CSIRO DIVISION OF RADIOPHYSICS

THE AUSTRALIA TELESCOPE

Overall Systems and Performance
AT/20.1.1/010

Interference Studies
AT/15.5/037

Allowable levels of C.W. Interference for the Australia Telescope

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We define the maximum acceptable interference as that which produces an RMS power in the map equal to 0.1 times that produced by system noise. Thompson (1982) has shown that for a synthesis array, this corresponds to a flux of interference at the antenna given by:-

$$F_i = \frac{4\pi k T_s \sqrt{2\omega_o \beta}}{10 G_s \lambda^2 \sqrt{\alpha}} \left[\frac{1}{N} \sum_N q' \right]^{\frac{1}{2}} \text{ watts/m}^2 \qquad (1)$$

where ω_o is the angular frequency of earth rotation

β the channel bandwidth

G_s the antenna sidelobe gain

α the fraction of U,V tracks intersecting U=0, i.e. with zero fringe rate at some stage during observation.

The term in brackets is related to the mean baseline length and for our purposes can be approximated as $\frac{B_{max}}{2\lambda}$ where B_{max} is the maximum baseline length.

If we substitute some worst case parameters into equation (1), we find that $F_i \approx 2.2 \times 10^{-19}$ watts/m² for B_{max} = 3Km, λ = 0.21 m (1400 MHz), β = 0.49 kHz, G_s = 1, $\alpha \approx 1$ and $T_s \approx 25$K.

A more useful calculation is to relate the acceptable CW interference power to the system noise power in the smallest channel bandwidth (0.49 kHz) or in the narrowest front end bandwidth (64 MHz). In this case, the allowable interference power at the receiver input is:-

$$I = \frac{k T_s \sqrt{2\omega_o \beta}}{10\sqrt{\alpha}} \left[\frac{1}{N} \sum_N q' \right]^{\frac{1}{2}} \text{ watts} \qquad (2)$$

or

$$I = \frac{k\,T_s\,\sqrt{\omega_o\,\beta\,B_{max}}}{10\,\sqrt{\alpha\lambda}} \text{ watts} \tag{3}$$

where β is the bandwidth of the narrowest correlator channel (i.e. 0.49 kHz).

The system noise power at the same point is:

$$N = k\,T_s\,\beta_N \text{ watts} \tag{4}$$

where in this case β_N is the bandwidth over which the noise is measured.

$$\text{Thus} \quad \frac{I}{N} = \frac{\beta}{10\,\beta_N}\sqrt{\frac{\omega_o\,B_{max}}{\alpha\,\lambda\,\beta}} \tag{5}$$

Using the same parameters as above, we have:-

$$\frac{I}{N}\left(\beta_N = 0.49 \text{ kHz}\right) = -23.3 \text{ dB}$$

and

$$\frac{I}{N}\left(\beta_N = 64 \text{ MHz}\right) = -75 \text{ dB}$$

It is of interest to compare these results with those for an equivalent total power system. In this case, it can be shown that:-

$$\left(\frac{I}{N}\right)_{\text{Total Power}} = \frac{\beta}{10\beta_N\sqrt{\beta\tau}} \tag{6}$$

$$\therefore \quad \frac{\left(\frac{I}{N}\right)_{\text{Synthesis}}}{\left(\frac{I}{N}\right)_{\text{Total Power}}} = \sqrt{\frac{\omega_o\,\beta_{max}\,\tau}{\alpha\lambda}} \tag{7}$$

which for a 12 hour integration

$$\simeq \sqrt{\frac{\pi B_{max}}{\lambda}}$$

$\simeq$ 23 dB for B_{max} = 3 km

and λ = 0.21 (1400 MHz)

Declination dependence

The above expressions are for $\delta = 0$ where maximum fringe rates produce the best interference rejection. The allowable interference is smaller when observing at higher declinations. F_i decreases by $\approx$1dB at $\delta \approx 70°$ and $\approx$2.3dB at $\delta = 80°$. Nearer the pole, the interference rejection deteriorates rapidly to that corresponding to a total power system.

Conclusion

If internally generated CW interference can be kept 100dB below the noise in a 64 MHz bandwidth at UHF and L bands, then observations down to the pole will be interference free. Interference as high as 75dB below noise will, however, be acceptable at most declinations. At higher frequencies where wider channel bandwidths will generally be used, then somewhat higher interference levels $\left(x\sqrt{\frac{P}{\lambda}}\right)$ may be acceptable.

For external CW interference, the acceptable field strength is $\simeq 10^{19}$ w/m^2 at L band. At frequencies above L band $G_s\lambda^2$ is probably constant so that an increase in interference $\left(x\sqrt{\frac{\beta}{\lambda}}\right)$ may be acceptable. At UHF, because of the prime focus feed, the sidelobe gain will be higher than estimated from the above expression. The acceptable interference level may therefore need to be $\approx$ 20dB lower.

20th September, 1985.

Reference

A.R. Thompson, 1982, [illegible] Antenna[illegible]