

# SN54LS297, SN74LS297 DIGITAL PHASE-LOCKED-LOOP FILTERS

SDLS155 – JANUARY 1981 – REVISED MARCH 1988

- Digital Design Avoids Analog Compensation Errors
- Easily Cascadable for Higher Order Loops
- Useful Frequency from DC to:  
50 MHz Typical (K Clock)  
35 MHz Typical (I/D Clock)

## description

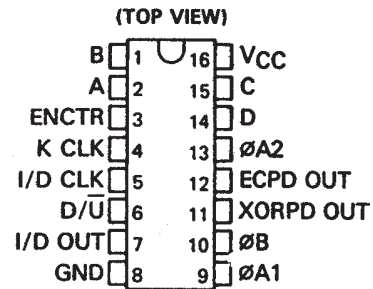
The SN54LS297 and SN74LS297 devices are designed to provide a simple, cost-effective solution to high-accuracy, digital, phase-locked-loop applications. These devices contain all the necessary circuits, with the exception of the divide-by-N counter, to build first order phase-locked loops as described in Figure 1.

Both exclusive-OR (XORPD) and edge-controlled (ECPD) phase detectors are provided for maximum flexibility.

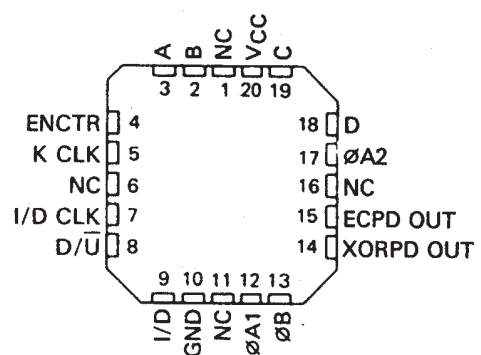
Proper partitioning of the loop function, with many of the building blocks external to the package, makes it easy for the designer to incorporate ripple cancellation or to cascade to higher order phase-locked loops.

The length of the up/down K counter is digitally programmable according to the K counter function table. With A, B, C, and D all low, the K counter is disabled. With A high and B, C, and D low, the K counter is only three stages long, which widens the bandwidth or capture range and shortens the lock time of the loop. When A, B, C, and D are all programmed high, the K counter becomes seventeen stages long, which narrows the bandwidth or capture range and lengthens the lock time. Real-time control of loop bandwidth by manipulating the A through D inputs can maximize the overall performance of the digital phase-locked loop.

SN54LS297 . . . J OR W PACKAGE  
SN74LS297 . . . N PACKAGE



SN54LS297 . . . FK PACKAGE  
(TOP VIEW)



