Making and breaking test of dead-tank type GCB rated on 800kV 50kA

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Introduction

- Breaker rating and type
  - 800kV, 50kA, 50Hz for GIS
  - 2-break dead-tank type
  - kpp(1st-pole-to clear factor) =1.3 (Earthed neutral system)
  - kcc (capacitive voltage factor) = 1.2

- Test item and test date

  (1) Certificate of short-circuit making and breaking performance

  Test item : STC, BTF, SLF, OP

  Date : September 2005 to February 2006

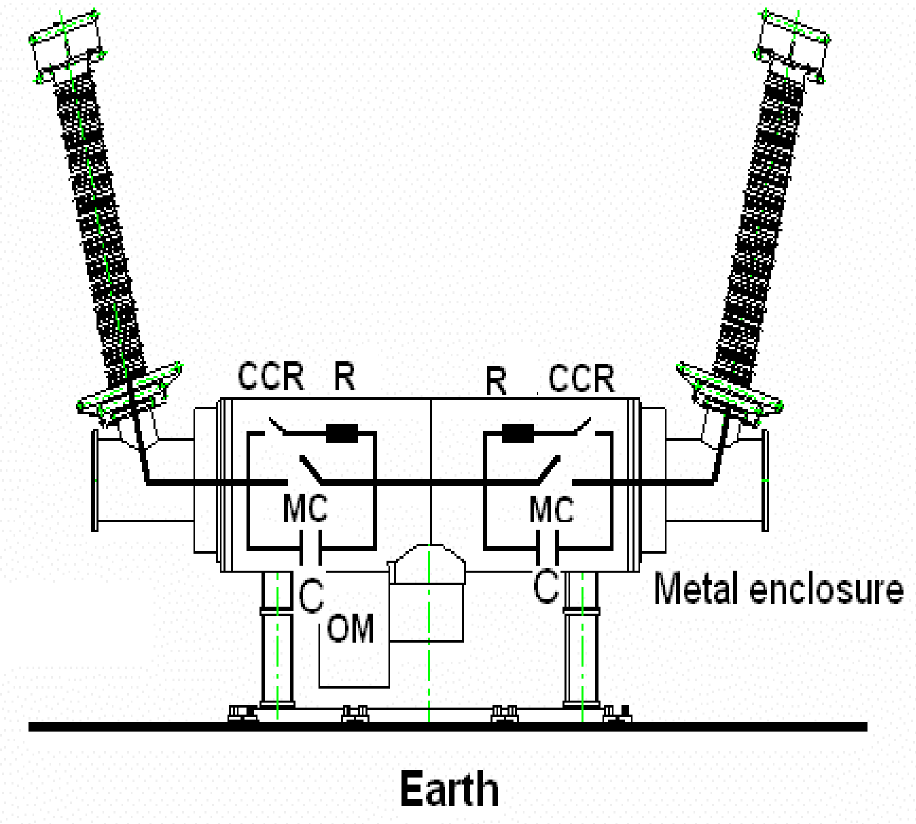
  (2) Certificate of capacitive current switching performance

  Test item : Line charging current switching

  Date : June 2006 to July 2006

Introduction

- Dead-tank circuit breaker



- MC : Main Contact
- CCR : Contact for Closing Resistor
- R : Closing Resistor
- OM : Operating Mechanism
- C : Grading Capacitor

Introduction

- Purpose of test

(1) Evaluate making and breaking performance between contacts (Short-circuit current, capacitive current)

(2) For dead-tank breaker, evaluate insulation performance of phase-to-enclosure in a condition of hot-gas during short-circuit current interruption

(3) For dead-tank breaker, evaluate insulation performance of phase-to-enclosure in a condition of capacitive current switching

Test requirement for short-circuit current

- Reference standard

  (1) IEC 62271-100 (2003)

  - High-voltage switchgear and controlgear –

    Part 100: High-voltage alternating-current circuit-breakers

    (*) General for circuit breaker testing

  (2) IEC 61633(1995)

  - High-voltage alternating current circuit-breakers –

    Guide for short-circuit and switching test procedures for metal enclosed and dead-tank circuit-breakers

    (*)Special requirement for dead-tank circuit breaker

Test requirements for short-circuit current (IEC)

