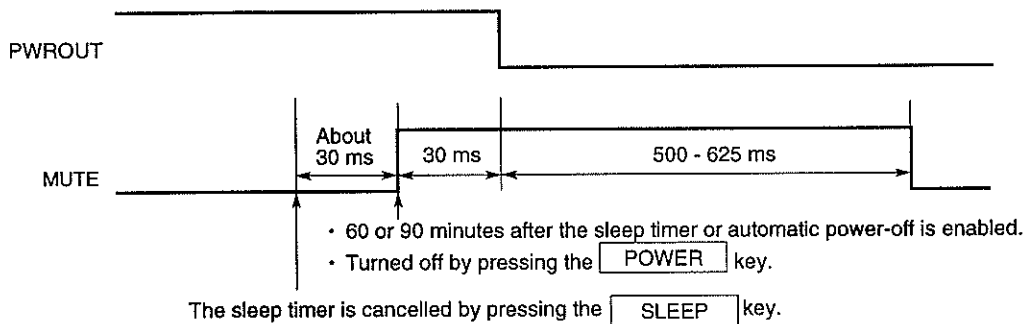


4.6 RADIO ON/OFF

(1) When the radio-off state is changed to the radio-on state

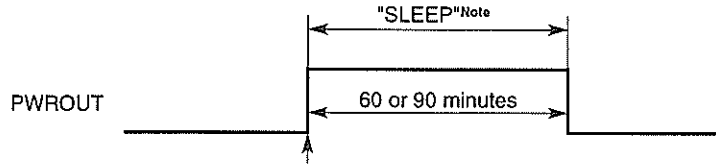


(2) When the radio-on state is changed to the radio-off state



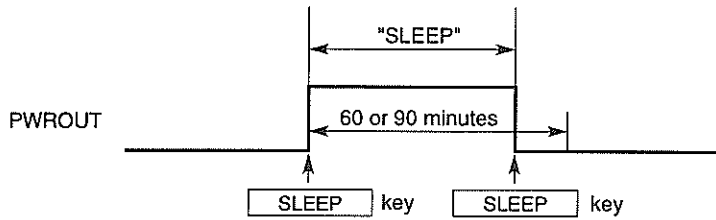
5. CONTROL PIN OUTPUT STATES

This chapter presents the output states of the PWROUT pin. The pin outputs an active-high signal. The corresponding LCD panel indications are enclosed in quotation marks. The output state depends on how a key is pressed.