NC—No internal connection

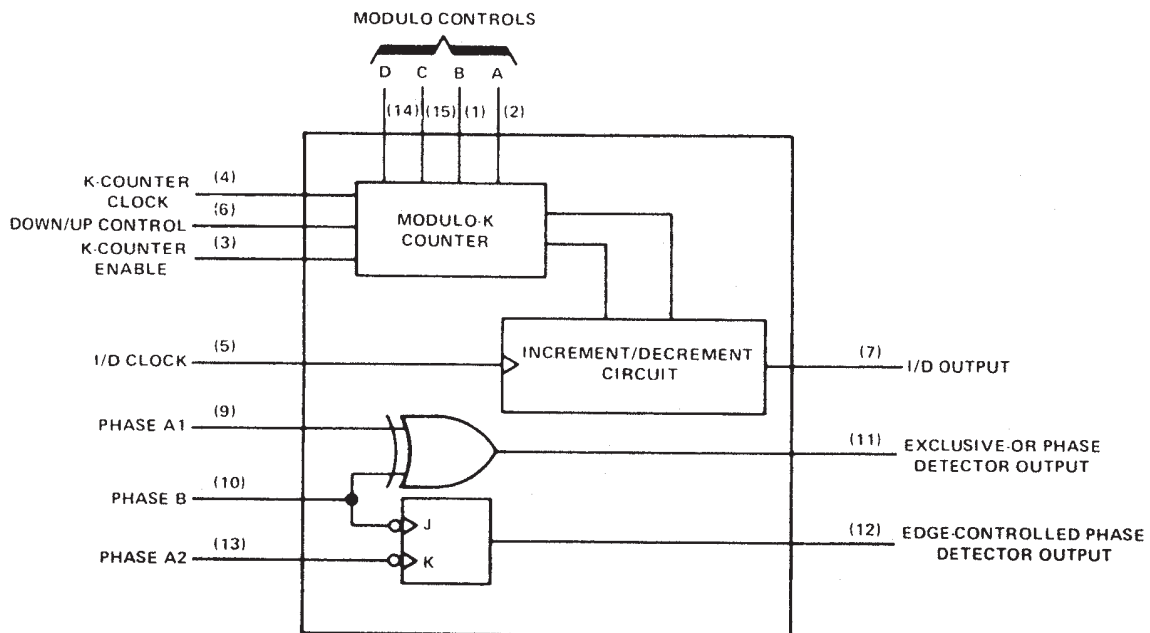


FIGURE 1—SIMPLIFIED BLOCK DIAGRAM

Pin numbers shown are for J, N and W packages.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

TEXAS  
INSTRUMENTS

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 1988, Texas Instruments Incorporated

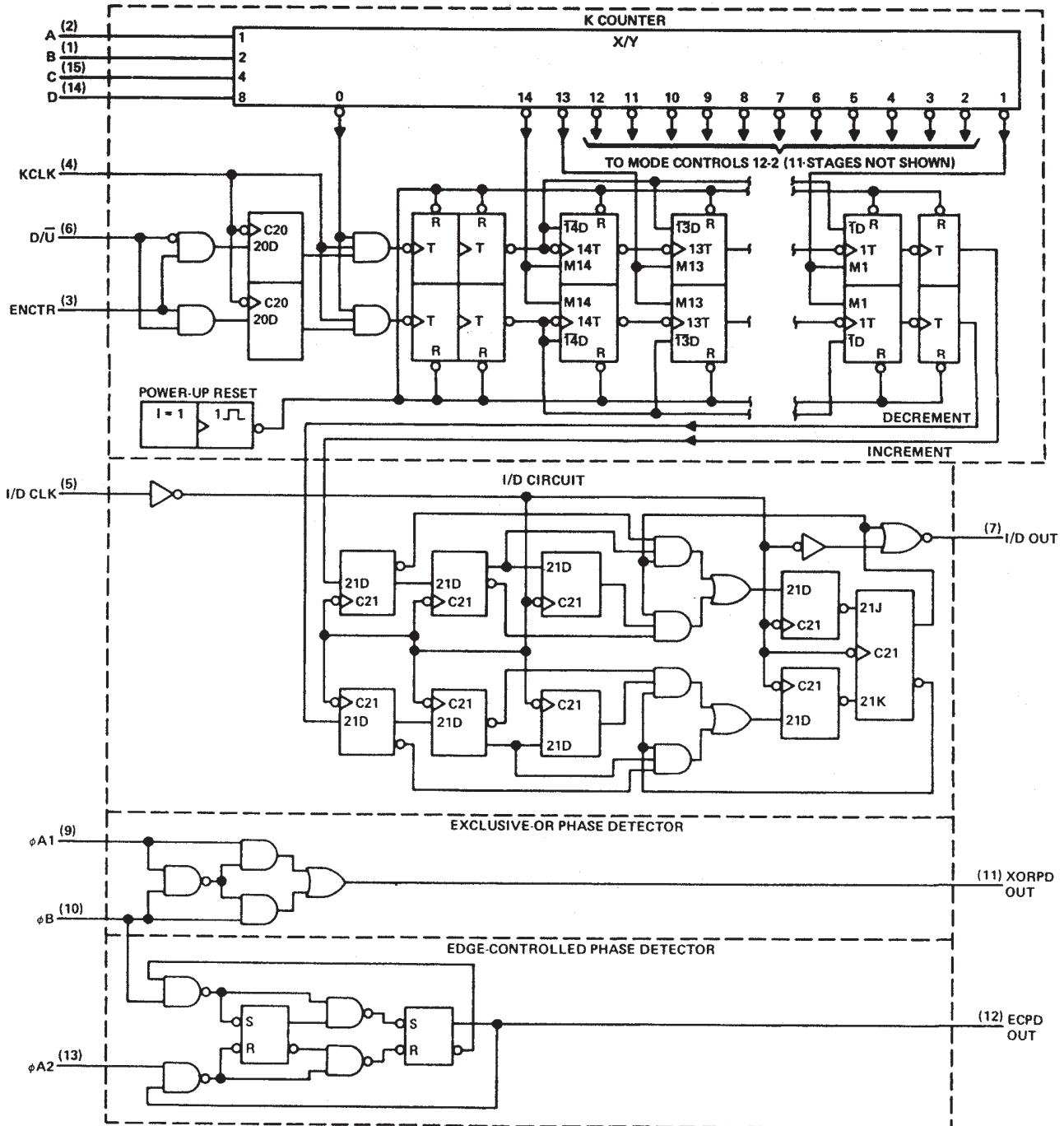
# SN54LS297, SN74LS297 DIGITAL PHASE-LOCKED-LOOP FILTERS