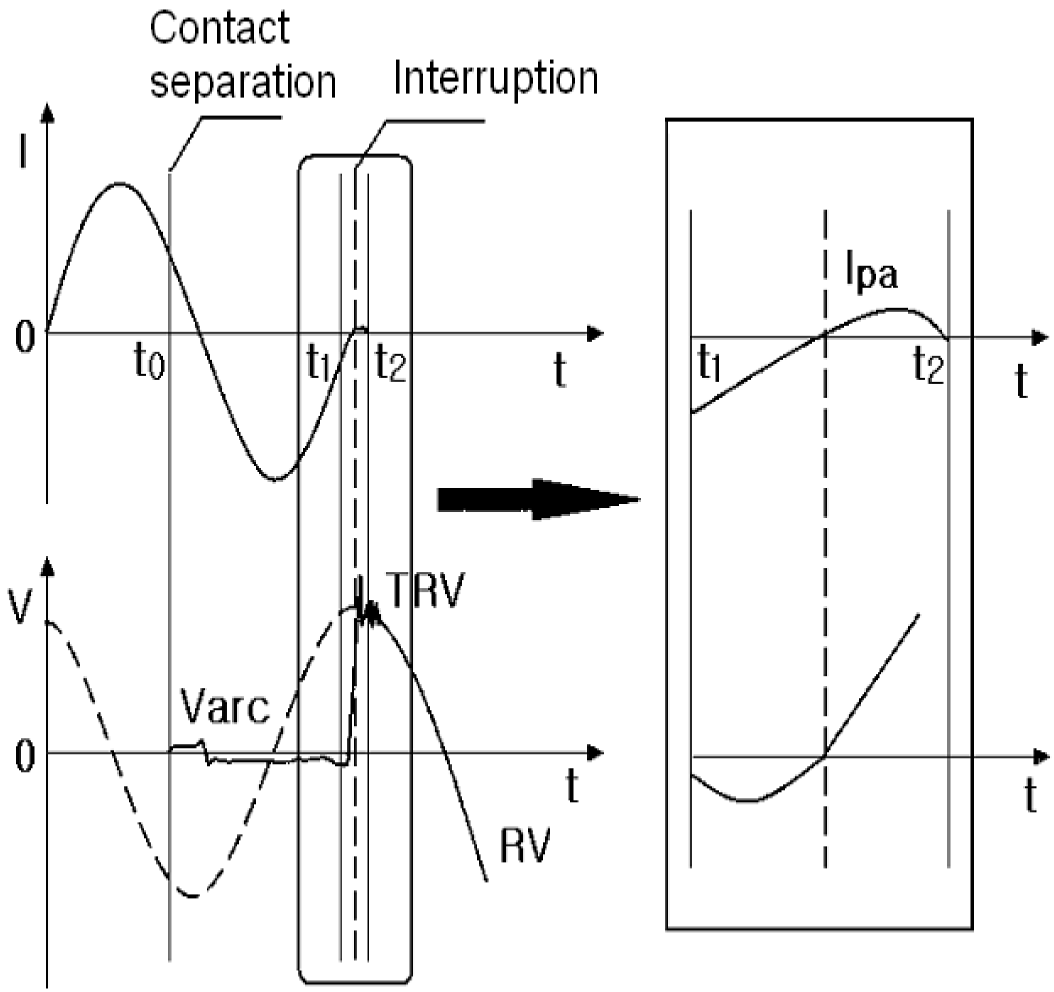
- Basic requirements for unit testing

(1) For verifying the performance against mechanical stress of the arc energy by the short-circuit current interruption, current should be interrupted by full-unit

(2) For verifying the interrupting performance between contacts, TRV/RV corresponding with number of unit shall be applied

(3) It is necessary to verify the dielectric performance for phase-to-enclosure of dead-tank type breaker
Even if unit-test, full-voltage should be applied phase-to-enclosure

Interrupting phenomena for short-circuit current



- High current interval (t**0** ~ t**1**)
  - High arc energy
  - Electromagnetic force
- Interaction interval (t**1** ~ t**2**)
  - Small post-arc current
- High voltage interval (t**2** ~)
  - TRV, RV

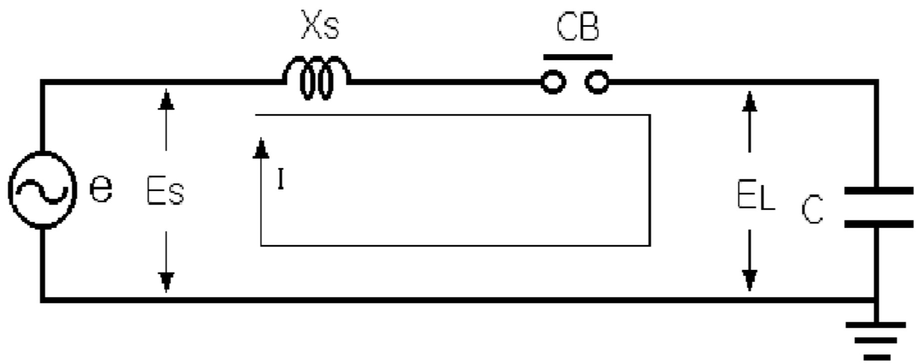
Test requirements for capacitive current (IEC standard)