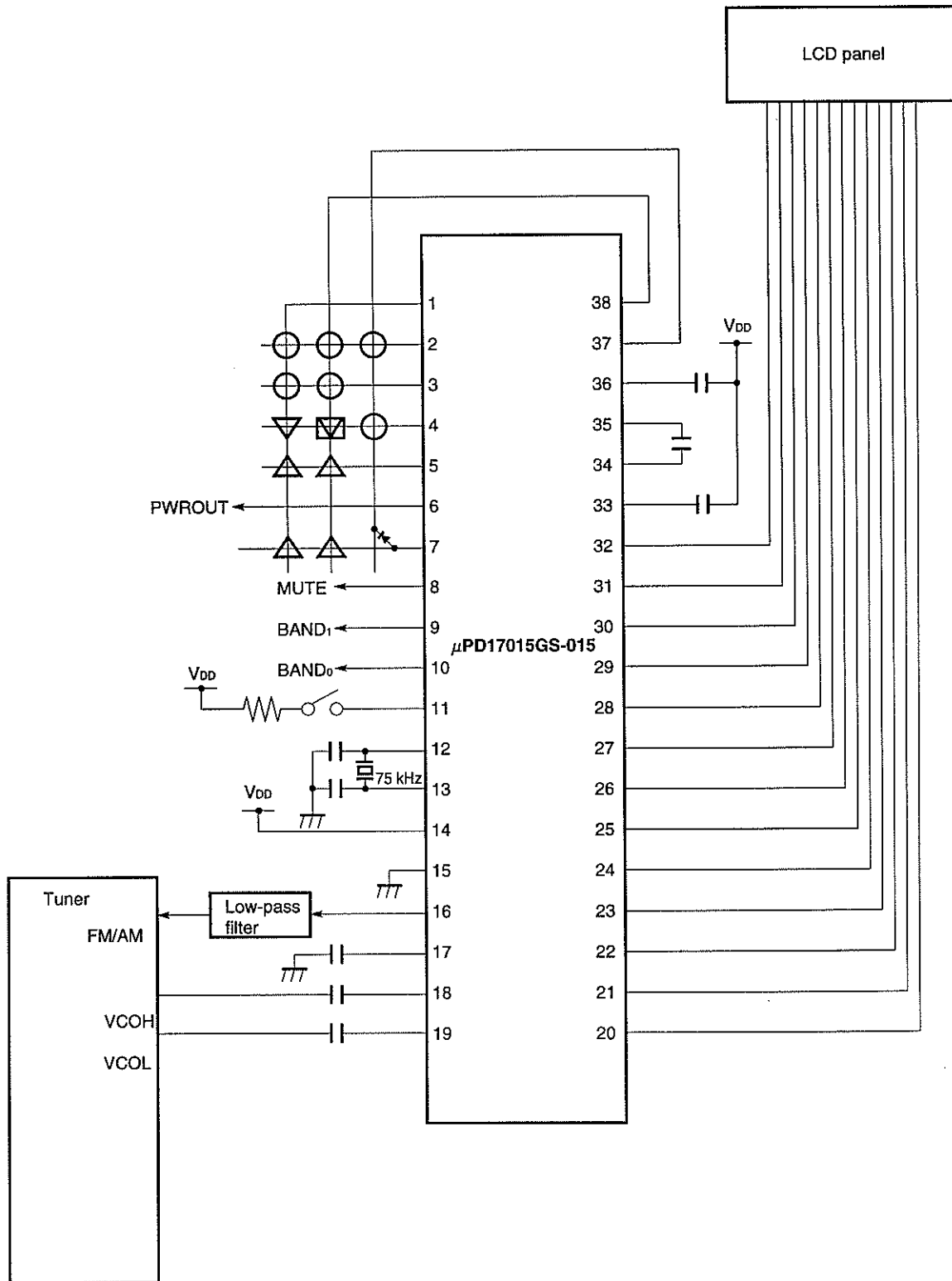


- SLEEP key
- Power-on (when automatic power-off is used)

Note Not displayed when automatic power-off is used.



6. SAMPLE SYSTEM CONFIGURATION



7. ELECTRICAL CHARACTERISTICS (PRELIMINARY)

ABSOLUTE MAXIMUM RATINGS (T_A = 25 °C)

Parameter	Symbol	Conditions	Rated value	Unit
Supply voltage	V _{DD}		-0.3 to +4.0	V
Input voltage	V _I	CE pin	-0.3 to V _{DD} + 0.6	V
		Except for the CE pin	-0.3 to V _{DD} + 0.3	V
Output voltage	V _O		-0.3 to V _{DD} + 0.3	V
Output high current	I _{OH}	Each pin	-3.0	mA
		Total for all pins	-20.0	mA
Output low current	I _{OL}	Each pin	3.0	mA
		Total for all pins	20.0	mA
Operating ambient temperature	T _A		-20 to +50	°C
Storage temperature	T _{stg}		-55 to +125	°C

Caution Absolute maximum ratings are rated values beyond which physical damage may be caused to the product; if any of the parameters in the table above exceeds its rated value, even momentarily, the quality of the product may deteriorate. Therefore, ensure that the product is used within the rated values.

