

## Product Overview

| Product Name | Number of channels | Package Name |
|--------------|--------------------|--------------|
| TFC0501MX    | 1                  | CSP-5-1208   |
| TFC0502NX    | 2                  | CSP-10-1216  |

## Feature

- One or two differential channel common-mode EMI Filter with integrated ESD protection
- Superior common-mode suppression over a wide frequency range
- Superior RF performance compared to other integrated filters or discrete filters with external ESD protection
- Extremely high symmetry between line pairs
- Very low PCB space consumption:
  - TFC0501MX: 1.2mm x 0.8mm
  - TFC0502NX: 1.2mm x 1.6mm
- Very thin package: 0.6mm max
- High efficiency in ESD suppression up to  $\pm 15\text{kV}$  (IEC 61000-4-2 level 4)
- Superior surge clamping voltage: 5.5V@6.5A
- High reliability offered by monolithic integration

## Description

The TFC050xxX series products are highly integrated, 1 or 2 channel devices designed to suppress EMI/RFI noise in systems exposed to electromagnetic interference. The devices are designed to provide low insertion loss for differential high-speed signals while unwanted common-mode signals are attenuated.

This filter incorporates ESD&Surge protection circuitry, which prevents damage to the application when subjected to 8/20 $\mu\text{s}$  surges up to 6.5A and ESD discharges up to 15kV on each I/O pin. It complies with IEC61000-4-2 (ESD, level 4) and IEC61000-4-5 (Surge).

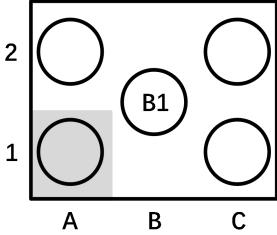
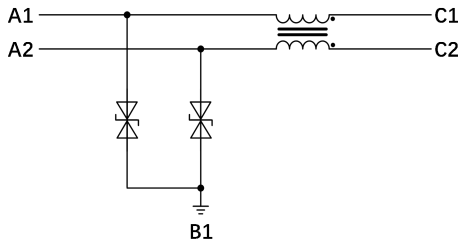
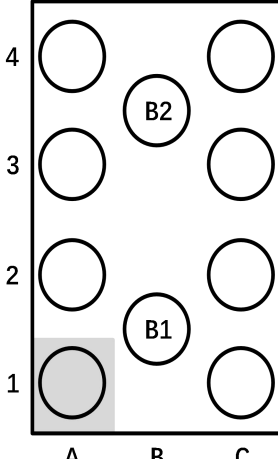
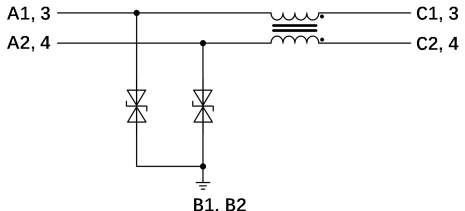
## Applications

- LCD and camera for mobile phones
- Computers and printers
- Communication systems
- High speed data lines:
  - USB 3.X
  - HDMI 1.4/2.0
- EMI & RFI filter and ESD protection

## Mechanical Characteristics

- Package:
  - TFC0501MX: CSP-5-1208
  - TFC0502NX: CSP-10-1216
- Marking: Part number
- Packaging: Tape and Reel
- ROHS compliant
- Moisture Sensitivity Level (MSL Level-1)

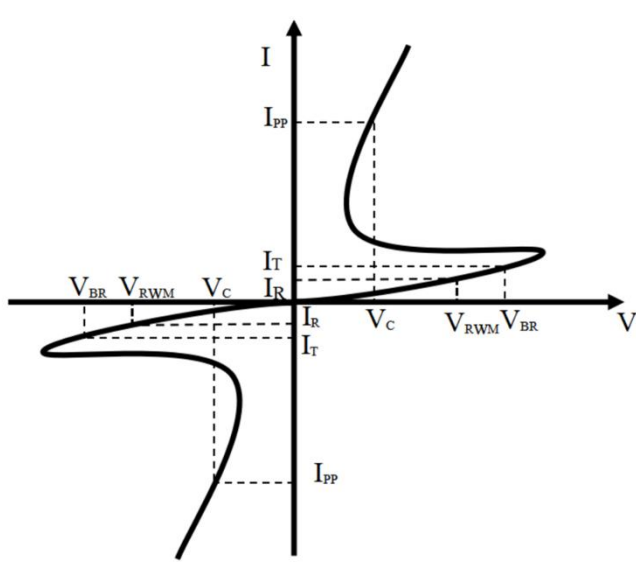
## Pin Configuration

| Pin              | Symbol   | Description               | Package Top View Outline  | Circuit Diagram  |
|------------------|----------|---------------------------|---|--|
| <b>TFC0501MX</b> |          |                           |   |  |
| A1               | CH1_IN+  | channel 1+, external port |  <p style="text-align: center;">CSP-5-1208</p>   |   |
| A2               | CH1_IN-  | channel 1-, external port |   |  |
| B1               | CH1_GND  | channel 1, ground         |   |  |
| C1               | CH1_OUT+ | channel 1+, internal port |   |  |
| C2               | CH1_OUT- | channel 1-, internal port |   |  |
|                  |          |                           |   |  |
| <b>TFC0502NX</b> |          |                           |   |  |
| A1               | CH1_IN+  | channel 1+, external port |  <p style="text-align: center;">CSP-10-1216</p> |  |
| A2               | CH1_IN-  | channel 1-, external port |   |  |
| A3               | CH2_IN+  | channel 2+, external port |   |  |
| A4               | CH2_IN-  | channel 2-, external port |   |  |
| B1               | CH1_GND  | channel 1, ground         |   |  |
| B2               | CH1_GND  | channel 2, ground         |   |  |
| C1               | CH1_OUT+ | channel 1+, internal port |   |  |
| C2               | CH1_OUT- | channel 1-, internal port |   |  |
| C3               | CH2_OUT+ | channel 2+, internal port |   |  |
| C4               | CH2_OUT- | channel 2-, internal port |   |  |

