# Corrugated Horn Design Report

## Dimensional Data

- Length (Throat to Aperture): $L = 80.0\,\text{mm}$.
- Wall thickness: $t_{\text{wall}} \in 3\,\text{mm}$ to $4\,\text{mm}$ (noted range).
- Number of corrugations: $N = 6$.
- Groove centers from throat plane (mm):
  $\{\,6.7,\ 20.0,\ 33.3,\ 46.6,\ 59.9,\ 73.2\,\}$.
- Groove radial depths (mm): $\{\,2,\ 4,\ 6,\ 8,\ 10,\ 10\,\}$.
- Groove axial width: $w_g = 8.8\,\text{mm}$.
- Groove pitch (center-to-center): $p = 13.33\,\text{mm}$.
- $2a$: the full aperture diameter ($D_a = 54\,\text{mm}$).
- $D_t$: the throat diameter ($35\,\text{mm}$).
- $p$: corrugation period (center-to-center), $13.33\,\text{mm}$.
- $w_g$: groove axial width, $8.8\,\text{mm}$.
- $d$: groove depth; sequence $\{2, 4, 6, 8, 10, 10\}\,\text{mm}$.
- $t_{\mathbf{wall}}$: metal wall thickness, $3\,\text{mm}$ to $4\,\text{mm}$.
- $t_{\mathbf{tooth}}$: axial land between grooves, $4.53\,\text{mm}$.
- $\alpha$: flare half-angle, $\approx 6.77^\circ$.
- **Aperture diameter** $2a$: equals $D_a = 54\,\text{mm}$ (i.e., $a = R_a = 27\,\text{mm}$).
- **Throat diameter** $D_t$: equals $35\,\text{mm}$.
- **Flare half-angle** $\alpha$: defined by the linear inner-wall cone between radii $R_t$ and $R_a$ over $L$.
- **Groove period** $p$: corrugation center-to-center spacing.
- **Groove width** $w_g$: axial width of each rectangular corrugation slot.
- **Tooth (land) thickness** $t_{\text{tooth}}$: axial metal between adjacent slots, $t_{\text{tooth}} = p - w_g$.
- **Groove depth** $d_k$: radial reduction of the inner wall within the $k$-th groove.

## 4. Geometric Model (inner/outer radii)

Let $z \in [0, L]$ measure distance from the throat plane toward the aperture. The *baseline* (ungrooved) inner radius is the linear cone

$$r_{\text{cone}}(z) = R_t + (R_a - R_t)\,\frac{z}{L}. \tag{1}$$

With rectangular corrugations, the actual inner radius is

$$r_{\text{in}}(z) = r_{\text{cone}}(z) - \sum_{k=1}^{N} d_k\,\chi_k(z), \qquad \chi_k(z) = \begin{cases} 1, & z \in [z_{ck} - \frac{w_g}{2},\, z_{ck} + \frac{w_g}{2}], \\ 0, & \text{otherwise}, \end{cases} \tag{2}$$

where $z_{ck}$ is the $k$-th groove center. The outer wall is smooth at approximately constant thickness; using the screenshot range,

$$r_{\text{out}}(z) = r_{\text{cone}}(z) + t_{\text{wall}}, \qquad t_{\text{wall}} \in [3\,\text{mm}, 4\,\text{mm}]. \tag{3}$$

**Flare half-angle.** From the data

$$\alpha = \arctan\!\left(\frac{R_a - R_t}{L}\right) = \arctan\!\left(\frac{27\,\text{mm} - 17.5\,\text{mm}}{80\,\text{mm}}\right) \approx 6.77^\circ. \tag{4}$$

**Tooth (land) thickness.** With $p = 13.33\,\text{mm}$ and $w_g = 8.8\,\text{mm}$,

$$t_{\text{tooth}} = p - w_g = 13.33\,\text{mm} - 8.8\,\text{mm} = 4.53\,\text{mm}. \tag{5}$$

## 5. Corrugation Rules from the Screenshots

The screenshots encode the standard subwavelength constraints:

$$p \approx \frac{\lambda}{3}, \tag{6}$$

$$w_g \approx 0.22\,\lambda, \tag{7}$$

$$d_{\max} \approx \frac{\lambda}{4}, \tag{8}$$

with depths increasing along $z$ and saturating near $\lambda/4$ (the last two grooves are 10 mm deep).

## 6. Operating Wavelength and Frequency (cross-check)

Using (6)–(8) with the provided numbers:

**From the pitch:**

$$\lambda_{(p)} \approx 3p = 3 \times 13.33\,\text{mm} = 39.99\,\text{mm}.$$

**From the groove width:**

$$\lambda_{(w_g)} \approx \frac{w_g}{0.22} = \frac{8.8\,\text{mm}}{0.22} = 40.0\,\text{mm}.$$

**From the max depth:**

$$\lambda_{(d)} \approx 4\, d_{\max} = 4 \times 10.0\,\text{mm} = 40.0\,\text{mm}.$$

All three estimates are consistent at $\lambda \approx 40.0\,\text{mm}$. Using the speed of light $c = 299\,792\,458\,\text{m/s}$,

$$f = \frac{c}{\lambda} = \frac{299\,792\,458\,\text{m/s}}{0.0400\,\text{m}} \approx 7.495\,\text{GHz}.$$

Hence the design center is approximately **7.5 GHz**, which aligns with a 7 GHz to 8 GHz operating band suggested by the geometry.

## What the Legends Mean (for drawings)

- $2a$: the full aperture diameter ($D_a = 54\,\text{mm}$).
- $D_t$: the throat diameter (35 mm).
- $p$: corrugation period (center-to-center), 13.33 mm.
- $w_g$: groove axial width, 8.8 mm.
- $d$: groove depth; sequence $\{2, 4, 6, 8, 10, 10\}$ mm.
- $t_{\mathbf{wall}}$: metal wall thickness, 3 mm to 4 mm.
- $t_{\mathbf{tooth}}$: axial land between grooves, 4.53 mm.
- $\alpha$: flare half-angle, $\approx 6.77°$.
- **A/B/C**: drawing segments (upstream/smooth/corrugated). Corrugations begin at $z = \ell_s = 2.3\,\text{mm}$.

## 8. Notes confined to the screenshots

- All numerical values above are *exactly* those shown or algebraic combinations thereof.
- No assumptions beyond the screenshot text and numbers have been introduced.
- Bandwidth, return loss, and pattern performance are not stated in the screenshots and thus are not asserted here.

*End of report.*