

## Features

- Single FHD Video Filter Support HDCVI-1080p /1080i/720p, VGA/SVGA/XGA
- Optimized 6th-order Butterworth Video reconstruction filter
- Support Multiple Input Biasing:
  - Provide 80-mV Level-Shift when DC-Coupled
  - Transparent Input Clamping when AC-Coupled
  - Support External DC Biasing when AC-Coupled
- Very Low Quiescent Current: 11.5 mA(at 3.3V, Typical)
- 6dB Gain(2V/V), Rail TO Rail Output
- AC- or DC-Coupled Output Driving Dual Video Loads (75Ω)
- Wide Power Supply: +3.0V to +5.5V Single Supply
- Robust ESD Protection:
  - Robust 8kV – HBM and 2kV – CDM ESD Rating
- Green Product, SOT23-6 Package

## Applications

- Video Signal Amplification
- Set-Top Box Video Driver
- PVR、DVD Player Video Buffer
- Video Buffer for Portable or USB-Powered Video Devices
- HDTV

## Related Resources

- AN-1201: Application notes of TPF1xx

## Description

TPF141N is a specially designed for consumer applications, high-performance, low-cost video reconstruction filter, it combine excellent video performance and low power consumption perfectly. It incorporates one Full high-definition (FHD) filter channels. The filter feature sixth-order Butterworth characteristics that are useful as digital-to-analog converter (DAC) reconstruction filters or as analog-to-digital converter (ADC) anti-aliasing filters. The FHD filters can be bypassed to support filters. The FHD filters can be bypassed to support 1080p60 video or up to quad extended graphics array (QXGA) RGB video.

As part of the TPF141N flexibility, the input can be configured for ac- or dc-coupled inputs. The 84-mV output level shift allows for a full sync dynamic range at the output with 0-V input. The ac-coupled modes include a transparent sync-tip clamp option for Y', and G'B'R' signals. AC- coupled biasing for C'/P'B/P'R channels can easily be achieved by adding an external resistor to VS+.

The TPF141N rail-to-rail output stage with 6-dB gain allows for both ac and dc line driving. The ability to drive two lines, or 75-Ω loads, allows for maximum flexibility as a video line driver. The 11.5-mA total quiescent current at 3.3 V makes it an excellent choice for power-sensitive video applications.

TPF141N is available in SOT23-6 package. Its operation temperature range is from -40°C to +85°C.

## Function block or application schematic

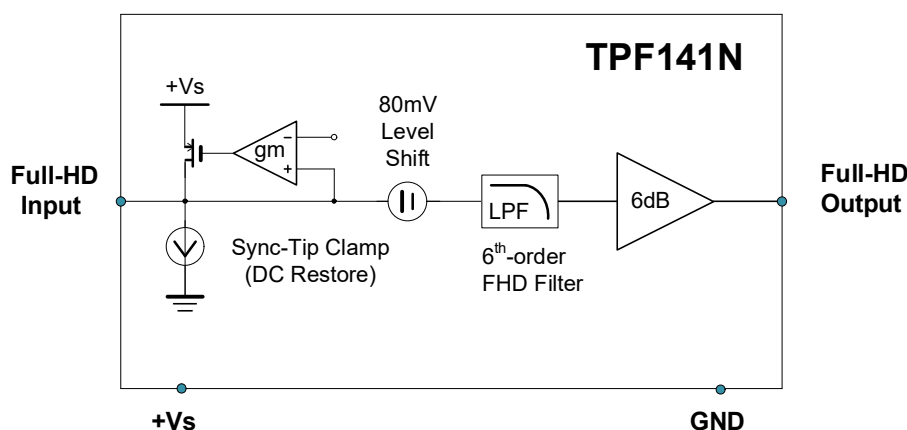


Figure 1.

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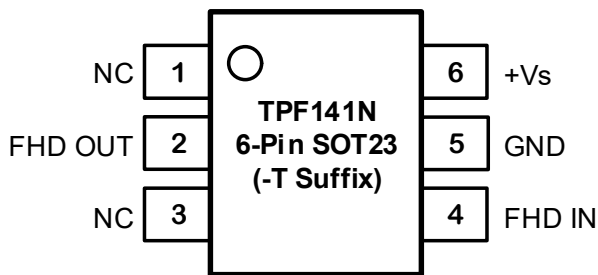
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## Revision History

Table 1.

| Date      | Revision | Notes           |
|-----------|----------|-----------------|
| 2017/9/15 | Rev.A.0  | Initial Version |

## Pin Configuration and Functions



| Pin Name | Pin Function          |
|----------|-----------------------|
| FHD IN   | Full-HD video input   |
| +Vs      | Positive Power Supply |
| GND      | Ground                |
| FHD OUT  | Full-HD video output  |
| NC       | No Connection         |

Table 2.