## Absolute Maximum Rating

| Symbol    | Parameter  | Value                | Units |
|-----------|--|----------------------|-------|
| $I_{PP}$  | Peak Pulse Current (8/20 $\mu$ s)                            | 6.5                  | A     |
| $P_{PK}$  | Peak Pulse Power (8/20 $\mu$ s)                              | 30                   | W     |
| $V_{ESD}$ | ESD per IEC61000-4-2 (Air)<br>ESD per IEC61000-4-2 (Contact) | $\pm 15$<br>$\pm 15$ | kV    |
| $T_{OPT}$ | Operating Temperature  | -55/+125             | °C    |
| $T_{STG}$ | Storage Temperature  | -55/+150             | °C    |

## Electrical Characteristics (T = 25°C)

| Symbol        | Parameter                              | Diagram   |
|---------------|--|---|
| $V_{RWM}$     | Nominal Reverse Working Voltage        |  |
| $I_R$         | Reverse Leakage Current @ $V_{RWM}$    |   |
| $V_{BR}$      | Reverse Breakdown Voltage @ $I_T$      |   |
| $I_T$         | Test Current for Reverse Breakdown     |   |
| $I_{PP}$      | Maximum Peak Pulse Current             |   |
| $V_C$         | Clamping Voltage @ $I_{PP}$            |   |
| $C_{ESD}$     | Parasitic Capacitance                  |   |
| $R_{dyn}$     | Dynamic Resistance                     |   |
| $R_{I/O}$     | Series resistance between Input&Output |   |
| $S_{CC21}$    | Common mode insertion loss             |   |
| $S_{DD21}$    | Differential mode insertion loss       |   |
| $\alpha_{IL}$ | Insertion Loss                         |   |
| $f_{-3dB}$    | Cut-off frequency at -3dB              |   |
| $Z_{DIFF}$    | Differential mode TDR impedance        |   |
| $f_r$         | Resonant Frequency                     |   |

| Symbol    | Test Condition   | Minimum | Typical | Maximum | Units |
|-----------|--|---------|---------|---------|-------|
| $V_{RWM}$ |  |         |         | 5.0     | V     |
| $I_R$     | $V_{RWM} = 5.0V$ , $T = 25^\circ C$<br>Between I/O and GND |         | 10      | 100     | nA    |
| $V_{BR}$  | $I_T = 10\mu A$<br>Between I/O and GND                     | 5.5     | 7.2     |         | V     |
| $V_C$     | $I_{PP} = 6.5A$ , $t_p = 8/20\mu s$<br>Between IO and GND  |         | 5.5     |         | V     |
| $C_{ESD}$ | $V_R = 0V$ , $f = 1MHz^{(1)}$<br>Between IO and GND        |         | 0.25    |         | pF    |

## Electrical Characteristics

| Symbol           | Test Condition   | Minimum | Typical | Maximum | Units |
|------------------|--|---------|---------|---------|-------|
| V <sub>C</sub>   | I <sub>PP</sub> = 8A, t <sub>p</sub> = 100ns <sup>(2)</sup><br>Between IO and GND    |         | 5.2     |         | V     |
|                  | I <sub>PP</sub> = 16A, t <sub>p</sub> = 100ns <sup>(2)</sup><br>Between IO and GND   |         | 7.0     |         | V     |
| R <sub>dyn</sub> | I <sub>PP</sub> = 12.0A, t <sub>p</sub> = 100ns <sup>(2)</sup><br>Between IO and GND |         | 0.23    |         | Ω     |
| R <sub>I/O</sub> | Between Input and Output   |         | 3       |         | Ω     |

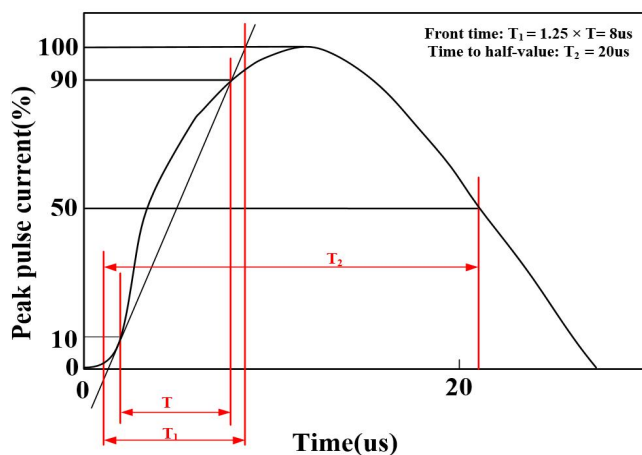
Notes:(1) This parameter is guaranteed by design.(2)Measurements performed using a 100ns Transmission Line Pulse(TLP) system.

## Frequency Characteristics

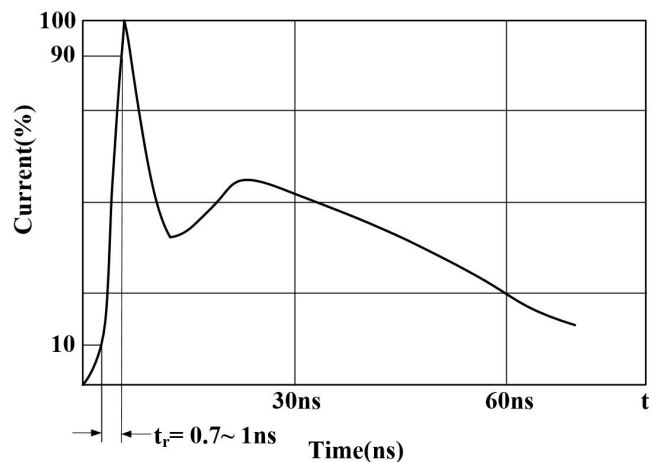
| Symbol                                     | Test Condition                  | Minimum | Typical | Maximum | Units |
|--|---------------------------------|---------|---------|---------|-------|
| <b>Common mode: S<sub>CC21</sub></b>       |                                 |         |         |         |       |
| f <sub>r</sub>                             |                                 |         | 2.3     |         | GHz   |
| α <sub>IL</sub>                            | f=2.0GHz                        |         | -17     |         | dB    |
|  | f=3.0GHz                        |         | -22     |         | dB    |
| <b>Differential mode: S<sub>DD21</sub></b> |                                 |         |         |         |       |
| α <sub>IL</sub>                            | f=370MHz                        |         | -0.8    |         | dB    |
| f <sub>-3db</sub>                          |                                 |         | 7.6     |         | GHz   |
| Z <sub>DIFF</sub>                          | Time Domain Reflectometer (TDR) |         | 90      |         | Ω     |

