

## 133MHz Clock Generator and Integrated Buffer for PowerPC™

### General Description

The ICS9341 generates all clocks required for high speed PowerPC RISC microprocessor systems. Generating clocks in phase with an external reference frequency.

Spread Spectrum may be enabled by driving the SS\_EN pin active. Spread spectrum typically reduces system EMI by 8dB to 10dB. This simplifies EMI qualification without resorting to board design iterations or costly shielding. The ICS9341 employs a proprietary closed loop design, which tightly controls the percentage of spreading over process and temperature variations.

### Features

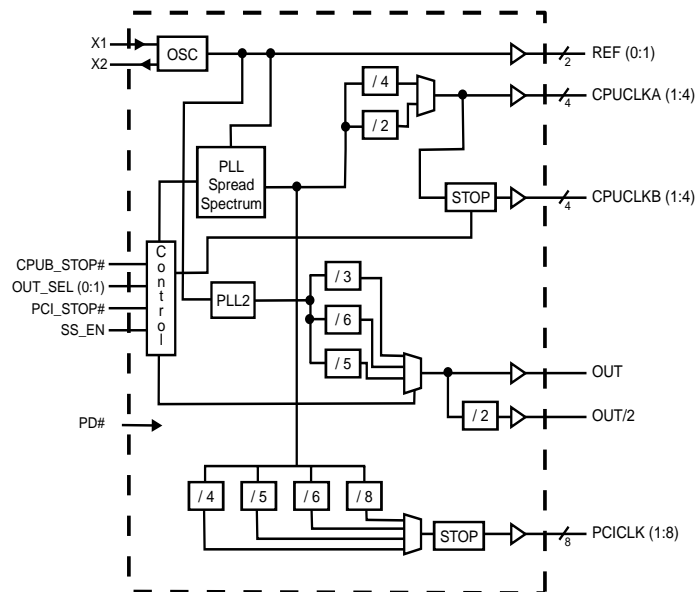
**Generates the following system clocks:**

- 4-CPUA (3.3V, up to 133MHz)
  - 4-CPUB (3.3V, up to 133MHz)
  - 8-PCI (3.3V, 33.3MHz)
  - 1-OUT (3.3v, 64MHz)
  - 1-OUT/2 (3.3V, OUT/2MHz)
  - 2-REF (3.3V, 14.318MHz)
- Up to 133MHz frequency support.
  - Stop clocks for power management
  - Spread Spectrum for EMI control  
±.25% center spread

**Skew characteristics:**

- CPU - CPU: <350ps
- CPU - PCI: <500ps
- PCI - PCI: <500ps

### Block Diagram



### Power Groups:

VDDREF, GNDREF=REF, X1, X2

GNDPCI, VDDPCI=PCICLK

VDD66, GND66=3V66

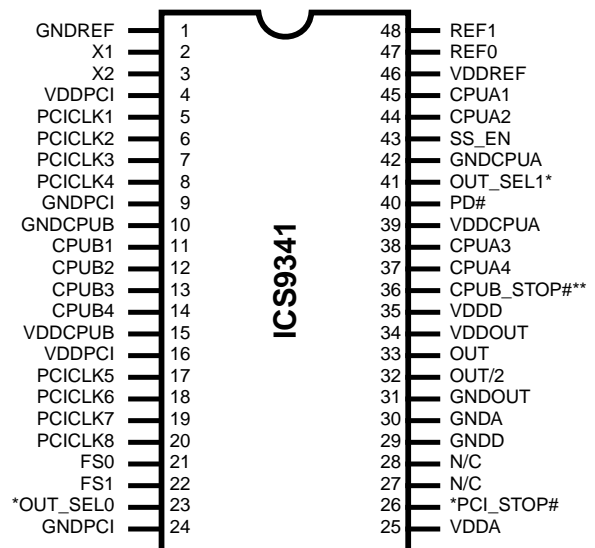
VDD48, GND48=48MHz

VDDCOR, GNDCOR=PLL Core

VDDLCPU/2, GNDLCPU/2=CPU/2

VDDLIOAPIC, GNDIOAPIC=IOAPIC

### Pin Configuration



### 48-pin SSOP

\* Internal pull-up resistor of 120K to 3.3V on indicated inputs

\*\* Internal pull-down resistor of 120K to GND on indicated inputs.

