



HT16565

24 Hour System VFD Digital Clock

Features

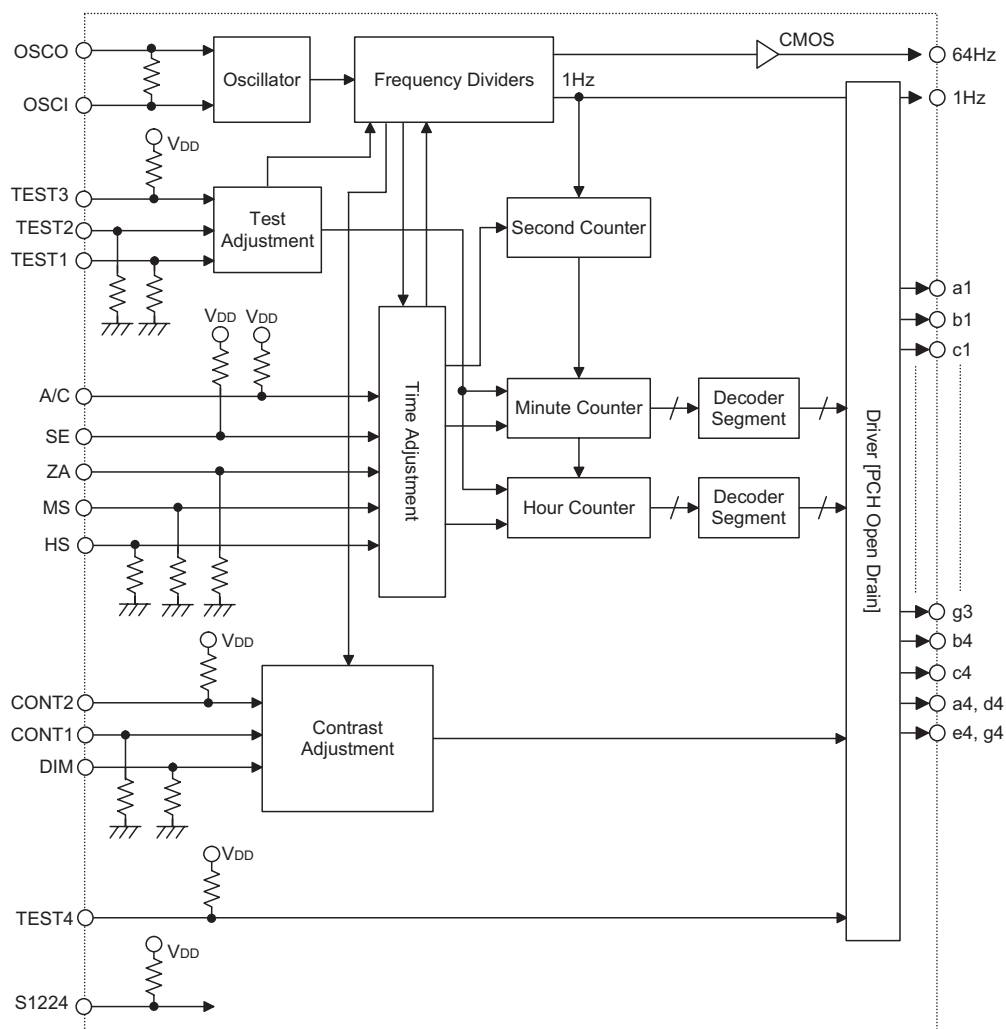
- VFD display 24 hour clock function
- 4.194304MHz crystal oscillation
- Zero adjust function
- Integrated voltage regulator permits wide 4V to 16V operating voltage range
- Four level contrast control function
- 44-pin QFP package