## Typical Performance Characteristics

8/20μs surge waveform (IEC61000-4-5)

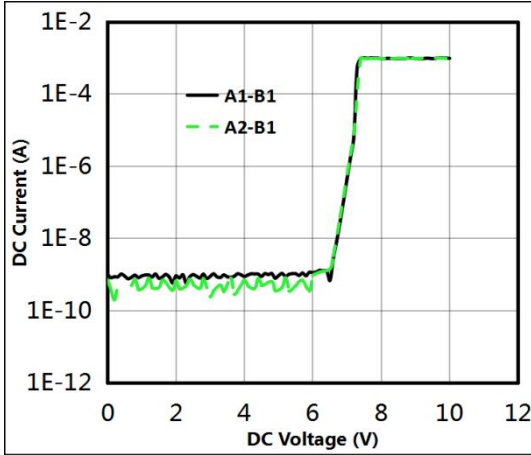


Contact discharge current waveform (IEC61000-4-2)

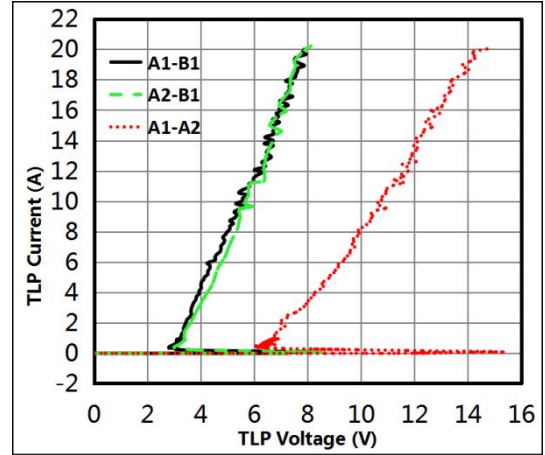


## Typical Performance Characteristics

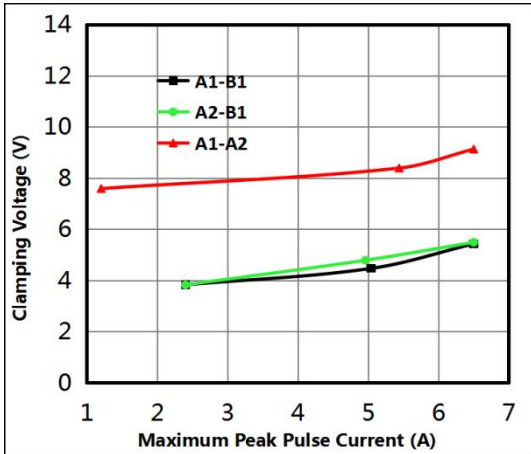
### DC Measurement



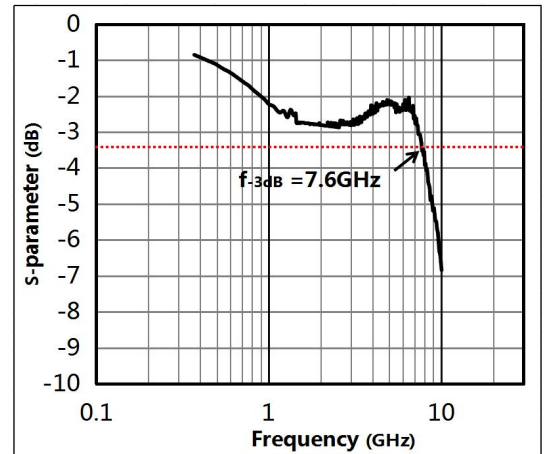
### TLP Measurement



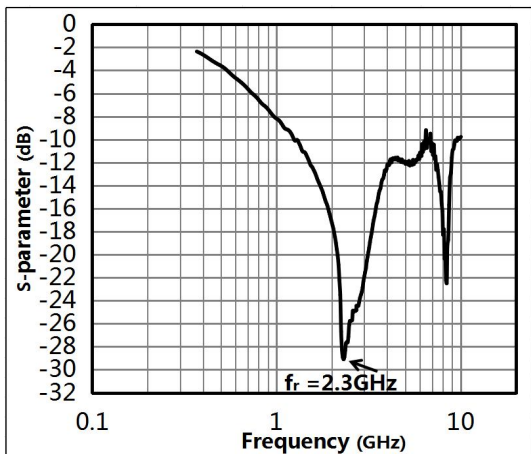
### 8/20µs Surge Measurement



### Differential-mode insertion loss



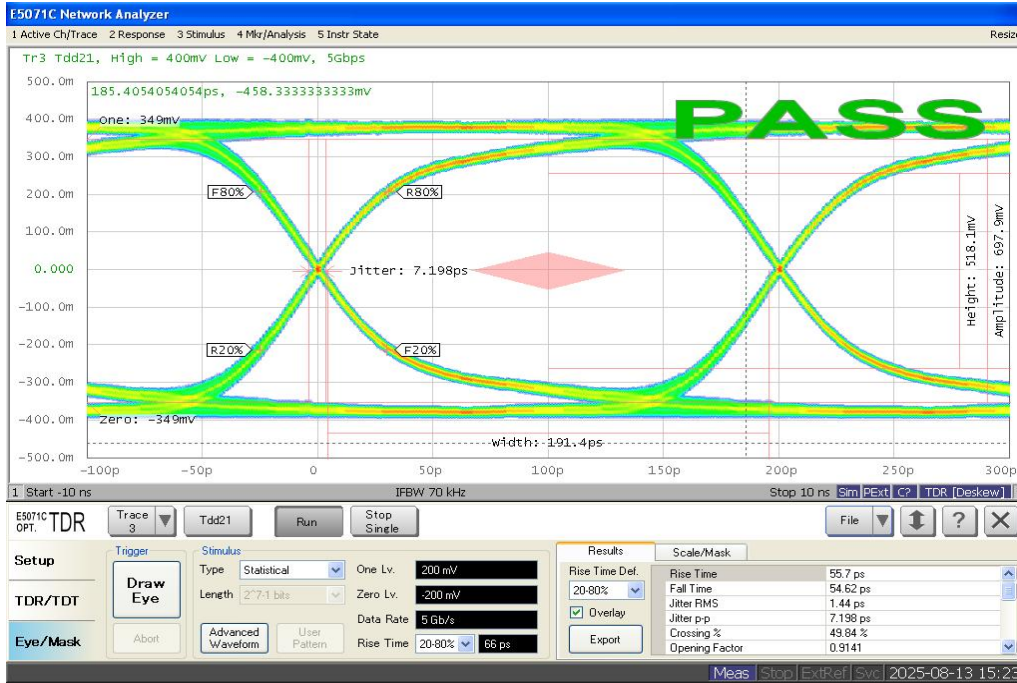
### Common-mode insertion loss



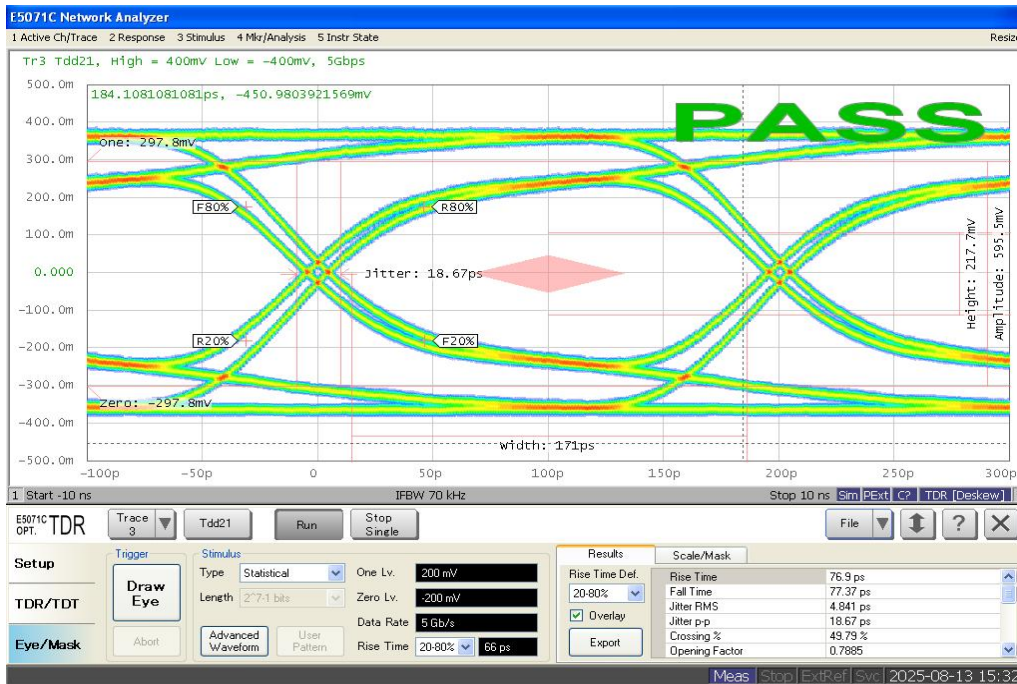
### Differential Time Domain Reflectometer



