Stripline Design for Tune Measurement in the ILSF Storage Ring

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Abstract

The Iranian Light Source Facility Storage Ring is under design with a 528 m circumference and will store the electron bunches with 3 GeV energy to produce high-flux radiation that ranges from infrared to hard X-rays. The stripline is planned to be installed in the ILSF storage ring for beam tune measurement and transverse feedback system (TFS). This stripline can be used for exciting the beam in tune measurement system and damping the transverse instabilities in TFS. In this paper, the design of the striplines for the ILSF storage ring is investigated. Each stripline is matched to 50Ω impedance and has 4 strips (electrodes) that are placed at 45 degrees to the beam axis, the best geometry is achieved and optimized by CST Microwave Studio simulation

About the Design

Four electrodes are placed in the 45,135,225, and 315 degrees at a distance equal to the radius of the storage ring vacuum chamber (a). Each stripline consists of four strips (electrodes), eight coaxial feed-throughs, and water colling connectors. This system must be matched to the 50Ω impedance of the coaxial feed-through cables. The impedance is calculated by using CST Microwave Studio's Frequency domain solver in the vertical and horizontal dipole, quadrupole, and sum modes.

The mechanical design of the stripline depends to geometric parameters such as electrode thickness (t=2mm), opening angles (φ_s) and the distance between the electrode and chamber (housing) $(G = \varphi_g - a)$ (have a high geometric factor)

The electrode lengths are given by:

$$l = \frac{c}{4f} = \frac{\lambda}{4} = 75\ cm \qquad (1)$$

And geometry factor is given by:

$$g_{\perp} = \frac{8}{\varphi_g \pi} \sin\left(\frac{\varphi_g}{2}\right) \sin\left(\frac{\varphi_s+\varphi_g}{2}\right) \qquad (2)$$

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Table 1: 9 stripline designs with different geometric parameters and their geometric factor for comparison

No.Design	φ_s (°)	φ_g (°)	$g_{\perp}$
1	60	5	0.6839
2	60	8	0.7114
3	45	6	0.5479
4	45	8	0.5677
5	45	10	0.5872
6	40	10	0.5374
7	40	12	0.5571
8	30	12	0.4555
9	30	15	0.4859

Table 2: Impedance in different modes for selected designs in Table 1 with different G

No. Design	G	$Z_{H-Dipole}$ (Ω)	$Z_{V-Dipole}$ (Ω)	Z_{Quad} (Ω)	Z_{ch} (Ω)
2	7	43.690	43.686	41.829	43.687
	10	46.300	46.293	44.177	46.296
4	7	48.706	48.706	47.576	47.706
	10	50725	50.732	49.522	50.727
5	5	49.373	49.370	48.108	49.371
	7	53.233	53.165	51.648	53.198
7	5	55.039	55.037	53.669	55.037

