ASSET Measurement of the CERN Tapered Damped Structure (TDS)

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SLAC
Technical features of the TDS

The TDS design exploits both damping and detuning of transverse modes\(^1\). Damping is accomplished by coupling each cell of the structure to its own set of four radial waveguides. The waveguides' cutoff frequency is above the fundamental but below the transverse modes. Each waveguide is terminated by an individual silicon carbide load. Detuning is accomplished by the usual variation of iris and cell diameters.

Structure parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iris diameter range</td>
<td>8.90 to 7.11 mm</td>
</tr>
<tr>
<td>Cell diameter range</td>
<td>16.74 to 15.77 mm</td>
</tr>
<tr>
<td>Cell length</td>
<td>6.66 mm</td>
</tr>
<tr>
<td>Number of cells</td>
<td>150</td>
</tr>
<tr>
<td>Active length</td>
<td>1000 mm</td>
</tr>
<tr>
<td>Fundamental (not tuned)</td>
<td>15 GHz</td>
</tr>
<tr>
<td>Damping waveguide cutoff frequency</td>
<td>16.5 GHz</td>
</tr>
<tr>
<td>Dominant part of the dipole modespectrum</td>
<td>18 to 29 GHz</td>
</tr>
<tr>
<td>Transverse mode Q values (depends on phase advance)</td>
<td>15 to 200</td>
</tr>
<tr>
<td>Damping-waveguide load reflection coefficient</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Detuning of an equivalent undamped structure</td>
<td>1 GHz</td>
</tr>
<tr>
<td>Short range transverse wake</td>
<td>125 V/(pC/mm)</td>
</tr>
<tr>
<td>Transverse wake at 1.33 nsec</td>
<td>&lt; 1.25 V/(pC/mm)</td>
</tr>
</tbody>
</table>

Detail of geometry

# CLIC Tapered Damped Structure

*RF parameters of the middle cell*

<table>
<thead>
<tr>
<th>General parameters</th>
<th>RF parameters</th>
<th>Frequency sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>iris diameter</td>
<td>2Pi/3 mode</td>
<td>29.985 GHz</td>
</tr>
<tr>
<td>cell diameter</td>
<td>group velocity</td>
<td>8% of c</td>
</tr>
<tr>
<td>WG iris width</td>
<td>R/Q</td>
<td>23.9 (+/- 1%) kΩ/m</td>
</tr>
<tr>
<td>WG width</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Silicon Carbide Complex Permittivity
Measured by Inverse Scattering Method

![Graph showing dielectric constant and loss tangent vs. frequency.](image-url)
S11  REF  1.0  Units
1  100.0  mUnits/
   99.755  mU.

ASSET structure lead

START  16.700000000  GHz
STOP   30.700000000  GHz

40 mm long
(15 GHz structure)
Single cell measurement

S21
REF -34.11 dB
5.0 dB/
-57.604 dB

$GHz$
$GHz$

$Q = 14$

$Q = 130$

x3.5 scaled
middle cell
Single half-cell
shorted in the
mid-iris plane

N.B. Synchronism,
correct coupling to
beams not included
in such a measurement.
middle cell
15 GHz, ASSET
perfect load
n.b. Detuning not included

MAFIA time domain
Detuning of the undamped geometry
Double-band circuit model

15 GHz, ASSET
15G cells
- measured load reflection coefficient
CERN TDS (156kHz) Wakefield

Load as of 3.3.94

Line: about 13, 15, 13, 15

166 kHz modulation

Wt. (V/pC/mm/m)

0.01

0.1

1

10

100

1000

s/m

0

0.5

1

1.5

2

2.5

3

3.5

4

Time (ns)

0

1.7

3.3

5.0

Asse ResoLution
Double-band circuit model, frequency spectrum

\[ W_t (\text{VHz/pC/mm/m}) \]

\[ f/\text{Hz} \]

15 GHz, ASSET
150 cells
CLIC Tapered Damped Structure (TDS) in ASSET
Zero Crossing

cy_0_2: WY-ang amp = 66.84 +/- 0.07 V/pC/m/mm amp/err = 945.9

sdr phase (degrees)