## Pin Descriptions

| Pin number                 | Pin name       | Type | Description  |
|----------------------------|----------------|------|--|
| 1                          | GNDREF         | PWR  | Ground pin for REF clocks.   |
| 2                          | X1             | IN   | XTAL_IN 14.318MHz crystal input.   |
| 3                          | X2             | OUT  | XTAL_OUT Crystal output.   |
| 4, 16                      | VDDPCI         | PWR  | 3.3Volts power pin for PCICLKs.  |
| 5, 6, 7, 8, 17, 18, 19, 20 | PCICLK (1:8)   | OUT  | PCI clock output at 3.3V. Synchronous to CPU clocks.   |
| 9, 24                      | GNDPCI         | PWR  | Ground pin for PCI clocks.   |
| 10                         | GNDCPUB        | PWR  | Ground pin for CPUB clocks.  |
| 11, 12, 13, 14             | CPUB (1:4)     | OUT  | CPUCLK outputs up to 133.3MHz.   |
| 15                         | VDDCPUB        | PWR  | Power pin for the CPU bank B CLKs. 3.3V.   |
| 21, 22                     | FS (0:1)       | IN   | Logic - input for frequency selection.   |
| 23, 41                     | *OUT_SEL (0:1) | IN   | These control the output functionality of the OUT and OUT/2 pins. Refer to table for details.  |
| 24                         | GNDPCI         | PWR  | Gnd pin for PCICLKs.   |
| 25                         | VDDA           | PWR  | Power for analog outputs.  |
| 26                         | *PCI_STOP#     | IN   | This active low input stops PCI clocks.  |
| 27, 28                     | N/C            | -    | Not connected  |
| 29                         | GNDD           | PWR  | Digital ground   |
| 30                         | GNDA           | PWR  | Analog ground  |
| 31                         | GNDOUT         | PWR  | Ground for output pins.  |
| 32                         | OUT/2          | OUT  | Half the OUT frequency. Dependent on OUT_SEL. Refer to table for details.  |
| 33                         | OUT            | OUT  | This output frequency is dependent on OUT_SEL. Refer to table for details.   |
| 34                         | VDDOUT         | PWR  | Power for OUT pins 3.3V.   |
| 35                         | VDDD           | PWR  | Power for digital outputs.   |
| 36                         | CPUB_STOP#**   | IN   | This active low input stops the CPUB clocks at a logic "0" level when input low.   |
| 45, 44, 38, 37             | CPUA (1:4)     | OUT  | CPUCLK outputs up to 133.3MHz.   |
| 39                         | VDDCPUA        | PWR  | Power pin for the CPU bank A CLKs. 3.3V.   |
| 40                         | PD#            | IN   | This asynchronous input powers down the chip when drive active(Low). The internal PLLs are disabled and all the output clocks are held at a Low state. |
| 42                         | GNDCPUA        | PWR  | Ground pin for CPUB clocks.  |
| 43                         | SS_EN          | IN   | Spread spectrum is turned on by driving this input high and turned off by driving low.   |
| 46                         | VDDREF         | PWR  | Power pin for REF clocks.  |
| 47, 48                     | REF            | OUT  | 14.318MHz reference clock outputs at 3.3V.   |