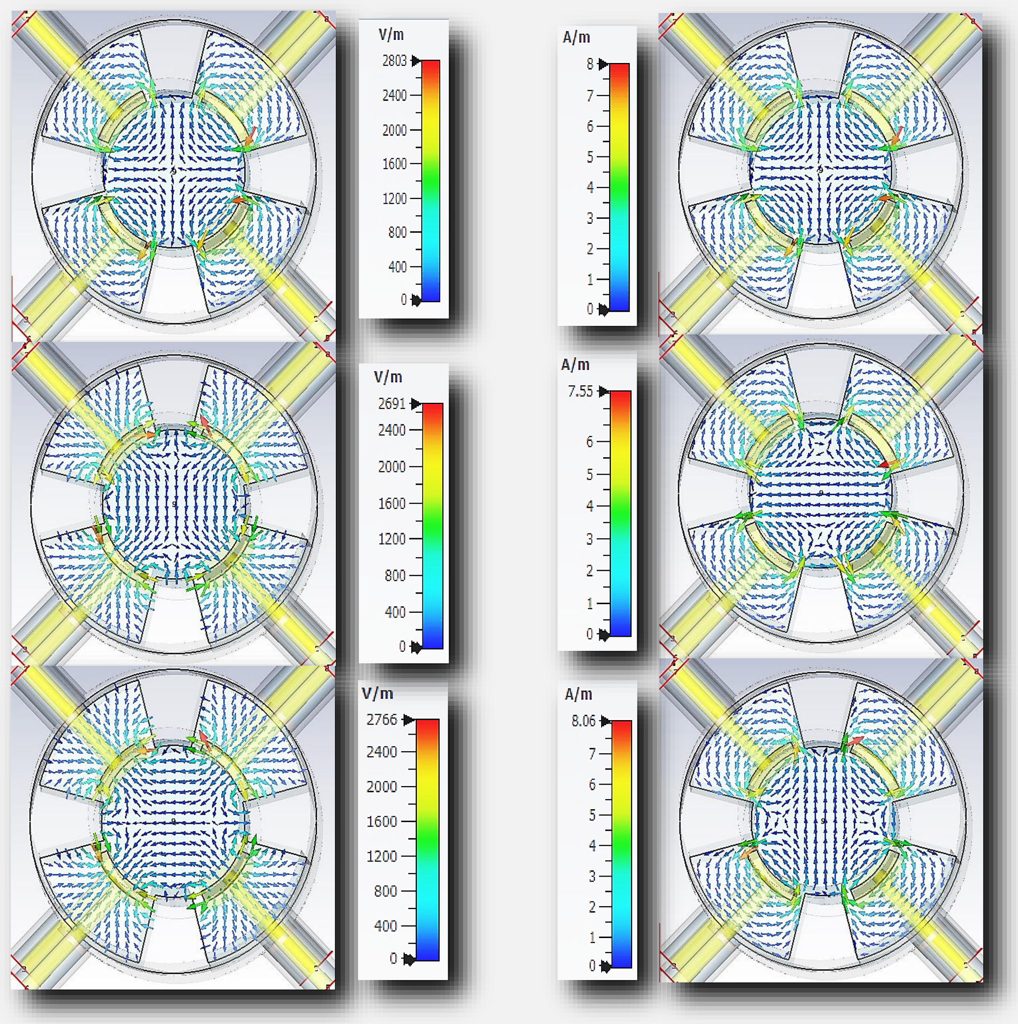


Figure 2: E-field (left) H-field (right) in V-dipole mode results in the stripline kicker in the x-y plan.

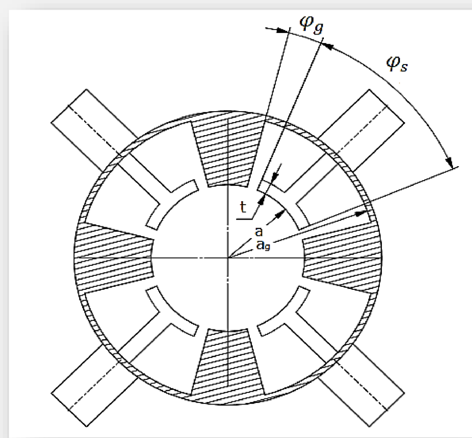


Figure 1: Overview of the ILSF stripline. The cross section of the nominal section.

CST simulation

The Wakefield analysis for three different electrode (strip) lengths is performed by using CST software (The bunch length (σ) is set to 2 mm, and the mesh consists of 88 million cells)

The wake loss factor and power loss are compared too.

(k_{loss}) for the bunch length σ=2mm and σ=7.9mm is given by:

$$k_{loss} = -\int_{-\infty}^{\infty} \lambda(s) W\|(s) ds \qquad (3)$$

The power loss (P_{loss}) is calculated by:

$$P_{loss} = T_0 \frac{I_{av}^2}{M} k_{loss} \qquad (4)$$

Table 2: Geometric factor comparison for three different electrode lengths

length of strip	$g_{\perp d}$	$Z_{H-Dipole}$ (Ω)	$Z_{V-Dipole}$ (Ω)	Z_{Quad} (Ω)	Z_{ch} (Ω)
75	0.5677	50.730	50.730	49.514	50.730
30	0.5677	50.731	50.734	49.470	50.732
15	0.5677	50.664	50.725	49.507	50.684