General Description

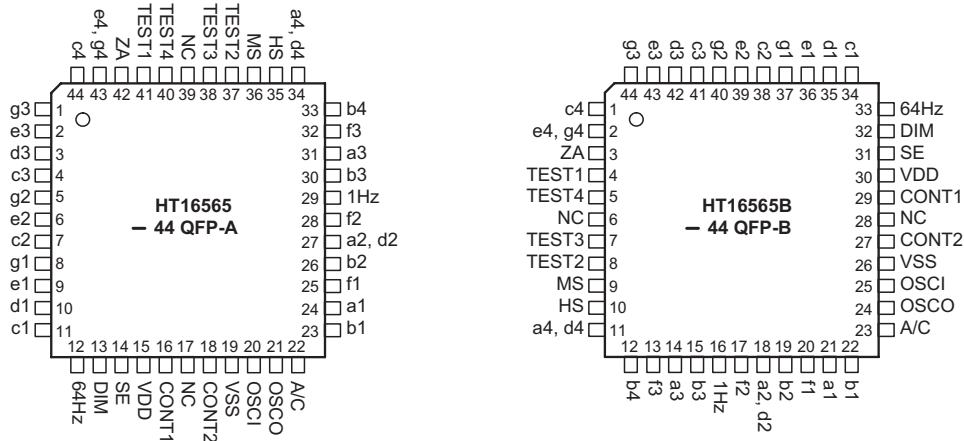
The HT16565 provides direct drive to VFD panels to implement a 24 hour clock function. In addition to obtaining its time base from a 4.194304MHz crystal oscillation source and in having a wide operating voltage, the device also contains a host of other features. These in-

clude a choice of adjustment modes, including single push increment or 2Hz fast forward functions. Additional features are provided in the form of Zero adjustment and four levels of contrast control.

