Harmonics in Transformers

AIM

To use the CRO to investigate waveforms of exciting current and voltages in single-phase transformers and in 3-phase banks of single-phase transformers

THEORY

- The **magnetising current** comprises a fundamental term and a series of odd harmonics. If the flux density is fairly high, the magnitudes of the harmonics become greater. The amplitude of the third harmonic depends upon degree of saturation of the transformer core, but it may reach about 40 % of the amplitude of the fundamental component.
- In transformers with **delta-connected** windings, the fifth & seventh harmonics may be more important than the third harmonic, since delta connection does not suppress them. The third & ninth harmonics circulate round the delta and are less evident in the line currents.
- In **star-star** connection, if the secondary distributes single-phase power by means of a four-wire system, then each single-phase supply would contain unacceptably high third-harmonic voltages. If a fourth wire connects the star of the primary to the source star point, third harmonic currents would flow in the primary lines and in the neutral return path. If the impedance of the return path were negligible, the phase voltages of the transformer would be sinusoidal. However, the use of an earth path for conduction of harmonic currents may be objectionable from several points of view, for example, because of interference with adjacent communication cables.

When it is desirable to connect both primary and secondary windings in star, a tertiary winding may be used. Then, the third harmonic current of the exciting current flows through the tertiary winding.

- In **star-delta** connection, the third harmonic emf's induced in the three secondary windings would drive a third harmonic current around he secondary delta.

APPARATUS

Three single-phase transformers (each 2 kVA, 250/120 V, 50 Hz)
CRO
10.8 ohm/8.5 A rheostat

PROCEDURE

(a) Transformer magnetising current & output voltage

Connect as in Fig.1 to isolate the CRO from he 240 V supply. View, record, and sketch the waveforms of the magnetising current (across XX) and the output voltage of transformer # 2 (across YY).

(b) Current & voltage waveforms for three -phase transformer connections

(i) STAR-STAR

1. Disconnect the supply neutral in Fig.2
2. Observe & sketch the waveform of secondary phase voltage of transformer #1 , (a1,a8)
3. Repeat for secondary line voltage, (a1, a1).
4. Now connect supply neutral to primary star point S and repeat steps 1 & 2.
5. Connect the 10.8-ohm rheostat in the line between N& S and observe & sketch the voltage waveform across it (current in the neutral).

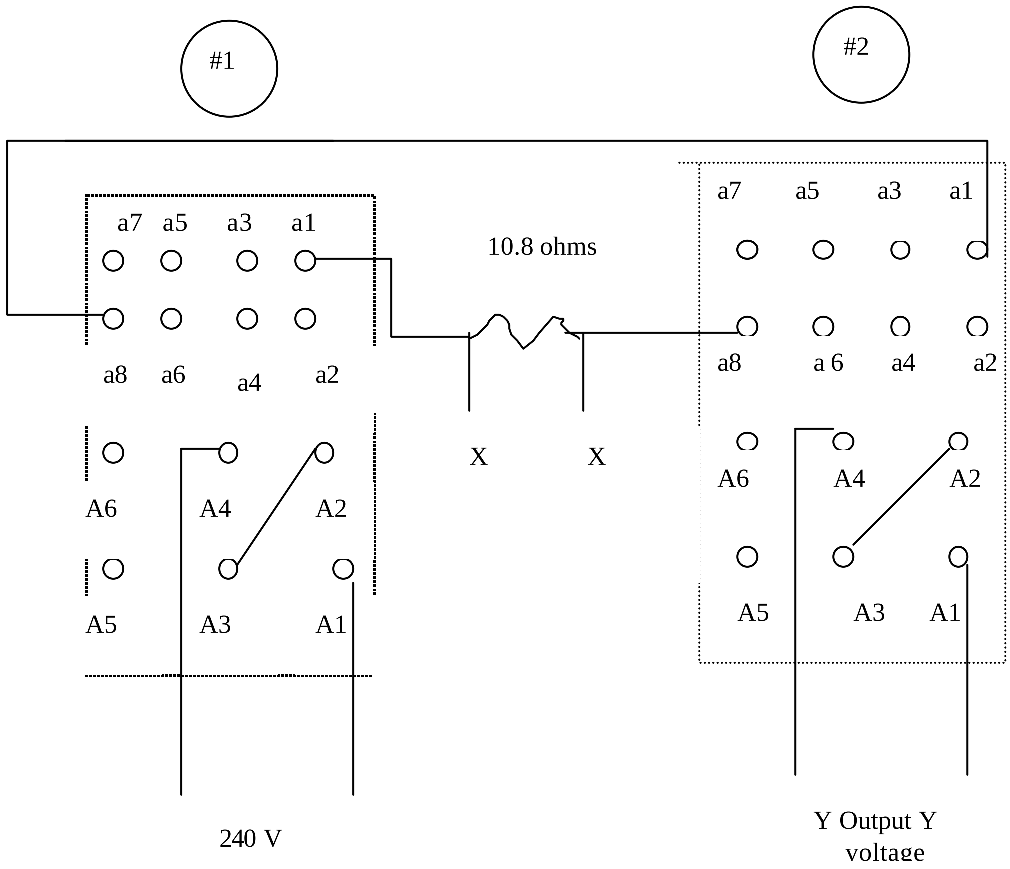
- **It is important throughout this experiment to leave the time base setting of the CRO undisturbed.**