Figure 2.

## Order Information

Table 3.

| Order Number | Operating Temperature Range | Package | Marking Information | MSL                 | Transport Media, Quantity |
|--------------|-----------------------------|---------|---------------------|---------------------|---------------------------|
| TPF141N-TR   | -40 to 85°C                 | SOT23-6 | 41N                 | Tape and Reel, 3000 | TPF141N-TR                |

## Absolute Maximum Ratings\*

Table 4.

| Parameters               |                                     | Value                    | Unit |
|--------------------------|-------------------------------------|--------------------------|------|
| Power Supply, VDD to GND |                                     | 6.0                      | V    |
| VIN                      | Input Voltage                       | VDD + 0.3V to GND - 0.3V |      |
| Io                       | Output Current                      | 65                       | mA   |
| Tj                       | Maximum Junction Temperature        | 150                      | °C   |
| Ta                       | Operating Temperature Range         | -45 to 85                | °C   |
| Tstg                     | Storage Temperature Range           | -65 to 150               | °C   |
| Tl                       | Lead Temperature (Soldering 10 sec) | 300                      | °C   |

\* Note: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

(1) This data was taken with the JEDEC low effective thermal conductivity test board.

(2) This data was taken with the JEDEC standard multilayer test boards.

## ESD, Electrostatic Discharge Protection

**Table 5.**

| Symbol | Parameter                | Condition                  | Minimum Level | Unit |
|--------|--------------------------|----------------------------|---------------|------|
| HBM    | Human Body Model ESD     | MIL-STD-883H Method 3015.8 | 8             | kV   |
| CDM    | Charged Device Model ESD | JEDEC-EIA/JESD22-C101E     | 2             | kV   |

## Electrical Characteristics

All test condition is  $V_{DD} = 3.3V$ ,  $T_A = +25^{\circ}C$ ,  $R_L = 150\Omega$  to GND, unless otherwise noted.