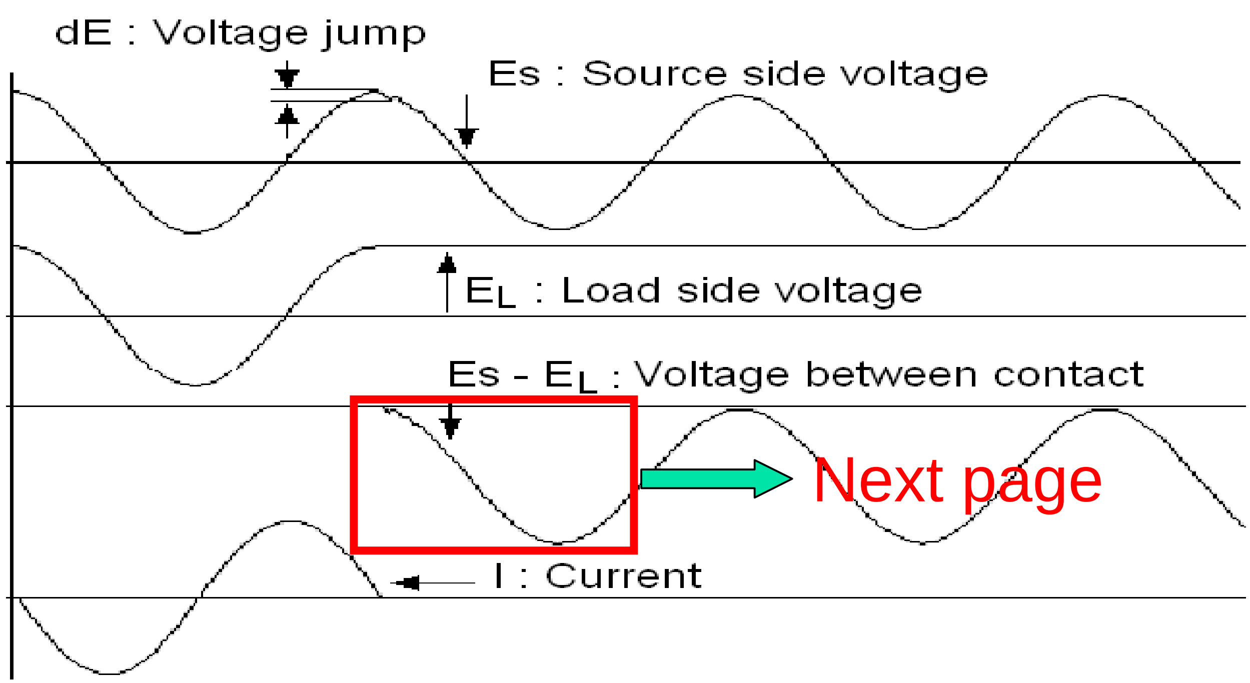
- Basic requirements

  (1) It is necessary to verify the dielectric performance for phase-to-enclosure of dead-tank type breaker

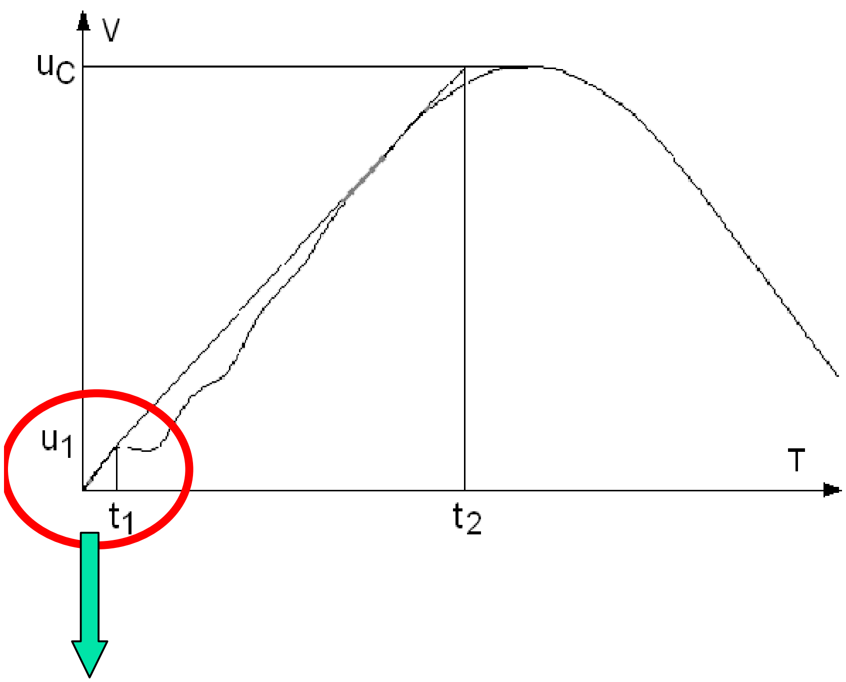
  (2) Initial voltage jump should be limited for appropriate evaluation of interrupting performance

Interrupting phenomena for capacitive current





Interrupting phenomena for capacitive current



Initial voltage jump (u_1, t_1)

Test Duty	It	TRV			
		Uc (PU)	U1 (PU)	t1	t2 (ms)
1	10~30%	≥1.98	≤0.02×k af	≥ t1 or t3 (#)	8.7ms (50Hz)
2	100%	≥1.95	≤0.05×k af		7.3ms (60Hz)

1pu : Peak of power frequency test voltage

(#) : t**1** or t**3** of T100s

4-parameter TRV of KERI

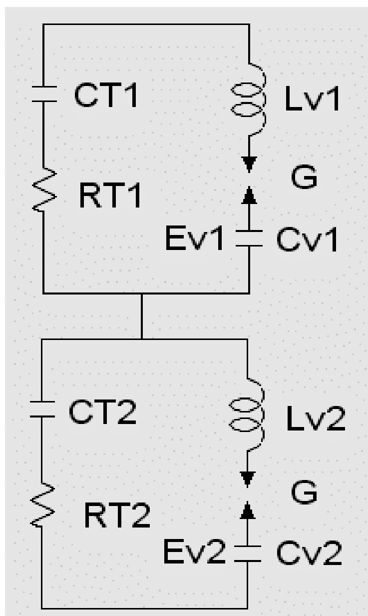
- Circuit for generating double frequency TRV

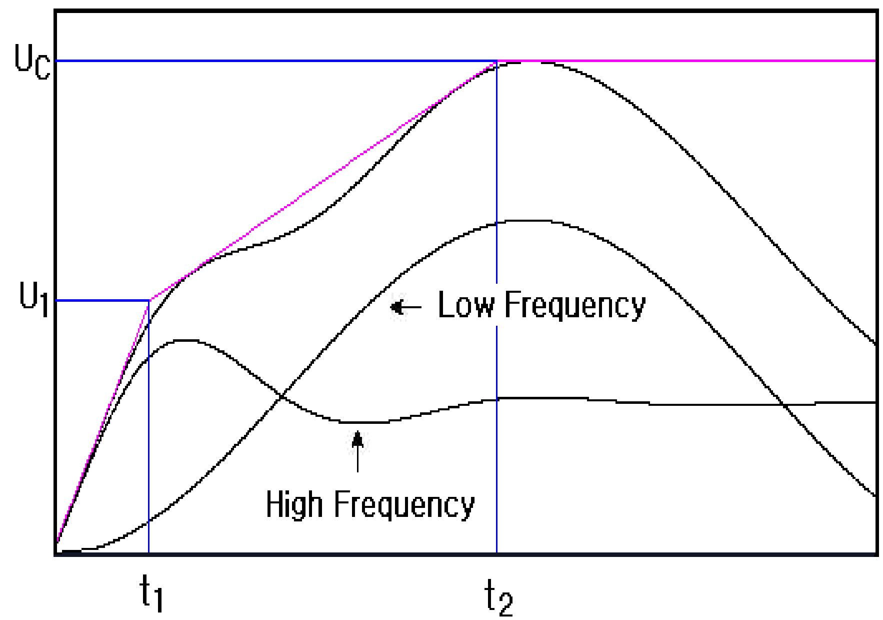
  Circuit-1 : High-frequency circuit for U_1, t_1