SDLS155 – JANUARY 1981 – REVISED MARCH 1988

## description (continued)

The 'LS297 can perform the classic first-order phase-locked loop function without using analog components. The accuracy of the digital phase-locked loop (DPLL) is not affected by  $V_{CC}$  and temperature variations, but depends solely on accuracies of the K clock, I/D clock, and loop propagation delays. The I/D clock frequency and the divide-by-N modulus will determine the center frequency of the DPLL. The center frequency is defined by the relationship  $f_c = I/D \text{ Clock}/2N \text{ (Hz)}$ .

## logic diagram (positive logic)



Pin numbers shown are for J, N, and W packages.



POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

# SN54LS297, SN74LS297 DIGITAL PHASE-LOCKED-LOOP FILTERS

SDLS155 – JANUARY 1981 – REVISED MARCH 1988

**K COUNTER FUNCTION TABLE  
(DIGITAL CONTROL)**

| D | C | B | A | MODULO (K)      |
|---|---|---|---|-----------------|
| L | L | L | L | Inhibited       |
| L | L | L | H | 2 <sup>3</sup>  |
| L | L | H | L | 2 <sup>4</sup>  |
| L | L | H | H | 2 <sup>5</sup>  |
| L | H | L | L | 2 <sup>6</sup>  |
| L | H | L | H | 2 <sup>7</sup>  |
| L | H | H | L | 2 <sup>8</sup>  |
| L | H | H | H | 2 <sup>9</sup>  |
| H | L | L | L | 2 <sup>10</sup> |
| H | L | L | H | 2 <sup>11</sup> |
| H | L | H | L | 2 <sup>12</sup> |
| H | L | H | H | 2 <sup>13</sup> |
| H | H | L | L | 2 <sup>14</sup> |
| H | H | L | H | 2 <sup>15</sup> |
| H | H | H | L | 2 <sup>16</sup> |
| H | H | H | H | 2 <sup>17</sup> |

