

To Obtain an Expression  
for the  
Instantaneous Circulating Current

- $v_{O1}$  = Instantaneous o/p voltage of converter 1.
- $v_{O2}$  = Instantaneous o/p voltage of converter 2.
- The circulating current  $i_r$  can be determined by integrating the instantaneous voltage difference (which is the voltage drop across the circulating current reactor  $L_r$ ), starting from  $\omega t = (2\pi - \alpha_1)$ .
- As the two average output voltages during the interval  $\omega t = (\pi + \alpha_1)$  to  $(2\pi - \alpha_1)$  are equal and opposite their contribution to the instantaneous circulating current  $i_r$  is zero.

$$i_r = \frac{1}{\omega L_r} \left[ \int_{(2\pi - \alpha_1)}^{\omega t} v_r \cdot d(\omega t) \right] ; \quad v_r = (v_{o1} - v_{o2})$$

As the o/p voltage  $v_{o2}$  is negative

$$v_r = (v_{o1} + v_{o2})$$

$$\therefore i_r = \frac{1}{\omega L_r} \left[ \int_{(2\pi - \alpha_1)}^{\omega t} (v_{o1} + v_{o2}) \cdot d(\omega t) \right] ;$$

$$v_{o1} = -V_m \sin \omega t \text{ for } (2\pi - \alpha_1) \text{ to } \omega t$$

$$i_r = \frac{V_m}{\omega L_r} \left[ \int_{(2\pi - \alpha_1)}^{\omega t} -\sin \omega t . d(\omega t) - \int_{(2\pi - \alpha_1)}^{\omega t} \sin \omega t . d(\omega t) \right]$$

$$i_r = \frac{2V_m}{\omega L_r} (\cos \omega t - \cos \alpha_1)$$

The instantaneous value of the circulating current depends on the delay angle.

For trigger angle (delay angle)  $\alpha_1 = 0$ ,  
the magnitude of circulating current becomes min.  
when  $\omega t = n\pi$ ,  $n = 0, 2, 4, \dots$  & magnitude becomes  
max. when  $\omega t = n\pi$ ,  $n = 1, 3, 5, \dots$

If the peak load current is  $I_p$ , one of the  
converters that controls the power flow  
may carry a peak current of

$$\left( I_p + \frac{4V_m}{\omega L_r} \right),$$

where

$$I_p = I_{L(\max)} = \frac{V_m}{R_L},$$

&

$$i_{r(\max)} = \frac{4V_m}{\omega L_r} = \text{max. circulating current}$$

# The Dual Converter Can Be Operated In Two Different Modes Of Operation

- Non-circulating current (circulating current free) mode of operation.
- Circulating current mode of operation.

# Non-Circulating Current Mode of Operation

- In this mode only one converter is operated at a time.
- When converter 1 is ON,  $0 < \alpha_1 < 90^\circ$
- $V_{dc}$  is positive and  $I_{dc}$  is positive.
- When converter 2 is ON,  $0 < \alpha_2 < 90^\circ$
- $V_{dc}$  is negative and  $I_{dc}$  is negative.



# Circulating Current Mode Of Operation

- In this mode, both the converters are switched ON and operated at the same time.
- The trigger angles  $\alpha_1$  and  $\alpha_2$  are adjusted such that  $(\alpha_1 + \alpha_2) = 180^\circ$  ;  $\alpha_2 = (180^\circ - \alpha_1)$ .

- When  $0 < \alpha_1 < 90^\circ$ , converter 1 operates as a controlled rectifier and converter 2 operates as an inverter with  $90^\circ < \alpha_2 < 180^\circ$ .
- In this case  $V_{dc}$  and  $I_{dc}$ , both are positive.
- When  $90^\circ < \alpha_1 < 180^\circ$ , converter 1 operates as an Inverter and converter 2 operated as a controlled rectifier by adjusting its trigger angle  $\alpha_2$  such that  $0 < \alpha_2 < 90^\circ$ .
- In this case  $V_{dc}$  and  $I_{dc}$ , both are negative.