Block Diagram



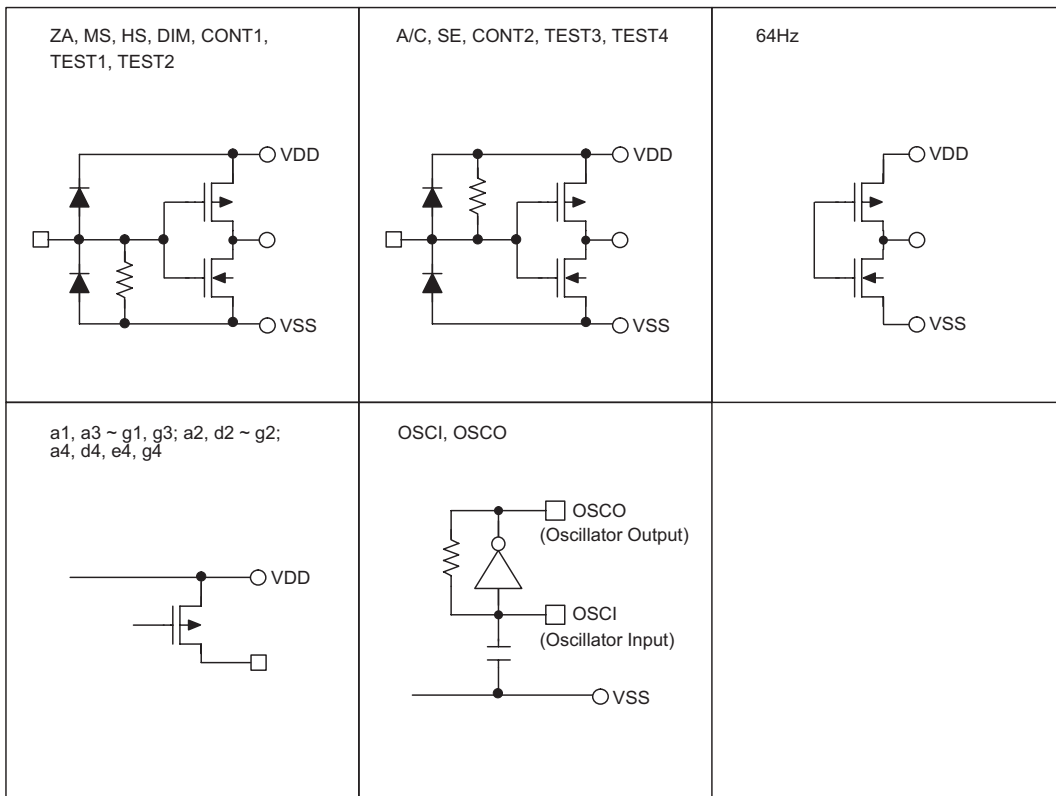
Pin Assignment



Pin Description

| Pin Name | I/O | Description |
|---------------------|-----|--|
| VDD | O | High voltage power supply pin. |
| VSS | — | Ground pin. |
| DIM | I | Illumination level control pins. |
| CONT1 | I | Internally connected to pull-down resistors. |
| CONT2 | I | Illumination level control pins. Internally connected to pull-up resistors. |
| A/C | I | When the A/C pin is low, the internal circuits are reset. The reset pulse width should be more than 2 μ s. Internally connected to a pull-up resistor. |
| ZA | I | Zero adjustment pin. Internally connected to a pull-down resistor. |
| HS | I | Hour adjustment pin. Internally connected to a pull-down resistor. |
| MS | I | Minute adjustment pin. Internally connected to a pull-down resistor. |
| SE | I | Set enable pin. Internally connected to a pull-up resistor. |
| OSCO | O | Crystal oscillator pin |
| OSCI | I | |
| TEST1, TEST2 | I | IC test pin - should be left open or kept at a low level |
| TEST3, TEST4 | I | IC test pin - should be left open or kept at a high level |
| 64Hz | O | 64Hz signal output pin for oscillation frequency adjustment |
| a1, a3 ~ b2, b4, c4 | O | Segment output pins for VFD |
| a4, d4, e4, g4 | | |
| 1Hz | | |

Approximate Internal Connections



Absolute Maximum Ratings

| | |
|--|---|
| Logic Supply Voltage $V_{SS}-0.3V$ to $V_{SS}+6.5V$ | Driver Supply Voltage $V_{SS}-0.3V$ to $V_{SS}+20V$ |
| High Input Voltage $V_{SS}-0.3V$ to $V_{CC}+0.3V$ | High Output Voltage $V_{SS}-0.3V$ to $V_{CC}+0.3V$ |
| Driver Output Voltage $V_{SS}-0.3V$ to V_{DD} | Driver Output Current (Segment Driver) $-10mA$ to $+2mA$ |
| Driver Output Current (Grid Driver) $-7mA$ to $+20mA$ | Storage Temperature $-55^{\circ}C$ to $+150^{\circ}C$ |
| Operating Temperature $-40^{\circ}C$ to $+85^{\circ}C$ | |