**FUNCTION TABLE  
EXCLUSIVE-OR PHASE DETECTOR**

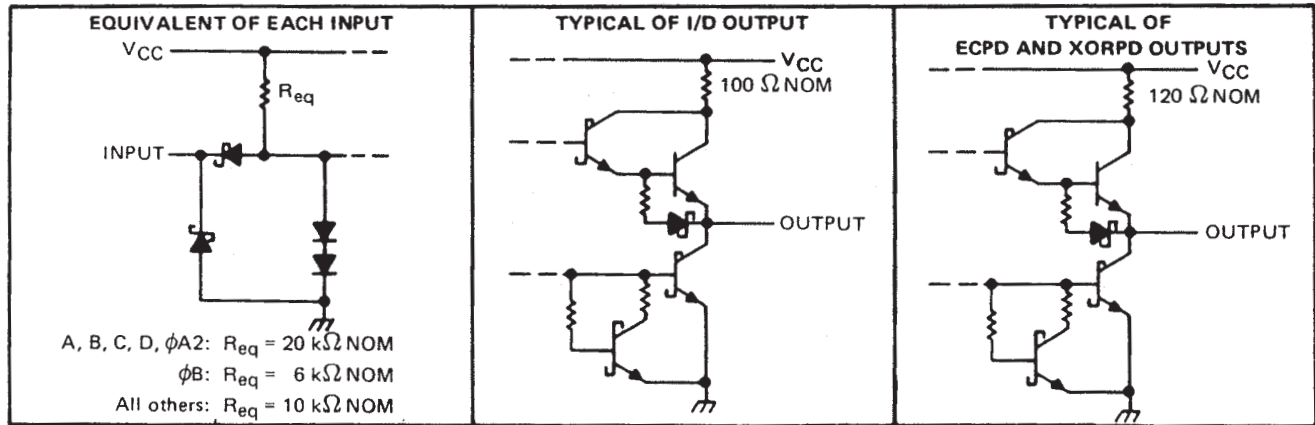
| $\phi A1$ | $\phi B$ | XORPD OUT |
|-----------|----------|-----------|
| L         | L        | L         |
| L         | H        | H         |
| H         | L        | H         |
| H         | H        | L         |

**FUNCTION TABLE  
EDGE-CONTROLLED PHASE DETECTOR**

| $\phi A2$ | $\phi B$ | ECPD OUT  |
|-----------|----------|-----------|
| H or L    | ↓        | H         |
| ↓         | H or L   | L         |
| H or L    | ↑        | No change |
| ↑         | H or L   | No change |

H = steady-state high level  
L = steady-state low level  
↓ = transition from high to low  
↑ = transition from low to high

## schematics of inputs and outputs



## operation

The phase detector generates an error signal waveform that, at zero phase error, is a 50% duty cycle square wave. At the limits of linear operation, the phase detector output will be either high or low all of the time, depending on the direction of the phase error ( $\phi_{in} - \phi_{out}$ ). Within these limits, the phase detector output varies linearly with the input phase error according to the gain  $k_D$ , which is expressed in terms of phase detector output per cycle of phase error. The phase detector output can be defined to vary between  $\pm 1$  according to the relation:

$$\text{PD Output} = \frac{\% \text{ high} - \% \text{ low}}{100} \quad (1)$$

The output of the phase detector will be  $k_D \phi_e$ , where the phase error  $\phi_e = \phi_{in} - \phi_{out}$ .

# SN54LS297, SN74LS297 DIGITAL PHASE-LOCKED-LOOP FILTERS

SDLS155 – JANUARY 1981 – REVISED MARCH 1988

Exclusive-OR phase detectors (XORPD) and edge-controlled phase detectors (ECPD) are commonly used digital types. The ECPD is more complex than the XORPD logic function, but can be described generally as a circuit that changes states on one of the transitions of its inputs.  $k_d$  for an XORPD is 4 because its output remains high (PD output = 1) for a phase error of 1/4 cycle. Similarly,  $k_d$  for the ECPD is 2 since its output remains high for a phase error of 1/2 cycle. The type of phase detector will determine the zero-phase-error point, i.e., the phase separation of the phase detector inputs for  $\phi_e$  defined to be zero. For the basic DPLL system of Figure 2,  $\phi_e = 0$  when the phase detector output is a square wave. The XORPD inputs are 1/4 cycle out of phase for zero phase error. For the ECPD,  $\phi_e = 0$  when the inputs are 1/2 cycle out of phase.

