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.

$$i_r = \frac{1}{\omega L_r}\left[\int_{(2\pi-\alpha_1)}^{\omega t} v_r . d(\omega t)\right] \; ; \quad v_r = (v_{O1} - v_{O2})$$

As the o/p voltage v_{O2} is negative

$$v_r = (v_{O1} + v_{O2})$$

$$\therefore \quad i_r = \frac{1}{\omega L_r}\left[\int_{(2\pi-\alpha_1)}^{\omega t} (v_{O1} + v_{O2}) . d(\omega t)\right];$$

$$v_{O1} = -V_m \sin \omega t \text{ for } (2\pi - \alpha_1) \text{ to } \omega t$$

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

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

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 $\omega t = n\pi,\ n = 0, 2, 4, ...$ & magnitude becomes
max. when $\omega t = n\pi,\ n = 1, 3, 5, ...$

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, $0 < \alpha_1 < 90^0$
- V_{dc} is positive and I_{dc} is positive.
- When converter 2 is ON, $0 < \alpha_2 < 90^0$
- 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 α_1 and α_2 are adjusted such that $(\alpha_1 + \alpha_2) = 180^0$; $\alpha_2 = (180^0 - \alpha_1)$.

- When $0 < \alpha_1 < 90^0$, converter 1 operates as a controlled rectifier and converter 2 operates as an inverter with $90^0 < \alpha_2 < 180^0$.
- In this case V_{dc} and I_{dc}, both are positive.
- When $90^0 < \alpha 1 < 180^0$, converter 1 operates as an Inverter and converter 2 operated as a controlled rectifier by adjusting its trigger angle α_2 such that $0 < \alpha_2 < 90^0$.
- In this case V_{dc} and I_{dc}, both are negative.