Reflectionless and Transition Time Converters (TTC) Filters

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Motivation for Reflectionless Filters*

As Data Rate Increases….

Frequency Domain:
• Operational Frequency Increases
• Harmonic Matching - Amplifiers might self oscillate if Harmonics are not terminated.
• Bouncing Back Energy at the output of a Mixer and a Multiplier causes deficiency
• Cascaded Filters never yield the sum of their Rejections.

Time Domain:
• Signal Rise Time is getting shorter
• Pulse Shaping - The faster the data rate, the wider the modulation BW, however when transmitted through a band limited channel it creates Inter-Symbol Interference, ISI.
• Rise Time Alteration - Reducing the Rise Time reduces the amount of Overshoot and its sensitivity to Reflections. Commonly used In signal generators. Passing a square signal through a filter one can alter the rise time and the BW of the output signal.
• Reducing Transients - Placing Reflectionless High-Pass Filters between the control lines reduce amplitude of transients signals produced during fast switching
• BERT, AWG and PHY Measurements of High Speed Digital Receiver Testing

* “Reflectionless Filters” by Matthew A. Morgan
Reflectionless Filters on Thin Film Technology

Chebyshev Response
Frequency Domain
- Steep rejection with prescribed TZ’s
- $S_{11}$ and $S_{22}$ are matched $3 \times F_c$

Gaussian Response
Time Domain
- Flat Group Delay
  - $S_{11}$ and $S_{22}$ are matched $3 \times F_c$
  - BERT Applications
In General…..

- Suspended between two layers of Air Substrate of Alumina Titenate
  - Inductors are narrow lines
  - Capacitors are Broad-Side Coupled Lines
  - Resistors are Thin Film Resistors
New Reflectionless LPF Fc~1400MHz + TZ on RO4003 60mils

- Ideal for rejection 2\textsuperscript{nd} harmonic between two stages of an Amplifier
Examples of Reflectionless Filters
• What is a TTC?
  - It enables to modify / manipulate the output of test equipment, such as e.g. a BERT (Bit Error Ratio Tester) or a AWG (Arbitrary Waveform Generator) to achieve a common and comparable test impulse towards the DUT amongst different test equipment vendors.
Time Domain:
Reducing the Rise-Time=Better Overshoot

“Overshoot” is Bad!
Passing the input signal through a Low-Pass with increased 3dB cut-off frequency, tend to smooth the corner, which improves the sensitivity of Inter-Symbol-Interference, AKA-ISI
60PS TTC Filter
Transition Time Converters - TTC Products

Features:
- Designed Specifically for High Speed Digital Networks utilizing modified Bessel Filter Function.
- Covers the 10 MHz to 20 GHz Frequency Range.
- Minimum Ringing / Overshoot.
- Minimizes Inter-Symbol Interference.
- Broad Band VSWR Match.
- Supports Sonnet OC-1 to OC-192, SDH STM-0 to STM 64, Fiber Channel and Gigabit Ethernet.

TTC Series - Transition Time Converters, (TTC)

Designed Specifically for High Speed Digital Networks
Covers the 10 MHz to 20 GHz Frequency Range
Minimum Ringing / Overshoot
Minimizes Inter-Symbol Interference
Broad Band VSWR Available

Data Sheet  Add to Cart
# Transition Time Converters (TTC)

**Features:**
- Designed specifically for high speed digital networks utilizing modified Beausell fiber function.
- Covers the 10 MHz to 20 GHz frequency range.
- Minimum ringing / overshoot.
- Minimizes inter-symbol interference.
- Broad band VSWR Match.
- Supports Sonnet OC-1 to OC-192, SDH STM-0 to STM 64, Fiber Channel and Gigabit Ethernet.

**Specifications:**

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>VSWR In/Out</th>
<th>Rise Time</th>
<th>Impedance (Ohms)</th>
<th>Rejection</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 20,000</td>
<td>1.5:1 DC to 3 X / /, Typical</td>
<td>0.38 / /, Typical</td>
<td>50</td>
<td>2 dB X / /, Typical</td>
<td>0 to +80 °C</td>
</tr>
</tbody>
</table>

**Standard Part Numbers:**

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition Time (ns)</td>
<td>1 ns</td>
<td>100 ns</td>
<td>156 ns</td>
<td>256 ns</td>
<td>650 ns</td>
<td>750 ns</td>
<td>950 ns</td>
<td>1350 ns</td>
</tr>
<tr>
<td>Bit Rate (Mb/s)</td>
<td>15 Mb/s</td>
<td>65 Mb/s</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tbody>
</table>

**Rejection:**

Can be estimated using the formula above.

**Example:**

- 3 dB cut-off frequency = 100 MHz
- Rejection Frequency of Interest @ 400 MHz

\[
20 \log_{10} \left( \frac{100}{400} \right) \approx 3 \text{ dB}
\]

**To Order:**

**Code**

- 2250/1750 - Q / O / OP
- 1 2 3 4 5 6

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Time Domain Lowpass</td>
</tr>
<tr>
<td>2</td>
<td>3 dB Cutoff Frequency in MHz</td>
</tr>
<tr>
<td>3</td>
<td>Transition Time</td>
</tr>
<tr>
<td>4</td>
<td>NS = Nanoseconds, PS = Picoseconds</td>
</tr>
<tr>
<td>5</td>
<td>Input Connector Type</td>
</tr>
<tr>
<td>6</td>
<td>Output Connector Type</td>
</tr>
</tbody>
</table>

**Connectors:**

- SMA Female
- SMA Male
- 2.92 mm Female
- 2.92 mm Male
- KP

www.klmicrowave.com
Phone: 410-749-2682 • Fax: 410-310-2238
Contact: Ralf Heering • ralf@klmicrowave.com

www.kllinterfilter.com
2250 Northwood Drive
Salisbury, MD 21801
TTC-5833/60PS-O/OP - TTC Data Sheet

Description:
TTC-5833/60PS-O/OP is a transition time converter featuring a lowpass response with a nominal 3 dB cutoff frequency of 6000 MHz. This filter exhibits VSWR I/O match 1.5:1 up to 4 x f_s with a rise time to impulse response of 60 ps +/- 0.5 ps.

Features:
- Designed Specifically for High Speed Digital Networks utilizing modified Bessel Filter Function.
- Covers the 10 MHz to 20 GHz Frequency Range
- Minimum Ringing / Overshoot
- Minimizes Inter-Symbol Interference
- Broad Band VSWR Match
- Supports SONET OC-1 to OC-192, SDH STM-4 to STM 64, Fiber Channel and Gigabit Ethernet
- Typical Size 1.65"L x 0.63"W x 0.46"H

Eye Diagram of Step Response

TTC-5833/60PS-O/OP used in DisplayPort® receiver test, courtesy of BitEye Digital Test Solutions GmbH
Display Port Receiver Test - Courtesy of Bitifeye Digital Test Solutions, GmbH
We Customize all Filtering Solutions

Thank You