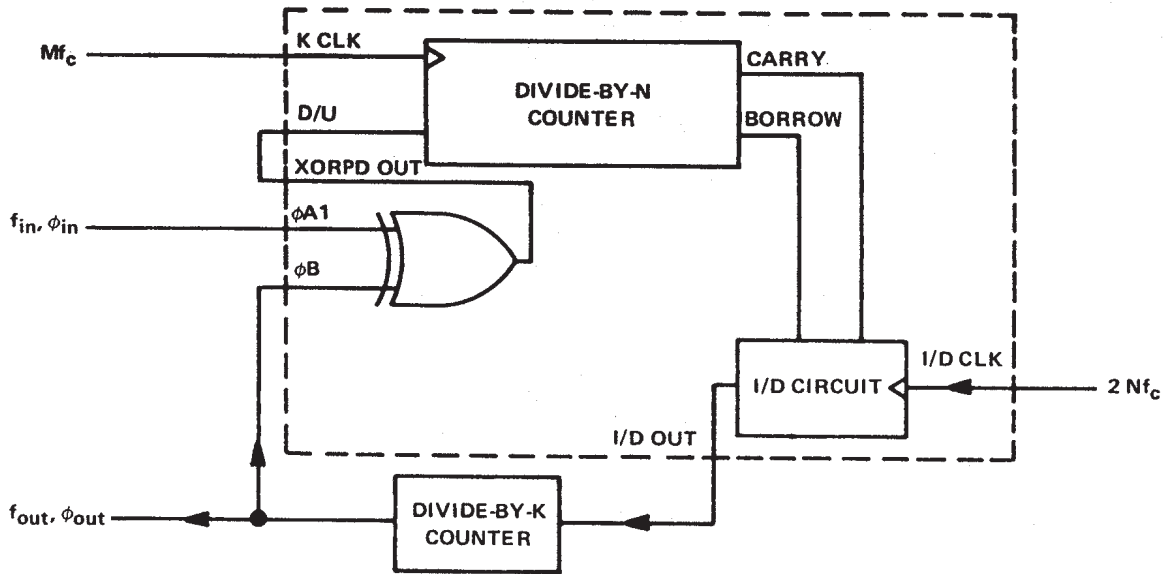


FIGURE 2—DPLL USING EXCLUSIVE-OR PHASE DETECTION

The phase detector output controls the up/down input to the K counter. The counter is clocked by input frequency  $Mf_c$ , which is a multiple  $M$  of the loop center frequency  $f_c$ . When the K counter recycles up, it generates a carry pulse. Recycling while counting down generates a borrow pulse. If the carry and borrow outputs are conceptually combined into one output that is positive for a carry and negative for a borrow, and if the K counter is considered as a frequency divider with the ratio  $Mf_c/K$ , the output of the K counter will equal the input frequency multiplied by the division ratio. Thus the output from the K counter is  $(k_d \phi_e Mf_c)/K$ .

The carry and borrow pulses go to the increment/decrement (I/D) circuit, which, in the absence of any carry or borrow pulse, has an output that is 1/2 of the input clock I/D CLK. The input clock is just a multiple,  $2N$ , of the loop center frequency. In response to a carry or borrow pulse, the I/D circuit will either add or delete a pulse at I/D OUT. Thus the output of the I/D circuit will be  $Nf_c + (k_d \phi_e Mf_c)/2K$ .

The output of the N counter (or the output of the phase-locked loop) is thus:

$$f_o = f_c + (k_d \phi_e Mf_c)/2KN$$

If this result is compared to the equation for a first-order analog phase-locked loop, the digital equivalent of the gain of the VCO is just  $Mf_c/2KN$  or  $f_c/K$  for  $M = 2N$ .

Thus the simple first-order phase-locked loop with an adjustable K counter is the equivalent of an analog phase-locked loop with a programmable VCO gain.

