Balancing National Grid and Self-Power Generation Using Synchronizers

Shaker J Gatan
Riga Technical University
Azenesiela
12/1, Riga LV-1048, Latvia
{Shaker.gatan@outlook.com}

ABSTRACT: *Parallel power generation is natural and there should be a synergy between them. Due to the anonhomogeneous of transformers CTs and VTs and a load shedding system, the balanced act between self-power generation and national grid power system. The unit which is considered for case study has difficulty in synchronizing the national grid with the current oil circuit breakers and switch boards. During the complete operation, the instrument protection system often fails. We in this work study the switching surge phenomena relatively with circuit breakers, including the necessary of parallel operating methods and synchronizing both CTs & VTs for steady operation with stream power flows between tie systems for full operation loads.*

Keywords: Arcing Currents and Chopping Currents, Synchronizing CTs & VTs

Received: 18 March 2021, Revised 29 June 2021, Accepted 20 July 2021

DOI: 10.6025/jes/2021/11/3/69-77

1. Introduction

The Switch board power plants works for transferring a power to the facilities, but thoroughly the normal operation, some terms effective under operating such as; firstly a switching surge phenomena, this critical circuit conditions: such as arcing currents and chopping currents with generated high frequency over voltages and frequency of re-ignition. Secondly, the none homogenous of instrumentation and malfunctions also effect to critical case condition.

ARC has running a three steam turbines to generate 7200KVA each, including a gas turbine of 23MVA as the self-unit connects with national grid with two feeders of IF1 & IF2 of 63MVA, but from time to time have many shut downs have been abruptly.

I was made a deeply investigation analysis for this critical conditions and studying precisely for make diagnoses about why do the repeated shut downs happened. This analysis of characteristics of power switch board basically on NEPLAN software as followings:

1. Circuit breaker conditions
2. Instrument transformers functions
3. Characteristics of protection Relays
4. Characteristics of Load shedding device

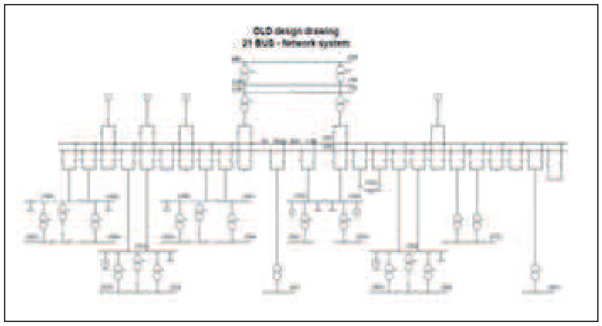


Figure 1. Single line diagram of ES-1

2. Analysis Application

Circuit breaker using different media for interrupter current my exhibit different characteristics with respect to all of primary functional requirements of the breaker. Each type of circuit breaker has a unique set of characteristics which must be thoroughly understood before the breaker can be applied with safety and confidence.

The switching surge phenomena usually associated with both oil circuit breakers and vacuum interrupters. This includes current chopping, multiple re-ignitions, and prestrike over voltages. Current chopping refers to the prospective over voltage events which can result with certain of inductive loads (Transformers & motors) due to the premature suppression of the power frequency current before normal current-zero inside electroplates of interrupters [1].

2.1. Chopping Currents Calculation
The process of current chopping is the premature suppression of 50 *Hz* or 60 *Hz* circuit current before normal current zero due to instability of the arcs in a vacuum interrupter [2]-[4]. Although the current in the vacuum interrupter can chop to zero almost instantaneously (fraction of microsecond), the current in the load inductance cannot attain zero value instantaneously. Time is required for magnetic energy to be transferred from the inductance "Transform inductance loads", and for the magnetic field associated with stored energy to collapse. When current chop occurs, the energy stored in the effective load inductance is transferred to the available load-side capacitance to produce the so called chop over voltage, given by $I_c\sqrt{(1-\gamma)}\ L_b/C_s$ where I_C called chopping current level and $\sqrt{\ L_b/C_s}$ ionization of medium voltage impedance γ represents circuit losses generate joule heating and lightning impulse, especially ions loss and very significant in limiting chop overvoltage [2]-[5].

