

## Low Power, 3-channel Video Filter for HD Video

### Features

- 3-HDTV Video Filter Support Y'Pb'Pr'-1080i/720p, R'G'B' or VGA/SVGA/XGA
- Optimized 6<sup>th</sup>-order Butterworth Video reconstruction filter:  
HD Channel: -3dB ≥ 36MHz
- 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: 11.7 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, SOIC-8 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

### Description

TPF133A 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 three high-definition (HD) filter channels. All filters 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 HD filters can be bypassed to support filters. The HD filters can be bypassed to support 1080p60 video or up to quad extended graphics array (QXGA) RGB video.

As part of the TP133A 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 TP133A 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 27.6-mA total quiescent current at 3.3 V makes it an excellent choice for power-sensitive video applications.

TPF133A is available in SOIC-8 package. Its operation temperature range is from -40°C to +85°C.

### Related Resources

AN-1201: Application notes of TPF1xx

### Pin configuration (Top View)

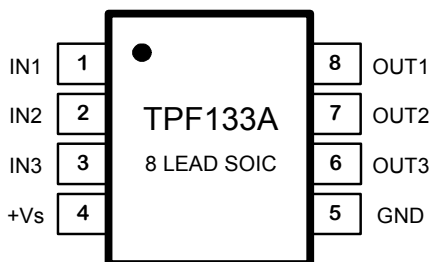


Figure 1.

| Pin Number | Pin Name | Function              |
|------------|----------|-----------------------|
| 1          | IN1      | First Input           |
| 2          | IN2      | Second input          |
| 3          | IN3      | Third input           |
| 4          | +Vs      | Positive power supply |
| 5          | GND      | Ground                |
| 6          | OUT3     | Third output          |
| 7          | OUT2     | Second output         |
| 8          | OUT1     | First output          |

# TPF133A

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### Function Block

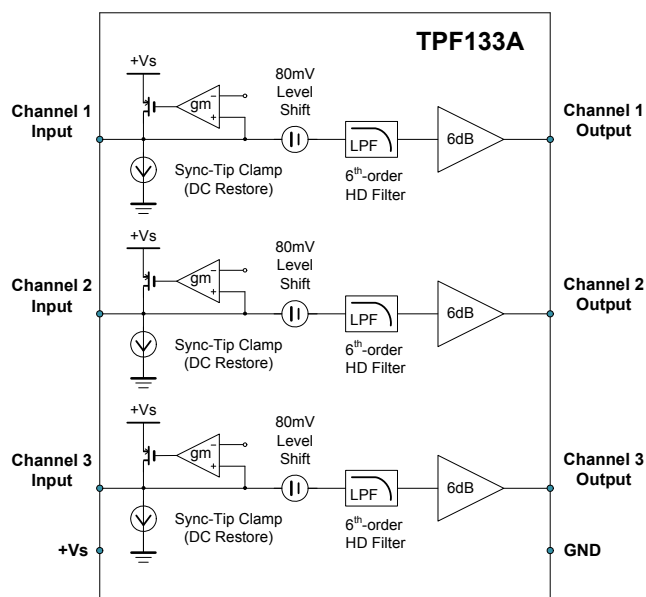


Figure 2.

### Order Information

| Order Number | Operating Temperature Range | Package | Package Options | Transport Media, Quantity |
|--------------|-----------------------------|---------|-----------------|---------------------------|
| TPF133A-SR   | -40 to 85°C                 | SOIC-8  | MSL-3           | Tape and Reel, 4000       |

### Absolute Maximum Ratings\*

| Parameters                    |                                                           | Value                                                | Units |
|-------------------------------|-----------------------------------------------------------|------------------------------------------------------|-------|
| Power Supply, $V_{DD}$ to GND |                                                           | 6.0                                                  | V     |
| PD                            | Power Dissipation, $T_A = 25^\circ\text{C}$ , 8-Lead SOIC | 800 <sup>(1)</sup>                                   | mW    |
| $V_{IN}$                      | Input Voltage                                             | $V_{DD} + 0.3\text{V}$ to $\text{GND} - 0.3\text{V}$ |       |
| $I_O$                         | Output Current                                            | 65                                                   | mA    |
| $T_J$                         | Maximum Junction Temperature                              | 150                                                  | °C    |
| $T_A$                         | Operating Temperature Range                               | -45 to 85                                            | °C    |
| $T_{STG}$                     | Storage Temperature Range                                 | -65 to 150                                           | °C    |
| TL                            | Lead Temperature (Soldering 10 sec)                       | 300                                                  | °C    |
| $\theta_{JA}$                 | 8-Lead SOIC Thermal Resistance                            | 130 <sup>(2)</sup>                                   | °C/W  |

