Attenuation in Melting Layer of Precipitation

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minority and majority-carrier injection and the switching performance is explained. It can be concluded that the increase in temperature enhances the feedback regenerative mechanism.
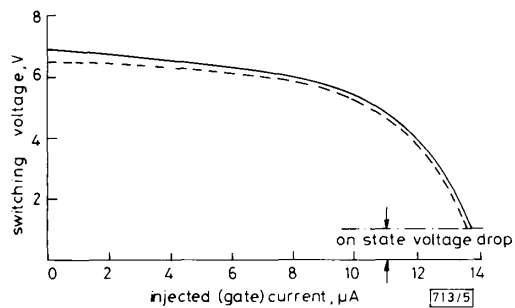

Fig. 5 *Variation of V_{SW} with gate current J_{inj}^n for TB switch*

$N_{d1} = 1.8 \times 10^{18}\,cm^{-3}$, $N_{d2} = 1.5 \times 10^{18}\,cm^{-3}$, $N_t = 2 \times 10^{12}$ cm^{-2}, $d_2 = 7d_1 = 350\,nm$, $L_{CO} = 1.2\,\mu m$, $L = 200\,nm$

———— theory ———— experiment (Reference 6)

On the other hand, minority- or majority-carrier injection reduces the switching voltage and increases the switching current density. The holding parameters remain unchanged with carrier injections. Gated BU(B)Ss have possible applications as high-speed logic elements, fast pulse genreators, peak detectors and in optical communication.

A. AL-BUSTANI   27th May 1988

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ATTENUATION IN MELTING LAYER OF PRECIPITATION

Indexing terms: Radiowave propagation, Atmospheric propagation, Atmospheric precipitation effects, Attenuation

A model of the melting layer is employed on radar measurements to simulate the attenuation of radio waves at 12, 20 and 30 GHz. The attenuation in the melting layer is simulated to be slightly larger than that of rain with the same path length and precipitation intensity. The result appears to depend on the maximum reflectivity in the melting layer.

Model: The melting layer model has been described by Klaassen.[2] The main features are:

(a) The average dielectric constant of a melting snowflake is calculated by assuming that the melted water surrounds the elliptical needles and plates that form the flake. This is in contrast to previous models where the water was assumed to surround the flake as a whole.

(b) The density of the ice particles is allowed to vary over the complete range from snow to hail. In this way the simulated brightness of the melting layer is adapted to the radar observations.

(c) The air temperature, and thus the melting rate, is calculated from the energy balance. The cooling by melting and heating by incoming air result in an almost isothermal layer on top of the melting layer. In this way the depth of the simulated melting layer is made in agreement with the radar observations.

Data: The data were obtained with the FM-CW Doppler radar, described by Ligthart and Nieuwkerk.[4] The radar scanned vertically, with a resolution of 30 m.

The data have been described.[2] From the recordings in the spring of 1983 a subset of 50 averages of one minute was taken to represent the full range of rain reflectivity values Z_r measured just below the bright band. Z_r ranged from 20–45 dBZ, corresponding to rain intensities from 1–20 mm/hr.

The ratio between the maximum reflectivity in the bright band and Z_r is referred to as maximum reflectivity excess Z_{xm}. In the data set Z_{xm} is found to vary between 4 and 16 dB, with an average of 11 dB. Z_{xm} appears to be almost independent of Z_r. The vertical extension of the bright band increases from 200 m at $Z_r = 20\,dBZ$ to 600 m at $Z_r = 45\,dBZ$, with a scatter of 100 m. These results deviate slightly from the Chilbolton results,[1] the latter do not show a dependence of the bright band extension on reflectivity and show an increase of reflectivity excess from $Z_{xm} = 5\,dB$ at $Z_r = 25\,dBZ$ to 12 dB at 35 dBZ. These deviations can be caused by different meteorological conditions or by the poorer range resolution of the Chilbolton radar. According to the simulations, the maximum reflectivity excess is mainly determined by the density of the ice particles at the top of the melting layer and hardly by the precipitation intensity.

Results: As a main result, the simulated attenuation in the melting layer is found to be equal to, or larger than the value for rain of the same intensity and path length. Thus, the total attenuation can be calculated assuming rain up to the 0°C level (or to the *top* of the radar bright band) with a small correction. The correction for the melting layer is expressed as the attenuation excess $A_e(F)$ as a function of the radio frequency F. The term 'excess' is used to indicate the additional attenuation through the melting layer at vertical propagation relative to the attenuation of the same path length of the resulting rain. The attenuation is calculated for three frequencies: 12, 20 and 30 GHz, corresponding to the frequency bands of the Olympus satellite.

The simulated attenuation excess appears to be proportional to the rain intensity and increases with the maximum reflectivity excess. Figs. 1 and 2 show the result at 20 GHz. Generally speaking, the attenuation excess at vertical incidence is some tenths of a dB and the value of 1 dB was not exceeded. The highest values of A_e are found at 20 GHz. At 30 GHz the attenuation itself is still larger than at 20 GHz, but the simulated difference with the rain starts to decrease. At high frequencies the relative influence of the bright band decreases while the melting particles are larger than the resulting raindrops and the Mie scattering becomes less effective for large particles with a small dielectric constant.