## Frequency Selection

| FS1 | FS0 | CPUA, CPUB<br>(MHz) | PCI<br>(MHz) | REF<br>(MHz) |
|-----|-----|---------------------|--------------|--------------|
| 1   | 1   | 133.3               | 33.3         | 14.318       |
| 1   | 0   | 100                 | 33.3         | 14.318       |
| 0   | 1   | 83.3                | 33.3         | 14.318       |
| 0   | 0   | 66.6                | 33.3         | 14.318       |

| OUT_SEL1 | OUT_SEL0 | OUT<br>(MHz) | OUT/2<br>(MHz) |
|----------|----------|--------------|----------------|
| 1        | 1        | 48           | 24             |
| 1        | 0        | 40           | 20             |
| 0        | 1        | 64           | 32             |
| 0        | 0        | Stopped      | Stopped        |

## PD# Timing Diagram

The power down selection is used to put the part into a very low power state without turning off the power to the part. PD# is an asynchronous active low input. This signal needs to be synchronized internal to the device prior to powering down the clock synthesizer.

Internal clocks are not running after the device is put in power down. When PD# is active low all clocks need to be driven to a low value and held prior to turning off the VCOs and crystal. The power up latency needs to be less than 3 mS. The power down latency should be as short as possible but conforming to the sequence requirements shown below. The REF and 48MHz clocks are expected to be stopped in the LOW state as soon as possible. Due to the state of the internal logic, stopping and holding the REF clock outputs in the LOW state may require more than one clock cycle to complete.

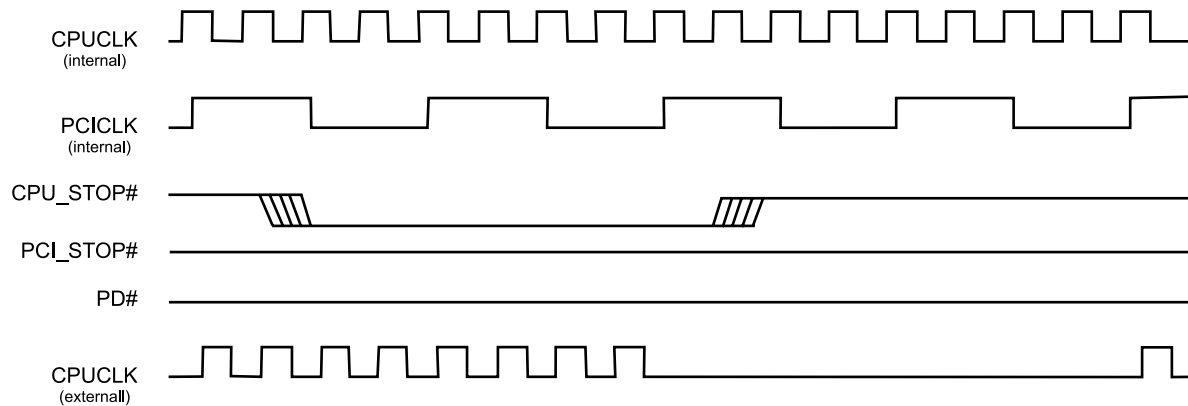


### Notes:

1. All timing is referenced to the Internal CPUCLK (defined as inside the ICS9341 device).
2. As shown, the outputs Stop Low on the next falling edge after PD# goes low.
3. PD# is an asynchronous input and metastable conditions may exist. This signal is synchronized inside this part.
4. The shaded sections on the VCO and the Crystal signals indicate an active clock.
5. Diagrams shown with respect to 133MHz. Similar operation when CPU is 100MHz.

## CPU\_STOP# Timing Diagram

CPU\_STOP# is an asynchronous input to the clock synthesizer. It is used to turn off the CPU and 3V66 clocks for low power operation. CPU\_STOP# is asserted asynchronously by the external clock control logic with the rising edge of free running PCI clock (and hence CPU clock) and must be internally synchronized to the external output. All other clocks will continue to run while the CPU clocks are disabled. The CPU clocks must always be stopped in a low state and started in such a manner as to guarantee that the high pulse width is a full pulse.