\* **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

| 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   |

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

| SYMBOL                          | PARAMETER                                          |            | CONDITIONS                                                    | MIN  | TYP  | MAX  | UNITS |
|---------------------------------|----------------------------------------------------|------------|---------------------------------------------------------------|------|------|------|-------|
| Input Electrical Specifications |                                                    |            |                                                               |      |      |      |       |
| V <sub>DD</sub>                 | Supply Voltage Range                               |            |                                                               | 3.0  |      | 5.5  | V     |
| I <sub>DD</sub>                 | Quiescent current (I <sub>Q</sub> ) <sup>(1)</sup> |            | V <sub>DD</sub> = 3.3V, V <sub>IN</sub> = 500mV, no load      |      | 27.6 | 34.5 | mA    |
|                                 |                                                    |            | V <sub>DD</sub> = 5.0V, V <sub>IN</sub> = 500mV, no load      |      | 36.0 | 44.7 | mA    |
| I <sub>CLAMP-DOWN</sub>         | Clamp Discharge Current                            |            | V <sub>IN</sub> =300mV, measure current                       | 1.5  | 2.0  | 5.1  | μA    |
| I <sub>CLAMP-UP</sub>           | Clamp Charge Current                               |            | V <sub>Y</sub> = -0.2V                                        | -1.5 | -1.7 |      | mA    |
| V <sub>CLAMP</sub>              | Input Voltage Clamp                                |            | I <sub>Y</sub> = -100μA                                       | -40  | 0    | +40  | mV    |
| R <sub>IN</sub>                 | Input Impedance                                    |            | 0.5V < V <sub>Y</sub> < 1V                                    | 0.5  | 3    |      | MΩ    |
| AV                              | Voltage Gain                                       |            | V <sub>IN</sub> =0.5V,1V or 2V<br>R <sub>L</sub> =150Ω to GND | 5.91 | 6.01 | 6.03 | dB    |
| V <sub>OLS</sub>                | Output Level Shift Voltage                         |            | V <sub>IN</sub> = 0V, no load, input referred                 | 54   | 80   | 124  | mV    |
| V <sub>OL</sub>                 | Output Voltage Low Swing                           |            | V <sub>IN</sub> = -0.3V, R <sub>L</sub> =75Ω                  |      | 0.05 |      | V     |
| V <sub>OH</sub>                 | Output Voltage High Swing                          |            | V <sub>IN</sub> = 3V, R <sub>L</sub> =75Ω to GND (dual load)  |      | 3.18 |      | V     |
| PSRR                            | Power Supply Rejection Ratio                       |            | ΔV <sub>DD</sub> = 3.3V to 3.6V                               |      | 57   |      | dB    |
|                                 |                                                    |            | ΔV <sub>DD</sub> = 5.0V to 5.5V, 50Hz                         |      | 61   |      | dB    |
| I <sub>SC</sub>                 | Short-circuit current                              |            | V <sub>IN</sub> = 2V, 10Ω, output to GND                      | 65   |      |      | mA    |
|                                 |                                                    |            | V <sub>IN</sub> =0.1V, output short to V <sub>DD</sub>        | 65   |      |      | mA    |
| AC Electrical Specifications    |                                                    |            |                                                               |      |      |      |       |
| f <sub>-1dB</sub>               | -1dB Bandwidth                                     | HD Channel | R <sub>L</sub> =150Ω                                          | 31.5 |      |      | MHz   |
| f <sub>-3dB</sub>               | -3dB Bandwidth                                     | HD Channel | R <sub>L</sub> =150Ω                                          | 36   |      |      | MHz   |
| dG                              | Differential Gain                                  |            | Video input range 1V                                          |      | 0.1  | 1    | %     |
| dP                              | Differential Phase                                 |            | Video input range 1V                                          |      | 0.25 |      | °     |
| THD                             | Total Harmonic Distortion                          | HD Channel | f=1MHz, V <sub>OUT</sub> =1.4V <sub>PP</sub>                  |      | 0.2  |      | %     |
| D/DT                            | Group Delay Variation                              | HD Channel | f = 100kHz to 60MHz                                           |      | 6.0  |      | ns    |
| 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                             | HD Channel | f= 100kHz to 30MHz                                            | 66   | 71   |      | dB    |
| R <sub>OUT_AC</sub>             | Output Impedance                                   |            | f = 10MHz                                                     |      | 0.5  |      | Ω     |

