VARIABL REACTANCE TRANSFORMER AN EMERGING TECHNOLOGY

1. Prof. S. M. Kulkarni
, P.E.S. College of Engineering Aurangabad. M.S. India, app1911@gmail.com

ABSTRACT: The paper illustrates about the newly developed technology for Variable Reactance Transformer or VRT is not a device, which transforms power, but it is a device which transforms volt-amperes from one circuit to another circuit. has an infinitely variable coupling between primary and secondary. It is not a voltage-controlling device, but makes available to the secondary more or less amperes; dependent upon the DC signal applied The system can best be compared with a Saturable Core Reactor in series with the primary of the transformer.

INTRODUCTION

Newly developed technology awaiting to establish in the market, through out in the world, is VRT. Used in control of power factor even having variations in resistive loads during switching and frequent load changes, which is helpful in single phase distribution systems.

Basically, the VRT is a transformer, which can be designed over a wide range of ratios and has similar to a transformer with a variable inductor connected in series with the primary.

In order to understand the operation of the VRT, it is necessary to examine several applications together with the basic mathematics, associated with its performance in each case.

We can think about the VRT with the help of some example.

CONSTRUCTION

The construction of the VRT is just like three winding transformer having third winding an infinitely variable coupling between primary and secondary. It is not a voltage-controlling device, but makes available to the secondary more or less amperes, dependent upon the DC signal applied. The available secondary power and secondary voltage are therefore always a product of the available current and the exact load impedance involved.

The system can best be compared with a Saturable Core Reactor in series with the primary of the transformer. Like the Reactor - Transformer combination, the VRT does introduce lagging powder factor at less than full rated out put. A vector diagram would be

CIRCUIT DIAGRAM

connected to DC supply. For temperature control, the WATER circulation through core ducts is managed, this is the most critical and high skilled job

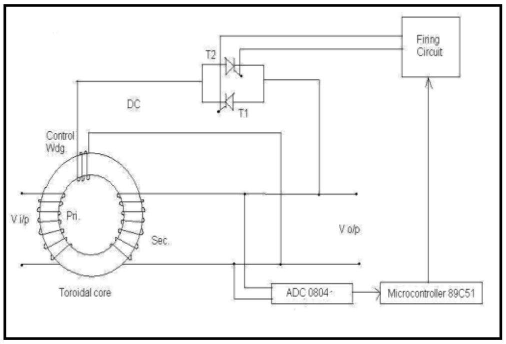

Fig.1

The VRTs are constructed in such a way that the third control winding is excited by DC which is a result of logical calculations carried out by the controller .The output Volt Amps are sensed by the sensors and compared with the required value of it.

According to the required correction in the power factor the DC is injected to vary the reactance of the windings.(Refer Fig.1). The DC source is taken from the out put terminals connected with the rectifier parallel to load.

OPERATION

Most VRTs have been used with closed loop temperature control systems. In order to avoid 'Hard' Starts, It is not advisable to apply control signal prior to energizing the primary main line. If control signal is applied first, then the initial impedance of the VRT will become very low. This may result in fuse blowing, breaker tripping and possible damage to load elements due to high in-rush currents. The ideal system would consist of primary power first, followed by application of DC control power, as a pre-conditioning of the load switching, followed by removal of the AC line. How ever, such a system would require the use of time delay circuits, and simultaneous application of AC & DC with simultaneous interruption of AC & DC is acceptable.

Like all water-cooled devices the life expectancy of the VRT is dependant on the adequacy and quality of the water supply. In general, there should be an adequate water supply, whenever the primary is energized. How ever, this water should not be allowed to circulate for longer periods of time without some power being drawn from the system. This is particularly applicable where the water supply is below the due point and large amounts of condensation could accumulate on the supply hoses, and on the transformers themselves. The recommended water specifications are as follows:

Flow as specified for the particular unit involved:

1. Outlet water temperature not to exceed 140^0 F.
2. Incoming water should be above due point, max.100^0F.
3. Cooling water should not exceed 200 ppm TDS or be less than 6000 Ω/Cm in normal supply operation. Emergency water supply may exceed 200 ppm but shall not be less than 6000 Ω / cm.
4. Connections to cooling water inlets and outlets should be via non-conductive plastic pipe or rubber hose at least 36" long with physical characteristics suitable for water and temperature described above.