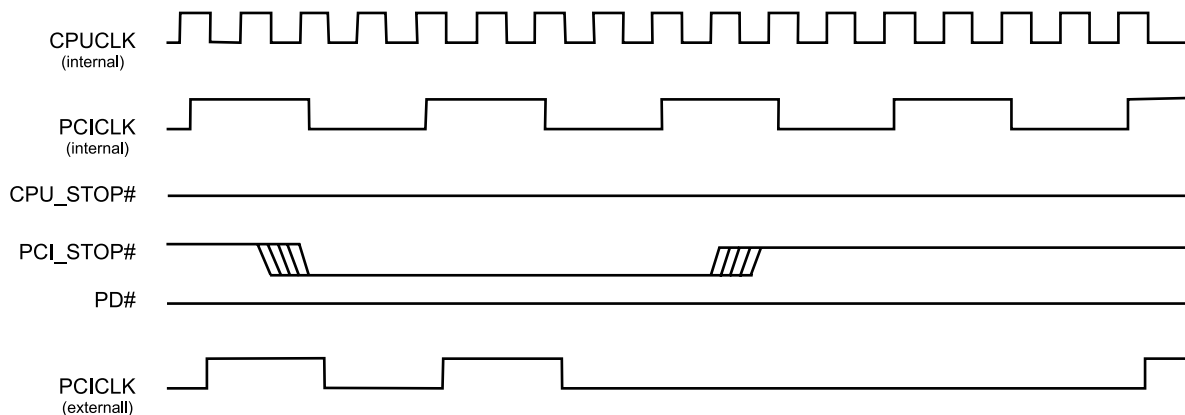


**Notes:**

1. All timing is referenced to the internal CPUCLK.
2. The internal label means inside the chip and is a reference only. This in fact may not be the way that the control is designed.
3. PD# and PCI\_STOP# are shown in a high state.

## PCI\_STOP# Timing Diagram

PCI\_STOP# is an input to the clock synthesizer. It is used to turn off the PCI clocks for low power operation. PCI clocks are required to be stopped in a low state and started such that a full high pulse width is guaranteed. **ONLY one rising edge of PCICLK\_F is allowed** after the clock control logic switched for the PCI outputs to become enabled/disabled.



**Notes:**

1. All timing is referenced to CPUCLK.
2. Internal means inside the chip.
3. All other clocks continue to run undisturbed.
4. PD# and CPU\_STOP# are shown in a high state.

## Absolute Maximum Ratings

|                               |                             |
|-------------------------------|-----------------------------|
| Supply Voltage                | 7.0 V                       |
| Logic Inputs                  | GND–0.5 V to $V_{DD}+0.5$ V |
| Ambient Operating Temperature | 0°C to +70°C                |
| Storage Temperature           | –65°C to +150°C             |

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

## Electrical Characteristics - Input/Supply/Common Output Parameters

$T_A = 0 - 70^\circ\text{C}$ ; Supply Voltage  $V_{DD} = V_{DDL} = 3.3$  V +/-5% (unless otherwise stated)

