Klystron RF Gradient Regulation

Local application for Linac Upgrade

Thu, Nov 18, 1993

Introduction

The klystron RF systems drive the accelerating cavities in the Linac Upgrade. Due to temperature variations, the gradient in the cavities exhibits a variation over a period of minutes or hours. This note describes a local application that compensates for such variations to maintain more constant gradient readings.

The gradient amplitude affects the beam significantly. During beam cycles, the gradient is reduced by beam loading. Regulation of the gradient must concentrate on regulating *beam* cycles, using as a reference the nominal gradient value used by the alarm scanning system. On *no-beam* cycles, when no beam is accelerated, the program can measure the amount of beam loading by comparing the gradient reading against the last beam cycle reading. Then, after some time has passed without beam cycles, this beam loading estimate can be used to derive the appropriate reference for no-beam gradient regulation.

Parameters

The "Page-E" parameters are as follows:

```
E LOC APPL PARAMS 11/12/93 0835
NODE<0622>  NTRY<11>
NAME=KRFG   CNTR=0113
TITL"KLYSTRON RF GRADIENT REG"
SVAR=00033442
ENABLE  B<0090> KFRG K2 ON/OFF
NBWAIT  C<0091> K2WAIT      CYC
GRREAD  C<0484> K2GRAD      NRM
GRSET   C<0422> L2MSDA      V
GAIN    C<0090> K2LPGN
AVGCYC   <0020>
LOADCYC  <0080>
```

After the required enable Bit# parameter, NBWAIT is the Chan# whose value specifies the number of cycles after the last beam pulse at which time the program switches from beam regulation into no-beam regulation.

The gradient reading and setting Chan# are next. The gradient reading is in "normalized units," while the gradient setting is in "volts" units.

The relationship between a change in the setting in these units that produces a change in the reading units is about 0.25; *i.e.*, $\Delta\text{reading} \approx 4*\Delta\text{setting}$. As a result, the next parameter, the gain Chan#, should be about 0.25 to correspond to full correction. Note that significantly larger values of the gain may produce an oscillation.

The last two parameters specify periods in 15 Hz cycles. They are not Chan#'s, so their values must be changed via "Page-E" directly. The AVGCYC parameter specifies for the no-beam regulation mode the number of cycles over which readings are averaged to give a result that is compared with the expected no-beam reference value. It is probably easier to consider this as the minimum period between making no-beam adjustments. The LOADCYC parameter specifies the averaging parameter that is used in the computation of beam loading. The formula is as follows:

```
avgLoading:= (avgLoading*(loadCyc – 1) + loading)/loadCyc;
```

A new value of beam loading is measured on each no-beam cycle during the beam regulation mode, when there has been a "recent" beam pulse. This value of loading is combined in the above formula to produce an updated average value of beam loading. The average is used during no-beam regulation mode to derive the no-beam reference value for the gradient. The formula is as follows:

```
noBeamRef:= beamRef + avgLoading;
```

The `beamRef` is the nominal value of the gradient as used in the alarm scan.

Internal constants

Several internal constants are used by the program. To change them, one must modify the local application program called KRFG.

`minGrad = 0.75;`	Minimum gradient reading for regulation
`maxChange = 0.01;`	Maximum setting adjustment made at once
`maxSample = 30;`	#cycles period for sampling parameter values
`beamLoadStart = 0.04;`	Initialized default value of beam loading

Adjustment limits

If a calculated new setting is made that would take the setting channel outside of its alarm tolerance range, the setting is not performed. This serves to keep the range of adjustment within bounds, even if the gradient readings exhibit peculiar characteristics.