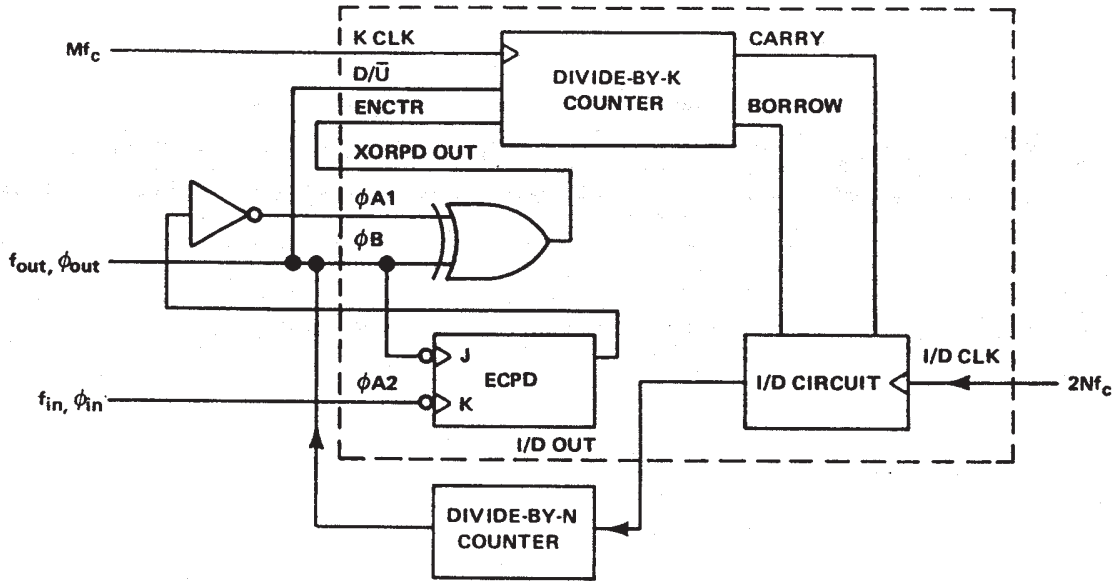


FIGURE 3—DPLL USING BOTH PHASE DETECTORS IN A RIPPLE-CANCELLATION SCHEME

absolute maximum rating over operating free-air temperature range (unless otherwise noted)

|   |                |
|---|----------------|
| Supply voltage, $V_{CC}$ (see Note 1) .....           | 7 V            |
| Input voltage .....                                   | 7 V            |
| Operating free-air temperature range: SN54LS297 ..... | -55°C to 125°C |
| SN74LS297 .....                                       | 0°C to 70°C    |
| Storage temperature range .....                       | -65°C to 150°C |

NOTE 1: Voltage values are with respect to network ground terminal.

recommended operating conditions

|                |                                  | SN54LS297            |     |      | SN74LS297 |     |         | UNIT |
|----------------|----------------------------------|----------------------|-----|------|-----------|-----|---------|------|
|                |                                  | MIN                  | NOM | MAX  | MIN       | NOM | MAX     |      |
| $V_{CC}$       | Supply voltage                   | 4.5                  | 5   | 5.5  | 4.75      | 5   | 5.25    | V    |
| $I_{OH}$       | High-level output current        | I/D OUT              |     | -1.2 | -1.2      |     | mA      |      |
|                |                                  | EXOR, ECPD           |     | -400 | -400      |     | $\mu$ A |      |
| $I_{OL}$       | Low-level output current         | I/D OUT              |     | 12   | 24        |     | mA      |      |
|                |                                  | XOR, ECPD            |     | 4    | 8         |     | mA      |      |
| $f_{clock}$    | Clock frequency                  | K Clock              |     | 0    | 32        | 0   | 32      | MHz  |
|                |                                  | I/D Clock            |     | 0    | 16        | 0   | 16      | MHz  |
| $t_w$          | Width of clock input pulse       | K Clock              |     | 16   | 16        |     | ns      |      |
|                |                                  | I/D Clock            |     | 33   | 33        |     | ns      |      |
| $t_{su, to K}$ | Setup time to K Clock $\dagger$  | U/ $\bar{D}$ , ENCTR |     | 30   | 30        |     | ns      |      |
| $t_h$          | Hold time from K Clock $\dagger$ | U/ $\bar{D}$ , ENCTR |     | 0    | 0         |     | ns      |      |
| $T_A$          | Operating free-air temperature   | -55                  | 125 | 0    | 70        | °C  |         |      |

