LM1391 Phase-Locked Loop

General Description
The LM1391 integrated circuit has been designed primarily for use in the horizontal section of TV receivers, but may find use in other low frequency signal processing applications. It includes a stable VCO, linear pulse phase detector, and variable duty cycle output driver.

Features
- Internal active regulator for improved supply rejection
- Uncommitted collector of output transistor
- Output transistor with low saturation and high voltage swing
- APC of the oscillator with a synchronizing signal
- DC controlled output duty cycle
- ±300 Hz typical pull-in
- Linear balanced phase detector
- Low thermal frequency drift
- Small static phase error
- Adjustable DC loop gain

Schematic Diagram

(*) Pin 4 Base of Q16 (LM1391) for use with (+) flyback pulse
Absolute Maximum Ratings
If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

- Supply Current: 40 mA DC
- Output Voltage: 40 V DC
- Output Current: 30 mA DC
- Sync Input Voltage (Pin 3): 5.0 Vp-p
- Flyback Input Voltage (Pin 4): 5.0 Vp-p
- Power Dissipation (Package Limitation): 1000 mW
- Operating Temperature Range (Ambient): 0°C to +70°C
- Storage Temperature Range: -65°C to +150°C
- Lead Temperature (Soldering, 10 sec.): 260°C

Electrical Characteristics $T_A = 25^\circ$C (see test circuit, all switches in position 1)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulated Voltage (Pin 6)</td>
<td>$I_6 = 22$ mA DC</td>
<td>8.0</td>
<td>8.6</td>
<td>9.2</td>
<td>V DC</td>
</tr>
<tr>
<td>Supply Current (Pin 6)</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td>mA DC</td>
</tr>
<tr>
<td>Collector-Emitter Saturation Voltage of Output Transistor (Pin 1)</td>
<td>$I_{C1} = 20$ mA</td>
<td>0.30</td>
<td>0.40</td>
<td></td>
<td>V DC</td>
</tr>
<tr>
<td>Pin 4 Voltage</td>
<td></td>
<td>2.0</td>
<td></td>
<td></td>
<td>V DC</td>
</tr>
<tr>
<td>Oscillator Pull-in Range</td>
<td>Adjust $R_H$</td>
<td>±300</td>
<td></td>
<td></td>
<td>Hz</td>
</tr>
<tr>
<td>Oscillator Hold-in Range</td>
<td>Adjust $R_H$</td>
<td>±900</td>
<td></td>
<td></td>
<td>Hz</td>
</tr>
<tr>
<td>Static Phase Error</td>
<td>$\Delta f = 300$ Hz</td>
<td>0.5</td>
<td></td>
<td></td>
<td>$\mu$s</td>
</tr>
<tr>
<td>Free-running Frequency Supply Dependence</td>
<td>$S1$ in position 2</td>
<td>±3.0</td>
<td></td>
<td></td>
<td>Hz/V DC</td>
</tr>
<tr>
<td>Phase Detector Leakage (Pin 5)</td>
<td>All switches in position 2</td>
<td>±1.0</td>
<td></td>
<td></td>
<td>$\mu$A</td>
</tr>
<tr>
<td>Sync Input Voltage (Pin 3)</td>
<td></td>
<td>2.0</td>
<td>5.0</td>
<td></td>
<td>Vp-p</td>
</tr>
<tr>
<td>Sawtooth Input Voltage (Pin 4)</td>
<td></td>
<td>1.0</td>
<td>3.0</td>
<td></td>
<td>Vp-p</td>
</tr>
<tr>
<td>Maximum Oscillator Frequency Dependence</td>
<td></td>
<td>500</td>
<td></td>
<td></td>
<td>kHz</td>
</tr>
</tbody>
</table>

Note: For operation in ambient temperatures above 25°C, the device must be derated based on a 150°C maximum junction temperature and a thermal resistance of 120°C/W junction to ambient.

Typical Performance Characteristics

[Graphs of Frequency Drift vs Warm-Up Time, Frequency vs Temperature, Output Duty Cycle vs $V_M$ Voltage]
Application Information

The following equations may be considered when using the LM1391 in a particular application.

\[ R_{201} = R_{301} = \frac{V_{CC} - 8.6}{0.02} \]
\[ f_0 = \frac{1}{0.5 R_0 C_0} \text{Hz} \quad 1.5k \leq R_0 < 51k \]
\[ R_{204} = 10 R_0 \]
\[ C_{203} - C_{204} = \frac{1}{600 f_0(\text{Hz})} \]

DC Loop Gain: \[ \mu \beta = 3.2 \times 10^{-5} R_0 f_0 \text{Hz/ rad} \]
Noise Bandwidth: \[ f_{mb} = \frac{1 + 2\pi R_x C_x \mu \beta}{4 R_Y C_C} \text{Hz} \]
Damping Factor: \[ K = \frac{\pi R_x^2 C_x \mu \beta}{2 R_Y} \]

Test Circuit

Connection Diagram

Dual-In-Line Package

Order Number LM1391N
See NS Package Number N08E
Typical Applications

**FIGURE 1. TV Horizontal Processor**

**FIGURE 2. General Purpose Phase-Lock Loop**
(See Applications Information)
FIGURE 3. Variable Duty Cycle Oscillator
(See Applications Information)
LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.

2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.