**Table 7.**

| Symbol                                 | Parameter                    | Conditions  | Min  | Typ  | Max   | Unit       |
|--|------------------------------|---|------|------|-------|------------|
| <b>Input Electrical Specifications</b> |                              |   |      |      |       |            |
| $V_{DD}$                               | Supply Voltage Range         |   | 3.0  |      | 5.5   | V          |
| $I_{CC}$                               | Quiescent current ( $I_Q$ )  | $V_{DD} = 3.3V$ , $V_{IN} = 500mV$ , no load          |      | 11.5 | 14.27 | mA         |
|  |                              | $V_{DD} = 5.0V$ , $V_{IN} = 500mV$ , no load          |      | 15   | 18.53 | mA         |
| $V_{OLS}$                              | Output Level Shift Voltage   | $V_{IN} = 0V$ , no load, input referred               | 53   | 80   | 124   | mV         |
| $I_{CLAMP-DOWN}$                       | Clamp Discharge Current      | $V_{IN}=300mV$ , measure current                      | 1.1  | 2.0  | 5.3   | $\mu A$    |
| $I_{CLAMP-UP}$                         | Clamp Charge Current         | $V_Y = -0.2V$   | -1.5 | -1.7 |       | mA         |
| $V_{CLAMP}$                            | Input Voltage Clamp          | $I_Y = -100\mu A$                                     | -40  | 0    | +40   | mV         |
| AV                                     | Voltage Gain                 | $V_{IN}=0.5V, 1V$ or $2V$<br>$R_L=150\Omega$ to GND   | 5.9  | 6.01 | 6.03  | dB         |
| PSRR                                   | Power Supply Rejection Ratio | $\Delta V_{DD} = 3.3V$ to $3.6V$                      |      | 61   |       | dB         |
|  |                              | $\Delta V_{DD} = 5.0V$ to $5.5V$ , 50Hz               |      | 67   |       | dB         |
| $V_{OL}$                               | Output Voltage Low Swing     | $V_{IN} = -0.3V$ , $R_L = 75\Omega$                   |      | 0.05 | 0.1   | V          |
| $V_{OH}$                               | Output Voltage High Swing    | $V_{IN} = 3V$ , $R_L = 75\Omega$ to GND (dual load)   | 3    | 3.05 | 3.1   | V          |
| $I_{SC}$                               | Short-circuit current        | $V_{IN} = 2V$ , $10\Omega$ , output to GND            | 65   |      |       | mA         |
|  |                              | $V_{IN}=0.1V$ , output short to $V_{DD}$              | 65   |      |       | mA         |
| <b>AC Electrical Specifications</b>    |                              |   |      |      |       |            |
| $f_{-1dB}$                             | -1dB Bandwidth               | $R_L=150\Omega$                                       |      | 41.5 |       | MHz        |
| $f_{-3dB}$                             | -3dB Bandwidth               | $R_L=150\Omega$                                       |      | 51   |       | MHz        |
| $Att_{148MHz}$                         | Stop Band Attenuation        | $f = 148MHz$  |      | 39   |       | dB         |
| SR                                     | Slew Rate                    | 2V output step, 80% to 20%                            |      | 300  |       | V/ $\mu s$ |
| dG                                     | Differential Gain            | Video input range 1V                                  |      | 0.1  | 1     | %          |
| dP                                     | Differential Phase           | Video input range 1V                                  |      | 0.3  | 0.6   | $^{\circ}$ |
| THD                                    | Total Harmonic Distortion    | $f=10MHz$ , $V_{OUT}=1.4V_{PP}$                       |      | 0.15 |       | %          |
|  |                              | $f=22MHz$ , $V_{OUT}=1.4V_{PP}$                       |      | 0.6  |       | %          |
| D/DT                                   | Group Delay Variation        | $f = 100kHz$ to $27MHz$                               |      | 2.5  |       | ns         |
|  |                              | $f = 100kHz$ to $60MHz$                               |      | 6.0  |       | ns         |
| $t_{PD}$                               | Propagation Delay            | Maximum delay from input to output: (100kHz to 60MHz) |      | 11.0 | 18.0  | ns         |

**Full-HD Composite Video Filter Driver**

|                     |                        |  |     |     |  |    |
|---------------------|------------------------|--|-----|-----|--|----|
| X <sub>TALK</sub>   | Channel Crosstalk      | f = 1MHz, V <sub>OUT</sub> =1.4V <sub>PP</sub> | -68 | -74 |  | dB |
| SNR                 | Signal-to-Noise Ration | f= 100kHz to 60MHz                             |     | 64  |  | dB |
| R <sub>OUT_AC</sub> | Output Impedance       | f = 10MHz                                      |     | 0.5 |  | Ω  |

## Application Information

The TPF141N is targeted for systems that require one full high-definition (FHD) video outputs. Although it can be used for numerous other applications, the needs and requirements of the video signal are the most important design parameters of the TPF141N. The TPF141N incorporates many features not typically found in integrated video parts while consuming very low power.

## Internal Sync Clamp

The typical embedded video DAC operates from a ground referenced single supply. This becomes an issue because the lower level of the sync pulse output may be at a 0V reference level to some positive level. The problem is presenting a 0V input to most single supply driven amplifiers will saturate the output stage of the amplifier resulting in a clipped sync tip and degrading the video image. A larger positive reference may offset the input above its positive range.

The TPF141N features an internal sync clamp and offset function to level shift the entire video signal to the best level before it reaches the input of the amplifier stage. These features are also helpful to avoid saturation of the output stage of the amplifier by setting the signal closer to the best voltage range.

The simplified block diagram of the TPF141N in Figure-1. The AC coupled video sync signal is pulled negative by a current source at the input of the comparator amplifier. When the sync tip goes below the comparator threshold the output comparator is driven negative, The PMOS device turns on clamping sync tip to near ground level. The network triggers on the sync tip of video signal.

## Droop Voltage and DC Restoration

Selection of the input AC-coupling capacitance is based on the system requirements. A typical sync tip width of a 64 $\mu$ s NTSC line is 4 $\mu$ s during which clamp circuit restores its DC level. In the remaining 60 $\mu$ s period, the voltage droops because of a small constant 2.0 $\mu$ A sinking current. If the AC-coupling capacitance is 0.1 $\mu$ F, the maximum droop voltage is about 1mV which is restored by the clamp circuit. The maximum pull-up current of the clamp circuit is 1.7mA. For a 4 $\mu$ s sync tip width and 0.1 $\mu$ F capacitor, the maximum restoration voltage is about 80mV.