For determine the actual value of first peak of chopping current

$$V_T = I_C \, . \, Z_{LOAD} \tag{1}$$

V_T – Voltage transient,

I_C – Current chop, First peak value,

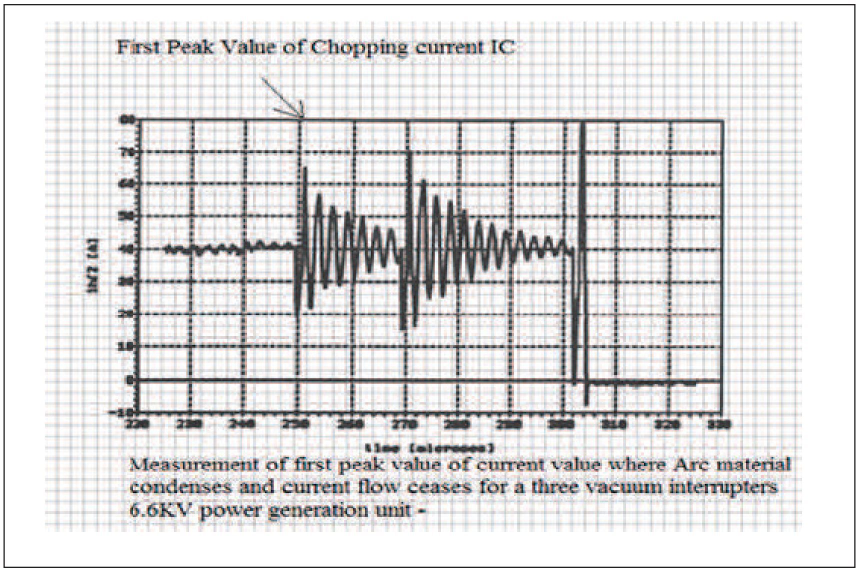
Z_{LOAD} – Load impedance,

U – Operating voltage of inductance Load- KV

Ur – Rated voltage –maximum RMS –KV

U d – Insulation level - Rated power frequency RMS-KV

Up – Rated lightning impulse withstand level –KV; 1.2/50us withstand level of IEEE



Figures 2. Chopping currents characteristics

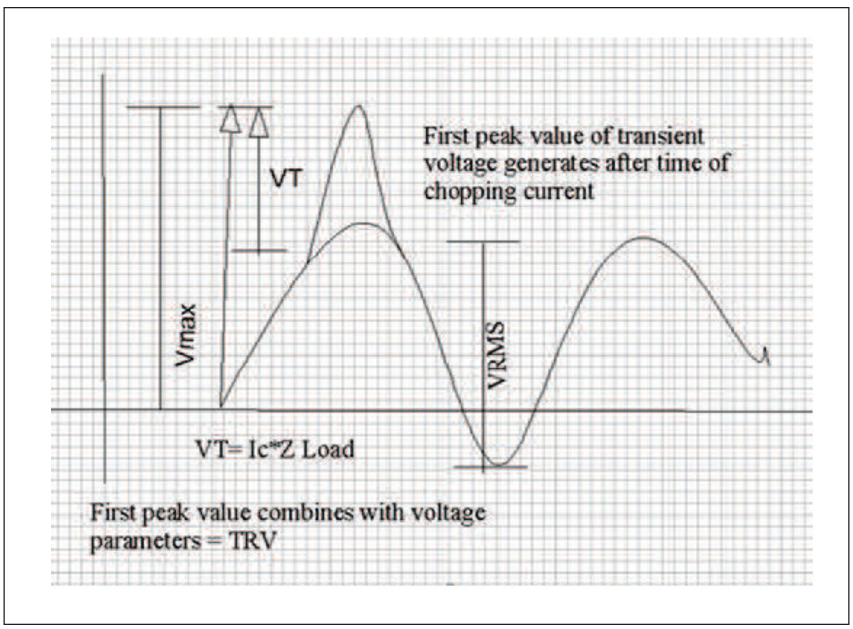


Figure 3. First peak value of transient over voltage

According to the Eq. (1), I was made my calculation thoroughly both physically and software application for the cubicles no.7 & 8 in main switchboard of ES-1.

