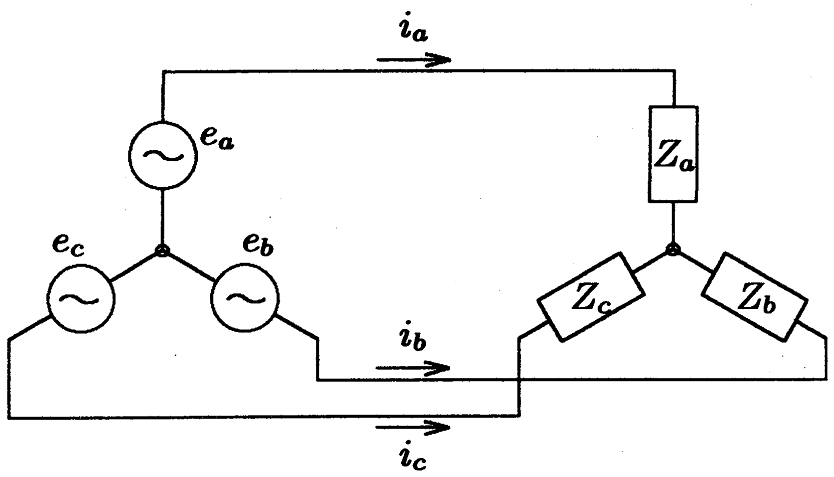

Fig. 1. Three-phase three-wire circuit, including the instantaneous voltages and currents.

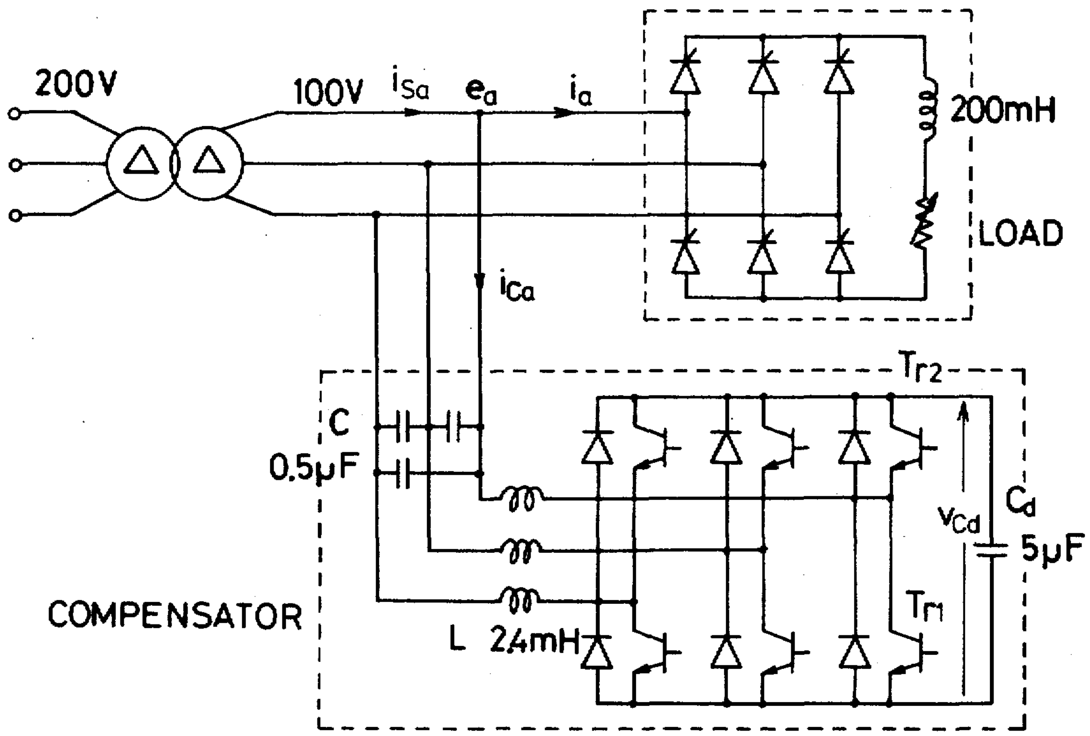

Fig. 2. Experimental system configuration that was designed, built, and tested in 1982 [2].