**Note: (1). 100% tested at  $T_A=25^{\circ}C$ .**

## Typical Application

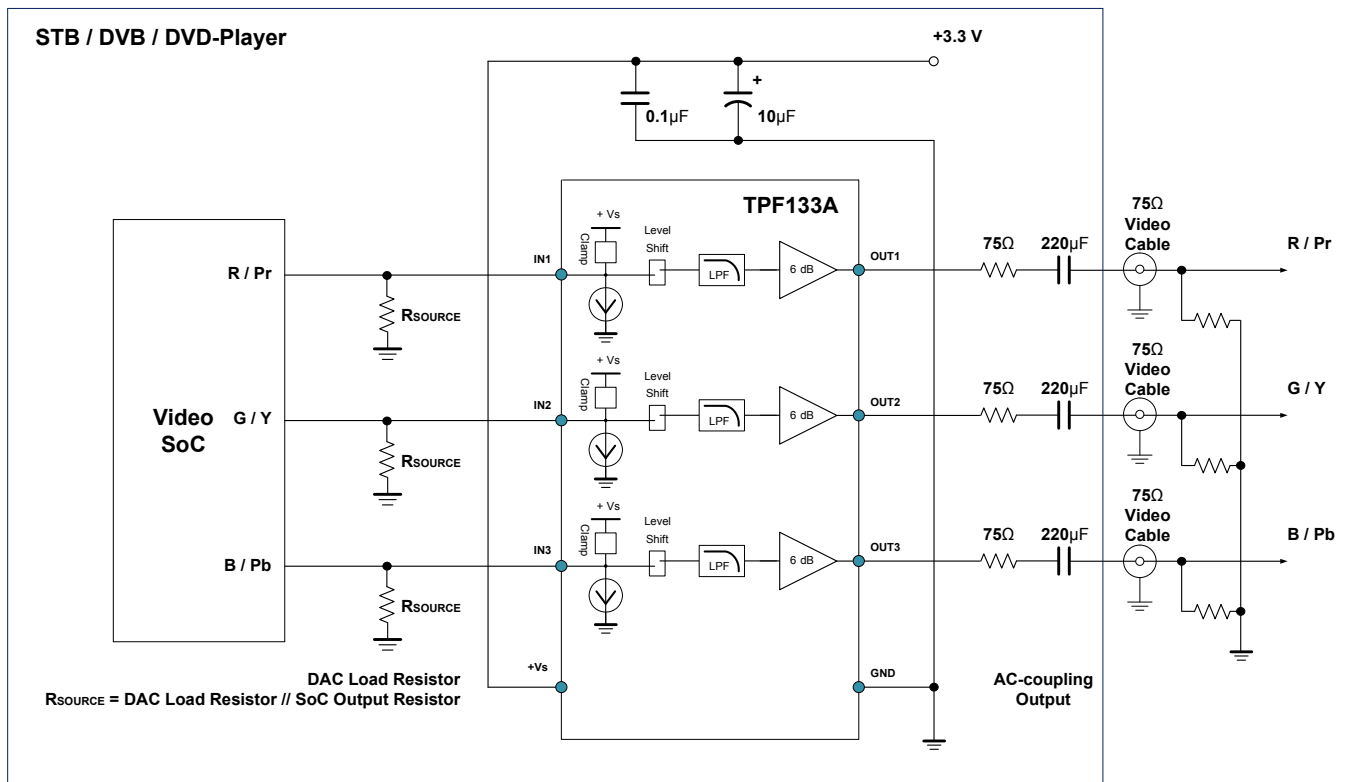


Figure3. Reference Application Design

## Application Information

The TPF133A is targeted for systems that require three high-definition (HD) 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 TPF133A. The TPF133A 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 TPF133A 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 TPF133A in Figure-2. 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 1. Maximum restoration voltage and droop voltage of Y signals for different capacitance**

| CAP VALUE<br>(nF) | DROOP IN 60 $\mu$ s<br>(mV) | CHARGE IN 4 $\mu$ s<br>(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 TPF133A, the six-pole roll-off at around 36MHz. The six-pole function is accomplished with an RC low pass network placed in series with and before the Sallen Key.