The line droop voltage will increase if a smaller AC-coupling capacitance is used. For the same reason, if larger capacitance is used the line droop voltage will decrease. Table 1 is droop voltage and maximum restoration voltage of the clamp for typical capacitance.

**Table 8. Maximum restoration voltage and droop voltage of Y signals for different capacitance**

| CAP VALUE (nF) | DROOP IN 60 $\mu$ s (mV) | CHARGE IN 4 $\mu$ s (mV) |
|----------------|--------------------------|--------------------------|
| 100            | 1.2                      | 68                       |
| 1,000          | 0.12                     | 6.8                      |

## Low Pass Filter—Sallen-Key

The Sallen-Key is a classic low pass configuration. This provides a very stable low pass function, and in the case of the TPF141N, the six-pole roll-off at around 51MHz. The six-pole function is accomplished with an RC low pass network placed in series with and before the Sallen Key.

## Output Couple

TPF141N output could support both “AC Couple” and “DC Couple”, if use “AC Couple”, this capacitor is typically between 220- $\mu$ F and 1000- $\mu$ F, although 470- $\mu$ F is common. This value of this capacitor must be this large to minimize the line tilt (droop) and/or field tilt associated with ac-coupling as described previously in this document.

The TPF141N internal sync clamp makes it possible to DC couple the output to a video load, eliminating the need for any AC coupling

capacitors, thereby saving board space and additional expense for capacitors. This makes the TPF141N extremely attractive for portable video applications. Additionally, this solution completely eliminates the issue of field tilt in the lower frequency. The trade off is greater demand of supply current. Typical load current for AC coupled is around 1mA, compared to typical 6.6mA used when DC coupling.

## Output Drive Capability and Power Dissipation

With the high output drive capability of the TPF141N, it is possible to exceed the +125°C absolute maximum junction temperature under certain load current conditions. Therefore, it is important to calculate the maximum junction temperature for an application to determine if load conditions or package types need to be modified to assure operation of the amplifier in a safe operating area. The maximum power dissipation allowed in a package is determined according to Equation:

$$PD_{MAX} = \frac{T_{JMAX} - T_{AMAX}}{\theta_{JA}}$$

Where:

TJMAX = Maximum junction temperature

TAMAX = Maximum ambient temperature

⊙ JA = Thermal resistance of the package

The maximum power dissipation actually produced by an IC is the total quiescent supply current times the total power supply voltage, plus the power in the IC due to the load, or: for sourcing:

$$PD_{MAX} = V_s \times I_{SMAX} + (V_s - V_{OUT}) \times \frac{V_{OUT}}{R_L}$$

Where:

VS = Supply voltage

ISMAX = Maximum quiescent supply current

VOUT = Maximum output voltage of the application

RLOAD = Load resistance tied to ground

By setting the two PDMAX equations equal to each other, we can solve the output current and RLOAD to avoid the device overheat.

## Power Supply Bypassing Printed Circuit Board Layout

As with any modern operational amplifier, a good printed circuit board layout is necessary for optimum performance. Lead lengths should be as short as possible. The power supply pin must be well bypassed to reduce the risk of oscillation. For normal single supply operation, a single 4.7μF tantalum capacitor in parallel with a 0.1μF ceramic capacitor from VS+ to GND will suffice.