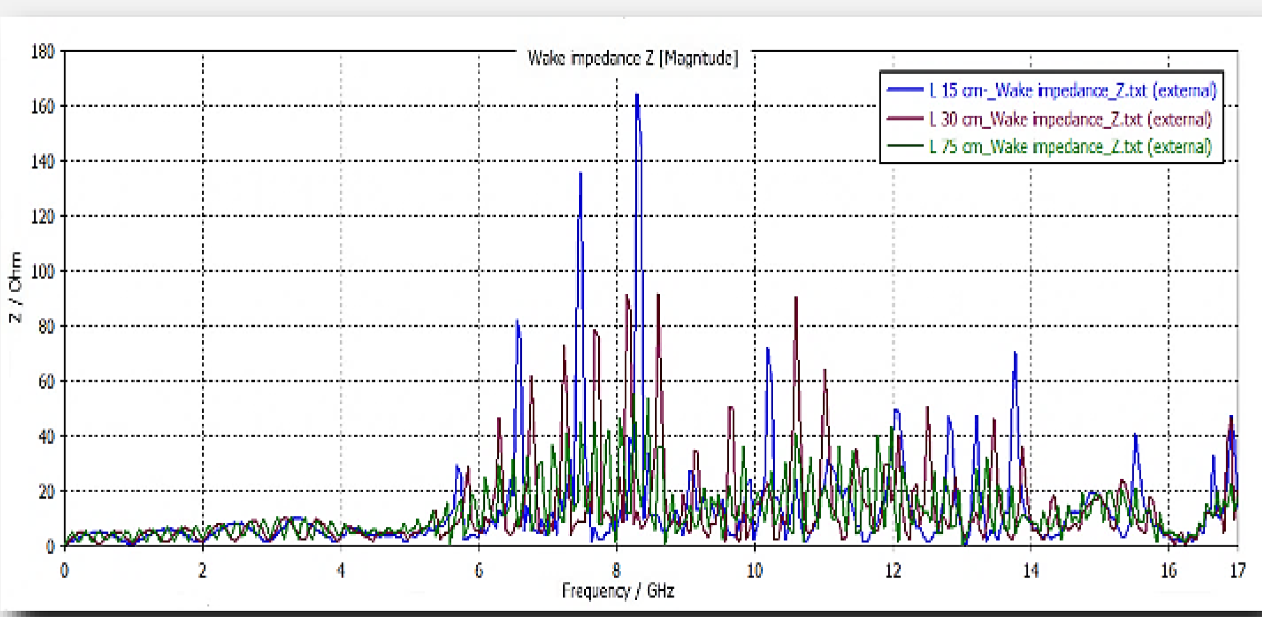


Figure 3: Longitudinal wake impedance for 3 strip length.