| PARAMETER                      | SYMBOL           | CONDITIONS                                       | MIN          | TYP    | MAX          | UNITS         |
|--------------------------------|------------------|--|--------------|--------|--------------|---------------|
| Input High Voltage             | $V_{IH}$         |  | 2            |        | $V_{DD}+0.3$ | V             |
| Input Low Voltage              | $V_{IL}$         |  | $V_{SS}-0.3$ |        | 0.8          | V             |
| Input High Current             | $I_{IH}$         | $V_{IN} = V_{DD}$                                |              | 0.1    | 5            | $\mu\text{A}$ |
| Input Low Current              | $I_{IL1}$        | $V_{IN} = 0$ V; Inputs with no pull-up resistors | -5           | 2.0    |              | $\mu\text{A}$ |
| Input Low Current              | $I_{IL2}$        | $V_{IN} = 0$ V; Inputs with pull-up resistors    | -200         | -100   |              | $\mu\text{A}$ |
| Operating Supply Current       | $I_{DD3.3OP66}$  | Select @ 66MHz; Max discrete cap loads           |              | 215    | 250          | mA            |
|                                | $I_{DD3.3OP83}$  | Select @ 83MHz; Max discrete cap loads           |              | 200    | 225          | mA            |
|                                | $I_{DD3.3OP100}$ | Select @ 100MHz; Max discrete cap loads          |              | 180    | 200          | mA            |
|                                | $I_{DD3.3OP133}$ | Select @ 133MHz; Max discrete cap loads          |              | 160    | 175          | mA            |
| Power Down Supply Current      | $I_{DD3.3PD}$    | PD# = 0  |              | 160    | 300          | $\mu\text{A}$ |
| Input frequency                | $F_i$            | $V_{DD} = 3.3$ V                                 | 12           | 14.318 | 16           | MHz           |
| Input Capacitance <sup>1</sup> | $C_{IN}$         | Logic Inputs                                     |              |        | 5            | pF            |
|                                | $C_{INX}$        | X1 & X2 pins                                     | 13.5         | 18     | 22.5         | pF            |
| Transition Time <sup>1</sup>   | $T_{Trans}$      | To 1st crossing of target Freq.                  |              |        | 3            | ms            |
| Settling Time <sup>1</sup>     | $T_S$            | From 1st crossing to 1% target Freq.             |              | 1      |              | ms            |
| Clk Stabilization <sup>1</sup> | $T_{STAB}$       | From $V_{DD} = 3.3$ V to 1% target Freq.         |              |        | 3            | ms            |
| Skew <sup>1</sup>              | $t_{CPUA-CPUB}$  | $V_T = 1.5$ V                                    |              | 100    | 350          | ps            |
| Skew <sup>1</sup>              | $t_{CPU-PCI}$    | $V_T = 1.5$ V                                    |              | 500    | 800          | ps            |

## Electrical Characteristics - CPUA

$T_A = 0 - 70^\circ \text{C}$ ;  $V_{DD} = V_{DDL} = 3.3 \text{ V} \pm 5\%$ ;  $C_L = 20 \text{ pF}$  (unless otherwise stated)

| PARAMETER              | SYMBOL                | CONDITIONS                                       | MIN | TYP  | MAX | UNITS |
|------------------------|-----------------------|--|-----|------|-----|-------|
| Output High Voltage    | $V_{OH2B}$            | $I_{OH} = -8.0 \text{ mA}$                       | 2   | 2.4  |     | V     |
| Output Low Voltage     | $V_{OL2B}$            | $I_{OL} = 12 \text{ mA}$                         |     | 0.32 | 0.4 | V     |
| Output High Current    | $I_{OH2B}$            | $V_{OH} = 1.7 \text{ V}$                         |     | -37  | -16 | mA    |
| Output Low Current     | $I_{OL2B}$            | $V_{OL} = 0.7 \text{ V}$                         | 19  | 26   |     | mA    |
| Rise Time              | $t_{r2B}^1$           | $V_{OL} = 0.4 \text{ V}, V_{OH} = 2.4 \text{ V}$ |     | 1.5  | 2.5 | ns    |
| Fall Time              | $t_{f2B}^1$           | $V_{OH} = 2.4 \text{ V}, V_{OL} = 0.4 \text{ V}$ |     | 1    | 2.5 | ns    |
| Duty Cycle             | $d_{t2B}^1$           | $V_T = 1.5 \text{ V}$                            | 40  | 50   | 55  | %     |
| Skew                   | $t_{sk2B}^1$          | $V_T = 1.5 \text{ V}$                            |     | 125  | 175 | ps    |
| Jitter, Cycle-to-cycle | $t_{j_{cyc-cyc2B}}^1$ | $V_T = 1.5 \text{ V}$                            |     | 230  | 350 | ps    |

<sup>1</sup>Guaranteed by design, not 100% tested in production.