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

Recommended Operating Conditions

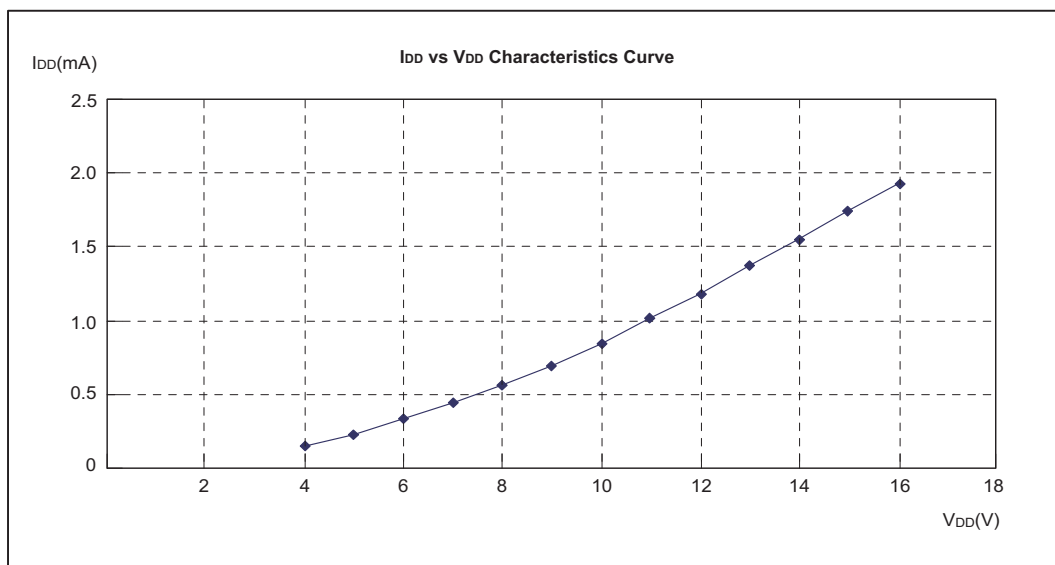
| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|-----------|-----------------------|-------|----------|------|-------------|
| V_{DD} | Power Supply Voltage | 4 | — | 16 | V |
| f_{OSC} | Oscillation Frequency | — | 4.194304 | — | MHz |
| t_{OP} | Operating Temperature | -40 | — | 85 | $^{\circ}C$ |

D.C. Characteristics

 $V_{DD}=6.0V$, $V_{SS}=0V$, $T_a=-40^{\circ}C-85^{\circ}C$

| Symbol | Parameter | Test Conditions | | Min. | Typ. | Max. | Unit |
|-----------|-----------------------------|-----------------|--|------|------|-------|---------|
| | | V_{DD} | Conditions | | | | |
| V_{IH} | High Input Voltage | 6V | — | 4.3 | — | — | V |
| V_{IL} | Low Input Voltage | 6V | — | — | — | 1.0 | V |
| I_{IH} | Hi-level Input Current | 6V | $V_I=V_{DD}$ for TEST1, TEST2, ZA, MS, HS, DIM, CONT1 | 30 | — | 150 | μA |
| I_{IL1} | Low-level Input Current | 6V | $V_I=V_{SS}$ for TEST3, TEST4 | -120 | — | -800 | μA |
| I_{IL2} | | | $V_I=V_{SS}$ for A/C | -3 | — | -12 | μA |
| I_{IL3} | | | $V_I=V_{SS}$ for SE, CONT2 | -30 | — | -150 | μA |
| V_{OL} | Low-level Output current | 6V | $I_{OL}=V_{SS}$ for all pin | 5.9 | — | — | V |
| V_{OH} | Hi-level Output current | 6V | $I_{OH}=V_{SS}$ for 64Hz pin | — | — | 0.1 | V |
| I_{OH1} | Output Current | 6V | $V_{OH}=4.0V$ for 1Hz, a2, d2, a4, d4, e4, g4 | — | — | -2000 | μA |
| I_{OL1} | Output Current | 6V | $V_{OL}=0V$ for 1Hz, a2, d2, a4, d4, e4, g4 | 1 | — | — | μA |
| I_{OH2} | Output Current | 6V | $V_{OH}=4.0V$. Other segment output pins except above | — | — | -1000 | μA |
| I_{OL2} | Output Current | 6V | $V_{OL}=V_{SS}$. Other segment output pins except above | 1 | — | — | μA |
| I_{OH3} | Output Current | 6V | $V_{OH}=5.5V$ for 64Hz pin | — | — | -100 | μA |
| I_{OL3} | Output Current | 6V | $V_{OL}=0.5V$ for 64Hz pin | 100 | — | — | μA |
| I_{DD} | Dynamic Current Consumption | 6V | $f_{OSC}=4.194304MHz$, No load, $C_{IN}=39pF\pm 5\%$, $C_{OUT}=33pF\pm 5\%$, $C_I=70\Omega\pm 5\%$ | — | — | 2 | mA |