## Output Couple

TPF133A 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 TPF133A 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 TPF133A 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 TPF133A, 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:

$T_{JMAX}$  = Maximum junction temperature

$T_{AMAX}$  = Maximum ambient temperature

$\theta_{JA}$  = 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:

$V_s$  = Supply voltage

$I_{SMAX}$  = Maximum quiescent supply current

$V_{OUT}$  = Maximum output voltage of the application

$R_{LOAD}$  = Load resistance tied to ground

By setting the two  $PD_{MAX}$  equations equal to each other, we can solve the output current and  $R_{LOAD}$  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

| 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 |

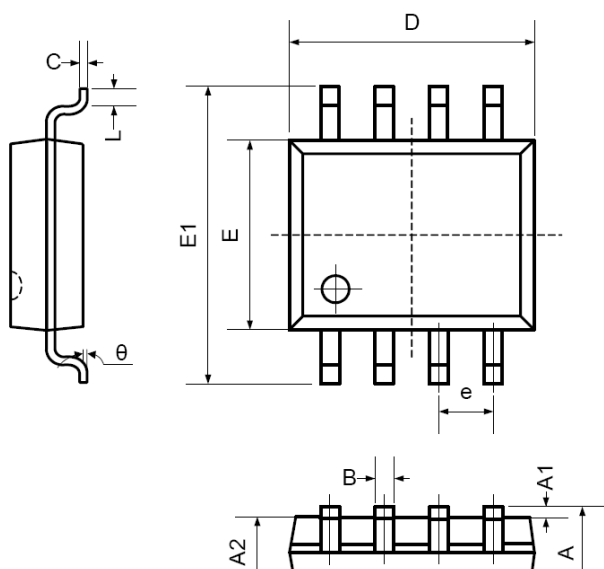
**TPF133A****Low Power, 3-channel Video Filter for HD Video**

|        |                                                                                               |                |               |                     |
|--------|-----------------------------------------------------------------------------------------------|----------------|---------------|---------------------|
| TPF136 | Low power 3 channel, 6th-order<br>36MHz HD video filter and 3 channel<br>SD video filter      | 3-SD&<br>3-HD  | 9MHz<br>36MHz | TSSOP-20            |
| TPF143 | Low power 3 channel, 6th-order<br>72MHz Full HD video filter                                  | 3-FHD          | 72MHz         | SO-8                |
| TPF144 | Low power 3 channel, 6th-order<br>72MHz Full HD video filter and 1<br>channel SD video filter | 1-SD&<br>3-FHD | 9MHz<br>72MHz | MSOP-10<br>TSSOP-14 |
| TPF146 | Low power 3 channel, 6th-order<br>72MHz Full HD video filter and 3<br>channel SD video filter | 3-SD&<br>3-FHD | 9MHz<br>72MHz | TSSOP-20            |
| TPF153 | Low power 3 channel, 6th-order<br>220MHz Full HD video filter                                 | 3-CH           | 220MHz        | SO-8                |



## Package Outline Dimensions

SOIC-8



| Symbol | Dimensions<br>In Millimeters |       | Dimensions In<br>Inches |       |
|--------|------------------------------|-------|-------------------------|-------|
|        | Min                          | Max   | Min                     | Max   |
| A      | 1.350                        | 1.750 | 0.053                   | 0.069 |
| A1     | 0.100                        | 0.250 | 0.004                   | 0.010 |
| A2     | 1.350                        | 1.550 | 0.053                   | 0.061 |
| B      | 0.330                        | 0.510 | 0.013                   | 0.020 |
| C      | 0.190                        | 0.250 | 0.007                   | 0.010 |
| D      | 4.780                        | 5.000 | 0.188                   | 0.197 |
| E      | 3.800                        | 4.000 | 0.150                   | 0.157 |
| E1     | 5.800                        | 6.300 | 0.228                   | 0.248 |
| e      | 1.270TYP                     |       | 0.050TYP                |       |
| L1     | 0.400                        | 1.270 | 0.016                   | 0.050 |
| θ      | 0°                           | 8°    | 0°                      | 8°    |

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