



# Low Skew, 1-to-4 LVCMOS/LVTTL Fanout Buffer

8304

8304AMLN - PDN CQ-16-01 - LAST TIME BUY EXPIRES MAY 6, 2017

DATA SHEET

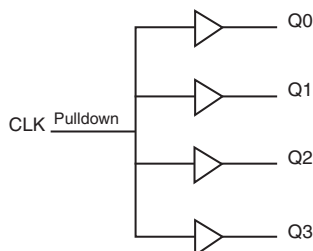
## GENERAL DESCRIPTION

The 8304 is a low skew, 1-to-4 Fanout Buffer. The 8304 is characterized at full 3.3V for input ( $V_{DD}$ ), and mixed 3.3V and 2.5V for output operating supply modes ( $V_{DDO}$ ). Guaranteed output and part-to-part skew characteristics make the 8304 ideal for those clock distribution applications demanding well defined performance and repeatability.

## FEATURES

- Four LVCMOS / LVTTL outputs
- LVCMOS / LVTTL clock input
- CLK can accept the following input levels: LVCMOS, LVTTL
- Maximum output frequency: 200MHz
- Additive phase jitter, RMS: 0.173ps (typical) @ 3.3V
- Output skew: 45ps (maximum) @ 3.3V
- Part-to-part skew: 500ps (maximum)
- Small 8 lead SOIC package saves board space
- 3.3V input, outputs may be either 3.3V or 2.5V supply modes
- 0°C to 70°C ambient operating temperature
- Available in lead-free (RoHS 6) compliant package

## BLOCK DIAGRAM



## PIN ASSIGNMENT

|           |   |   |    |
|-----------|---|---|----|
| $V_{DDO}$ | 1 | 8 | Q3 |
| $V_{DD}$  | 2 | 7 | Q2 |
| CLK       | 3 | 6 | Q1 |
| GND       | 4 | 5 | Q0 |

**8304**  
**8-Lead SOIC**  
3.9mm x 4.9mm, x 1.375mm package body  
**M Package**  
Top View

TABLE 1. PIN DESCRIPTIONS

| Number | Name             | Type   |          | Description                                             |
|--------|------------------|--------|----------|---------------------------------------------------------|
| 1      | V <sub>DDO</sub> | Power  |          | Output supply pin.                                      |
| 2      | V <sub>DD</sub>  | Power  |          | Positive supply pin.                                    |
| 3      | CLK              | Input  | Pulldown | LVC MOS / LVTTTL clock input.                           |
| 4      | GND              | Power  |          | Power supply ground.                                    |
| 5      | Q0               | Output |          | Single clock output. LVC MOS / LVTTTL interface levels. |
| 6      | Q1               | Output |          | Single clock output. LVC MOS / LVTTTL interface levels. |
| 7      | Q2               | Output |          | Single clock output. LVC MOS / LVTTTL interface levels. |
| 8      | Q3               | Output |          | Single clock output. LVC MOS / LVTTTL interface levels. |

NOTE: *Pulldown* refers to internal input resistors. See Table 2, Pin Characteristics, for typical values.

TABLE 2. PIN CHARACTERISTICS

| Symbol                | Parameter                                  | Test Conditions                             | Minimum | Typical | Maximum | Units |
|-----------------------|--------------------------------------------|---------------------------------------------|---------|---------|---------|-------|
| C <sub>IN</sub>       | Input Capacitance                          |                                             |         | 4       |         | pF    |
| C <sub>PD</sub>       | Power Dissipation Capacitance (per output) | V <sub>DD</sub> , V <sub>DDO</sub> = 3.465V |         |         | 15      | pF    |
| R <sub>PULLDOWN</sub> | Input Pulldown Resistor                    |                                             |         | 51      |         | kΩ    |
| R <sub>OUT</sub>      | Output Impedance                           |                                             | 5       | 7       | 12      | Ω     |

# ABSOLUTE MAXIMUM RATINGS

|                                          |                           |
|------------------------------------------|---------------------------|
| Supply Voltage, $V_{DD}$                 | 4.6V                      |
| Inputs, $V_I$                            | -0.5V to $V_{DD} + 0.5V$  |
| Outputs, $V_O$                           | -0.5V to $V_{DDO} + 0.5V$ |
| Package Thermal Impedance, $\theta_{JA}$ | 112.7°C/W (0 lfpm)        |
| Storage Temperature, $T_{STG}$           | -65°C to 150°C            |

