

# Optimization of a Parabolic Reflector Antenna Parameters for Malaysia Beam Coverage

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**Abstract** – When covering Malaysia area by multi beams in satellite antenna, many feed horns are employed. In a previous designing, severe horn overlapping was shown. In this paper, overlapping problem of feed horn is analytically studied. The relation of feed horn size and feed position displacement is numerically clarified with parameter of the beam separation angle and F/D of a parabolic reflector. As a result, antenna structural parameters for escaping feed horn overlapping are clarified.

**Index Terms** —Satellite antenna, horn antenna, horn overlapping, feed position displacement, F/D, parabolic reflector.

## 1. Introduction

For satellite TV service contour beam design of a parabolic reflector antenna was made. When achieving a contour beam by multi beams, feed horn overlapping was shown [1]. In order to escape feed horn overlapping, array feed was employed instead of feed horns [2]. By designing array element excitation coefficients adequately, fine contour beam was achieved. However employing feed horns has advantages designing contour beams more easily. In order to employ feed horns, overlapping problem of feed horns should be reconsidered.

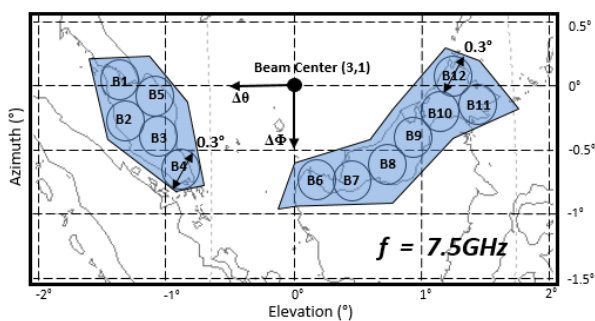


Fig. 1. Beam Coverage of coverage

In this paper, multi beam configuration shown in fig. 1 is employed for Malaysia area coverage. Frequency is selected as 7.5GHz that is used in satellite communication [3]. First of all, feed horn allocation in this case is calculated. Severe feed horn overlapping is shown. Next, equation relating beam shift angle and feed displacement and equation relating reflector edge level and feed horn size and horn displacement

is deduced. Important design graph of feed horn size and displacement is obtained.

## 2. Design Example

Based on the multi beam allocation of Fig. 1, beam width of 0.3° is determined. By using parameter shown in Fig. 2, antenna parameters achieving 0.3° beam width and feed horn achieving edge level of -10dB are shown in Table 1. Designed feed allocation is shown in Fig. 3. Severe feed horn overlapping is shown.

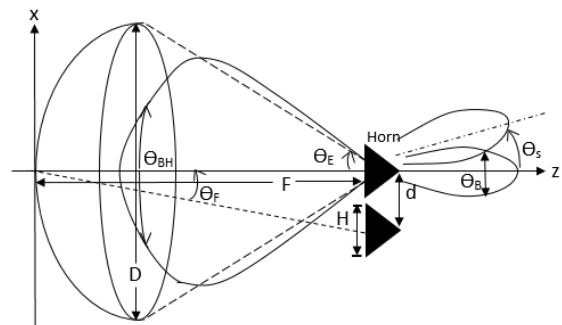


Fig. 2. Parameters of a Reflector and Feed Horn

TABLE 1  
Antenna Parameters

| Antenna Part        | Parameters              | Value  |
|---------------------|-------------------------|--------|
| Parabolic Reflector | Frequency               | 7.5GHz |
|                     | Diameter                | 10m    |
|                     | Focal Length            | 10m    |
|                     | Efficiency              | 75%    |
| Horn Antenna        | Height of horn aperture | 0.07m  |
|                     | Width of horn aperture  | 0.1m   |
|                     | Length of Horn          | 0.38m  |

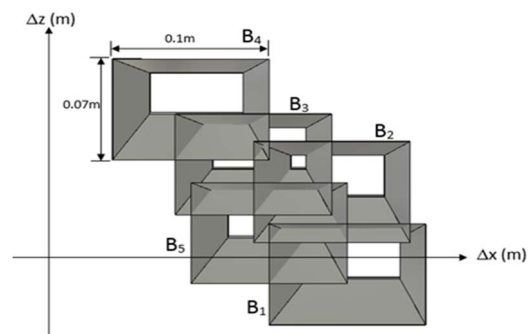


Fig. 3. Feed Horn Arrangement

### 3. Analysis of Overlapping Feed Horn

#### 3.1 Horn Parameter

Beam width of a horn is approximately given by the next expression.

$$\theta_{BH} = 1.2 \left( \frac{\lambda}{H} \right) \quad [rad] \quad (1)$$

The reflector edge level is determined by setting adequately  $\alpha$  value given by the next expression.

$$\theta_E = \alpha \theta_{BH} = 1.2 \alpha \frac{\lambda}{H} \quad (2)$$

Here,  $\alpha$  value is usually set as  $0.7 < \alpha < 1$ .