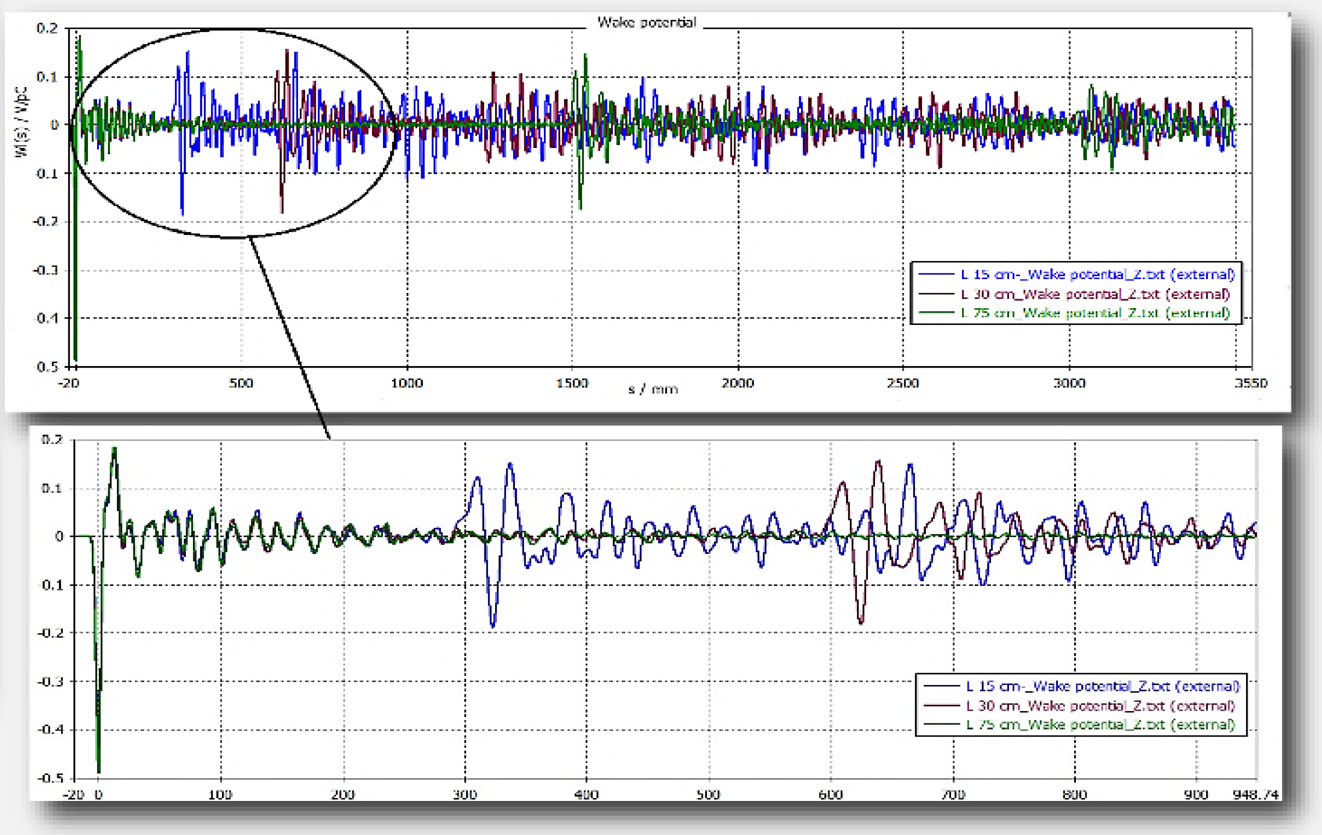


Figure 4: Wake potential for 3 strip length.

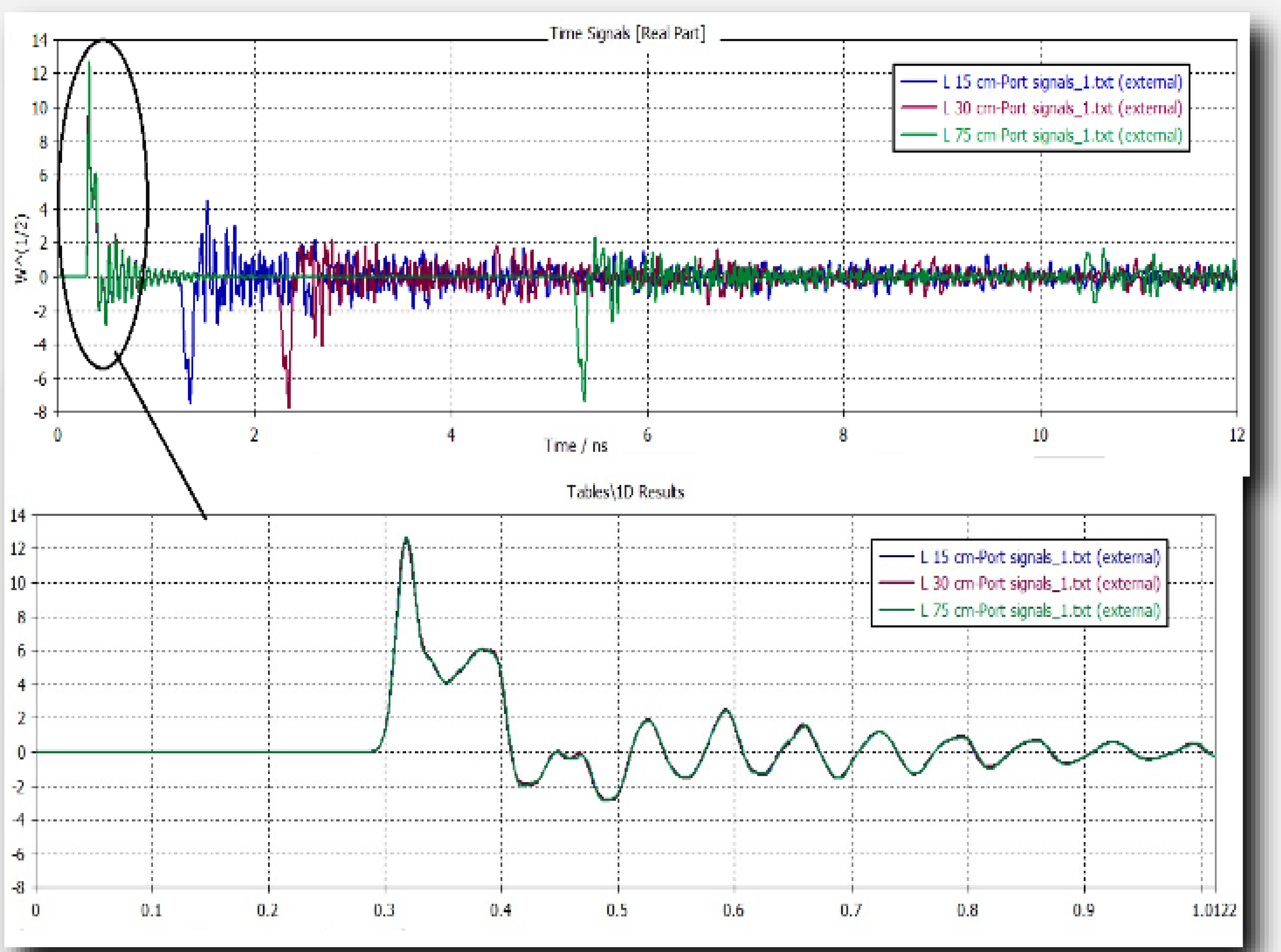
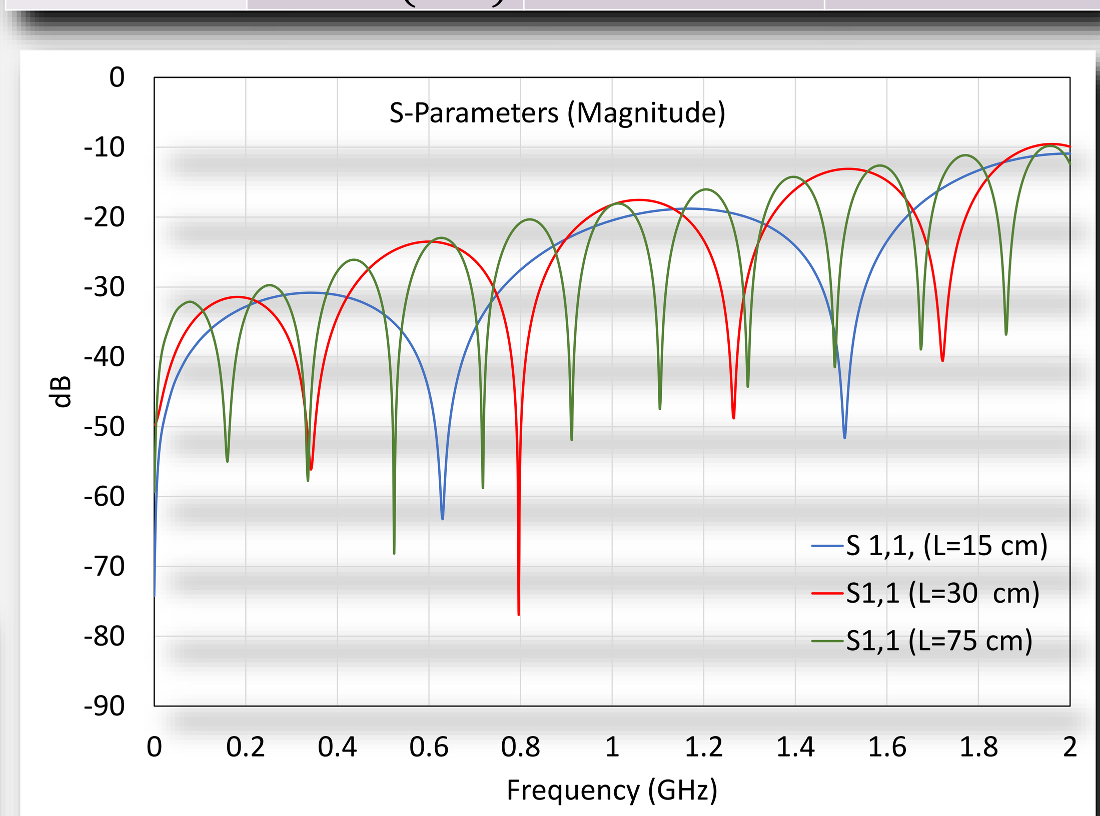