NOTE: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in the *DC Characteristics* or *AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

**TABLE 3A. POWER SUPPLY DC CHARACTERISTICS,  $V_{DD} = V_{DDO} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$**

| Symbol    | Parameter                   | Test Conditions | Minimum | Typical | Maximum | Units |
|-----------|-----------------------------|-----------------|---------|---------|---------|-------|
| $V_{DD}$  | Power Supply Voltage        |                 | 3.135   | 3.3     | 3.465   | V     |
| $V_{DDO}$ | Output Power Supply Voltage |                 | 3.135   | 3.3     | 3.465   | V     |
| $I_{DD}$  | Power Supply Current        |                 |         |         | 15      | mA    |
| $I_{DDO}$ | Output Supply Current       |                 |         |         | 8       | mA    |

**TABLE 3B. POWER SUPPLY DC CHARACTERISTICS,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$**

| Symbol    | Parameter               | Test Conditions | Minimum | Typical | Maximum | Units |
|-----------|-------------------------|-----------------|---------|---------|---------|-------|
| $V_{DD}$  | Positive Supply Voltage |                 | 3.135   | 3.3     | 3.465   | V     |
| $V_{DDO}$ | Output Supply Voltage   |                 | 2.375   | 2.5     | 2.625   | V     |
| $I_{DD}$  | Power Supply Current    |                 |         |         | 15      | mA    |
| $I_{DDO}$ | Output Supply Current   |                 |         |         | 8       | mA    |

**TABLE 3C. LVCMOS / LVTTTL DC CHARACTERISTICS,  $V_{DD} = V_{DDO} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$**

| Symbol   | Parameter           | Test Conditions                | Minimum | Typical | Maximum        | Units   |
|----------|---------------------|--------------------------------|---------|---------|----------------|---------|
| $V_{IH}$ | Input High Voltage  |                                | 2       |         | $V_{DD} + 0.3$ | V       |
| $V_{IL}$ | Input Low Voltage   |                                | -0.3    |         | 1.3            | V       |
| $I_{IH}$ | Input High Current  | $V_{DD} = V_{IN} = 3.465V$     |         |         | 150            | $\mu A$ |
| $I_{IL}$ | Input Low Current   | $V_{DD} = 3.465V, V_{IN} = 0V$ | -5      |         |                | $\mu A$ |
| $V_{OH}$ | Output High Voltage | Refer to NOTE 1                | 2.6     |         |                | V       |
|          |                     | $I_{OH} = -16mA$               | 2.9     |         |                | V       |
|          |                     | $I_{OH} = -100\mu A$           | 3       |         |                | V       |
| $V_{OL}$ | Output Low Voltage  | Refer to NOTE 1                |         |         | 0.5            | V       |
|          |                     | $I_{OL} = 16mA$                |         |         | 0.25           | V       |
|          |                     | $I_{OL} = 100\mu A$            |         |         | 0.15           | V       |

NOTE 1: Outputs terminated with  $50 \text{ to } V_{DDO}/2$ . See Parameter Measurement Section, "3.3V Output Load Test Circuit".

**TABLE 3D. LVCMOS / LVTTTL DC CHARACTERISTICS,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$** 

| Symbol   | Parameter                   | Test Conditions                   | Minimum | Typical | Maximum        | Units   |
|----------|-----------------------------|-----------------------------------|---------|---------|----------------|---------|
| $V_{IH}$ | Input High Voltage          |                                   | 2       |         | $V_{DD} + 0.3$ | V       |
| $V_{IL}$ | Input Low Voltage           |                                   | -0.3    |         | 1.3            | V       |
| $I_{IH}$ | Input High Current          | $V_{DD} = V_{IN} = 3.465V$        |         |         | 150            | $\mu A$ |
| $I_{IL}$ | Input Low Current           | $V_{DD} = 3.465V$ , $V_{IN} = 0V$ | -5      |         |                | $\mu A$ |
| $V_{OH}$ | Output High Voltage; NOTE 1 |                                   | 2.1     |         |                | V       |
| $V_{OL}$ | Output Low Voltage; NOTE 1  |                                   |         |         | 0.5            | V       |

NOTE 1: Outputs terminated with 50 to  $V_{DDO}/2$ . See Parameter Measurement Section, "3.3V/2.5V Output Load Test Circuit".