## Electrical Characteristics - CPUB

$T_A = 0 - 70^\circ \text{C}$ ;  $V_{DD} = V_{DDL} = 3.3 \text{ V} \pm 5\%$ ;  $C_L = 30 \text{ pF}$  (unless otherwise stated)

| PARAMETER              | SYMBOL                | CONDITIONS                                       | MIN | TYP  | MAX | UNITS |
|------------------------|-----------------------|--|-----|------|-----|-------|
| Output High Voltage    | $V_{OH2B}$            | $I_{OH} = -8.0 \text{ mA}$                       | 2   | 2.4  |     | V     |
| Output Low Voltage     | $V_{OL2B}$            | $I_{OL} = 12 \text{ mA}$                         |     | 0.32 | 0.4 | V     |
| Output High Current    | $I_{OH2B}$            | $V_{OH} = 1.7 \text{ V}$                         |     | -37  | -16 | mA    |
| Output Low Current     | $I_{OL2B}$            | $V_{OL} = 0.7 \text{ V}$                         | 19  | 26   |     | mA    |
| Rise Time              | $t_{r2B}^1$           | $V_{OL} = 0.4 \text{ V}, V_{OH} = 2.4 \text{ V}$ |     | 1.9  | 3   | ns    |
| Fall Time              | $t_{f2B}^1$           | $V_{OH} = 2.4 \text{ V}, V_{OL} = 0.4 \text{ V}$ |     | 1.6  | 3   | ns    |
| Duty Cycle             | $d_{t2B}^1$           | $V_T = 1.5 \text{ V}$                            | 40  | 49   | 55  | %     |
| Skew                   | $t_{sk2B}^1$          | $V_T = 1.5 \text{ V}$                            |     | 90   | 175 | ps    |
| Jitter, Cycle-to-cycle | $t_{j_{cyc-cyc2B}}^1$ | $V_T = 1.5 \text{ V}$                            |     | 230  | 350 | ps    |

<sup>1</sup>Guaranteed by design, not 100% tested in production.

## Electrical Characteristics - PCI

$T_A = 0 - 70^\circ \text{C}$ ;  $V_{DD} = V_{DDL} = 3.3 \text{ V} \pm 5\%$ ;  $C_L = 30 \text{ pF}$

| PARAMETER                           | SYMBOL                 | CONDITIONS  | MIN | TYP  | MAX | UNITS |
|-------------------------------------|------------------------|---|-----|------|-----|-------|
| Output High Voltage                 | $V_{OH1}$              | $I_{OH} = -11 \text{ mA}$                           | 2.4 | 3.1  |     | V     |
| Output Low Voltage                  | $V_{OL1}$              | $I_{OL} = 9.4 \text{ mA}$                           |     | 0.17 | 0.4 | V     |
| Output High Current                 | $I_{OH1}$              | $V_{OH} = 2.0 \text{ V}$                            |     | -60  | -22 | mA    |
| Output Low Current                  | $I_{OL1}$              | $V_{OL} = 0.8 \text{ V}$                            | 25  | 47   |     | mA    |
| Rise Time <sup>1</sup>              | $t_{r1}$               | $V_{OL} = 0.4 \text{ V}$ , $V_{OH} = 2.4 \text{ V}$ | 0.5 | 1.8  | 2.5 | ns    |
| Fall Time <sup>1</sup>              | $t_{f1}$               | $V_{OH} = 2.4 \text{ V}$ , $V_{OL} = 0.4 \text{ V}$ | 0.5 | 1.7  | 2.5 | ns    |
| Duty Cycle <sup>1</sup>             | $d_{t1}$               | $V_T = 1.5 \text{ V}$                               | 45  | 50   | 55  | %     |
| Skew <sup>1</sup>                   | $t_{sk1}$              | $V_T = 1.5 \text{ V}$                               |     | 150  | 500 | ps    |
| Jitter, Cycle-to-cycle <sup>1</sup> | $t_{j\text{cyc-cyc}1}$ | $V_T = 1.5 \text{ V}$                               |     | 120  | 500 | ps    |

<sup>1</sup>Guaranteed by design, not 100% tested in production.