  Circuit-2 : Low-frequency circuit for U_C, t_2

HF TRV

LF TRV





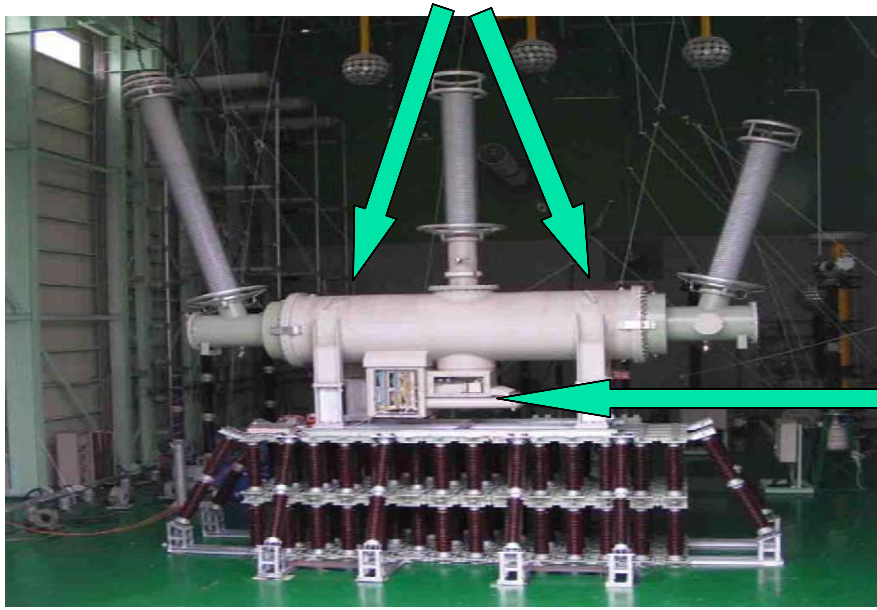
G : Spark-gap switch

Circuit breaker for test

- Type-1

  * Dead-tank breaker

  * Designed with 2-break unit and single-operating mechanism

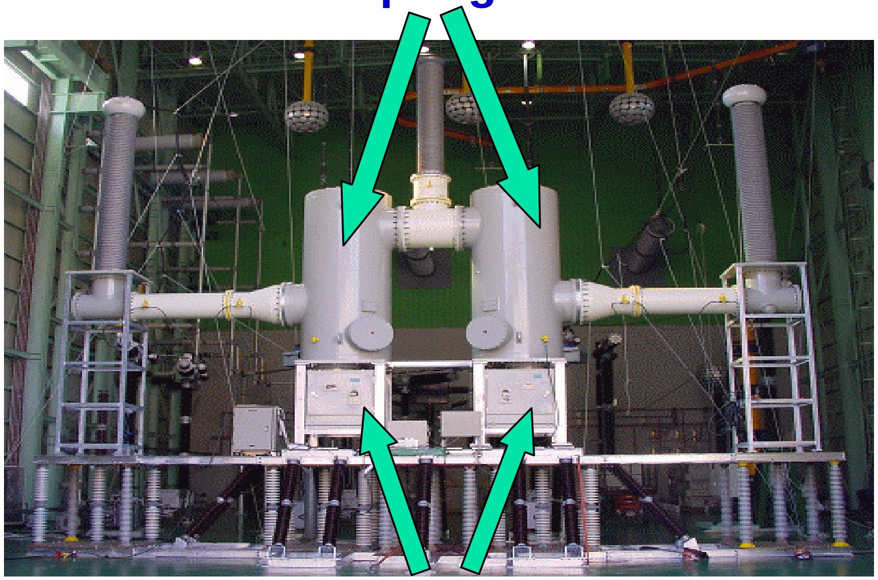


Circuit breaker for test

- Type-2

  * Dead-tank breaker

  * Designed with 2-break unit and two separated operating mechanism



Test method for each test duty

- T100s(a)

  Half-pole synthetic making test by step-up transformer method

- T100s(b), T100a

  Full-pole voltage injection test to verify full-insulation of phase-to-enclosure to fulfill IEC requirements