**TABLE 4A. AC CHARACTERISTICS,  $V_{DD} = V_{DDO} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$** 

| Symbol    | Parameter                                                                 | Test Conditions                          | Minimum | Typical | Maximum | Units |
|-----------|---------------------------------------------------------------------------|------------------------------------------|---------|---------|---------|-------|
| $f_{MAX}$ | Maximum Output Frequency                                                  |                                          |         |         | 200     | MHz   |
| $tp_{LH}$ | Propagation Delay, Low-to-High; NOTE 1                                    | $f \leq 166MHz$                          | 2.0     |         | 3.3     | ns    |
|           |                                                                           | $166MHz < f \leq 189.5MHz$               | 2.0     |         | 3.4     | ns    |
| tjit      | Buffer Additive Phase Jitter, RMS; refer to Additive Phase Jitter Section | 125MHz, Integration Range: 12kHz – 20MHz |         | 0.173   |         | ps    |
| tsk(o)    | Output Skew; NOTE 2, 4                                                    | $f = 133MHz$                             |         |         | 45      | ps    |
| tsk(pp)   | Part-to-Part Skew; NOTE 3, 4                                              |                                          |         |         | 500     | ps    |
| $t_R$     | Output Rise Time                                                          | 30% to 70%                               | 250     |         | 500     | ps    |
| $t_F$     | Output Fall Time                                                          | 30% to 70%                               | 250     |         | 500     | ps    |
| odc       | Output Duty Cycle                                                         | $f \leq 189.5MHz$                        | 40      |         | 60      | %     |

All parameters measured at  $f_{MAX}$  unless noted otherwise.

NOTE 1: Measured from  $V_{DD}/2$  of the input to  $V_{DDO}/2$  of the output.

NOTE 2: Defined as skew between outputs at the same supply voltage and with equal load conditions.

Measured at  $V_{DDO}/2$ .

NOTE 3: Defined as skew between outputs on different devices operating at the same supply voltages and with equal load conditions. Using the same type of inputs on each device, the outputs are measured at  $V_{DDO}/2$ .

NOTE 4: This parameter is defined in accordance with JEDEC Standard 65.