RECOMMENDED OPERATING RANGES

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply voltage	V _{DD1}	CPU operation, T _A = -10 to +50 °C	1.8	3.0	3.6	V
	V _{DD2}	CPU operation, T _A = -20 to +50 °C	1.9	3.0	3.6	V
Rise time of supply voltage	t _{rise}	V _{DD} : 0 → 1.8 V T _A = -20 to +50 °C			500	ms

DC CHARACTERISTICS (T_A = -10 to +50 °C, V_{DD} = 1.8 to 3.6 V)

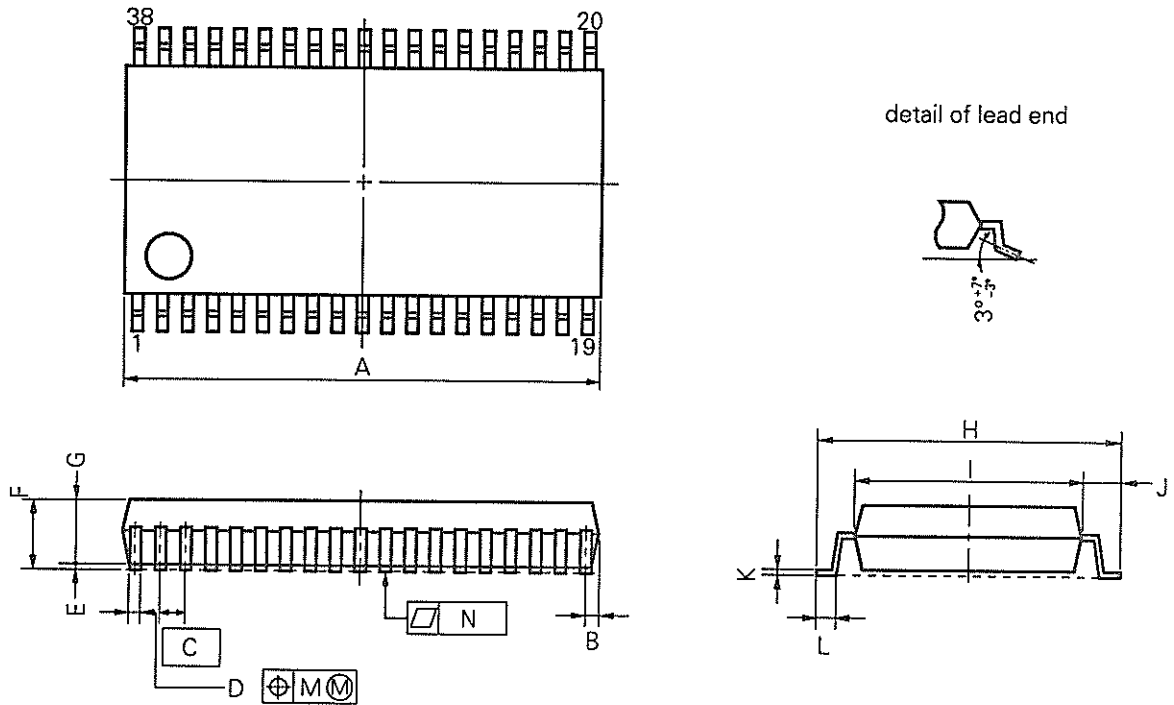
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply current	I _{DD1}	When the CPU and PLL are operating, with a sinusoidal wave applied to the X _{IN} pin (f _{IN} = 75 kHz, V _{IN} = V _{DD}) and VCOH pin (f _{IN} = 220 MHz, V _{IN} = 0.2 V _{P-P})		9	16	mA
	I _{DD2}	When the CPU is operating but the PLL is not, with a sinusoidal wave applied to the X _{IN} pin (f _{IN} = 75 kHz, V _{IN} = V _{DD})		30	70	μA
	I _{DD3}	When the CPU is operating but the PLL is not (when the HALT instruction is issued), with a sinusoidal wave applied to the X _{IN} pin (f _{IN} = 75 kHz, V _{IN} = V _{DD})		15	30	μA
Data hold voltage	V _{DDR}	When a power failure is detected with basic timer 0F/F	1.8		3.6	V
Data hold current	I _{DDR1}	When the crystal oscillation is stopped T _A = 25 °C, V _{DD} = 3.0 V			3	μA
	I _{DDR2}	When the crystal oscillation is stopped V _{DD} = 3.0 V			10	μA
Input high voltage	V _{IH1}	CE, P0A ₀ , P0A ₁	0.8V _{DD}		V _{DD}	V
	V _{IH2}	P0B ₀ -P0B ₂	0.6V _{DD}		V _{DD}	V
Input low voltage	V _{IL1}	CE, P0A ₀ , P0A ₁	0		0.2V _{DD}	V
	V _{IL2}	P0B ₀ -P0B ₂	0		0.1V _{DD}	V
Output high current	I _{OH1}	P0A ₀ , P0A ₁ , P0C ₀ -P0C ₃ , P0D ₀ V _{OH} = V _{DD} - 1 V	-0.5			mA
	I _{OH2}	EO V _{OH} = V _{DD} - 1 V	-0.2			mA
	I _{OH3}	LCD ₀ -LCD ₈ V _{OH} = V _{LCD1} - 1 V V _{LCD1} = 2.7 to 3.3 V	-20			μA
Output low current	I _{OL1}	P0A ₀ , P0A ₁ , P0D ₀ V _{OL} = 1 V	0.5			mA
	I _{OL2}	EO V _{OL} = 1 V	0.2			mA
	I _{OL3}	P0C ₀ -P0C ₃ V _{OL} = 1 V	5		150	μA
	I _{OL4}	LCD ₀ -LCD ₈ V _{OL} = 1 V, V _{LCD1} = 2.7 to 3.3 V	20			μA
Input high current	I _{IH1}	When the P0B ₀ to P0B ₂ pins are pulled down	3		100	μA
	I _{IH2}	When the X _{IN} pin is pulled down V _{IH} = V _{DD}	35			μA
LCD drive voltage	V _{LCD1}	Output between LCD ₀ and LCD ₈ pins must be left open. Between V _{LCD0} and GND pins = 0.1 μF, between V _{LCD1} and GND pins = 0.1 μF, and between CAP ₀ and CAP ₁ pins = 0.01 μF T _A = 25 °C	2.7	3.0	3.3	V
Output-off leakage current	I _L	EO			±1	μA