$$= 0.5A*3000\Omega = 1500 \text{ volt}$$

$$V_{Max} = V_{RMS} + Vt = 1.5+7.5= 9KV$$

This is a first calculation which is acceptable value for the first peak value of transient over voltage

N:B The specification of circuit breaker

$U = 6.6$KV

$Ur = 7.2$KV –RMS-KV

$U_d = 20$KV- Maximum withstand level of Insulation

Ic	U_{MAX}	U_d	Max Rated level	Notes
0.5A	9KV	20KV	Acceptable IEC	T
0.7A	9.3KV	20KV	Acceptable IEC	T
0.75A	9.45KV	20KV	Acceptable IEC	T
0.8A	9.6KV	20KV	Acceptable IEC	T
0.9A	9.9KV	20KV	Acceptable IEC	T
1A	10.2KV	20KV	Acceptable IEC	T
2A	13.2KV	20KV	Acceptable IEC	T
3A	16.2KV	20KV	Acceptable IEC	T
5A	22.2KV	20KV	Acceptable IEC	T
6A	25.2KV	20KV	Not Acceptable	S
10A	37.2KV	20KV	Disruptive	S
11A	40.2KV	20KV	Disruptive	S
12A	43.2KV	20KV	Disruptive	S

Table 1. First Table Calculation at $Z = 3000\Omega$

The above table explains the effective of transient over voltages due to increasing multi chopping current of the cubicles (C.Bs) because very fast transients caused the over voltage to be non-uniformly distributed in the transformer windings and circuit breaker together. The abruptly shut down was caused to stop parallel operation machines together and the all digital Relays were not involving about this critical condition. When the two feeders were connected together which ties with ES-1, the existing two oil circuit breaker were explosion due to high chopping currents in both of C.Bs going to up to maximum of scale 12A.

3. Calbration and Synchroning

In order to ensure of a parallel operating power generators its necessary to make a new method of measurement of all CTs and VTs for the maintain correctly connection as following;

1. Measurement of ohms Ω reading for all instruments.
2. A new calibration for magnitude & rotating phasors.
3. An Integrated tests by using of A Relay SPAU-140C (calibrating tests) [6].

Since the rated burden of a c.t .is referred to its rated current of each c.t.. One method is to calculate the rated burdens of each c.t. and all the equipment connected to it in ohms. The purpose of this experiment is to facilities for connection all current instrument for a parallel operating correctly. To maintain its accuracy, the maximum ohmic burdens c.t. is

$$Z_{ph} = VA/I^2 \qquad (2)$$

$$= 50VA/5^2 = 2\Omega$$

But the burdens in ohms are different for each single of c.t. when connected with the each cubicle of ES-1.

ALF needs to be recalculating to get a homogenous synchronous of parallel operation CTs mode.

Feeder No.	**C.T Ratio**	**Power VA**	**Type**	**Theoretical Ω**	**Reading Ω**
IF1	1600/5/5A	50VA	5p10	2	0.770Ω
IF2	1600/5/5A	50VA	5p10	2	0.773Ω
G1	1600/5/5A	50VA	5p10	2	0.664Ω
G2	600/5/5A	50VA	5p10	2	0.668Ω
G3	600/5/5A	50VA	5p10	2	0.661Ω
G901	2000/5/5A	50VA	5p10	2	0.882Ω

Table 2

According to the actual elements of all c.ts and v.ts in the site, there is a need for circuits which have balanced for each element has ability to detect any variation abruptly from one level of power flows to another when the input voltage of each c.t reach a selected value of each power generation changes, may be very slow or fast. We need a transducer which detects this rise or fall of values in large capacity. Such circuits are known for calibration is called a comparator circuit or trigger circuits [6]-[8].