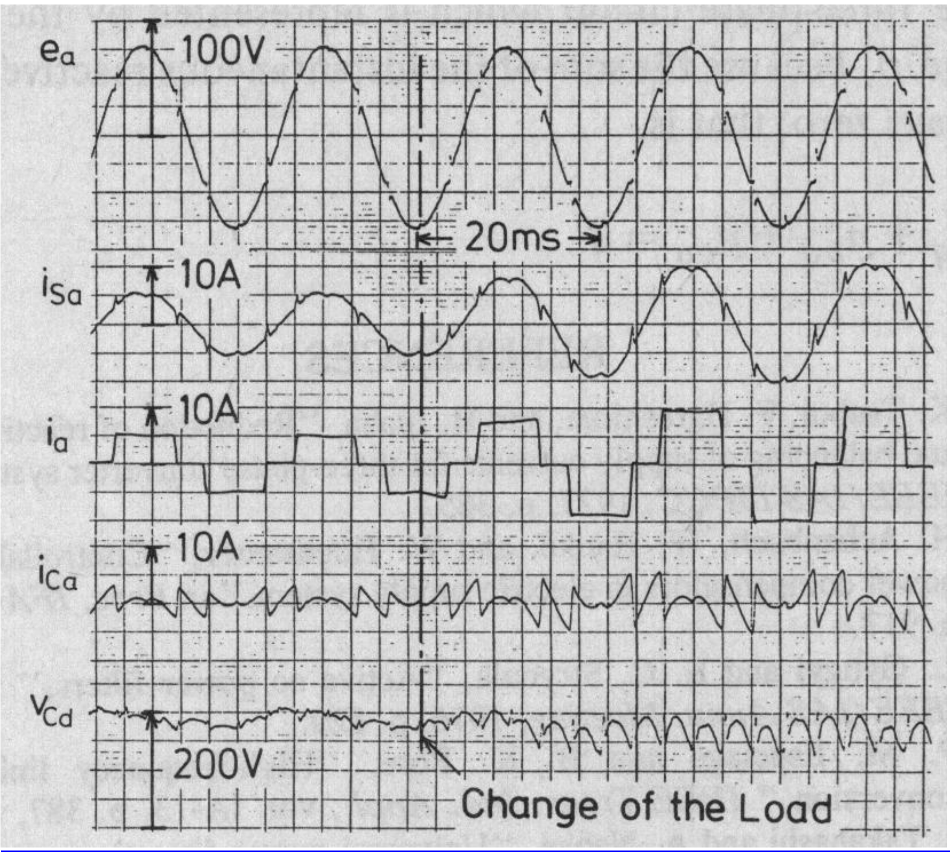

Fig. 3. Experimental waveforms before and after a step change was made in the dc load resistor of the thyristor rectifier, where the control angle of the thyristors was kept zero [2].

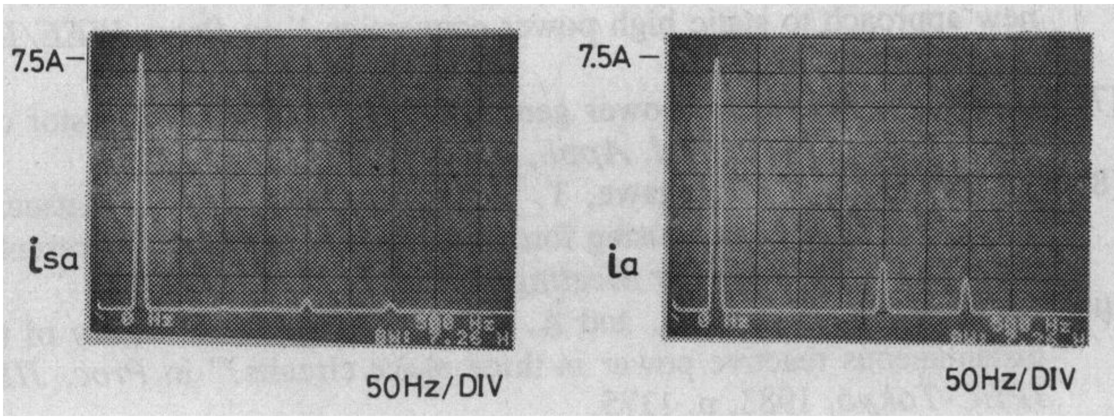

Fig. 4. Experimental harmonic spectra of i_{Sa} (left) and i_a (right), where three spectra in each of the two measured results correspond to the fundamental (50 Hz), 5th-harmonic (250 Hz), and 7th-harmonic (350 Hz) currents from the left to the right [2].