**TABLE 4B. AC CHARACTERISTICS,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$** 

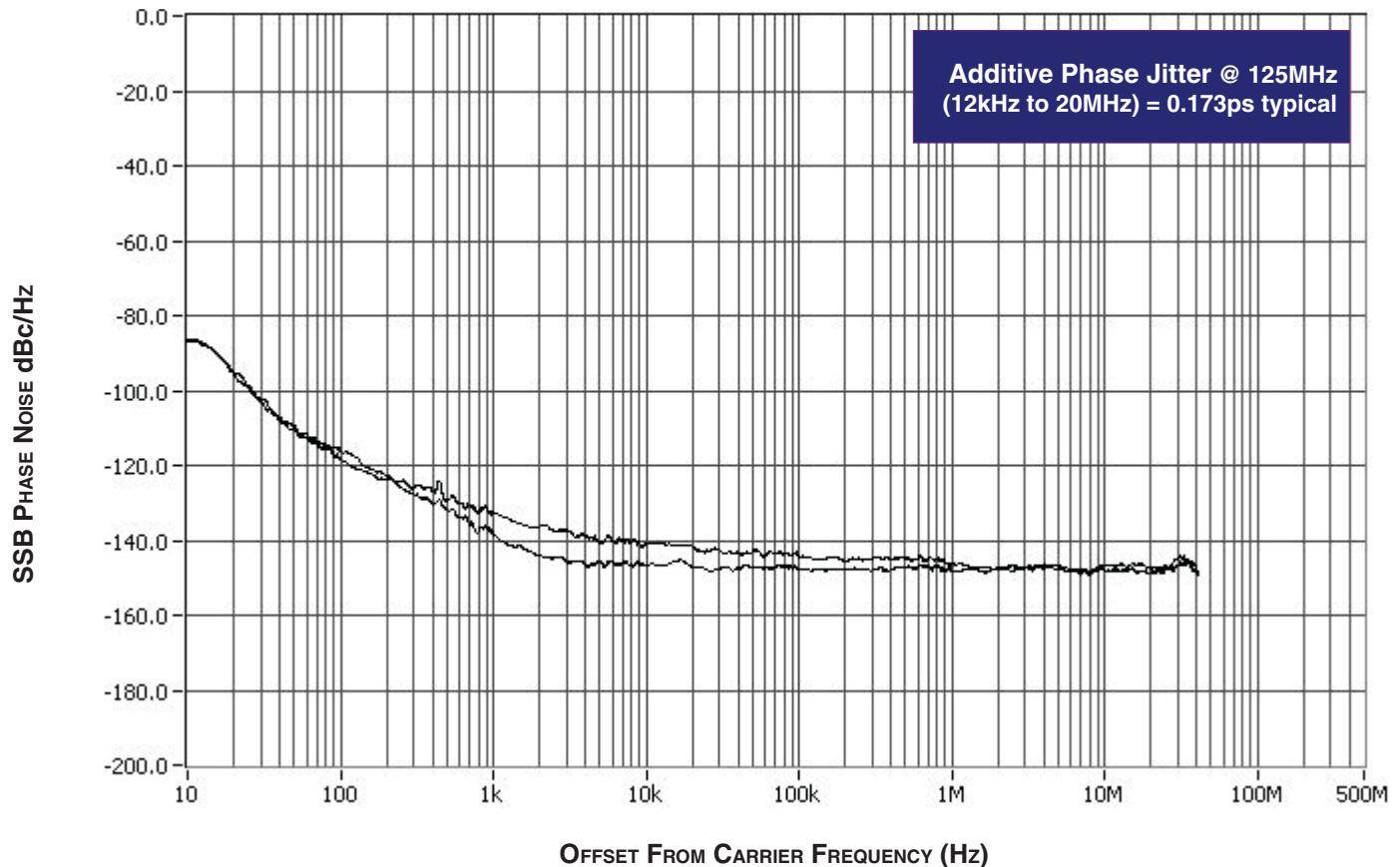
| Symbol    | Parameter                              | Test Conditions            | Minimum | Typical | Maximum | Units |
|-----------|----------------------------------------|----------------------------|---------|---------|---------|-------|
| $f_{MAX}$ | Maximum Output Frequency               |                            |         |         | 189.5   | MHz   |
| $tp_{LH}$ | Propagation Delay, Low-to-High; NOTE 1 | $f \leq 166MHz$            | 2.3     |         | 3.7     | ns    |
|           |                                        | $166MHz < f \leq 189.5MHz$ | 2.15    |         | 3.55    | ns    |
| tsk(o)    | Output Skew; NOTE 2, 4                 | $f = 133MHz$               |         |         | 60      | ps    |
| tsk(pp)   | Part-to-Part Skew; NOTE 3, 4           |                            |         |         | 500     | ps    |
| $t_R$     | Output Rise Time                       | 30% to 70%                 | 250     |         | 500     | ps    |
| $t_F$     | Output Fall Time                       | 30% to 70%                 | 250     |         | 500     | ps    |
| odc       | Output Duty Cycle                      | $f \leq 189.5MHz$          | 40      |         | 60      | %     |

For NOTES, please see above Table 4A.

## ADDITIVE PHASE JITTER

The spectral purity in a band at a specific offset from the fundamental compared to the power of the fundamental is called the **dBc Phase Noise**. This value is normally expressed using a Phase noise plot and is most often the specified plot in many applications. Phase noise is defined as the ratio of the noise power present in a 1Hz band at a specified offset from the fundamental frequency to the power value of the fundamental. This ratio is expressed in decibels