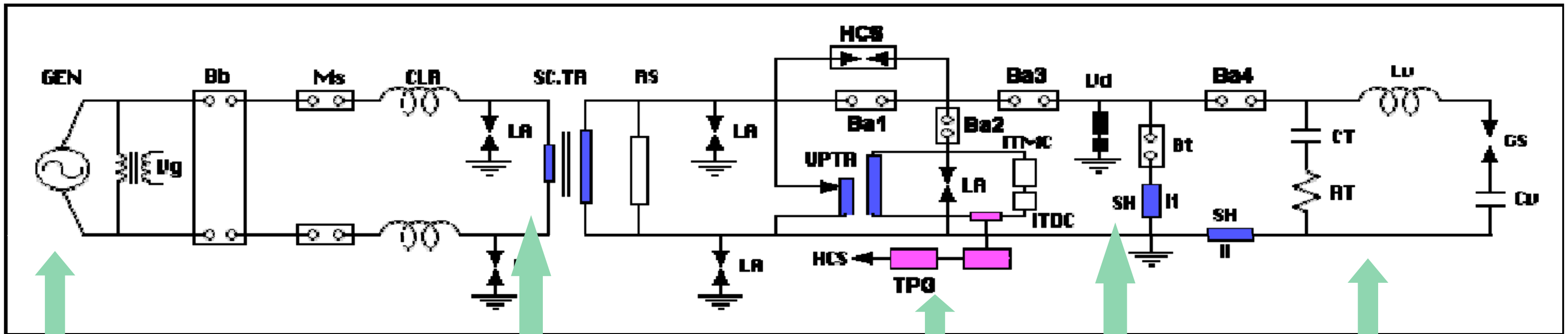
- T10, T30, T60, OP

  Half-pole voltage injection method to increase the test efficiency

- SLF (L90, L75)

  Half-pole current injection method to evaluate thermal failure

KERI Testing facilities



Short-circuit Generator

Synthetic making facilities

Synthetic breaking facilities

Short-circuit Transformer

Synthetic test cell

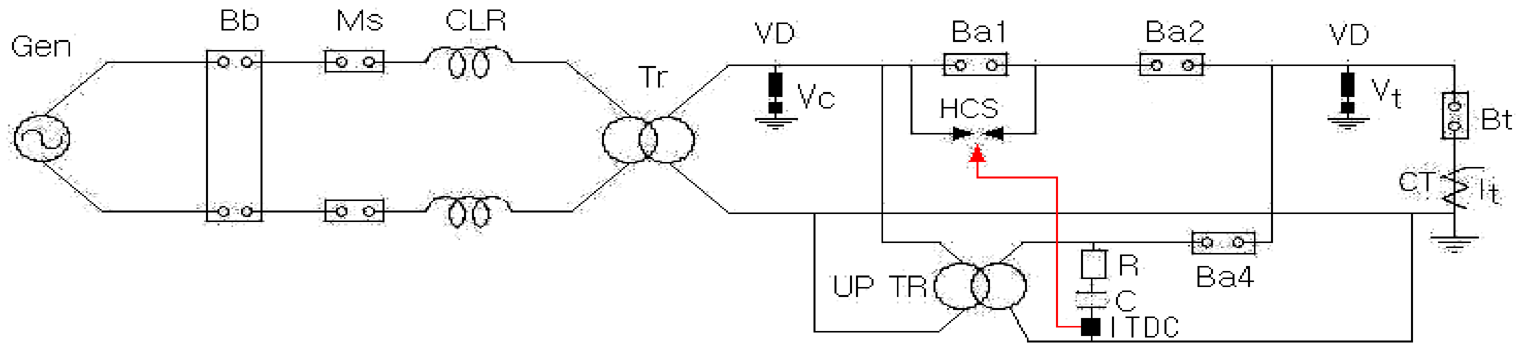
Synthetic making test facilities

- HCS : High-speed Closing Switch
  - Maximum operating voltage (UOV(max)) : 350kVac
  - Minimum Triggered operating voltage (UTOV(min)) : 10kVp
  Current / duration : 63kA/60ms

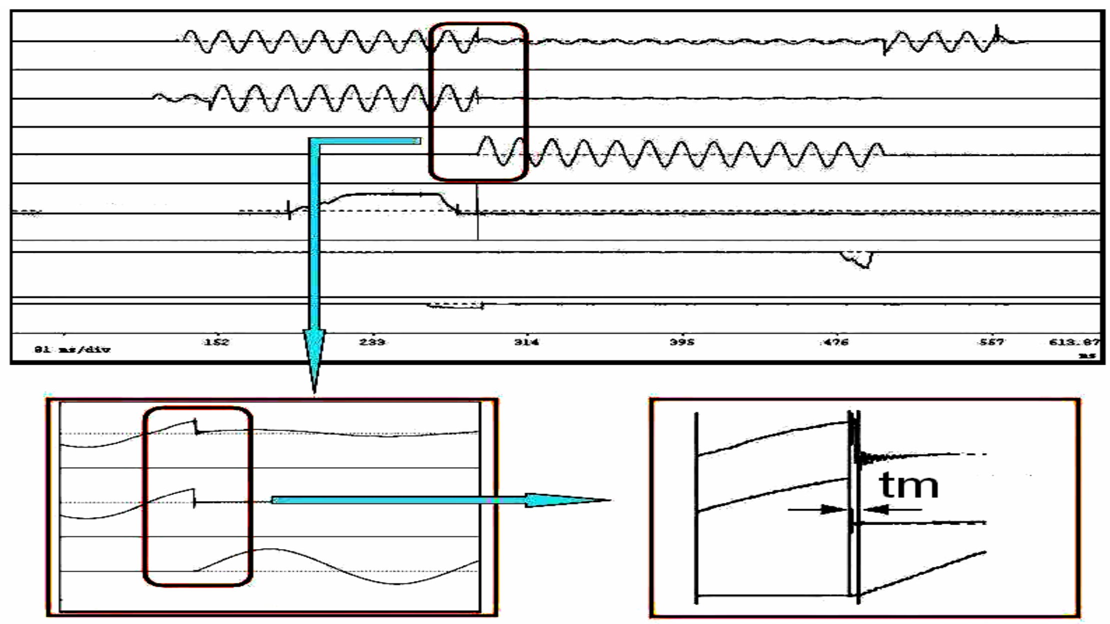
- ITMC : Initial Transient Making current circuit
  - R-C series