Equations

The above equations of (1)

$$e_a = \sqrt{2}E\ \cos\omega t$$
$$e_b = \sqrt{2}E\ \cos(\omega t - 2\pi/3)$$
$$e_c = \sqrt{2}E\ \cos(\omega t + 2\pi/3)$$

$$i_{Ca} = \sqrt{2}I_q\ \cos(\omega t \pm \pi/2)$$
$$i_{Cb} = \sqrt{2}I_q\ \cos(\omega t - 2\pi/3 \pm \pi/2)$$
$$i_{Cc} = \sqrt{2}I_q\ \cos(\omega t + 2\pi/3 \pm \pi/2)$$

$$p_C = e_a i_{Ca} + e_b i_{Cb} + e_c i_{Cc} = 0 \cdots\cdots\cdots\cdots (1)$$

$$\begin{bmatrix} e_\alpha \\ e_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} e_a \\ e_b \\ e_c \end{bmatrix} \quad (2)$$

$$\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} \quad (3)$$

$$\begin{bmatrix} i_p \\ i_q \end{bmatrix} = \begin{bmatrix} \cos\omega t & \sin\omega t \\ -\sin\omega t & \cos\omega t \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \cdots\cdots (4)$$

$$e_a + e_b + e_c = 0 \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (5)$$
$$i_a + i_b + i_c = 0 \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (6)$$

$$
\begin{aligned}
p &= e_a i_a + e_b i_b + e_c i_c \\
&= e_\alpha i_\alpha + e_\beta i_\beta \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (7)
\end{aligned}
$$

$$
q = e_\alpha i_\beta - e_\beta i_\alpha \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (8)
$$

$$
\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} e_\alpha & e_\beta \\ -e_\beta & e_\alpha \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \quad \cdots\cdots\cdots\cdots (9)
$$

$$
\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \begin{bmatrix} e_\alpha & e_\beta \\ -e_\beta & e_\alpha \end{bmatrix}^{-1} \begin{bmatrix} p \\ q \end{bmatrix} \quad \cdots\cdots\cdots\cdots (10)
$$

$$
\begin{aligned}
\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} &= \begin{bmatrix} e_\alpha & e_\beta \\ -e_\beta & e_\alpha \end{bmatrix}^{-1} \begin{bmatrix} p \\ 0 \end{bmatrix} + \begin{bmatrix} e_\alpha & e_\beta \\ -e_\beta & e_\alpha \end{bmatrix}^{-1} \begin{bmatrix} 0 \\ q \end{bmatrix} \\
&\equiv \begin{bmatrix} i_{\alpha p} \\ i_{\beta p} \end{bmatrix} + \begin{bmatrix} i_{\alpha q} \\ i_{\beta q} \end{bmatrix} \quad \cdots\cdots\cdots\cdots (11)
\end{aligned}
$$

$$
\begin{bmatrix} p_\alpha \\ p_\beta \end{bmatrix} = \begin{bmatrix} e_\alpha i_\alpha \\ e_\beta i_\beta \end{bmatrix} = \begin{bmatrix} e_\alpha i_{\alpha p} \\ e_\beta i_{\beta p} \end{bmatrix} + \begin{bmatrix} e_\alpha i_{\alpha q} \\ e_\beta i_{\beta q} \end{bmatrix} \quad (12)
$$

$$
\begin{aligned}
p &= p_\alpha + p_\beta \\
&= e_\alpha i_{\alpha p} + e_\beta i_{\beta p} + e_\alpha i_{\alpha q} + e_\beta i_{\beta q} \\
&= \frac{e_\alpha^2 p}{e_\alpha^2 + e_\beta^2} + \frac{e_\beta^2 p}{e_\alpha^2 + e_\beta^2} + \frac{-e_\alpha e_\beta q}{e_\alpha^2 + e_\beta^2} + \frac{e_\alpha e_\beta q}{e_\alpha^2 + e_\beta^2} \quad (13)
\end{aligned}
$$

$$e_\alpha i_{\alpha p} + e_\beta i_{\beta p} \equiv p_{\alpha p} + p_{\beta p} = p \quad \cdots\cdots\cdots\cdots (14)$$

$$e_\alpha i_{\alpha q} + e_\beta i_{\beta q} \equiv p_{\alpha q} + p_{\beta q} = 0 \quad \cdots\cdots\cdots\cdots (15)$$

The below equations of (15)

$$i_{\alpha p} = e_\alpha p/(e_\alpha^2 + e_\beta^2)$$
$$i_{\alpha q} = -e_\beta q/(e_\alpha^2 + e_\beta^2)$$
$$i_{\beta p} = e_\beta p/(e_\alpha^2 + e_\beta^2)$$
$$i_{\beta q} = e_\alpha q/(e_\alpha^2 + e_\beta^2)$$

$$p_{\alpha p} = e_\alpha^2 p/(e_\alpha^2 + e_\beta^2)$$
$$p_{\alpha q} = -e_\alpha e_\beta q/(e_\alpha^2 + e_\beta^2)$$
$$p_{\beta p} = e_\beta^2 p/(e_\alpha^2 + e_\beta^2)$$
$$p_{\beta q} = e_\alpha e_\beta q/(e_\alpha^2 + e_\beta^2)$$