## Application Curves

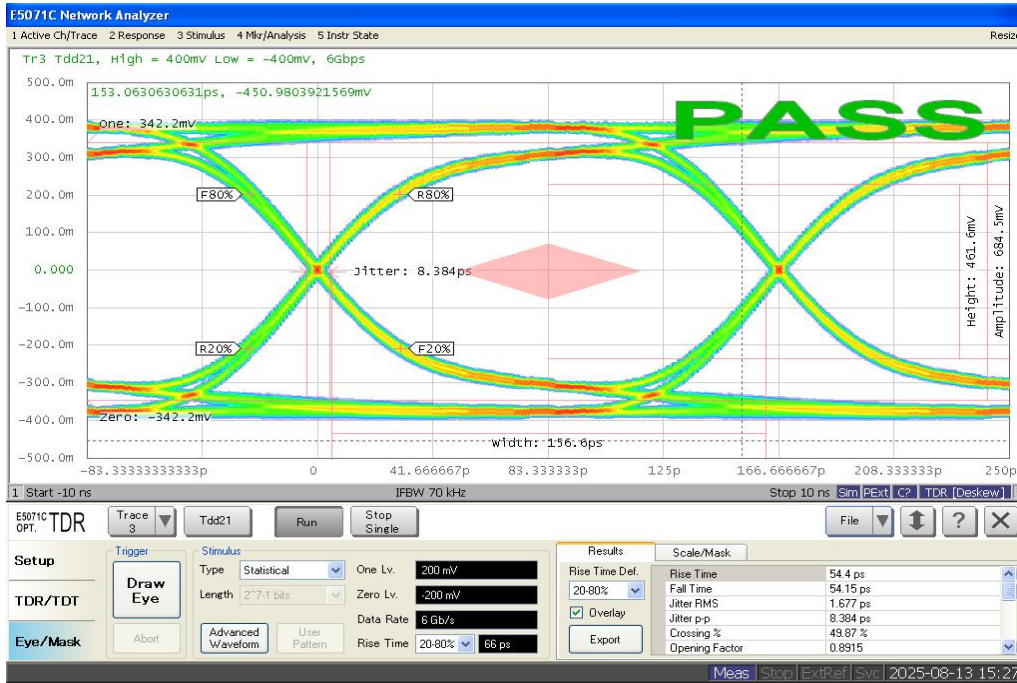


**USB3.0 Eye Diagram W/O Device (5Gbps)**

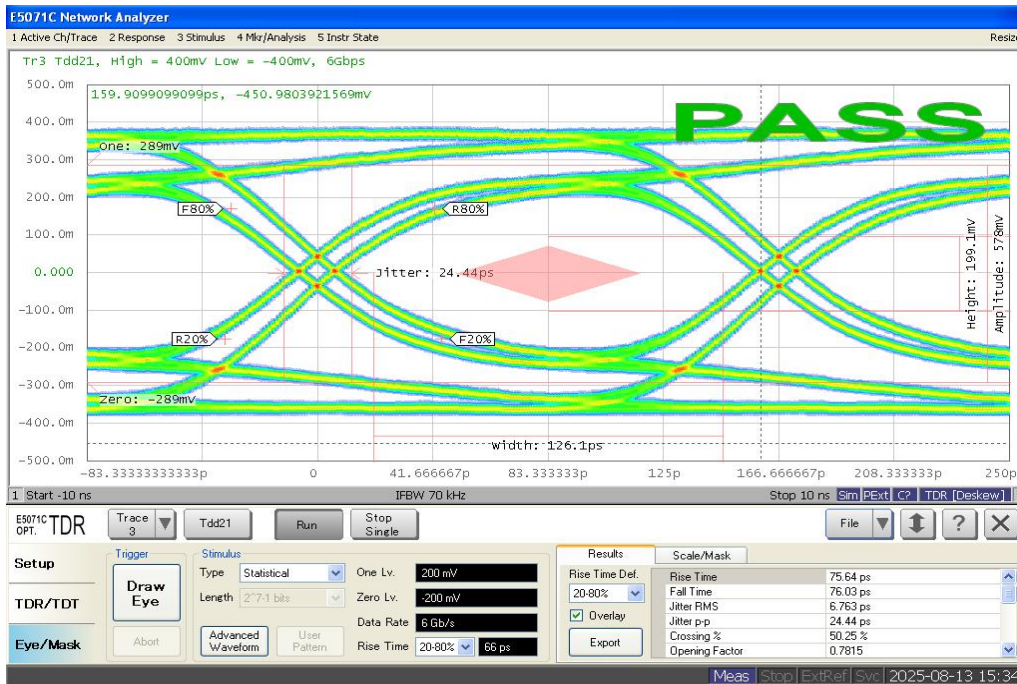


**USB3.0 Eye Diagram W/I Device (5Gbps)**

## Application Curves

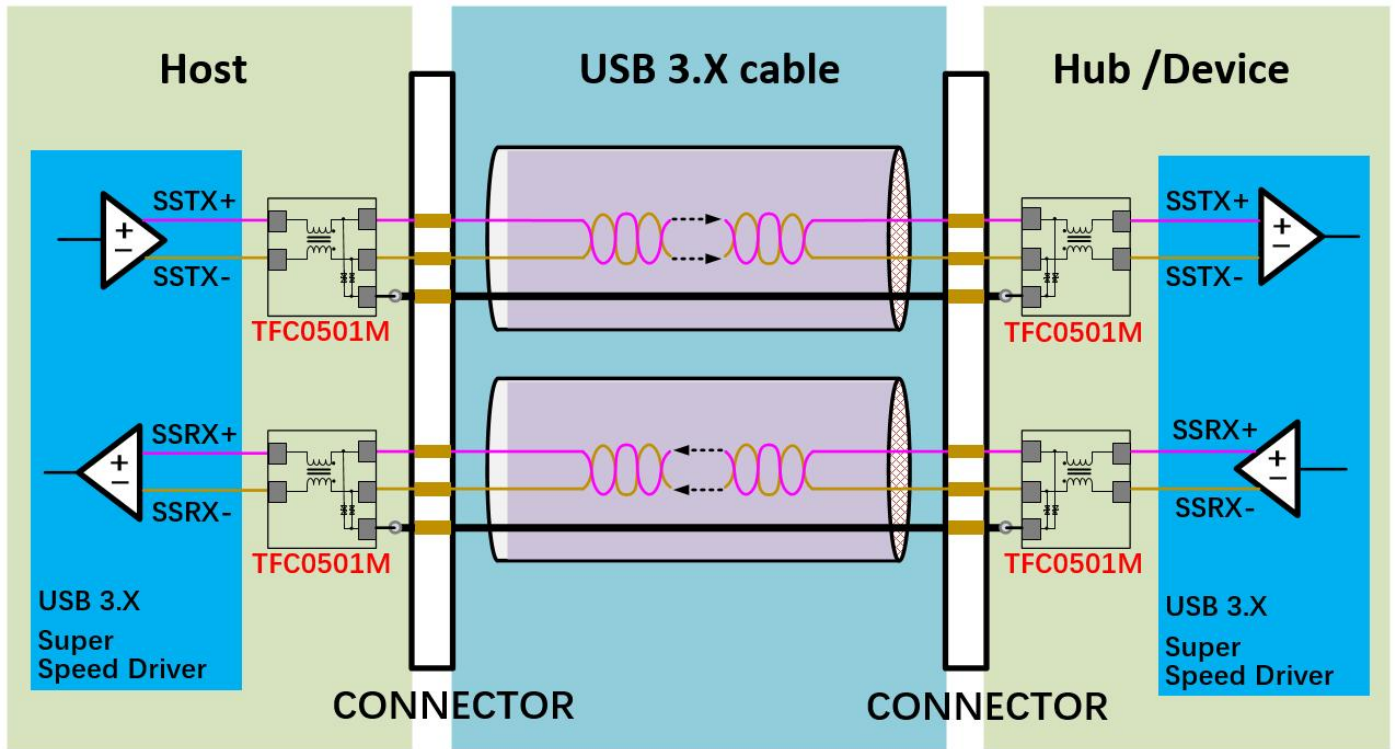


**HDMI2.0-6Gbps Eye Diagram W/O Device**



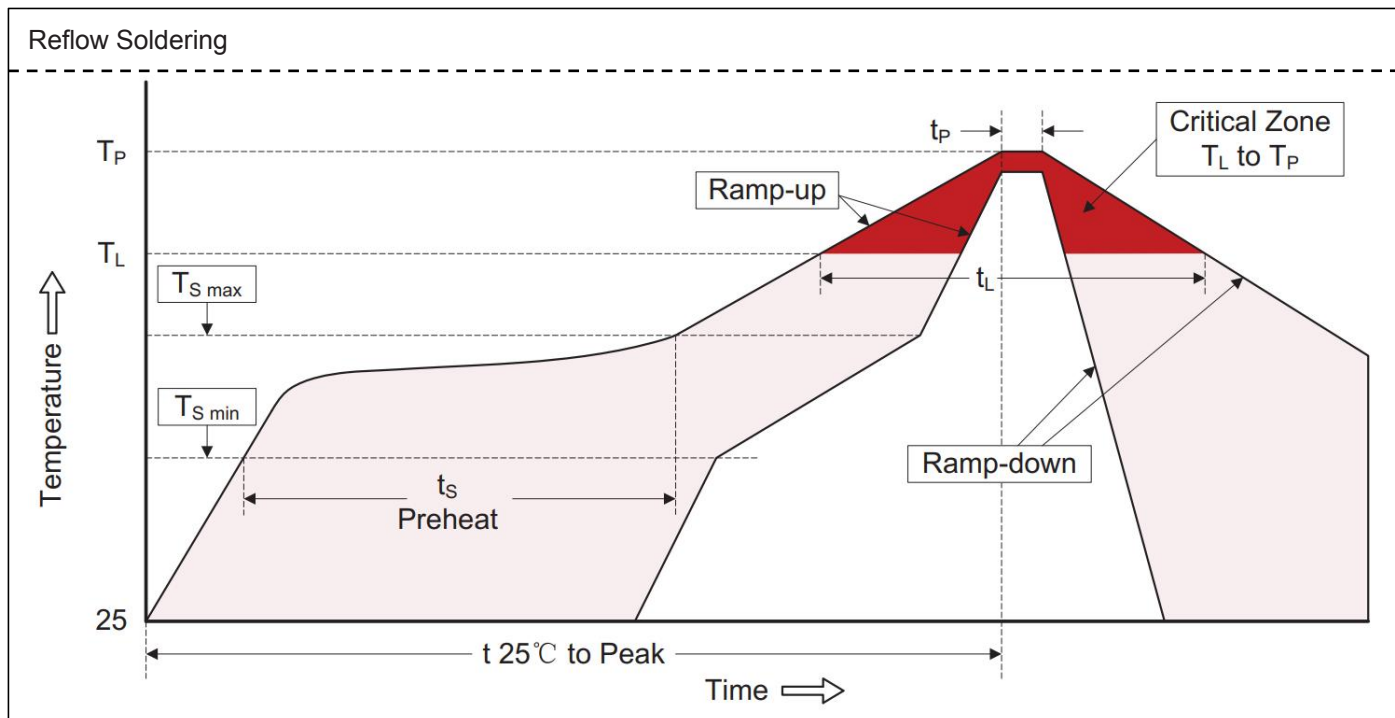
**HDMI2.0-6Gbps Eye Diagram W/I Device**

**Application Information**



The TFC0501MX and TFC0502NX product are designed to provide high-level ESD protection and common-mode filtering for differential high-speed data line pairs such as USB 3.X and HDMI 2.0. The compact chip scale package guarantees superior and stable electrical performances to ensure effective ESD and surge protection, the ports equipped with integrated TVS components (i.e., A1 and A2) must be positioned close to the connectors.