A comparator circuit using an operational amplifier, in which V_r is a stable reference of negative polarity, is shown in Figure 4.

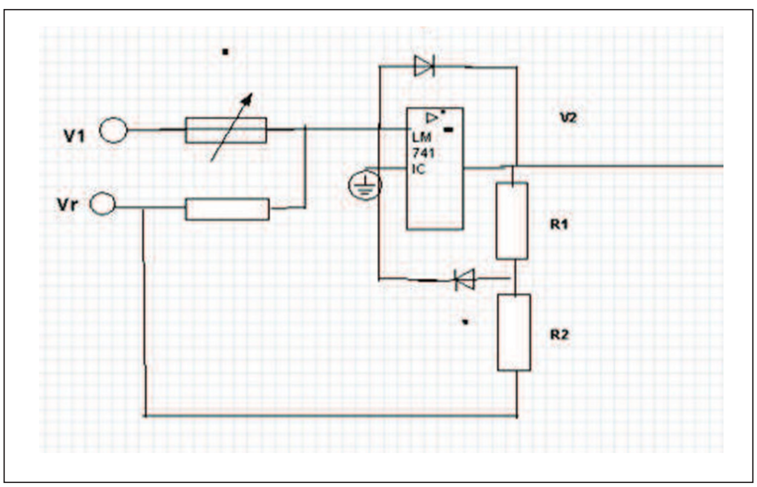


Figure 4. Comparator circuit for alignment of c.ts

The characteristic of the circuit is shown in Figure 5.

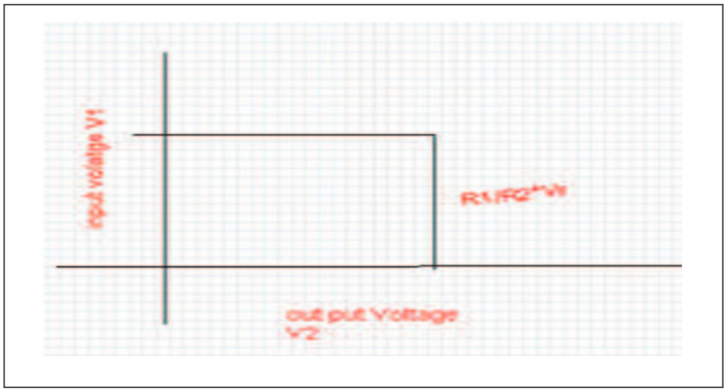


Figure 5. Output of trigger circuit

And we see that when the input voltage $V1$ is greater than V_r the output voltage is zero. When $V1 < V_r$, the output voltage is = R1. V_r / $R2$

$$\frac{R1}{R2} \; V_r \text{..........} \tag{3}$$

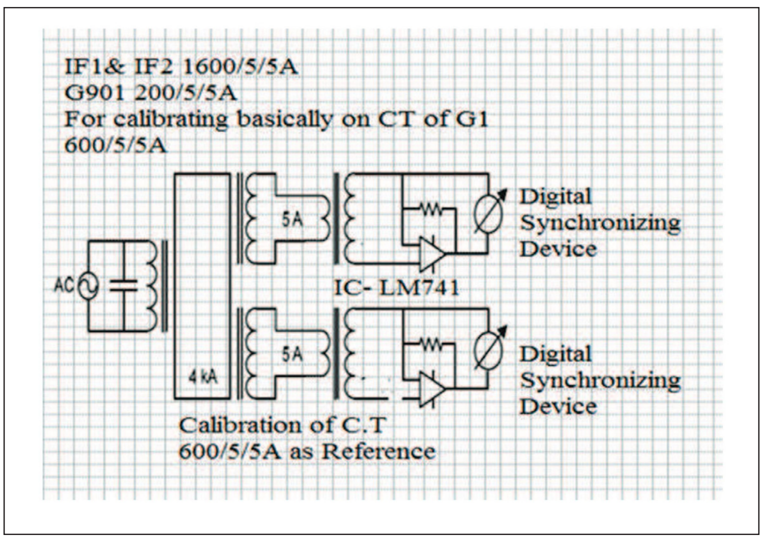


Figure 6. Measurement set up of two c.ts

The basic idea is to drive a current through the primary windings of the two CTs to be compared in series and to measure the two currents in the secondary windings of the CTs. If the current through the primary windings is equal, the ratio of the two secondary currents measured is equal to the ratios, one of which is the reference ratio and the other is the ration to be determined [9, 10].