# SN54LS297, SN74LS297 DIGITAL PHASE-LOCKED-LOOP FILTERS

SDLS155 – JANUARY 1981 – REVISED MARCH 1988

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

| PARAMETER       |  | TEST CONDITIONS†   | SN54LS297   |                         |      | SN74LS297 |      |      | UNIT |
|-----------------|--|--|---|-------------------------|------|-----------|------|------|------|
|                 |  |  | MIN   | TYP‡                    | MAX  | MIN       | TYP‡ | MAX  |      |
| V <sub>IH</sub> | High-level input voltage               |  | 2   |                         |      | 2         |      |      | V    |
| V <sub>IL</sub> | Low-level input voltage                |  |   | 0.7                     |      |           | 0.8  |      | V    |
| V <sub>IK</sub> | Input clamp voltage                    | V <sub>CC</sub> = MIN, I <sub>I</sub> = -18 mA               |   |                         | -1.5 |           |      | -1.5 | V    |
| V <sub>OH</sub> | High-level output voltage              | I/D OUT  | V <sub>CC</sub> = MIN, V <sub>IH</sub> = 2 V, I <sub>OH</sub> = MAX                 | 2.4                     |      | 2.4       |      |      | V    |
|                 |  | Others   | V <sub>IL</sub> = V <sub>IL max</sub> , I <sub>OH</sub> = MAX                       | 2.5                     |      | 2.7       |      |      |      |
| V <sub>OL</sub> | Low-level output voltage               | I/D OUT  | V <sub>CC</sub> = MIN, V <sub>IH</sub> = 2 V, V <sub>IL</sub> = V <sub>IL max</sub> | I <sub>OL</sub> = 12 mA | 0.25 | 0.4       | 0.25 | 0.4  | V    |
|                 |  |  |   | I <sub>OL</sub> = 24 mA |      |           | 0.35 | 0.5  |      |
|                 |  | Others   |   | I <sub>OL</sub> = 4 mA  | 0.25 | 0.4       | 0.25 | 0.4  |      |
|                 |  |  |   | I <sub>OL</sub> = 8 mA  |      |           | 0.35 | 0.5  |      |
| I <sub>I</sub>  | Input current at maximum input voltage | V <sub>CC</sub> = MAX, V <sub>I</sub> = 7 V                  |   |                         | 0.1  |           | 0.1  | mA   |      |
| I <sub>IH</sub> | High-level input current               | U/D, EN, φA1   | V <sub>CC</sub> = MAX, V <sub>I</sub> = 2.7 V                                       |                         |      | 40        |      | 40   | μA   |
|                 |  | φB   |   |                         |      | 60        |      | 60   |      |
|                 |  | All others   |   |                         |      | 20        |      | 20   |      |
| I <sub>IL</sub> | Low-level input current                | U/D, EN, φA1   | V <sub>CC</sub> = MAX, V <sub>I</sub> = 0.4 V                                       |                         |      | -0.8      |      | -0.8 | mA   |
|                 |  | φB   |   |                         |      | -1.2      |      | -1.2 |      |
|                 |  | All others   |   |                         |      | -0.4      |      | -0.4 |      |
| I <sub>OS</sub> | Short-circuit output current §         | I/D OUT  | V <sub>CC</sub> = MAX   | -30                     | -130 | -30       | -130 | mA   |      |
|                 |  | Others   |   | -20                     | -100 | -20       | -100 |      |      |
| I <sub>CC</sub> | Supply current                         | V <sub>CC</sub> = MAX, All inputs grounded, All outputs open | 75  | 120                     |      | 75        | 120  | mA   |      |

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

‡ All typical values are of V<sub>CC</sub> = 5 V, T<sub>A</sub> = 25°C.