- UP TR : Step-up transformer
  - Capacity (Pn) : 2.6MVA
  - Primary voltage : 13.5kV, 24kV
  - Secondary voltage : 50kV ~ 350kV
  - impedance : %Z=12.2%, X=5.88kΩ, R=0.89kΩ

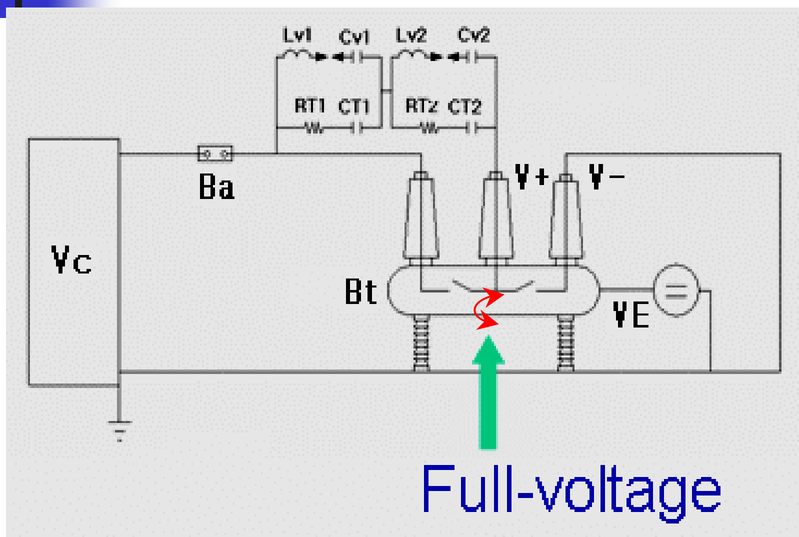
Synthetic making test

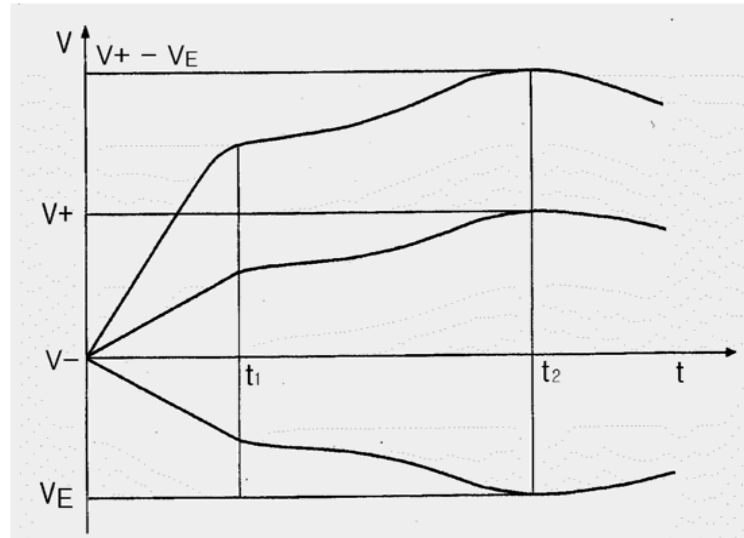


Vc : Current source voltage
Vt : Test voltage
It : Test current
Bt : Test breaker
Ba2 : Auxiliary breaker
Ba1 : Auxiliary breaker



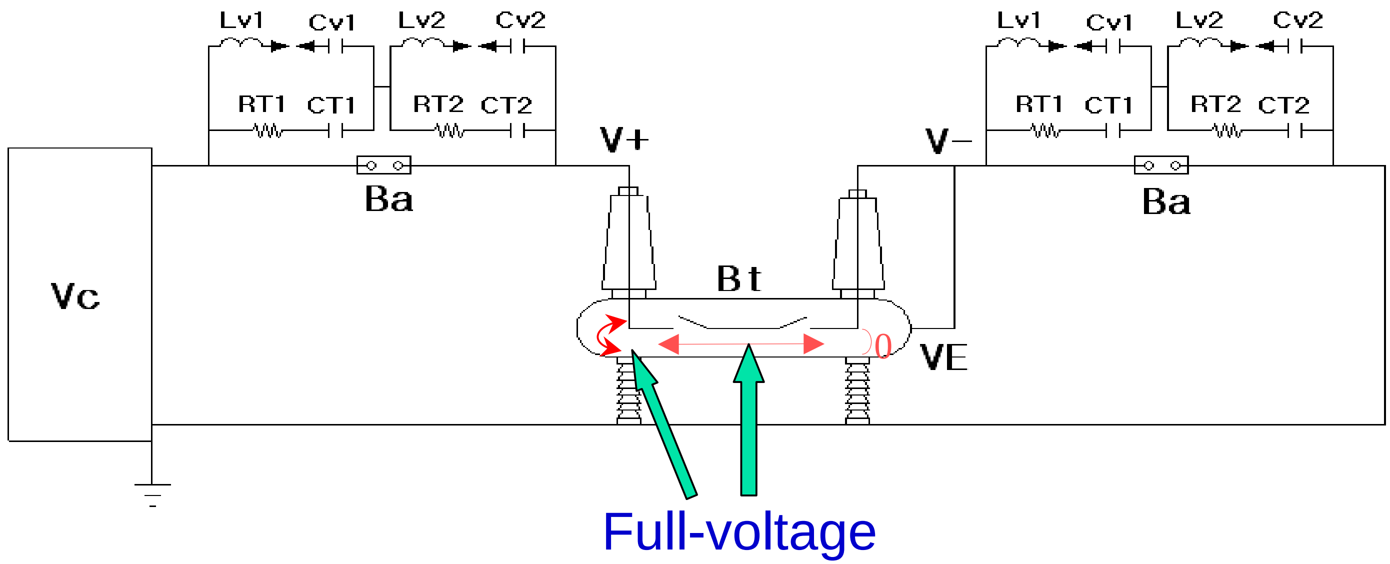
Unit test method (IEC 61633 requirements)





