GBT Memo No. 61

# Parameters for Filling or Covering Panel Gaps on the GBT

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## Summary

To reduce scattering from gaps between panels of the surface of the GBT we can either cover the gaps with a thin conducting tape on the front of the panels, fill the gaps with a gasket material, or close the gaps from the back of the panel surface. In all cases there will still be a discontinuity in the surface because of the tape thickness or depth of the closed gap. This memo gives an estimate of the residual scattering from this discontinuity and sets limits on tape width and thickness or gap depth for a chosen isotropic sidelobe level.

At 10 GHz, a 10 dB reduction in scattering from 2-mm wide panel gaps can be achieved by covering the gaps with 5-cm (2") wide conducting tape with a maximum thickness of 0.3-mm (0.012") or by closing the gap from the back of the surface if the gap depth is less than 1.5 mm (0.059"). Short-wavelength aperture efficiency performance will be degraded less by closing the gaps from the back of the surface than by covering the gaps with tape on the front of the surface. Scattering values for other tape and gap parameters may be computed from the equations below.

## The Equations

Let

e = Fractional Surface area of panel gaps or tape.

On the GBT

$$e \approx \frac{W(cm)}{130} \qquad (1)$$

where

W(cm) = gap width in centimeters.

Assume that the scattered power in the far sidelobes is equal to half of the aperture efficiency loss due to surface phase errors in the same sense that a 5% feed support blockage causes a 10% aperture efficiency loss. (The other 5% goes in broadening the main beam.) If we assume that the part of the surface represented by e is raised or depressed by a distance, t, its phase error with respect to the rest of the surface is then

$$\theta = \frac{2 \times 2 \times \pi \times t}{\lambda} \qquad (2)$$

where the extra factor of 2 comes from the error in both spherical and reflected ray paths, neglecting the projection cosine factor. The beam-center relative far <u>field</u> strength will be

$$E = 1 - e(1 - \cos\theta) \qquad (3)$$

If $e \ll 1$, the relative beam-center power is then

$$P \approx 1 - 2e(1-\cos\theta) \qquad (4)$$

$$P \approx 1 - 4e(\sin^2(\frac{\theta}{2})) \qquad (5)$$

$$P \approx 1 - e\theta^2 \qquad (6)$$

The far sidelobe scattered power is then

$$\Delta P \approx \frac{e}{2}\theta^2 \qquad (7)$$

$$\Delta P \approx \frac{e}{2}(\frac{4\pi t}{\lambda})^2 \qquad (8)$$

The relationship between tape thickness and tape width or gap depth and gap width is then

$$t = \frac{\lambda}{4\pi}\sqrt{\frac{260\,\Delta P}{W(cm)}} \qquad (9)$$

If we assumed that both the forward and backward fractional scattering from open panel gaps is equal to the ratio of the geometric areas of the gaps and the full surface, then the uncovered, 2-mm gaps will produce

$$\Delta P\,(open\ 2\ mm\ gap) = 0.003 \qquad (10)$$

and, if we want to improve this by a factor of 10, then

$$t = \frac{\lambda}{4\pi}\sqrt{\frac{260 \times 0.0003}{W(cm)}} \qquad (11)$$

At 10 GHz the relationship between maximum tape thickness and tape width is

$$t = 0.239\sqrt{\frac{0.078}{W(cm)}}\ \ centimeters \qquad (12)$$

Hence, at 10 GHz under the assumptions above, 5-cm (2") wide tape could have a maximum thickness of 0.3 mm (0.012"), or a 2-mm (0.08") wide gap could be as deep as 1.5 mm (0.059").

The small-angle approximation assumed in going from Equation (5) to Equation (6) is not valid when t approaches $\lambda/4$. Equation (8) will tend to overestimate the scattered power in this case. Therefore, of the family of solutions of Equation (11), the aperture efficiency at high frequencies will be somewhat higher for narrow, deep gaps than for wide, thin tape. In the extreme case, the 5-cm wide, 0.3-mm thick tape would cause an aperture efficiency loss of about 6% at 100 GHz, but an open or a 1.5-mm deep, 2-mm wide gap at this frequency would produce an aperture efficiency loss of only 0.6%. At 30 Ghz, the tape will produce about the same aperture efficiency loss as the open gaps.