EXAMPLE

Assume that the VRT is of following specifications.

1) 50 KVA
2) 400 V (Primary line voltage)
3) Frequency 50 Hz.
4) 48 V (Secondary volts)

From the above specifications, neglecting transformer losses, it is found that:

1. Primary line current = 50000VA / 400 V or 125 Amps.
2. Secondary line current = 50000 VA / 48V or 1041.66 Amps.
3. Sec.Load Resistance for maximum power is = 48V / 1041.66 A = 0.04608 Ω
4. Secondary Power =$(1041.66)^2$ x 0.04608 = 50 KW.
5. Primary KVA= 125 X 400 = 50KVA
6. Power Factor = 50KVA/50KW = 1

The conditions as out lined above, assume that the maximum control power is applied to the VRT and neglects power factor and losses. In actual practice the power factor will be in excess of 98%, so the line will carry this 2% difference plus the winding loss and core loss of the particular unit involved. The control signal required is generally ½% or less of the total power which is being controlled. These conditions would represent a fully "turned on" state and of course the VRT is capable of a fully "off" condition and infinitely variable between these two points.

A typical fully "OFF" state is outlined below:

1. Secondary current, 5 Amps.;
2. Secondary power = 5^2 x 0.04608 = 1.15W
3. Secondary line current reflected to primary by turns ratio = 0.5 Amps.;
4. Primary VA 0.5 x 400 = 200; and
5. Actual power factor, 1.15 / 200 = 0.575%

In actual practice the primary current would show a somewhat higher value at these very low power levels as the magnetizing current could be considerably higher than the load current, depending on the line voltage and other factors. From these minimum-maximum values it is possible to predict the power factor at any point, a load of fixed resistance.

If the load were less than optimum resistance, say 0.03 Ω, the following condition would exist in a fully “Turned On” condition:

1. Secondary current, = 1041.66Amps.
2. Second. Power = $(1041.66)^2$ x 0.03 = 32.55 KW
3. Primary current as reflected in secondary = 125 Amps.
4. Primary KVA = 125 x 400 = 50 KVA
5. Power factor = 32.55 / 50 = 65%

If the load were more than Optimum resistance, say 0.06 Ω the following condition would exist in a fully ‘turned On’ condition:

1. Secondary current= 48V/ 0.06 Ω = 800Amps
2. Secondary power = 800^2 x 0.06 = 38.4 KW
3. Primary current referred from secondary= 96 Amps.
4. Primary KVA =96Amp x 400V = 38.4 KVA
5. Power factor= 38.4 KW / 38.4 KVA =1

From above said examples the following guidelines become apparent:

1. Loads of an ohamic value less than optimum result is less than unity power factor with a corresponding reduction in useful KW available at the load because there is insufficient current.
2. Loads of an ohamic value greater than optimum result in Unity power factor, but less than rated KW because there is insufficient voltage.
3. Unity power factor will exist only at rated Kw in to a Load of Proper impedance .A reduction of power will always result in less than Unity power factor.
4. Because the secondary voltage is determined by the ratio of transformation, it is not possible to obtain greater than the designed voltage, except by rising the primary line voltage. (All VRTs will support 10% over voltage.)
5. All VRTs will supply the designed current + 10%.

In order to obtain 10% over current, it will be necessary to supply 10%more Amps. Into the control windings. Tapping the DC supply provides provision for this 10% over current.

CONCLUSION

The Variable Reactance Transformer is of the kind and quality in order to supply the maximum output power when proper control signal is applied, providing that the load impedance is correctly matched to the values of currents and voltage supplied. The inclusion in this equipment is of protective devices , intended to be an aid or assistance only to avoid over heating.

REFERENCES:

[1] Hunterdon, “Flemington Univ.Research and Development Annual Report” 2006 pp-201-735

[2] ANSI/IEEE C57.109-1993; “Guide for Transformer Through-Fault Current Duration.” pp- 93.

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