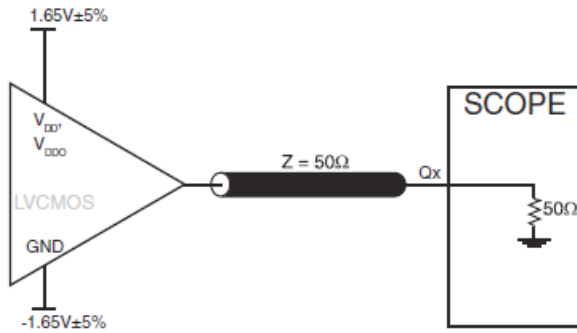
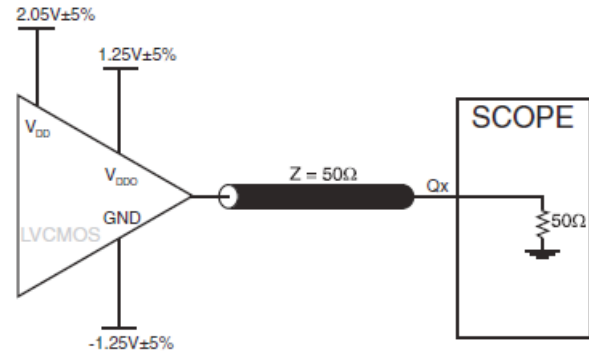
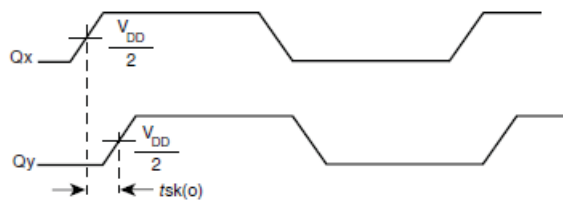
(dBm) or a ratio of the power in the 1Hz band to the power in the fundamental. When the required offset is specified, the phase noise is called a **dBc** value, which simply means dBm at a specified offset from the fundamental. By investigating jitter in the frequency domain, we get a better understanding of its effects on the desired application over the entire time record of the signal. It is mathematically possible to calculate an expected bit error rate given a phase noise plot.

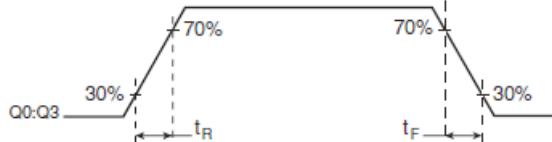
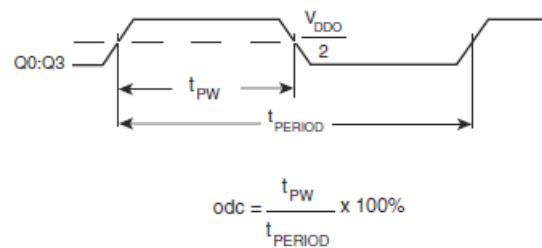
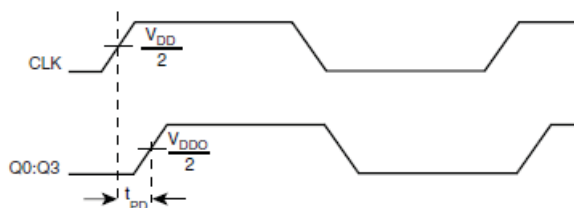


As with most timing specifications, phase noise measurements has issues. The primary issue relates to the limitations of the equipment. Often the noise floor of the equipment is higher than the noise floor

of the device. This is illustrated above. The device meets the noise floor of what is shown, but can actually be lower. The phase noise is dependant on the input source and measurement equipment.

## PARAMETER MEASUREMENT INFORMATION


**3.3V OUTPUT LOAD AC TEST CIRCUIT**

**2.5V OUTPUT LOAD AC TEST CIRCUIT**

**OUTPUT SKEW**

**PART-TO-PART SKEW**

**OUTPUT RISE/FALL TIME**

**OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD**

**PROPAGATION DELAY**

## APPLICATION INFORMATION

### RECOMMENDATIONS FOR UNUSED OUTPUT PINS

#### OUTPUTS:

##### LVC MOS OUTPUT:

All unused LVC MOS output can be left floating. There should be no trace attached.