AC CHARACTERISTICS (T_A = -10 to +50 °C, V_{DD} = 1.8 to 3.6 V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Operating frequency	f _{IN1}	VCOL MF mode, with a sinusoidal wave applied at V _{IN} = 0.2 V _{P-P}	0.5		8	MHz
	f _{IN2}	VCOL HF mode, with a sinusoidal wave applied at V _{IN} = 0.2 V _{P-P}	6		55	MHz
	f _{IN3}	VCOH VHF mode, with a sinusoidal wave applied at V _{IN} = 0.2 V _{P-P}	40		220	MHz

8. PACKAGE DRAWING

38 PIN PLASTIC SHRINK SOP (300 mil)



NOTE

Each lead centerline is located within 0.10 mm (0.004 inch) of its true position (T.P.) at maximum material condition.

P38GS-65-300B-1

ITEM	MILLIMETERS	INCHES
A	12.71 MAX.	0.501 MAX.
B	0.51 MAX.	0.020 MAX.
C	0.65 (T.P.)	0.026 (T.P.)
D	0.30±0.10	0.012 ^{+0.004} _{-0.005}
E	0.125±0.075	0.005±0.003
F	2.0 MAX.	0.079 MAX.
G	1.7±0.1	0.067±0.004
H	8.1±0.3	0.319±0.012
I	6.1±0.2	0.240±0.008
J	1.0±0.2	0.039 ^{+0.009} _{-0.008}
K	0.15 ^{+0.10} _{-0.05}	0.006 ^{+0.004} _{-0.002}
L	0.5±0.2	0.020 ^{+0.008} _{-0.009}
M	0.10	0.004
N	0.10	0.004

9. RECOMMENDED SOLDERING CONDITIONS

The conditions listed below shall be met when soldering the μPD17015GS-015.