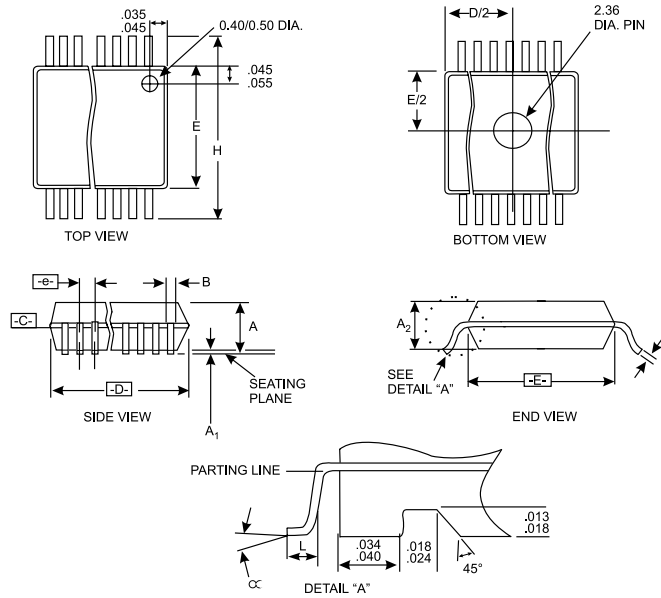
## Electrical Characteristics - REF, OUT, OUT/2

$T_A = 0 - 70^\circ \text{C}$ ;  $V_{DD} = V_{DDL} = 3.3 \text{ V} \pm 5\%$ ;  $C_L = 20 \text{ pF}$  (unless otherwise stated)

| PARAMETER                           | SYMBOL                 | CONDITIONS  | MIN | TYP  | MAX  | UNITS |
|-------------------------------------|------------------------|---|-----|------|------|-------|
| Output High Voltage                 | $V_{OH5}$              | $I_{OH} = -12 \text{ mA}$                                   | 2.4 | 2.9  |      | V     |
| Output Low Voltage                  | $V_{OL5}$              | $I_{OL} = 10 \text{ mA}$                                    |     | 0.33 | 0.4  | V     |
| Output High Current                 | $I_{OH5}$              | $V_{OH} = 2.0 \text{ V}$                                    |     | -30  | -20  | mA    |
| Output Low Current                  | $I_{OL5}$              | $V_{OL} = 0.8 \text{ V}$                                    | 16  | 23   |      | mA    |
| Rise Time <sup>1</sup>              | $t_{r5}$               | $V_{OL} = 0.4 \text{ V}$ , $V_{OH} = 2.4 \text{ V}$ ; OUT   | 1.5 | 1.8  | 4    | ns    |
| Fall Time <sup>1</sup>              | $t_{f5}$               | $V_{OH} = 2.4 \text{ V}$ , $V_{OL} = 0.4 \text{ V}$ ; OUT   | 1.5 | 2    | 4    | ns    |
| Duty Cycle <sup>1</sup>             | $d_{t5}$               | $V_T = 1.5 \text{ V}$ ; OUT                                 | 45  | 52   | 55   | %     |
| Rise Time <sup>1</sup>              | $t_{r5}$               | $V_{OL} = 0.4 \text{ V}$ , $V_{OH} = 2.4 \text{ V}$ ; OUT/2 | 1.5 | 2.2  | 4    | ns    |
| Fall Time <sup>1</sup>              | $t_{f5}$               | $V_{OH} = 2.4 \text{ V}$ , $V_{OL} = 0.4 \text{ V}$ ; OUT/2 | 1.5 | 2.1  | 4    | ns    |
| Duty Cycle <sup>1</sup>             | $d_{t5}$               | $V_T = 1.5 \text{ V}$ ; OUT/2                               | 45  | 50   | 55   | %     |
| Rise Time <sup>1</sup>              | $t_{r5}$               | $V_{OL} = 0.4 \text{ V}$ , $V_{OH} = 2.4 \text{ V}$ ; REF   | 1.5 | 2.7  | 4    | ns    |
| Fall Time <sup>1</sup>              | $t_{f5}$               | $V_{OH} = 2.4 \text{ V}$ , $V_{OL} = 0.4 \text{ V}$ ; REF   | 1.5 | 2.8  | 4    | ns    |
| Duty Cycle <sup>1</sup>             | $d_{t5}$               | $V_T = 1.5 \text{ V}$ ; REF                                 | 45  | 50   | 55   | %     |
| Jitter, Cycle-to-cycle <sup>1</sup> | $t_{j\text{cyc-cyc}5}$ | $V_T = 1.5 \text{ V}$ ; OUT, OUT/2                          |     | 280  | 500  | ps    |
| Jitter, Cycle-to-cycle <sup>1</sup> | $t_{j\text{cyc-cyc}5}$ | $V_T = 1.5 \text{ V}$ ; REF                                 |     | 450  | 1000 | ps    |