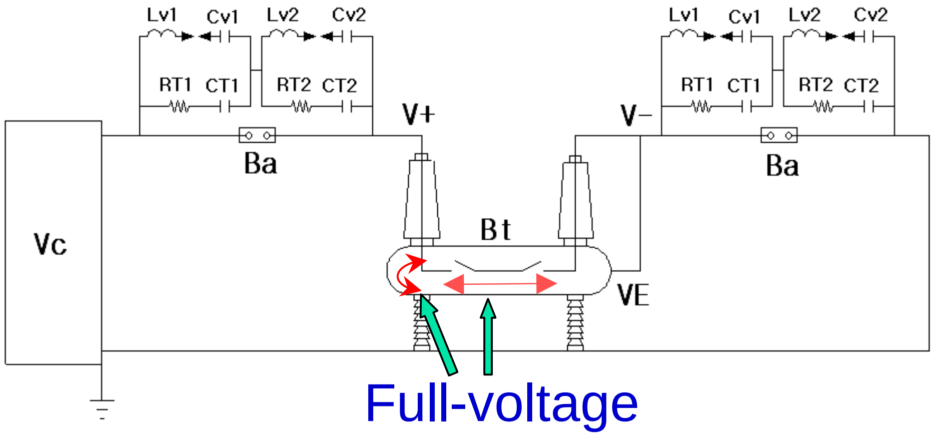
- Across contact : Voltage considering the voltage distribution factor between units is applied on unit (V+)
- Phase-to-enclosure : Full voltage (V+ - VE)
- Full-voltage is applied to center-part of circuit breaker
- Actual service condition : Full-voltage is applied on one of outer part

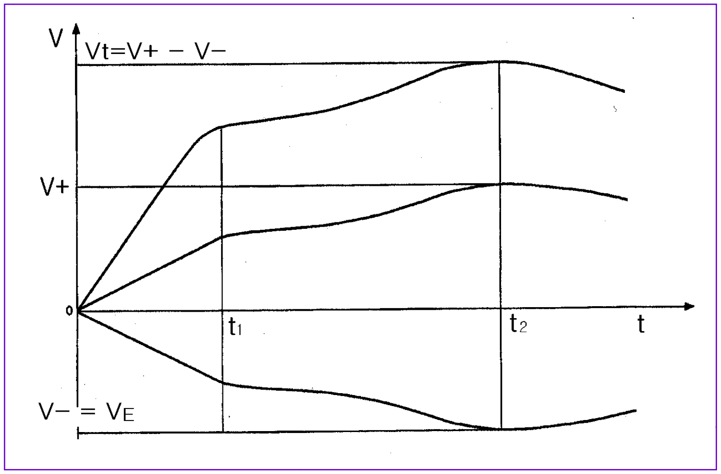
Full-pole breaking test (KERI method)



- Voltage injection synthetic test
- Test breaker was floated and insulated from earth on supporting structure
- Enclosure and one bushing were short-circuited
- T00s(b) and T100a have been performed by using full-pole testing method to verify the dielectric performance

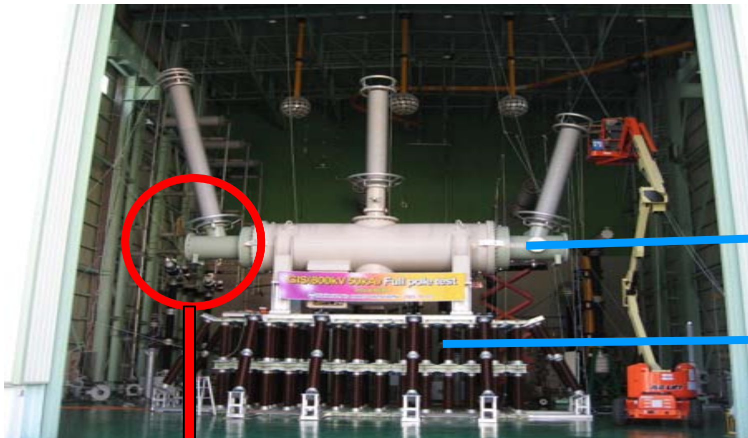
Full-pole breaking test

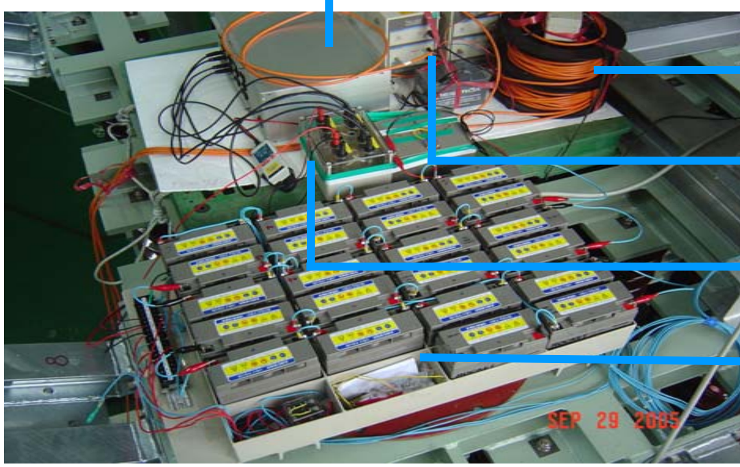




- Voltage application : Two divided voltage source
  - o 50% of total voltage (V+) applied to supply side bushing (□)
  - o 50% of total voltage (V-) applied to floated enclosure and load side bushing (□)
  - o Full voltage (Vt = V+ - V-) applied to
    - * Across contacts : Verification of interrupting performance
    - * Phase-to-enclosure : Verification of dielectric performance