For details of the recommended soldering conditions, refer to our document *SMD Surface Mount Technology Manual* (IEI-1207).

Please consult with our sales offices in case any other soldering process is used, or in case soldering is done under different conditions.

Table 9-1 Soldering Conditions for Surface-Mount Devices

μPD17015GS-015-GJG: 38-pin plastic shrink SOP (300 mil)

Soldering process	Soldering conditions	Symbol
Infrared ray reflow	Peak package's surface temperature: 235 °C Reflow time: 30 seconds or less (at 210 °C or more) Maximum allowable number of reflow processes: 2 <Cautions> (1) Do not start reflow-soldering the device if its temperature is higher than the room temperature because of a previous reflow soldering. (2) Do not use water for flux cleaning before a second reflow soldering.	IR35-00-2
VPS	Peak package's surface temperature: 215 °C Reflow time: 40 seconds or less (at 200 °C or more) Maximum allowable number of reflow processes: 2 <Cautions> (1) Do not start reflow-soldering the device if its temperature is higher than the room temperature because of a previous reflow soldering. (2) Do not use water for flux cleaning before a second reflow soldering.	VP15-00-2
Wave soldering	Solder temperature : 260°C or less Flow time : 10 seconds or less Number of flow processes: 1 Preheating temperature : 120°C max. (measured on the package surface)	WS60-00-1
Partial heating method	Terminal temperature: 300 °C or less Flow time: 3 seconds or less (for each side of device)	-

Caution Do not apply more than a single process at once, except for "Partial heating method."

Cautions on CMOS Devices

① Countermeasures against static electricity for all MOSs

Caution When handling MOS devices, take care so that they are not electrostatically charged. Strong static electricity may cause dielectric breakdown in gates. When transporting or storing MOS devices, use conductive trays, magazine cases, shock absorbers, or metal cases that NEC uses for packaging and shipping. Be sure to ground MOS devices during assembling. Do not allow MOS devices to stand on plastic plates or do not touch pins. Also handle boards on which MOS devices are mounted in the same way.

② CMOS-specific handling of unused input pins

Caution Hold CMOS devices at a fixed input level.

Unlike bipolar or NMOS devices, if a CMOS device is operated with no input, an intermediate-level input may be caused by noise. This allows current to flow in the CMOS device, resulting in a malfunction. Use a pull-up or pull-down resistor to hold a fixed input level. Since unused pins may function as output pins at unexpected times, each unused pin should be separately connected to the V_{DD} or GND pin through a resistor.

If handling of unused pins is documented, follow the instructions in the document.

③ Statuses of all MOS devices at initialization

Caution The initial status of a MOS device is unpredictable when power is turned on.

Since characteristics of a MOS device are determined by the amount of ions implanted in molecules, the initial status cannot be determined in the manufacture process. NEC has no responsibility for the output statuses of pins, input and output settings, and the contents of registers at power on. However, NEC assures operation after reset and items for mode setting if they are defined.

When you turn on a device having a reset function, be sure to reset the device first.

The application circuits and their parameters are for references only and are not intended for use in actual design-in's.

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NEC devices are classified into the following three quality grades:

"Standard", "Special", and "Specific". The Specific quality grade applies only to devices developed based on a customer designated "quality assurance program" for a specific application. The recommended applications of a device depend on its quality grade, as indicated below. Customers must check the quality grade of each device before using it in a particular application.

Standard: Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots

Special: Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support)

Specific: Aircrafts, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems or medical equipment for life support, etc.

The quality grade of NEC devices in "Standard" unless otherwise specified in NEC's Data Sheets or Data Books. If customers intend to use NEC devices for applications other than those specified for Standard quality grade, they should contact NEC Sales Representative in advance.

Anti-radioactive design is not implemented in this product.