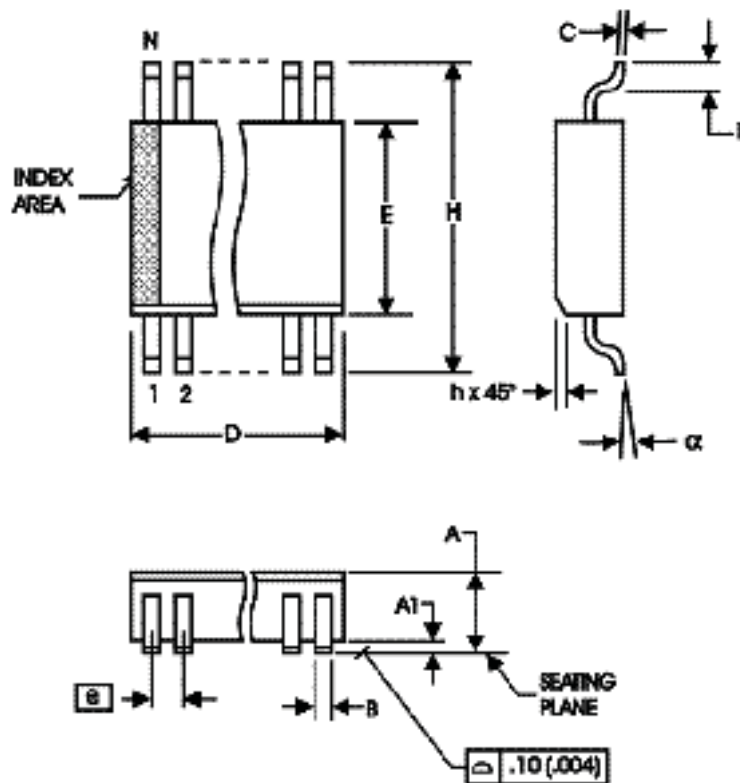
## RELIABILITY INFORMATION

TABLE 5.  $\theta_{JA}$  VS. AIR FLOW TABLE

| $\theta_{JA}$ by Velocity (Linear Feet per Minute)                                                                  |           |           |           |
|---------------------------------------------------------------------------------------------------------------------|-----------|-----------|-----------|
|                                                                                                                     | 0         | 200       | 500       |
| Single-Layer PCB, JEDEC Standard Test Boards                                                                        | 153.3°C/W | 128.5°C/W | 115.5°C/W |
| Multi-Layer PCB, JEDEC Standard Test Boards                                                                         | 112.7°C/W | 103.3°C/W | 97.1°C/W  |
| <b>NOTE:</b> Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs. |           |           |           |

#### TRANSISTOR COUNT

The transistor count for 8304 is: 416

**PACKAGE OUTLINE - SUFFIX M FOR 8 LEAD SOIC**

**TABLE 6. PACKAGE DIMENSIONS - SUFFIX M**

| SYMBOL   | Millimeters |         |
|----------|-------------|---------|
|          | MINIMUM     | MAXIMUM |
| N        | 8           |         |
| A        | 1.35        | 1.75    |
| A1       | 0.10        | 0.25    |
| B        | 0.33        | 0.51    |
| C        | 0.19        | 0.25    |
| D        | 4.80        | 5.00    |
| E        | 3.80        | 4.00    |
| e        | 1.27 BASIC  |         |
| H        | 5.80        | 6.20    |
| h        | 0.25        | 0.50    |
| L        | 0.40        | 1.27    |
| $\alpha$ | 0°          | 8°      |

Reference Document: JEDEC Publication 95, MS-012

**TABLE 7. ORDERING INFORMATION**

| Part/Order Number | Marking  | Package                         | Shipping Packaging | Temperature  |
|-------------------|----------|---------------------------------|--------------------|--------------|
| 8304AMLF          | 8304AMLF | 8 lead "Lead Free" SOIC         | Tube               | 0°C to +70°C |
| 8304AMLFT         | 8304AMLF | 8 lead "Lead Free" SOIC         | Tape and Reel      | 0°C to +70°C |
| 8304AMLN          | 8304AMLN | 8 lead SOIC, Lead Free/Annealed | Tube               | 0°C to +70°C |
| 8304AMLNT         | 8304AMLN | 8 lead SOIC, Lead Free/Annealed | Tape and Reel      | 0°C to +70°C |