Characteristics Curves

 V_{DD} vs I_{DD} Characteristics Curve $T_a=25^{\circ}C$ 

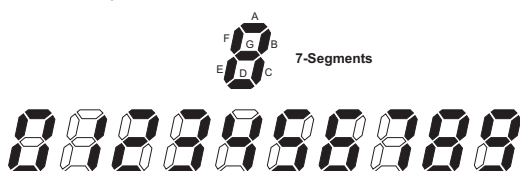
Functional Description

VFD Display Driving

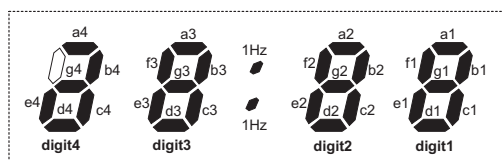
The device can directly drive VFD clock panels dynamically. The clock will be displayed in a 24-hour format with the hours ranging from 0 to 23 and minutes from 00 to 59. If the most significant numeral is zero then the display will be extinguished.

- Segment connections

A 7-segment display is shown below showing the illumination pattern for each numeral.



As the device is designed for clock applications, four 7-segment displays are required to display the correct time output. The connections for the segments are shown below, however it should be noted that the fourth segment only requires two of its segments to be driven.



Other Pin Functions

The external reset pin A/C is used to reset the internal circuit of the device. When this pin is pulled low the device will be reset, when the pin is allowed to go high, via its internal pull-high resistor, then the display will indicate a "0:00" output.

In the open status, the SE pin is held to "high" level by a pull-high resistor, enabling the inputs from MS, HS and ZA pins. These inputs become invalid by setting this pin to a "low" level externally.

The 64Hz pin allows monitoring of the system frequency to allow frequency adjustments to be executed. As the name suggests, this output pin will continuously output a frequency of 64Hz.

In the open status, the TEST1 and TEST2 pins are kept at a "0" level by pull-down resistors.

In the open status, the TEST3 and TEST4 pins are kept at a "1" level by pull-up resistors.

The Test pin function is as shown in the following table.

TEST select function 1

| Switch Pin Name | | | Operating mode |
|-----------------|----------------|----------------|--|
| TEST1 | TEST2 | TEST3 | |
| 0 (or Open) | 0 (or Open) | 1 (or Open) | Normal function. |
| Φ(Pulse) | 1 | 1 (or Open) | Input pulses to the 16.384kHz system of the circuit. |
| 1 | Φ(Pulse) | 1 (or Open) | Input pulses to the 16.384kHz system of the circuit. |
| 1 | Φ(Pulse) | 0 | Input pulses to the 64Hz system of the circuit. |
| Φ(Pulse) | 1 | 0 | Input pulses to the 64Hz system of the circuit. |
| Φ(Pulse) | 0 (or Open) | 0 | Input pulses for the minute and hour counters, which advances 1 count with 1 pulse. No carry functions for hour and minute counters. |

TEST select function 2

| Switch Pin Name | | | | Operating mode |
|-----------------|----------|-------|-------|---|
| TEST3 | DIM | CONT1 | CONT2 | |
| 0 | Φ(Pulse) | * | * | The pulse widths of the all segment outputs are controlled by the pulse width of the DIM signal |
| 0 | 0 | * | * | Sets all segment outputs to high impedance |

Note: "*" Indicates that the input level can be "0" and "1"

Three illumination level set pins, DIM, CONT1 and CONT2 are provided to give control over the display brightness level, as shown in the following table.

| Switch Pin Name | | | Operating mode |
|-----------------|----------------|----------------|-------------------------------------|
| DIM | CONT1 | CONT2 | |
| 0 (or Open) | * | * | 100% duty display |
| 1 | 0 (or Open) | 1 (or Open) | 25% (1/4) duty display at 4096Hz |
| 1 | 0 (or Open) | 0 | 12.5% (1/8) duty display at 4096Hz |
| 1 | 1 | 1 (or Open) | 6.25% (1/16) duty display at 4096Hz |

Note: "1" high level, "0" low level, "*" don't care

Device Functions

- Reset

Although the device is provided with an external reset pin A/C, the device will in fact reset itself when power is applied, eliminating the need for external reset components. The usual provision of an external capacitor is not required as an internal reset capacitor is integrated within the device.

