

# Cavity gradient, forward and reflected power amplitude calibration by RF measurements

V.Ayvazyan, D.Kostin, March 10, 2011

The forward and reflected signals to the single cavity are measured from the directional couplers installed on the waveguide which deliver RF power to the cavity. Below is the description of cavity gradient, forward and reflected power amplitude rough calibration procedure which is in use at FLASH.

For each accelerating module at FLASH we have direct RF power measurement for one cavity (Cavity 1 for ACC6 and Cavity 1 for ACC7). The RF power measurements are done using the waveguide directional couplers with calibrated RF cables and the RF power meters. Power meters are connected to those cavities through GPIB-Ethernet network to the computers, which are controlled by DOOCS system. Downconverter / ADC channel for  $P_{for}$ ,  $P_{ref}$  (from circulators) and  $P_{trans}$  (cavity probes) for each cavity is used to monitor the forward, reflected and transmitted power pulse shape. To measure the accelerating gradient ( $E_{acc}$ ) cavity probe (transmitted) power value was used, calibration coefficient  $k_t$  is to be measured at lower power rectangular pulse (see fig. 1), when pulse shape is precisely defined and  $E_{acc}$  is calculated as follow:

$$E_{acc} = \frac{\sqrt{4\frac{R}{Q}Q_{load}P_{for}}}{L_{cavity}} \times \left( 1 - e^{-\frac{\pi f_0 t_{fill}}{Q_{load}}} \right) = k_t \times \sqrt{P_{trans}} \quad [\text{V/m}]$$

Where:  $R/Q=1036\Omega$ ,  $L_{cavity}=1.036\text{m}$ ,  $Q_{load}=3 \times 10^6$ ,  $f_0=1.3\text{GHz}$ ,  $P_{for} \approx 3\text{kW}$  (for the calibration),  $t_{fill}=1.3\text{ms}$  (for the calibration,  $500\mu\text{s}$  for flat-top pulse). Evaluated error margins for accelerating gradients in this test are about  $\pm 10..16\%$ .

The formula can be used only if the forward power pulse is a rectangular one and there is no detuning, also cavity is exactly on the resonance.

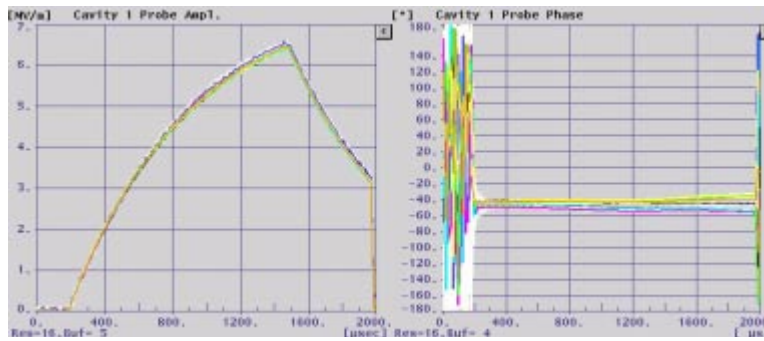


Figure 1: Cavity gradients for 1.3ms rectangular input RF power pulse

Since power distribution through the waveguide distribution system is well known we can calculate power level for all cavities from the reference cavity measurement (power meter measurement) which are connected to the same klystron. This calibration has been applied to the monitoring ADCs. For reflected power calibration one can completely detune the cavity. In such a case for reflected power we will have similar rectangle pulse shape like forward power and the same calibration procedure like forward power can be used. This simple method has been used for particularly during ACC6/7 power calibration.