## Video Filter Driver Selection Guide

**Table 6.**

| P/N                | Product Description  | Channel        | -3dB Bandwidth | Package             |
|--------------------|--|----------------|----------------|---------------------|
| TPF110<br>/TPF110L | Low power, enable function and SAG correction, 1 channel 6 <sup>th</sup> order 9MHz        | 1-SD           | 9MHz           | SC70-5<br>SOT23-6   |
| TPF113             | Low power 3 channel, 6th-order 9MHz SD video filter  | 3-SD           | 9MHz           | SO-8                |
| TPF114             | Low power 4 channel, 6th-order 9MHz SD video filter  | 4-SD           | 9MHz           | MSOP-10<br>TSSOP-14 |
| TPF116             | Low power 4 channel, 6th-order 9MHz SD video filter for CVBS, SVIDEO                       | 6-SD           | 9MHz           | TSSOP-14            |
| TPF123             | 3 channel 6th-order 13.5MHz, 960H/720H-CVBS video filter or Y'Pb'Pr 480P/576P video filter | 3-ED           | 13.5MHz        | SO-8                |
| TPF133             | Low power 3 channel, 6th-order 36MHz HD video filter                                       | 3-HD           | 36MHz          | SO-8                |
| TPF134             | Low power 3 channel, 6th-order 36MHz HD video filter and 1 channel SD video filter         | 1-SD&<br>3-SD  | 9MHz<br>36MHz  | MSOP-10<br>TSSOP-14 |
| TPF136             | Low power 3 channel, 6th-order 36MHz HD video filter and 3 channel SD video filter         | 3-SD&<br>3-HD  | 9MHz<br>36MHz  | TSSOP-20            |
| TPF143             | Low power 3 channel, 6th-order 72MHz Full HD video filter                                  | 3-FHD          | 72MHz          | SO-8                |
| TPF144             | Low power 3 channel, 6th-order 72MHz Full HD video filter and 1 channel SD video filter    | 1-SD&<br>3-FHD | 9MHz<br>72MHz  | MSOP-10<br>TSSOP-14 |
| TPF146             | Low power 3 channel, 6th-order 72MHz Full HD video filter and 3 channel SD video filter    | 3-SD&<br>3-FHD | 9MHz<br>72MHz  | TSSOP-20            |
| TPF153             | Low power 3 channel, 6th-order 220MHz Full HD video filter                                 | 3-CH           | 220MHz         | SO-8                |



### Package Outline Dimensions

#### SOT23-6

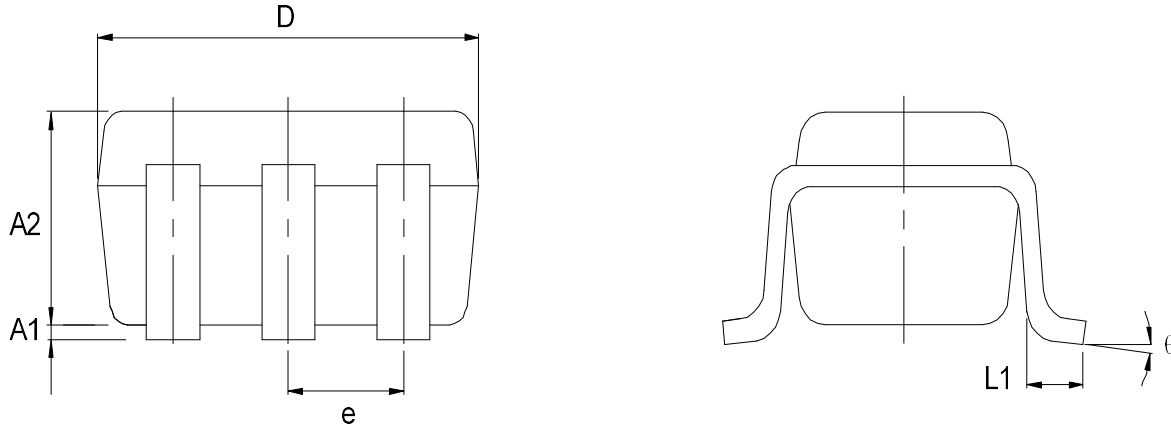


Table 7.

| Symbol | Dimensions<br>In Millimeters |       | Dimensions<br>In Inches |       |
|--------|------------------------------|-------|-------------------------|-------|
|        | Min                          | Max   | Min                     | Max   |
| A1     | 0.000                        | 0.100 | 0.000                   | 0.004 |
| A2     | 1.050                        | 1.150 | 0.041                   | 0.045 |
| b      | 0.300                        | 0.400 | 0.012                   | 0.016 |
| D      | 2.820                        | 3.020 | 0.111                   | 0.119 |
| E      | 1.500                        | 1.700 | 0.059                   | 0.067 |
| E1     | 2.650                        | 2.950 | 0.104                   | 0.116 |
| e      | 0.950TYP                     |       | 0.037TYP                |       |
| e1     | 1.800                        | 2.000 | 0.071                   | 0.079 |
| L1     | 0.300                        | 0.460 | 0.012                   | 0.024 |
| θ      | 0°                           | 8°    | 0°                      | 8°    |


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