- Chatter removal

The device contains circuits which are connected to input pins HS, MS and ZA to remove chatter of less than 31.25ms.

- Oscillator

The basic time base frequency for this device is determined by an external 4.194304MHz crystal. When an external crystal along with two small external capacitors are connected to the two oscillator pins, the internal oscillator circuit will ensure generation of the correct time base signals. The oscillation frequency, although determined by the external crystal frequency, will also be influenced by the external capacitors, the crystal inherent capacitance and the residual capacitance of the external PCB tracks. To ensure accurate frequency generation, the crystal specification should be taken into account and care taken to place the external capacitors and crystal as close to the device as possible.

Time Adjustment Operation

- Hour/minute adjustment

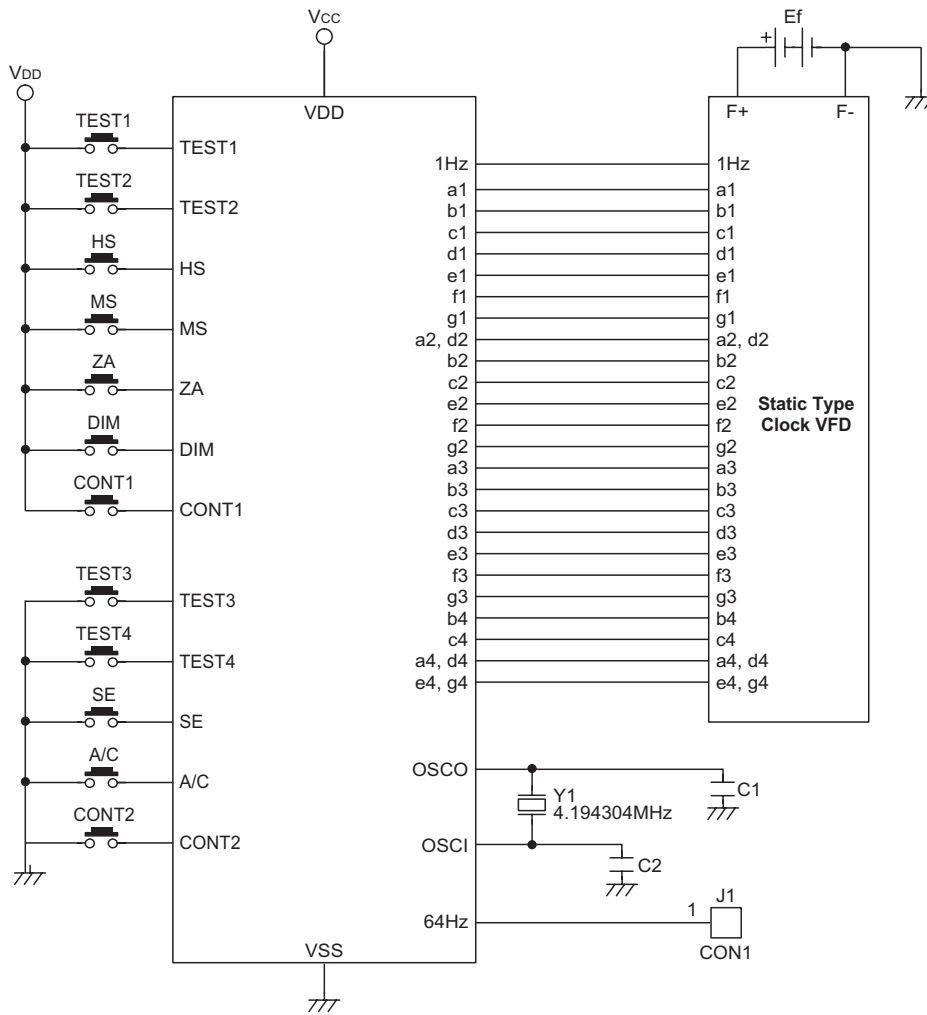
Both the minutes and hour displays can be adjusted separately or both together in a fast forward format. The hour set pin, HS, and the minutes set pin, MS, are used to make these adjustments. Both of these pins are connected to internal pull-low resistors. Each time one of these lines is pulled high, the respective hour or minute value will increment by one, also if the line is continuously held high then the respective value will increment automatically at a rate of 2Hz. Both values will increment together if both lines are pulled high simultaneously. Note that no carry functions will be implemented when either the hour or minute value overflows.