§ Not more than one output should be shorted at a time and the duration of the short-circuit should not exceed one second.

switching characteristics, V<sub>CC</sub> = 5 V, T<sub>A</sub> = 25°C

| PARAMETER¶       | FROM (INPUT) |                  | TO (OUTPUT) | TEST CONDITIONS  | MIN | TYP | MAX | UNIT |
|------------------|--------------|------------------|-------------|--|-----|-----|-----|------|
| f <sub>max</sub> | KCLK         |                  | I/D OUT     | R <sub>L</sub> = 667 Ω,<br>C <sub>L</sub> = 45 pF,<br>See Note 2 | 32  | 50  |     | MHz  |
|                  | I/D CLK      |                  | I/D OUT     |  | 16  | 35  |     |      |
| t <sub>PLH</sub> | I/D CLK ↑    |                  | I/D OUT     | See Note 2   |     | 15  | 25  | ns   |
| t <sub>PHL</sub> | I/D CLK ↑    |                  | I/D OUT     |  |     | 22  | 35  | ns   |
| t <sub>PLH</sub> | φA1 or φB    | Other input low  | XOR OUT     | R <sub>L</sub> = 2 k Ω,<br>C <sub>L</sub> = 45 pF,<br>See Note 2 |     | 10  | 15  | ns   |
|                  | φA1 or φB    | Other input high | XOR OUT     |  |     | 17  | 25  |      |
| t <sub>PHL</sub> | φA1 or φB    | Other input low  | XOR OUT     |  |     | 15  | 25  | ns   |
|                  | φA1 or φB    | Other input high | XOR OUT     |  |     | 17  | 25  |      |
| t <sub>PLH</sub> | φB ↓         |                  | ECPD OUT    |  |     | 20  | 30  | ns   |
| t <sub>PHL</sub> | φA2 ↓        |                  | ECPD OUT    |  |     | 20  | 30  | ns   |

¶ t<sub>PLH</sub> = propagation delay time, low-to-high-level output

t<sub>PHL</sub> = propagation delay time, high-to-low-level output

NOTE 2: Load circuits and voltage waveforms are shown in Section 1.



POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2) | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|-------------------------|----------------------|--------------|-------------------------|---------|
| SN74LS297N       | ACTIVE        | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)  | CU NIPDAU               | N / A for Pkg Type   | 0 to 70      | SN74LS297N              | Samples |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.





N (R-PDIP-T\*\*)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
  - The 20 pin end lead shoulder width is a vendor option, either half or full width.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### Products

|                              |  |
|------------------------------|--|
| Audio                        | <a href="http://www.ti.com/audio">www.ti.com/audio</a>                               |
| Amplifiers                   | <a href="http://amplifier.ti.com">amplifier.ti.com</a>                               |
| Data Converters              | <a href="http://dataconverter.ti.com">dataconverter.ti.com</a>                       |
| DLP® Products                | <a href="http://www.dlp.com">www.dlp.com</a>   |
| DSP                          | <a href="http://dsp.ti.com">dsp.ti.com</a>   |
| Clocks and Timers            | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>                             |
| Interface                    | <a href="http://interface.ti.com">interface.ti.com</a>                               |
| Logic                        | <a href="http://logic.ti.com">logic.ti.com</a>                                       |
| Power Mgmt                   | <a href="http://power.ti.com">power.ti.com</a>                                       |
| Microcontrollers             | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a>                   |
| RFID                         | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>                                 |
| OMAP Applications Processors | <a href="http://www.ti.com/omap">www.ti.com/omap</a>                                 |
| Wireless Connectivity        | <a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a> |

### Applications

|                               |  |
|-------------------------------|--|
| Automotive and Transportation | <a href="http://www.ti.com/automotive">www.ti.com/automotive</a>                         |
| Communications and Telecom    | <a href="http://www.ti.com/communications">www.ti.com/communications</a>                 |
| Computers and Peripherals     | <a href="http://www.ti.com/computers">www.ti.com/computers</a>                           |
| Consumer Electronics          | <a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>                   |
| Energy and Lighting           | <a href="http://www.ti.com/energy">www.ti.com/energy</a>                                 |
| Industrial                    | <a href="http://www.ti.com/industrial">www.ti.com/industrial</a>                         |
| Medical                       | <a href="http://www.ti.com/medical">www.ti.com/medical</a>                               |
| Security                      | <a href="http://www.ti.com/security">www.ti.com/security</a>                             |
| Space, Avionics and Defense   | <a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a> |
| Video and Imaging             | <a href="http://www.ti.com/video">www.ti.com/video</a>                                   |

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)