2.1. Parallel Operation Mode for CTs

The parallel operating modes shall be implemented by choosing of c.ts of steam turbine G1 as a reference and making alignment to be all cts of G2, G3, G901 and two feeders of IF1 & IF2. That indicates on the actual site experiment Figure 7 [10, 11].

2.2. Synchronizing Operation Mode for VTs

It is very necessary for all voltage transformer instrument to making synchronizing together by using a synchro scope device similar tocts that the scheme must prevent an incoming circuit being connected to the busbars if the wrong voltages are selected, it should be easy to operate with load shedding instrument [9-11].

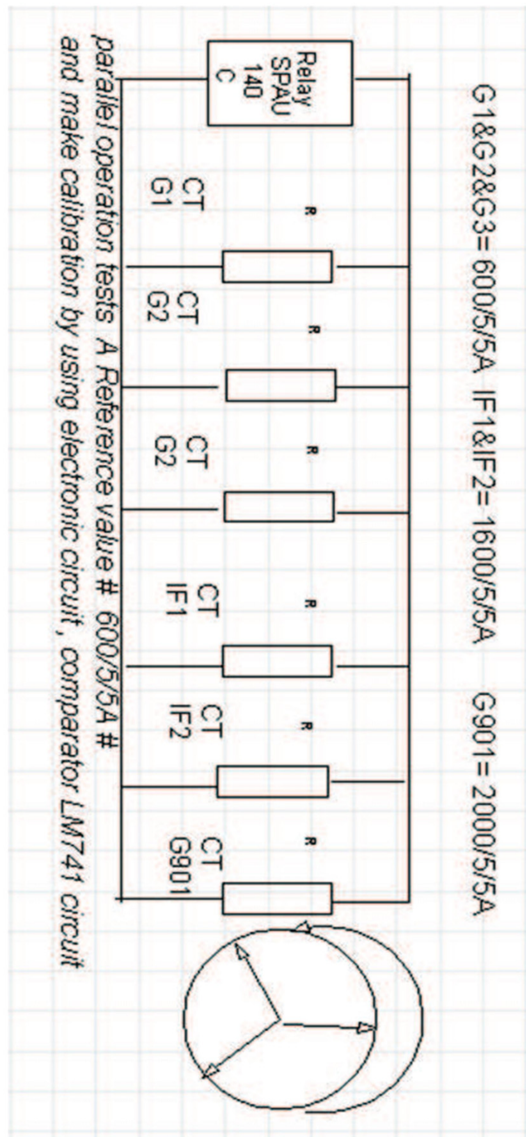


Figure 7. Parallel operating tests for CTs synchronizing

4. Conclusions

The main conclusions and recommendations are given below

1. Current Transformers Instrument

Analysis of the flux and calibrating of each c.t is necessary for balancing of burdens, basically with one of G1, G2, and G3 as a reference point and ensure that all other c.ts shall be not becoming saturation knee point in actual and practical conditions.

The protective Relays should have as small a burden as possible, and should operate correctly when the current transformers under full operation faults before saturation current .

2. Voltage Transformers Instrument

The main task of the duty of the 33KV transformer Vts that shall be balanced with the measuring cubicle of 6.6KV of ES-1.