Figure 5: Port signal for 3 strip length.

Table 3: Loss factor and power loss for bunch length ($\sigma = 2\ mm$) and real ILSF bunch $\sigma = 7.9mm$

Strip length	Bunch length	$k_{loss}(V/pC)$	$P_{loss}(Watt)$
L=75 cm	$\sigma = 2(mm)$	3.675×10^{-1}	$73.97 \times 10^{+1}$
	$\sigma = 7.9(mm)$	5.798×10^{-2}	20.121
L=30 cm	$\sigma = 2(mm)$	3.090×10^{-1}	$62.19 \times 10^{+1}$
	$\sigma = 7.9(mm)$	4.660×10^{-2}	20.128
L=15 cm	$\sigma = 2(mm)$	2.949×10^{-1}	$59.35 \times 10^{+1}$
	$\sigma = 7.9(mm)$	4.436×10^{-2}	20.127



CONCLUTION

The length of 15 cm results in lower Wakefield potential, leading to less energy loss and greater stability. Additionally, it has lower Wakefield potential and fewer peaks. The Wakefield impedance peaks are also shorter. At all three lengths, the impedance matching at the ports is good, with values less than -30 dB.

The optimal length for our ring is 75 cm, but based on the results, if an appropriate electronic system like the Libera Signal Pass is used for signal reading, the length can be reduced to 15 cm. This would also solve the space issue for placing the strip lines.