VSWR Calculation

Local application

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As an aid in tuning the low energy RF systems, Linac personnel asked for new channels that can hold the values of VSWR, or Voltage Standing Wave Ratio, for the 5 stages of each RF station, referred to as LL, IPA1, IPA2, DRV, and PA, in order of increasing power output. This note describes a local application VSWR that is designed to perform that calculation.

The formula

The calculation of VSWR depends only on the forward and reverse power readings in the following simple way:

```
rho = sqrt(revPwr/fwdPwr)
vswr = (1 + rho) / (1 - rho)
```

To get a feeling for this, here is a list of examples:

rev/fwd	*rho*	*vswr*
0.0	0.000	1.000
0.1	0.316	1.925
0.2	0.447	2.618
0.3	0.548	3.422
0.4	0.632	4.442
0.5	0.707	5.828
0.6	0.775	7.873
0.7	0.837	11.24
0.8	0.894	17.94
0.9	0.949	37.97
1.0	1.000	(inf)

Parameter layout

ENABLE B	Usual LA enable Bit#
CYCLES B	Optional status Bit# (state in hi bit) to enable calculation
REV PWR C	Reverse power Chan#
REV STEP	Step for series of rev channels
FWD PWR C	Forward power Chan#
FWD STEP	Step for series of fwd channels
VSWR C	Initial result Chan#
NCHANS	#channels in series

If the CYCLES parameter is nonzero, its low 15 bits is a Bit# whose status, if it matches the bit #15 state, enables calculation of the vswr(s). Otherwise, the calculation is done each cycle.

A series of channels can be specfied for both reverse and forward power readings, with REV STEP and FWD STEP specifying how to advance the Chan# in each case.

The result channels start at the VSWR Chan#, and NCHANS specifies the size of the series. If the series consists of only 1 channel, the step parameters are not used.

Details

For each pair of rev/fwd power readings, use ChanFlt to obtain the engineering units current values, and compute rho as given above. (If the fwd power is zero, or if the rev/fwd

quotient is negative, or too near 1, assume a 0.0 result.) Compute the `vswr` via the formula above. If the `NCHANS` is > 1, then advance the channel numbers accordingly and loop. The results are stored in a consecutive series of channel readings.

Using `ChanFlt` means that the readings accessed may include a nonzero offset constant, although such is not expected for these power channels. The results are delivered to the readings of the `VSWR` channels via `SetRealR`. This function uses the scale factors of the result channels to work out the 16-bit value to place into the `ADATA` entry. Thus one can choose the scale factors for the result channels fairly arbitrarily, in order to cover the range of interest.

Linac LE front ends house the following relevant RF power channels, where `x` ranges 1–5:

Chan#	*Name*
0104	PAxF
0105	PAxR
0106	DRxF
0107	DRxR
010A	LLxF
010B	LLxR
010C	IPA1xF
010D	IPA1xR
010E	IPA2xF
010F	IPA2xR

For the particular use planned here, the parameters might take on certain values. Using two instances of `VSWR` in each node, we might have these parameter values in `node0615`:

parameter	*inst1*	*inst2*
CYCLES B	0000	0000
REV PWR C	0105 PA5R	010B LL5R
REV STEP	0002	0002
FWD PWR C	0104 PA5F	010A LL5F
FWD STEP	0002	0002
VSWR C	01F0 PA5VSW	01F2 LL5VSW
NCHANS	0002	0003

The above two instances produce `vswr` values for `PA`, `DRV`, `LL`, `IPA1`, and `IPA2` in channels `01F0–01F4`. Channel names might be `PA5VSW`, `DR5VSW`, `LL5VSW`, `IPA15V`, `IPA25V`.