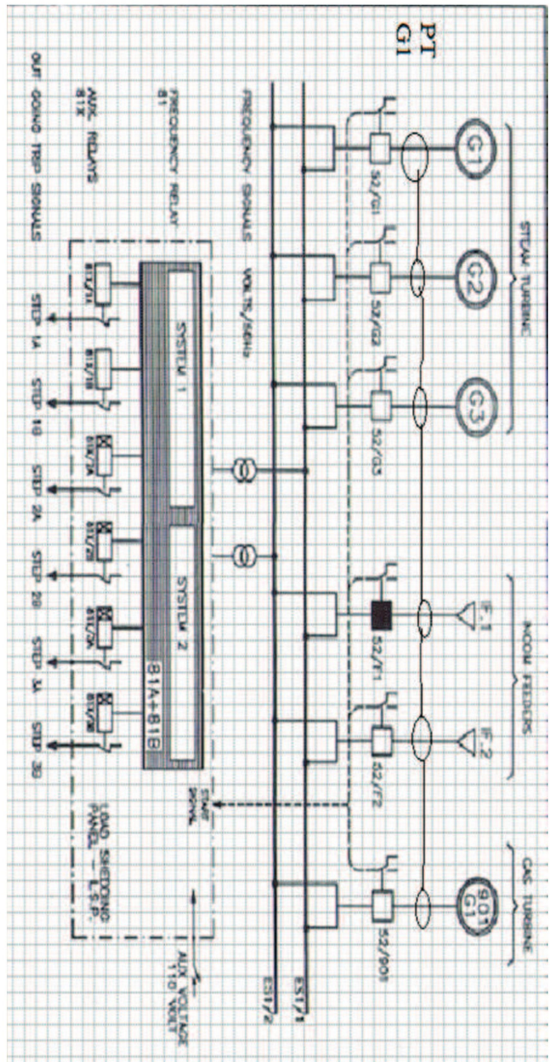


Figure 8. Synchronizing VTs by a new system

ARC have many problems when tie-connection with national grid of IF1 or IF2 that after synchronizing IF1or IF2 that The load shedding device have some detection of frequency detects and making load shed abruptly.

References

[1] Perkins, J. F. (1982). Evaluation of Switching Surge over Voltage Power System, Westinghouse Electric Corporation, Switchgear Division, *IEEE Trans.on Power Apparatus and Systems*, PAS-101, 6 (June).

[2] Greenwood, A. N. (1960). The Effect of Current Chopping in Circuit Breaker on Networks and Transformers, part II, *Trans. AIEEE*, 79, part 3, 545-555.

[3] Tuohy, E. J., Panek, J. (1977). Chopping of Transformer Magnetizing Currents: part I; Single Phase Transformers, paper no. F77 096-1, *IEEE PES Winter Meeting*, New York, February.

[4] Childs, S. E., Greenwood, A. N. Events Associated with Zero Current Passage During the Rapid Commutation of a Vacuum.

[5] Childs, S. E. (1980). Greenwood, A. N. (1980). A Model for DC Interruption in Diffuse Mode, *IEEE Trans. Plasma Science*, volume ps-8, p 289-294, (December).

[6] General Specification, Description of Operation and Installation of SPAU-140C, ABB Network Control & Protection.

[7] Wu, Z., Thoma, K., Sun, R., Centeno, V. A., Phadke, A. G. (2012). Three-Phase Instrument Transformer Calibration with Synchronized Phasor Measurements, *IEEE PES Innovative Smart Grid Technologies*.

[8] Morris, N. M. (1968). *Control Engineering*, (Measuring Signal A/D circuit, Digital Techniques and Digital Computer Control).

[9] van der Brom, H. E., Jol, L., Rietveld, G., So, E. (2012). High- Current AC Transformer Calibration Using an Automated Sampling System, 2012 *Conference on Precision Electromagnetic Measurements*, Washington, US.

[10] Jol, L., Rietveld, G. (2004). Improved Sampling Wattmeter for low Frequencies (45Hz-55Hz), *CPEM 2004 Conf. Digest*, p 297-298, (June).

[11] Gary, W., Wright, A. (1953). Voltage Transformers and Current Transformers Associated with Switchgear, Measurements section IEEE 621.314.22, *IEE - Part II: Power Engineering*, 100 (75), p 223-236, June 1953.