

## 频率最低点公式推导

$$|\Delta f(t_{tra})| = \begin{cases} \frac{\Delta P_{Max}^D}{D_t'} \cdot (1 - e^{-\frac{D_t'}{2H_t^{Sys}} t_{tra}}) & \text{if } t_{tra} \in [t, t_{DB}) \\ \Delta f_{DB} + (\frac{\Delta P_t'^D}{D_t'} + \frac{2H_t^{Sys} \cdot PFR_t'}{D_t'^2}) \cdot (1 - e^{-\frac{D_t'}{2H_t^{Sys}} (t_{tra} - t_{DB})}) - \frac{PFR_t'}{D_t'} \cdot t_{tra} - t_{DB} & \text{if } t_{tra} \in [t_{DB}, t_c) \\ \Delta f_c + (\frac{\Delta P_t''^D}{D_t'} + \frac{2H_t^{Sys} \cdot PFR_t''}{D_t'^2}) \cdot (1 - e^{-\frac{D_t'}{2H_t^{Sys}} (t_{tra} - t_c)}) - \frac{PFR_t''}{D_t'} \cdot (t_{tra} - t_c) & \text{if } t_{tra} \in [t_c, t_g) \end{cases} \quad (A-1)$$

式中：  $\Delta P_t'^D = \Delta P_{Max}^D - D_t' \cdot \Delta f_{DB}$ ；  $\Delta P_t''^D = \Delta P_{Max}^D - (\sum_g PFR_{g,t}^g(\xi^t) + \sum_w PFR_{w,t}^w(\xi^t)) \cdot T_c / T_g - \sum_c PFR_{c,t}^{PB}(\xi^t) - D_t' \cdot \Delta f_c$ ；  $PFR_t' = (\sum_g PFR_{g,t}^g(\xi^t) + \sum_w PFR_{w,t}^w(\xi^t)) / T_g + \sum_c PFR_{c,t}^{PB}(\xi^t) / T_c$ ；  $PFR_t'' = (\sum_g PFR_{g,t}^g(\xi^t) + \sum_w PFR_{w,t}^w(\xi^t)) / T_g$ 。

当  $\partial|\Delta f(t_{tra})|/\partial t=0$  时，可得：

$$t' = \begin{cases} t_{DB} - \frac{2H_t^{Sys}}{D_t'} \cdot \log(\frac{2\kappa'}{\Delta P_t'^D \cdot D_t' + 2\kappa'}) \\ t_c - \frac{2H_t^{Sys}}{D_t'} \cdot \log(\frac{2\kappa''}{\Delta P_t''^D \cdot D_t' + 2\kappa''}) \end{cases} \quad (A-2)$$

$$\Rightarrow \begin{cases} 2\kappa'_t \cdot \log(\frac{2\kappa'}{\Delta P_t'^D \cdot D_t' + 2\kappa'}) \leq D_t'^2 \cdot (\Delta f_{max} - \Delta f_{DB}) - D_t' \cdot \Delta P_t'^L & \text{if } t_{tra} \in [t_{DB}, t_c) \\ 2\kappa''_t \cdot \log(\frac{2\kappa''}{\Delta P_t''^D \cdot D_t' + 2\kappa''}) \leq D_t'^2 \cdot (\Delta f_{max} - \Delta f_c) - D_t' \cdot \Delta P_t''^L & \text{if } t_{tra} \in [t_c, t_g) \end{cases}$$

将(A-2)带入(A-1)，可得：

$$|\Delta f_{nadir}| = \begin{cases} \Delta f_{DB} + \frac{\Delta P_t'^L}{D_t'} + \frac{2\kappa'}{T_c \cdot D_t'^2} \cdot \log(\frac{2\kappa'}{T_c \cdot \Delta P_t'^L \cdot D_t' + 2\kappa'}) & \text{if } t_{tra} \in [t_{DB}, t_c) \\ \Delta f_c + \frac{\Delta P_t''^L}{D_t'} + \frac{2\kappa''}{T_g \cdot D_t'^2} \cdot \log(\frac{2\kappa''}{T_g \cdot \Delta P_t''^L \cdot D_t' + 2\kappa''}) & \text{if } t_{tra} \in [t_c, t_g) \end{cases} \quad (A-3)$$