## Recommended Soldering Conditions

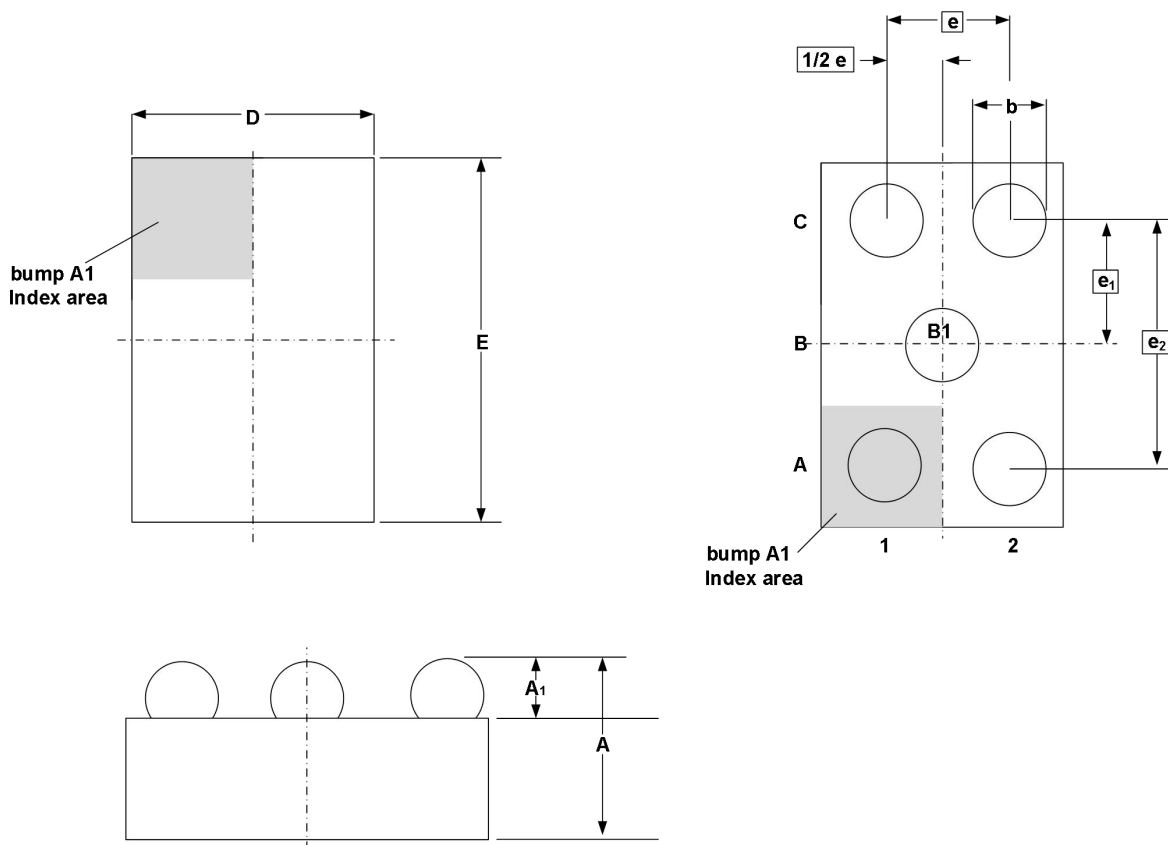


### Recommended Conditions

| Profile Feature   | Pb-Free Assembly                 |
|---|----------------------------------|
| Average ramp-up rate ( $T_L$ to $T_P$ )   | 3°C/second max                   |
| Preheat<br>-Temperature Min ( $T_{S\ min}$ )<br>-Temperature Max ( $T_{S\ max}$ )<br>-Time (min to max) ( $t_s$ ) | 150°C<br>200°C<br>60-180 seconds |
| $T_{S\ max}$ to $T_L$<br>-Ramp-up Rate  | 3°C/second max                   |
| Time maintained above:<br>-Temperature ( $T_L$ )<br>-Time ( $t_L$ )   | 217°C<br>60-150 seconds          |
| Peak Temperature ( $T_P$ )  | 260°C                            |
| Time within 5°C of actual Peak Temperature ( $t_P$ )  | 20-40 seconds                    |
| Ramp-down Rate  | 6°C/second max                   |
| Time 25°C to Peak Temperature   | 8 minutes max                    |

## Package Outline

TFC0501MX(CSP-5-1208)

