K8  Reflection and Termination in a Transmission Line

Pulse Generator:

Pulse Period: 2 µs
Pulse Duration: 0.1 µs

Decade Box Resistor: OUT
Setup, Recall 1

K9  RC Time Constant in a Transmission Line

Pulse Generator:

Pulse Period: 2ms
Pulse Duration: 1ms

Decade Box Resistor: IN
Setup, Recall 2
Reflection + Termination in a Transmission Line

Scope:
CH1 2V
CH2 5V
Sweep 200μs
8. REFLECTION + TERMINATION
IN A TRANSMISSION LINE

[Graphs showing waveforms for different conditions]
**Equipment Settings**

**PG 501A:**
- Pulse = .1 μSec
- Period = 2 μSec

→ **NOTE:** Pulse selection is contained in orange band on PG 501's face plate. Switch knob is denoted by orange stripe.

→ **NOTE:** Period selection is contained within orange band on PG 501's face plate. Switch knob is denoted by black stripe.

**HP 54600A:**
- Volts/Div. CH1 = 1 volt
- CH2 = 2
- Sweep = 200 nsec
- Horizontal Delay = 792 nsec
### Coaxial & Data Systems
#### Coaxial Cables

<table>
<thead>
<tr>
<th>Alpha No.</th>
<th>RG Type</th>
<th>AWG (mm²)</th>
<th>Inner Conductor</th>
<th>Dielectric</th>
<th>Shield</th>
<th>Jacket</th>
<th>UL Style No.</th>
<th>Impedance</th>
<th>Vp %</th>
<th>Cal %</th>
</tr>
</thead>
<tbody>
<tr>
<td>9884*</td>
<td>6/U</td>
<td>18</td>
<td>(0.82) Solid</td>
<td>C FPE</td>
<td>TC Braid</td>
<td>100</td>
<td>Black V</td>
<td>0.270</td>
<td>(6.86)</td>
<td>71</td>
</tr>
<tr>
<td>9843**</td>
<td>6/U</td>
<td>18</td>
<td>(0.82) Solid</td>
<td>C FPE</td>
<td>TC DW</td>
<td>100</td>
<td>White, Gray or Black V</td>
<td>0.242</td>
<td>(6.15)</td>
<td>75</td>
</tr>
<tr>
<td>9005A†</td>
<td>6/A/J</td>
<td>21</td>
<td>(0.41) Solid</td>
<td>CW PE</td>
<td>Double Braid inner:SC outer:C</td>
<td>96</td>
<td>Black NCV</td>
<td>0.336</td>
<td>(8.53)</td>
<td>75</td>
</tr>
<tr>
<td>9008B</td>
<td>8/U</td>
<td>13</td>
<td>7/21 (7×0.73) C</td>
<td>PE</td>
<td>C Braid</td>
<td>96</td>
<td>Black V</td>
<td>0.405</td>
<td>(10.28)</td>
<td>52</td>
</tr>
<tr>
<td>9006A†</td>
<td>8/A/U</td>
<td>13</td>
<td>7/21 (7×0.73) C</td>
<td>PE</td>
<td>C Braid</td>
<td>96</td>
<td>Black NCV</td>
<td>0.405</td>
<td>(10.28)</td>
<td>52</td>
</tr>
<tr>
<td>9009B</td>
<td>9/B/U</td>
<td>13</td>
<td>7/21 (7×0.73) SC</td>
<td>FE</td>
<td>Double SC Braid</td>
<td>99</td>
<td>Black NCV</td>
<td>0.420</td>
<td>(10.67)</td>
<td>50</td>
</tr>
</tbody>
</table>

**Standard Pull-Up:** 100 ft. (30.5m), 500 ft. (152m), 1000 ft. (305m)

**Attention Levels see Chart Page 147**

**Legend**

- C—Bare copper
- TC—Tinned copper
- CW—Coated copper
- A/M—Aluminum clad copper tape
- PE—Polyethylene cable
- FPE—Cellulose (foam) polyethylene
- V—Polyvinylchloride—Type I
- V—Polyvinylchloride—Type II
- DW—Drain wire
- SC—Silver coated copper

- *100% Sweep Test @ 3 to 500 MHz
- **Twist-on Connectors available, see Page 155
- † MIL-C-17D
- ‡ JAN-C-17A
- ▲ All Polyethylene jacketed material is Type III A per MIL-C-17
- ♦ Also available Flammability, see Page 146

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**Alpha twist-on coaxial cable BNC and TNC connectors—superior by design**
X91. Speed of Light (almost) in Coax Cable; Reflections and Termination - 12W.

**Purpose:** Measure speed of electromagnetic waves in a coaxial cable as example of 'speed of light' (actually 0.7 c); demonstrate effect of different terminations (as an aside because not studied).

**Equipment:** Coax cable RG9U (418 feet = 127.4 m); pulse generator; termination resistors (51 ohm).

**Procedure:**
- Demonstrates speed of light: measure 0.7 c
  - (a) Send pulse down cable and watch reflection.
    - Delay for round trip is 1.23 - 1.24 μs, giving \( v = 0.68 \) c.
  - (b) Terminate far end with short, open, or matched impedance.
    - Can see pulse at far end too - used 2 sweeps on CRT to see both ends.
  - (c) Observe multiple reflections by using high impedance at driving end.
    - (Output impedance of pulse driver can be changed)
    - Change far end from open to short while watching multiple reflections.
    - Can get some interesting effects; e.g. 2nd pulse larger than 1st pulse (Why?).
- To get effect of long cable (it is on a reel), we strung out some 40 m to end opposite end of lecture desk. Could have student put on terminations. Then bring end back to scope to see the pulse forms at both ends.

**Note:** All of this could be a bit much for students unless explained carefully as we did not spend any time on wave guides, terminations, etc. However, the demonstration of \( v \sim 2/3 \) c is effective. The mechanical torsion pendulum does set it up nicely, and students do see interesting phenomena, albeit w/o thorough derivation.
## REFLECTION & TERMINATION IN A TRANSMISSION LINE

### ELECTROMAGNETIC OSCILLATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEKTRONIX PG508</td>
<td></td>
</tr>
<tr>
<td>PULSE GENERATOR</td>
<td></td>
</tr>
<tr>
<td>TRIGGER LEVEL</td>
<td>0</td>
</tr>
<tr>
<td>TRIGGER SW</td>
<td>+</td>
</tr>
<tr>
<td>MODE</td>
<td>DELAY or UNDLY</td>
</tr>
<tr>
<td>DURATION</td>
<td>.1µSec</td>
</tr>
<tr>
<td>DELAY</td>
<td>.1µSec</td>
</tr>
<tr>
<td>PERIOD</td>
<td>2µSec</td>
</tr>
<tr>
<td>TRANSITION TIME</td>
<td>5nSec</td>
</tr>
<tr>
<td>OUTPUT</td>
<td>-5V (on scope)</td>
</tr>
<tr>
<td>PRESET SW</td>
<td>OUT</td>
</tr>
<tr>
<td>COMPLEMENT SW</td>
<td>OUT</td>
</tr>
</tbody>
</table>