#### 3.2 Reflector Parameters

The reflector edge level  $\Theta_E$  is given by the next expression [4].

$$\tan \frac{\theta_E}{2} = \frac{1}{4(F/D)} \quad (3)$$

The beam width of the radiated beam is expressed by the next equation.

$$\theta_B = 1.2 \frac{\lambda}{D} \quad [rad] \quad (4)$$

In designing beam allocation, beam shift angle  $\Theta_s$  is supposed to be determine by  $\beta$  value given by the next expression.

$$\theta_s = \beta \theta_B = 1.2 \beta \frac{\lambda}{D} \quad (5)$$

Here,  $\beta$  value is usually set as  $1 < \beta < 1.5$

#### 3.3 Relation of Horn Displacement and Beam Shift

The beam shift angle  $\Theta_s$  has relation with feed displacement  $\Theta_F$  as follows [4].

$$\frac{\theta_s}{\theta_F} = BDF = \frac{1+0.36(D/4F)^2}{1+(D/4F)^2} \quad (6)$$

Feed displacement angle  $\Theta_F$  has a relation with  $d$  and  $F$  as follows.

$$\tan \theta_F \approx \theta_F = \frac{d}{F} \quad [rad] \quad (7)$$

#### 3.4 Relation of Horn Displacement and Horn Size

The relation of  $d/H$  is found out through the following process.

- 1) By using Eq. (2) and Eq. (3),  $\alpha\lambda/H$  is related to  $F/D$ .
- 2) By inserting Eq. (5) and Eq. (7) into Eq. (6),  $\beta\lambda/d$  is related to  $F/D$ .
- 3) Relation of  $\alpha\lambda/H$  and  $\beta\lambda/d$  is given as parameter of  $F/D$ .
- 4) Relation of  $\lambda/H$  and  $\lambda/d$  is given as parameters of  $\alpha$  and  $\beta$ .

TABLE 2  
Relation of  $d/H$

| F/D | BDF    | B = $\beta \lambda/d$ | $\Theta_E$ [rad] | A = $\alpha \lambda/H$ | $\gamma = A/B$ |
|-----|--------|-----------------------|------------------|------------------------|----------------|
| 0.3 | 0.7377 | 2.049                 | 1.389            | 1.16                   | 0.57           |
| 0.5 | 0.8720 | 1.453                 | 0.93             | 0.77                   | 0.53           |
| 1.0 | 0.9624 | 0.802                 | 0.49             | 0.4                    | 0.51           |
| 1.5 | 0.9827 | 0.546                 | 0.33             | 0.28                   | 0.5            |

Finally,  $d/H$  graph is obtained with parameters of  $\alpha$  and  $\beta$  as shown in Fig. 4. The antenna configuration of  $d/H > 1$  give no overlapping feed horn. In the case of small  $\alpha$  and large  $\beta$ ,  $d/H$  value increases. When  $\alpha=0.6$  and  $\beta=1.3$ ,  $d/H > 1$  is achieved. In this case, the reflector edge level increases from -10dB and the beam overlapping level decreases from -3dB.

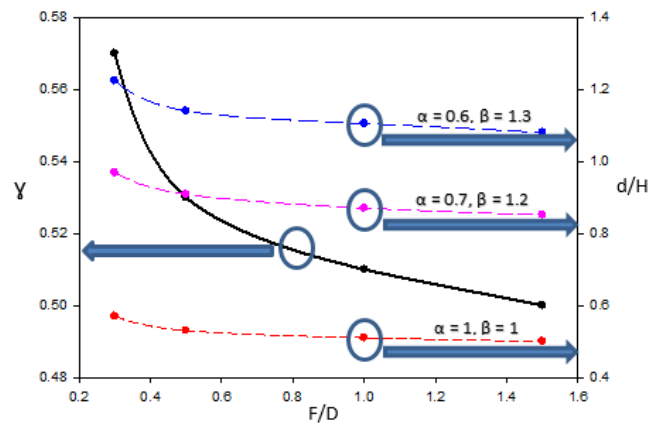


Fig. 4. Relation of  $d/H$

### 4. Conclusion

In order to solve overlapping problem of feed horns for multi-beam application, theoretical analysis is made. The important relations between feed horn size and beam separation angle with a parameter of  $F/D$  are derived. Finally, design graph of solving feed horn overlapping is obtained.

### 5. References

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