(WHY-ang V/pC/m/mm)

(15-Bruo 1 ps)
$T_{\text{imc}} = 350 \, \text{ps}$

cy$_{1\_1}$: WY-ang amp = 32.26 $\pm$ 0.05 V/pC/m/mm  amp/err = 604.8

![Graph showing sinusoidal waveform with labeled axes and frequency]

$f = 18.1 \, \text{kHz}$

sdr phase (degrees)
Time = 1.05 ns

cy_3_1: WY_ang amp = 0.72 +/- 0.04 V/pC/m/mm  amp/err = 16.7
$T_{\text{ime}} = 2.1 \text{ ns}$

cy_6_1: WY_ang amp = 0.29 +/- 0.05 V/pC/m/mm amp/err = 6.1

\[ f = 7.6 \text{ GHz} \]
\[\bar{\text{Time}} = 13.3 \text{ ns}\]

cy_28_1: WY-ang amp = 0.33 +/- 0.08 V/pC/m/mm amp/err = 4.0

\[f = 7.6 \text{ GHz}\]
Time = 19.6 ns

cy_56_1: WY-ang amp = 0.05 +/- 0.08 V/pC/m/mm amp/err = 0.7

\[ f = \pi/6 \angle H \]
$T_{ime} = 39.2 \, \text{ns}$

cy_{1121}: WY-ang amp = 0.09 +/- 0.09 V/pC/m/mm amp/err = 1.1

$f = 7.64 \, \text{Hz}$
cx_0_1: WX_ang amp = 36.75 +/- 0.05 V/pC/m/mm  amp/err = 708.0
Time = 350 \mu s

cx_1_1: WX_\text{ang} \text{amp} = 17.74 \pm 0.04 \text{ V/pC/m/mm} \text{ amp/err} = 468.6

\begin{figure}
\centering
\includegraphics[width=\textwidth]{sdr_phase_degrees.png}
\caption{sdr phase (degrees)}
\end{figure}
Time = 5.25 ns

cx_15_1: WX_ang amp = 0.29 +/- 0.10 V/pC/m/mm amp/err = 2.9
cx_28_2: WX_ang amp = 0.53 +/- 0.08 V/pC/m/mm amp/err = 6.9

Time = 9.8 ns
$T = 19.6 \text{ ns}$

cx_56_1: WX_ang amp = 0.15 +/- 0.07 V/pC/m/mm  amp/err = 2.2

$f = 7.6 \text{ GHz}$
MAFIA

#CONTOUR

COORDINATES/M
FULL RANGE / WINDOW
\[
\begin{align*}
\text{X:} & \quad 0.0000, 0.0800 \quad 0.0000, 0.0800 \quad 0.0000, 0.0800 \quad 0.0000, 0.0800 \\
\text{Y:} & \quad 0.0000, 0.2420 \quad 0.0000, 0.2420 \quad 0.0000, 0.2420 \quad 0.0000, 0.2420
\end{align*}
\]

SYMBOL: EDL_LAST_VOL
COMPONENT...: R
FUNCTION MIN: -9.994E-04
FUNCTION MAX: 2.694E-03
LOTTED MIN: -7.500E-05
LOTTED MAX: 8.500E-04
LOTTED STEP: 5.781E-05
INTERPOLATE.: 0
LOGSCALE...: 0
MATERIALS: 0.1,
MAFIA

# CONTOUR

COORDINATES/M
FULL RANGE / WINDOW
R: 0.0000, 0.0800001
  0.005765, 0.0192541
Z: 0.12700, 0.15400

SYMBOL: EDL_LAST_VOL
COMPONENT: R
FUNCTION MIN: -2.775E-04
FUNCTION MAX: 2.6943E-03
PLOTTED MIN: -7.500E-05
PLOTTED MAX: 8.500E-04
PLOTTED STEP: 5.781E-05
INTERPOLATE: 0
LOGSCALE: 0
MATERIALS: 0.1.

TRANSIT2.DRD
TDS TRANSITION FOR ASSET [ZOOM]
1 pC, 1 mm offset

R COMPONENT OF WAKE POTENTIAL IN r [DIRECT CALCULATION]