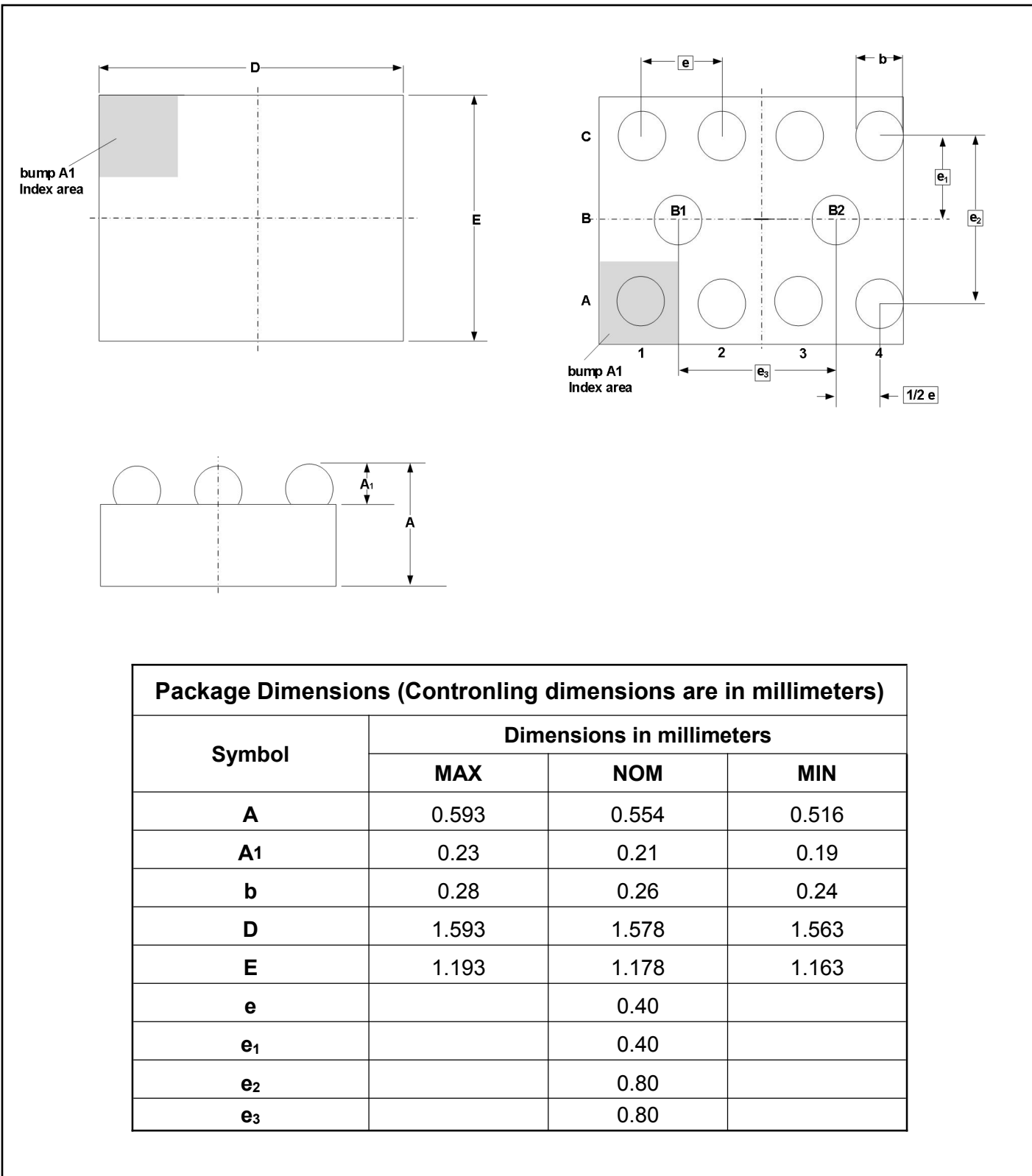


**Package Dimensions (Controlling dimensions are in millimeters)**

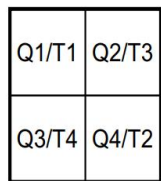
| Symbol         | Dimensions in millimeters |       |       |
|----------------|---------------------------|-------|-------|
|                | MAX                       | NOM   | MIN   |
| A              | 0.593                     | 0.554 | 0.516 |
| A1             | 0.23                      | 0.21  | 0.19  |
| b              | 0.28                      | 0.26  | 0.24  |
| D              | 0.793                     | 0.778 | 0.763 |
| E              | 1.193                     | 1.178 | 1.163 |
| e              |                           | 0.40  |       |
| e <sub>1</sub> |                           | 0.40  |       |
| e <sub>2</sub> |                           | 0.80  |       |

## Package Outline

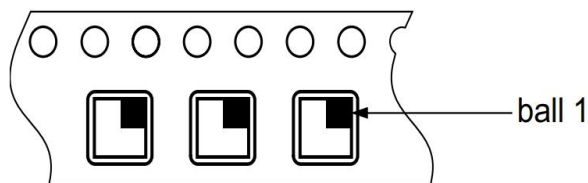
TFC0502NX(CSP-10-1216)



## Tape and Reel Specification



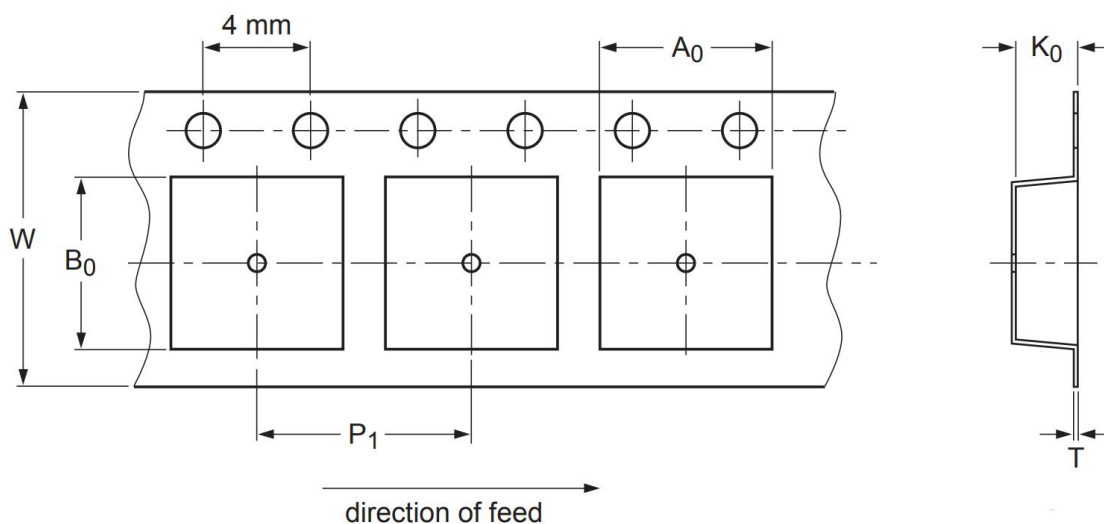
aaa-014313



Tape pocket quadrants

Ball 1 is in quadrant Q2/T3

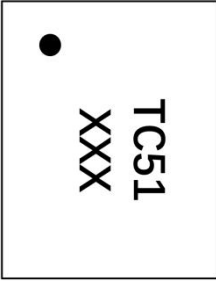
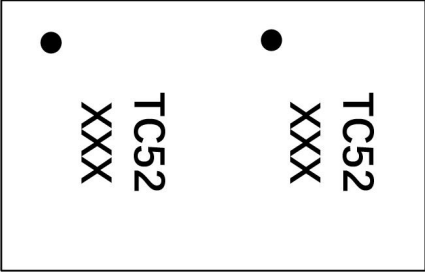