(ii) STAR-DELTA

1. Connect the secondary windings as in Fig.2 for 3-phase 415 V supply
2. Observe and sketch the waveform of the secondary line voltage (a1,a8) of transformer #1
3. Open the delta at a1, a7 between transformers #2 and #3 and again observe the waveform of the secondary line voltage (a1, a8).
4. Close the delta with the 10.8 ohm resistor and observe and sketch the waveform of the voltage across the resistance (Circulating current in the delta)

RESULTS & CONCLUSIONS

1. Label all the waveforms clearly
2. Give a brief explanation about each waveform
3. What is the effect of connecting the primary star point S (in the star-delta connection) to the neutral of the supply?
4. In the star-inter -star transformer connection without a supply neutral connection, would any voltage distortion appear in the secondary side of the transformer?



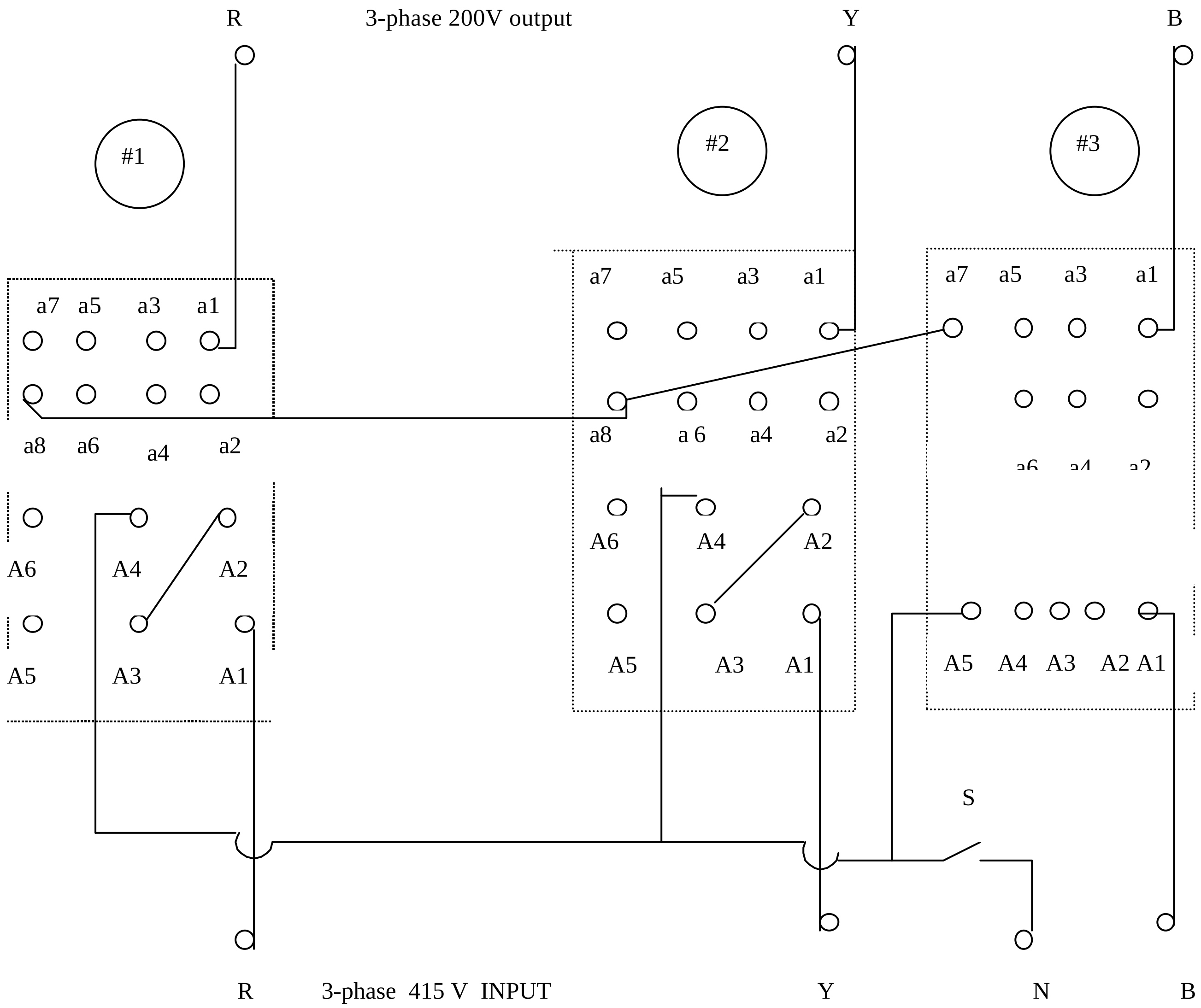
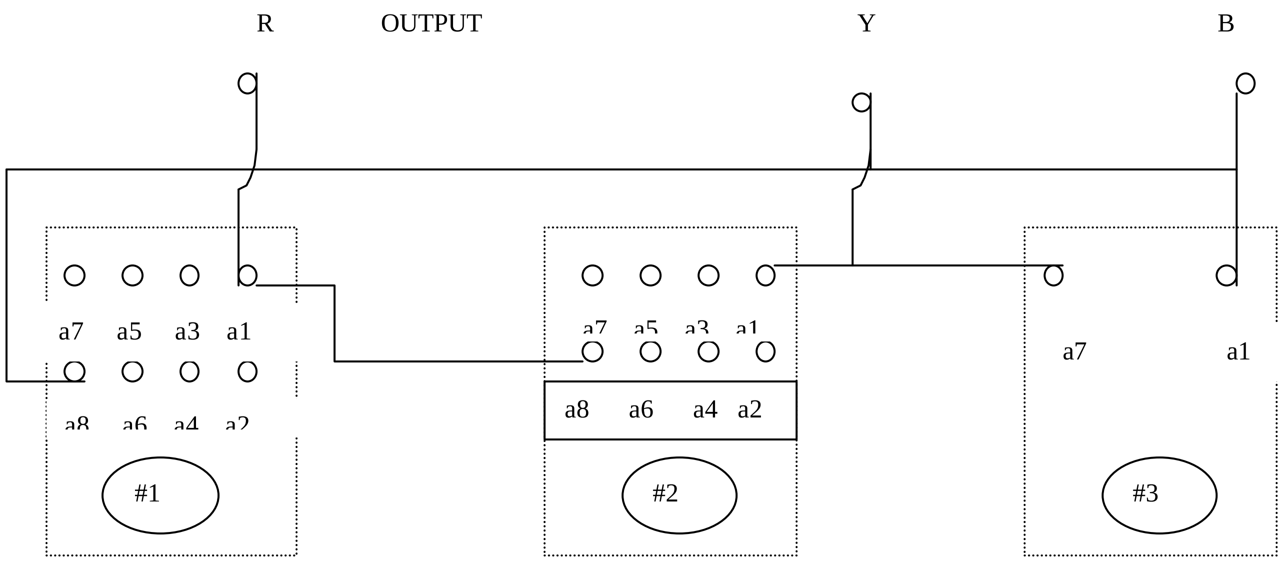


FIG.2



Primary connection as in FIG.2

FIG.3