## REVISION HISTORY SHEET

| Rev | Table     | Page  | Description of Change                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Date     |
|-----|-----------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| B   | T4A       | 3     | <ul style="list-style-type: none"> <li>Revised <math>tp_{LH}</math> (Propagation Delay) row from 2.3 Min. to 2 Min.</li> <li>Deleted <math>tp_{HL}</math> row.</li> <li>Revised <math>tsk(o)</math> (Output Skew) row from 35 Max. to 80 Max.</li> <li>Revised <math>tsk(pp)</math> (Part-to-Part Skew) row from 200 Max. to 500 Max.</li> <li>General note changed from "...measured at 166MHz..." to "...measured at 150MHz..."</li> </ul>                                                                                                                                                        | 12/4/01  |
|     | T4B       | 4     | <ul style="list-style-type: none"> <li>Revised <math>tp_{LH}</math> (Propagation Delay) row from 2.6 Min. to 2.3 Min.</li> <li>Deleted <math>tp_{HL}</math> row.</li> <li>Revised <math>tsk(o)</math> (Output Skew) row from 35 Max. to 85 Max.</li> <li>Revised <math>tsk(pp)</math> (Part-to-Part Skew) row from 200 Max. to 500 Max.</li> <li>General note changed from "...measured at 166MHz..." to "...measured at 150MHz..."</li> </ul>                                                                                                                                                      |          |
| C   | T4A       | 3     | <ul style="list-style-type: none"> <li>In AC table, revised <math>tsk(o)</math> row from 80ps Max. to 45ps Max.</li> <li>Added <math>f = 133\text{MHz}</math> in Test Conditions column.</li> <li>In odc row, deleted test conditions.</li> </ul>                                                                                                                                                                                                                                                                                                                                                   | 12/11/01 |
|     | T4B       | 4     | <ul style="list-style-type: none"> <li>In notes, changed 150MHz to <math>f_{MAX}</math>.</li> <li>In AC table, revised <math>tsk(o)</math> row from 80ps Max. to 60ps Max.</li> <li>Added <math>f = 133\text{MHz}</math> in Test Conditions column.</li> <li>In odc row, deleted test conditions</li> <li>In notes, changed 150MHz to <math>f_{MAX}</math>.</li> </ul>                                                                                                                                                                                                                              |          |
| C   | T7        | 10    | In the Ordering Information table, Marking column, revised marking to read 8304AM from 8304AM.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 3/11/02  |
| D   | T3B       | 3     | LVC MOS/LVTTL DC Characteristics Table, added $I_{OH}$ and $I_{OL}$ Test Conditions to $V_{OH}$ and $V_{OL}$ rows.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 4/4/02   |
| E   | T1        | 1     | <ul style="list-style-type: none"> <li>Pin Assignment - adjusted dimensions.</li> <li>Pin Descriptions - changed <math>V_{DD}</math> description to Core supply pin.</li> <li>Pin Characteristics - changed <math>C_{IN}</math> max 4pF to typical 4pF.</li> <li>Deleted <math>R_{PULLUP}</math> row.</li> <li>Added 5W min. and 12W max. to <math>R_{OUT}</math>.</li> <li>Power Supply tables - changed <math>V_{DD}</math> parameter from Power to Core.</li> <li>Ordering Information table - added "Lead Free/Annealed" marking.</li> <li>Updated format throughout the data sheet.</li> </ul> | 4/13/04  |
|     | T2        | 2     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |
|     | T3A & T3C | 3 & 4 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |
|     | T7        | 8     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |
| F   | T4A       | 1     | Features section, changed Maximum output frequency bullet from 166MHz to 200MHz.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 6/1/04   |
|     |           | 4     | 3.3V AC Table - changed 166MHz max. to 200MHz max.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |          |
|     |           |       | Added another line for Propagation Delay.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |          |
|     | T4B       | 4     | 3.3V AC Table - changed 166MHz max. to 189.5MHz max.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |          |
|     |           |       | Added another line for Propagation Delay.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |          |
|     |           |       | Changed test conditions in Output Duty Cycle from 166MHz to 189.5MHz                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |          |
| F   | T7        | 8     | Ordering Information table - added "Lead Free" marking.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 9/13/04  |
| G   | T4A       | 1     | Features Section - added Additive Phase Jitter bullet.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 6/11/07  |
|     |           | 4     | 3.3V AC Characteristics Table - added Additive Phase Jitter row.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |          |
|     |           | 5     | Added Additive Phase Jitter plot.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |
|     |           | 7     | Added Recommendations for Unused Output Pins.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |          |
| H   |           | 1     | Pin Assignment - corrected "pullup" label to "pulldown" label.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 10/29/10 |
| H   | T7        | 9     | Ordering Information - removed leaded devices.<br>Updated data sheet format.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 11/19/15 |
| H   |           |       | 8304AMLN - Product Discontinuation Notice - Last time buy expires May 6, 2017.<br>PDN CQ-16-01                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 5/9/16   |

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