The results of the simulations are summarised by:

$$A_e(12) = 3.47 \times 10^{-3} RZ_{xm}^{0.88} \pm 35\%$$

$$A_e(20) = 4.17 \times 10^{-3} RZ_{xm}^{0.96} \pm 50\%$$

$$A_e(30) = 1.86 \times 10^{-3} RZ_{xm}^{1.16} \pm 80\%$$

These results only hold for $Z_{xm} > 5\,dB$. For smaller values the simulated attenuation in the melting layer may be even smaller than in the rain, so $A_e < 0$; at 30 GHz this is common for $Z_{xm} < 3\,dB$ and at 12 GHz for $Z_{xm} < 1\,dB$. Although the model is capable of simulating the melting process in situations without a bright band it is hazardous to use those results directly: the situations without bright band are mostly found during strong upward winds (convection) when the ice

particles above the melting layer may be wetted which results in an increase of the attenuation.
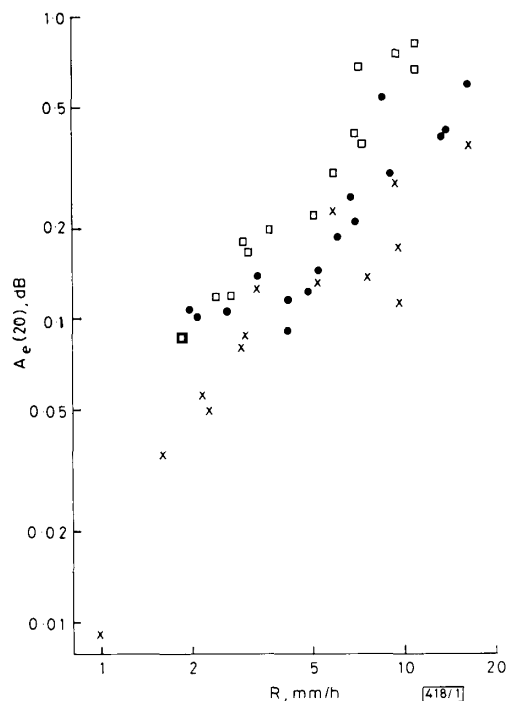

Fig. 1 *Simulated attenuation excess at 20 GHz in melting layer against rain intensity for three ranges of maximum reflectivity excess*

□□□ $Z_{xm} > 12\,dB$ ●●● $10\,dB \leq Z_{xm} \leq 12\,dB$
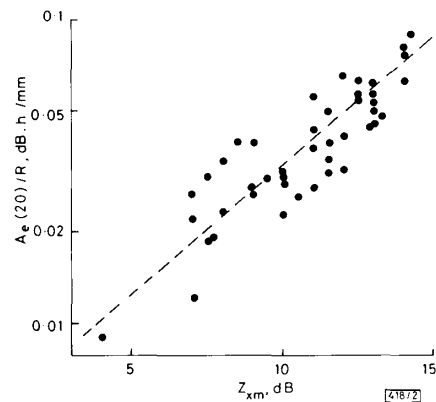× × × $Z_{xm} < 10\,dB$

Fig. 2 *Simulated attenuation excess at 20 GHz, divided by rain intensity against maximum reflectivity excess*

$$A_c(20) = 4\cdot17 \times 10^{-3} R Z_{xm}^{0\cdot96}$$

The results are derived for a radar frequency of $3\cdot3\,GHz$. At higher radar frequencies the observed reflectivity excess in the melting layer starts to decrease because of Mie scattering, necessitating a correction of the results.

The results fall into a similar range as that given by Leitao and Watson[3] and agree with their finding that the significance of the melting layer, relative to the rain, decreases with increasing frequency. The radar observations given here show that for an accurate estimation of the attenuation in the melting, the radar brightness of this layer must be taken into account. The correction factors were derived for only a restricted data set. Verification of these factors on observations of satellite signals is expected to be complicated because of the small value of the correction factors. Verification should be simple for the main result, that the specific attenuation in the melting layer is of the same order as in the resulting rain.

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REFLECTOR ANTENNA DISTORTION COMPENSATION BY ARRAY FEEDS: AN EXPERIMENTAL VERIFICATION

Indexing terms: Antennas, Antenna feeders, Distortion, Satellite links

Reflector antennas are subject to surface distortions which may result from thermal or gravitational effects. Surface distortions degrade antenna performance by reducing gain and introducing high sidelobe levels. In the letter, results of an experimental study have been presented to demonstrate how effectively a properly excited array feed in the focal plane of the reflector antenna can compensate for the undesirable effects of slowly varying surface distortions. The application of the array compensation concept could prove to be very useful for future large space or ground antennas.

Introduction: Recent satellite communication system demands require application of very large antennas. Furthermore, it is anticipated that these antennas will produce high gain and low sidelobes for future multiple beam satellites. These characteristics are very important to mobile satellite system (MSS) spacecraft antenna since they directly impact system capacity through increased frequency re-use capabilities. Among the different antenna concepts, reflectors still enjoy more acceptance among the designers of large antenna configurations. However, in the space environment the surface of these large reflectors will be distorted which will result in degraded antenna performance.[1] The effects of surface distortions are, in particular, more pronounced at higher frequencies and in the low sidelobe regions.

It is very likely that large antennas will suffer from distortions regardless of how rigid the antenna construction is. For this reason, the development of a technique to compensate for the distortion will be highly desirable provided that this technique can be implemented in a cost effective manner. Fig. 1 shows the mechanism which causes in the antenna performance degradation due to reflector surface distortion. The main cause is the introduction of effective aperture phase errors due to the distortion. Fig. 1 also shows how an array feed can be used to compensate for the distorted radiated phase front.

Concept implementation: Among different possibilities, recent investigations have revealed the effectiveness of compensating for reflector surface distortions using array feeds.[2,3] This approach is particularly useful in situations in which the reflector distortion is slowly varying, as is typically the case for large reflectors subject to thermal or gravitational distortions. Additionally, array feeds can be used to improve wide