Instantaneous Q_l/Q_{ext}-Measurements in CEBAF incl. Transmission Line Calibration

Procedure

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Frank Marhauser

Jefferson Lab

JSA

Procedure: Steps in Chronological Order

Step 1)   Compute attenuation factor: $\boldsymbol{Att = 10^{-\alpha(\text{dB})/10}}$

$$Att = \frac{I_{tot}V_c + \sqrt{(I_{tot}V_c)^2 + 4P_f \cdot P_r}}{2P_f}$$

$$0 \leq Att \leq 1$$

If $Att > 1$, then $Att = 1$

Step 2)   Compute attenuation in dB

$$\alpha(dB) = -10 \cdot Log10(Att)$$

$$\alpha(dB) \geq 0$$

Step 3)   Correct raw forward and reflected power levels using α

$$P_{f,c} = P_f \cdot 10^{-\alpha/10}$$

$$P_{r,c} = P_r \cdot 10^{+\alpha/10}$$

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Step 4) Solve for Q_l using P_{fwd} and P_{ref}

Step 4) Compute Ql − factors using corrected forward and reflected power levels

Step 4a)

$$Q_l\left(P_{f,c}, I_{tot}, V_c, \Psi, \frac{R}{Q}\right) = \frac{2P_{f,c} - I_{tot}V_c - 2P_{f,c}\sqrt{1 - \dfrac{I_{tot}V_c}{P_{f,c}} - \dfrac{I_{tot}^2 \cdot V_c^2}{4P_{f,c}^2}tan^2\Psi}}{R/Q\, I_{tot}^2}$$

Step 4b)

$$Q_l\left(P_{r,c}, I_{tot}, V_c, \Psi, \frac{R}{Q}\right) = \frac{2P_{r,c} + I_{tot}V_c - 2P_{r,c}\sqrt{1 + \dfrac{I_{tot}V_c}{P_{r,c}} - \dfrac{I_{tot}^2 \cdot V_c^2}{4P_{r,c}^2}tan^2\Psi}}{R/Q\, I_{tot}^2}$$

Cavity parameter

CRFP (kW)
CRRP (kW)
GMES (MV/m) → $V_c = GMES*L_{act}$
Detuning angle (T)DETA (deg.)
R/Q

Beam currents and recirculating passes

IBC1H04CRCUR2 (μA), MMSHLAPASS
IBC2C24CRCUR3 (nA), MMSHLBPASS
IBC3H00CRCUR4 (μA), MMSHLCPASS
IBCAD00CRCUR6 (nA), MMSHLDPASS

Note: Depending on where cavity resides (SL or NL), the total average beam current (I_{tot}) needs to be that of the SL or NL

South linac with Hall D beam current

$$I_{tot} = \begin{pmatrix} Hall\ A\ injected\ I \\ Hall\ B\ injected\ I \\ Hall\ C\ injected\ I \\ Hall\ D\ injected\ I \end{pmatrix} \cdot \begin{pmatrix} passes\ to\ Hall\ A \\ passes\ to\ Hall\ B \\ passes\ to\ Hall\ C \\ 5 \end{pmatrix}^T$$

North linac with Hall D 6th pass in NL

$$I_{tot} = \begin{pmatrix} Hall\ A\ injected\ I \\ Hall\ B\ injected\ I \\ Hall\ C\ injected\ I \\ Hall\ D\ injected\ I \end{pmatrix} \cdot \begin{pmatrix} passes\ to\ Hall\ A \\ passes\ to\ Hall\ B \\ passes\ to\ Hall\ C \\ 6 \end{pmatrix}^T$$

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Cavity Parameters

Parameter	Units	C20	C50	C75	C100
Q_0 spec at 2.07 K		2.4e9	6.8e9	8.0e9	7.2e9
Q_{ext} spec		6.6e6	8.0e6	2.0e7	3.2e7
β		**364**	**850**	**400**	**225**
R/Q	Ω	482.5	482.5	525.4	868.9
L_{act}	m	0.5	0.5	0.4916	0.7
E_{acc}	MV/m	5	12.5	19.1	19.2
(1+β)/4β		0.251	0.250	0.251	0.251
(β-1)/(β+1)		0.995	0.998	0.994	0.991

Only cavity parameters required depending on cavity type

Parameter	Units	OC shape C20	OC shape 7-cell SL21 and F100	OC shape C50	HC shape C75	LL shape C100
R/Q	Ω	482.5	672.38	482.5	525.4	868.9
L_{act}	m	0.5	0.7	0.5	0.4916	0.7