### Product orientation in carrier tape



### Carrier tape dimensions

| Product Name | Dimensions in millimeters |                |                |             |                |               |
|--------------|---------------------------|----------------|----------------|-------------|----------------|---------------|
|              | A <sub>0</sub>            | B <sub>0</sub> | K <sub>0</sub> | T           | P <sub>1</sub> | W             |
| TFC0501MX    | 1.32 ± 0.05               | 0.92 ± 0.05    | 0.70 ± 0.05    | 0.20 ± 0.02 | 4.0 ± 0.1      | 8 + 0.3/- 0.1 |
| TFC0502NX    | 1.32 ± 0.05               | 1.72 ± 0.05    | 0.70 ± 0.05    | 0.20 ± 0.02 | 4.0 ± 0.1      | 8 + 0.3/- 0.1 |

## Marking Codes

| Part Number | Marking Codes   | Marking Codes Note   |
|-------------|---|--|
| TFC0501MX   |  | (1) "TC51" is part number, fixed.<br>(2) "XXX" is last three numbers of lot number on wafer. |
| TFC0502NX   |  | (1) "TC52" is part number, fixed.<br>(2) "XXX" is last three numbers of lot number on wafer. |

## Ordering Information

| Part Number | Working Voltage | Quantity Per Reel | Reel Size |
|-------------|-----------------|-------------------|-----------|
| TFC0501MX   | 5.0V            | 3,000             | 7 Inch    |
| TFC0502NX   | 5.0V            | 3,000             | 7 Inch    |