<sup>1</sup>Guaranteed by design, not 100% tested in production.





### SSOP Package

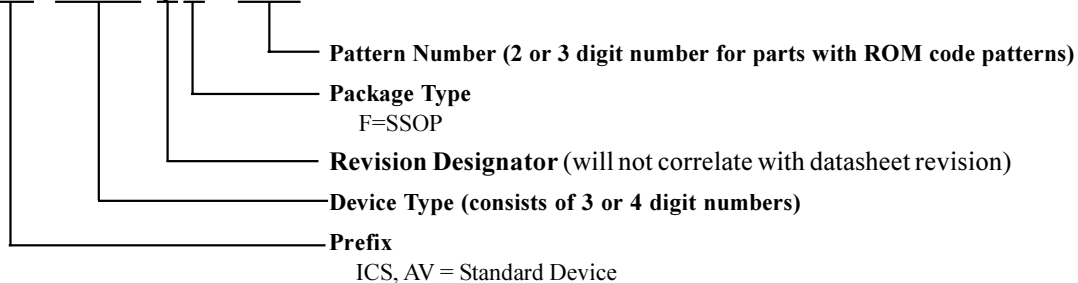
| SYMBOL | COMMON DIMENSIONS |      |       | VARIATIONS | D    |      |      | N  |
|--------|-------------------|------|-------|------------|------|------|------|----|
|        | MIN.              | NOM. | MAX.  |            | MIN. | NOM. | MAX. |    |
| A      | .095              | .101 | .110  | AC         | .620 | .625 | .630 | 48 |
| A1     | .008              | .012 | .016  |            |      |      |      |    |
| A2     | .088              | .090 | .092  |            |      |      |      |    |
| B      | .008              | .010 | .0135 |            |      |      |      |    |
| C      | .005              | -    | .010  |            |      |      |      |    |
| D      | See Variations    |      |       |            |      |      |      |    |
| E      | .292              | .296 | .299  |            |      |      |      |    |
| e      | 0.025 BSC         |      |       |            |      |      |      |    |
| H      | .400              | .406 | .410  |            |      |      |      |    |
| h      | .010              | .013 | .016  |            |      |      |      |    |
| L      | .024              | .032 | .040  |            |      |      |      |    |
| N      | See Variations    |      |       |            |      |      |      |    |
| ∞      | 0°                | 5°   | 8°    |            |      |      |      |    |
| X      | .085              | .093 | .100  |            |      |      |      |    |

### Ordering Information

ICS9341yF

Example:

ICS XXXX y F - PPP



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