- Zero adjustment

A zero adjust function is also included within the device and is controlled by the ZA pin. This pin is connected to an internal pull low resistor. Pulling this line high will reset both the internal minutes and seconds value, however the way in which the display is reset depends upon the present value of display. If the minute value is presently less than 30 the only the second and minute values will be reset to zero and the hour value remain unchanged. However if the minute value is presently at a value of 30 or higher then when the zero adjustment function is executed, a carry will be implemented and the hour value will be increment by one. The following table illustrates a few examples of this operation.

| Zero Adjust Examples | | | | | |
|----------------------|------|------|-------------------|------|------|
| Present Time | | | After Zero Adjust | | |
| Hr. | Min. | Sec. | Hr. | Min. | Sec. |
| 1 | 30 | 00 | 2 | 00 | 00 |
| 2 | 00 | 00 | 2 | 00 | 00 |
| 2 | 29 | 59 | 2 | 00 | 00 |
| 2 | 30 | 00 | 3 | 00 | 00 |
| 2 | 59 | 59 | 3 | 00 | 00 |
| 3 | 29 | 59 | 3 | 00 | 00 |

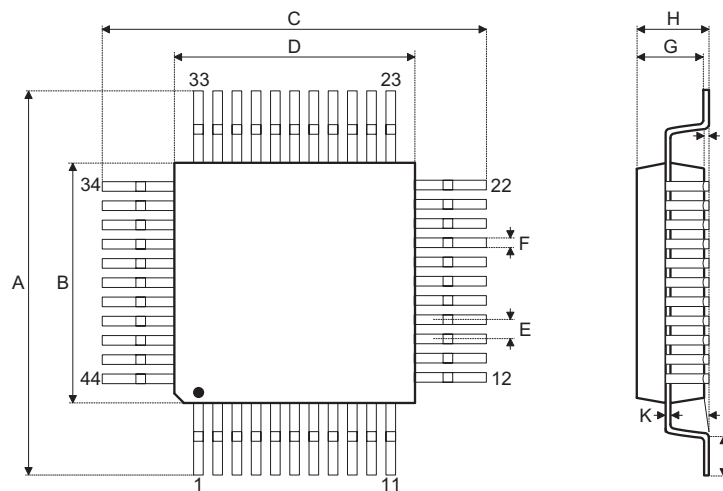
Application Circuits



Note: Capacitors C1 and C2 can adjust the frequency accuracy

Package Information

44-pin QFP (10×10) Outline Dimensions



| Symbol | Dimensions in mm | | |
|----------|------------------|------|------|
| | Min. | Nom. | Max. |
| A | 13 | — | 13.4 |
| B | 9.9 | — | 10.1 |
| C | 13 | — | 13.4 |
| D | 9.9 | — | 10.1 |
| E | — | 0.8 | — |
| F | — | 0.3 | — |
| G | 1.9 | — | 2.2 |
| H | — | — | 2.7 |
| I | — | 0.1 | — |
| J | 0.73 | — | 0.93 |
| K | 0.1 | — | 0.2 |
| α | 0° | — | 7° |

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