Full-pole breaking test





Full-pole breaking test

- About control and measurement

  * Under the high-potential (50% of TRVp, 600kVp)

    o Control of circuit breaker operation should be performed

    o Operating signal should be measured to verify the breaker performance

    o Therefore, optical signalization is necessary for test

Full-pole breaking test

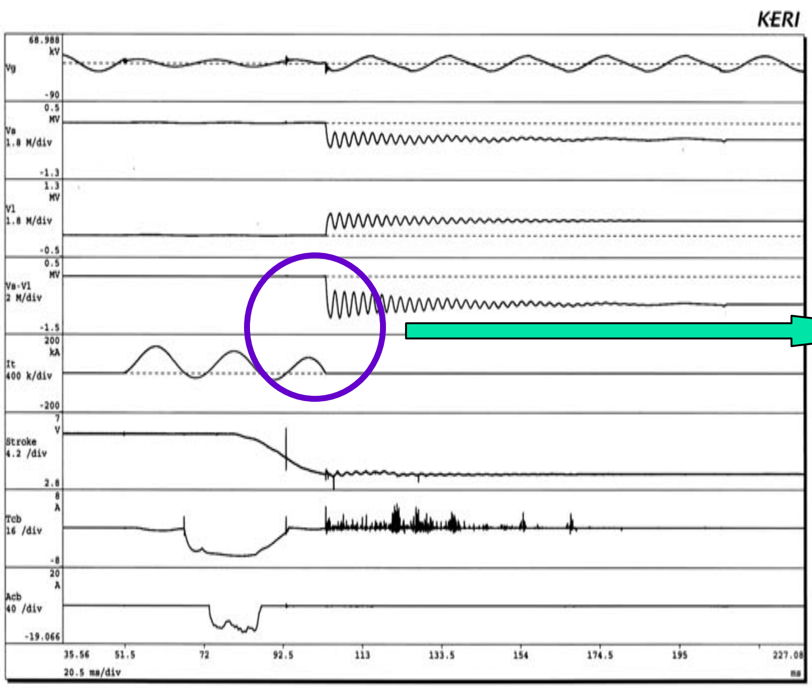
- Optical system for test

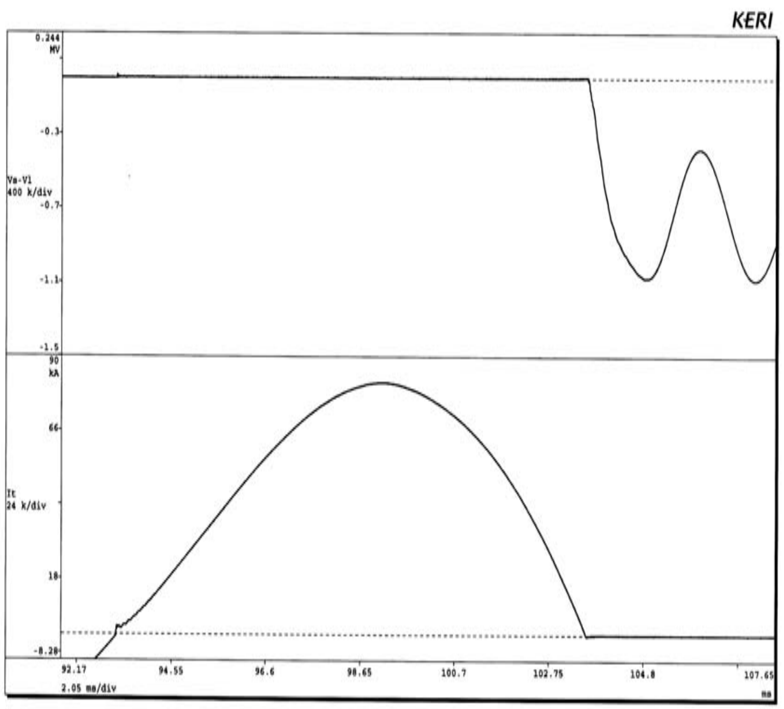
  - Battery for breaker operation : Installed on the insulated supporting structure
  - Optical operation control : Sequence timer
  - Optical measuring signal : Closing / Opening signal

    Stroke curve

Full-pole breaking test

- Test result





Full-pole breaking test

- What are the advantages of this method?

  o Full-voltage can be applied to contacts

  o Full-voltage is applied to the side that hot gas is emitted during interrupting process (equivalent with service condition)

  o Insulation stress of testing facilities is reduced to half of test rating

- What are the disadvantages of this method?

  o Insulated supporting structure

  o Difficulty in operation/control and measurement

Capacitive current switching test

- Test method
  - Power frequency current injection method by using L-C oscillating circuit
  - Between contact : Half-pole test
    Phase-to-enclosure : Full-voltage

- Purpose of test
  - Verification of re-strike between contacts
  - Full-pole voltage on phase-to-enclosure
  - Minimized voltage jump(u_1, t_1) to fulfill requirements specified in IEC 62271-100

Capacitive current switching test

- Test rating for half-pole unit testing

  - Test voltage : $(800/\sqrt{3})*k_c*k_d$=305kVrms

  - Test current : LC2-900A, LC1-270A

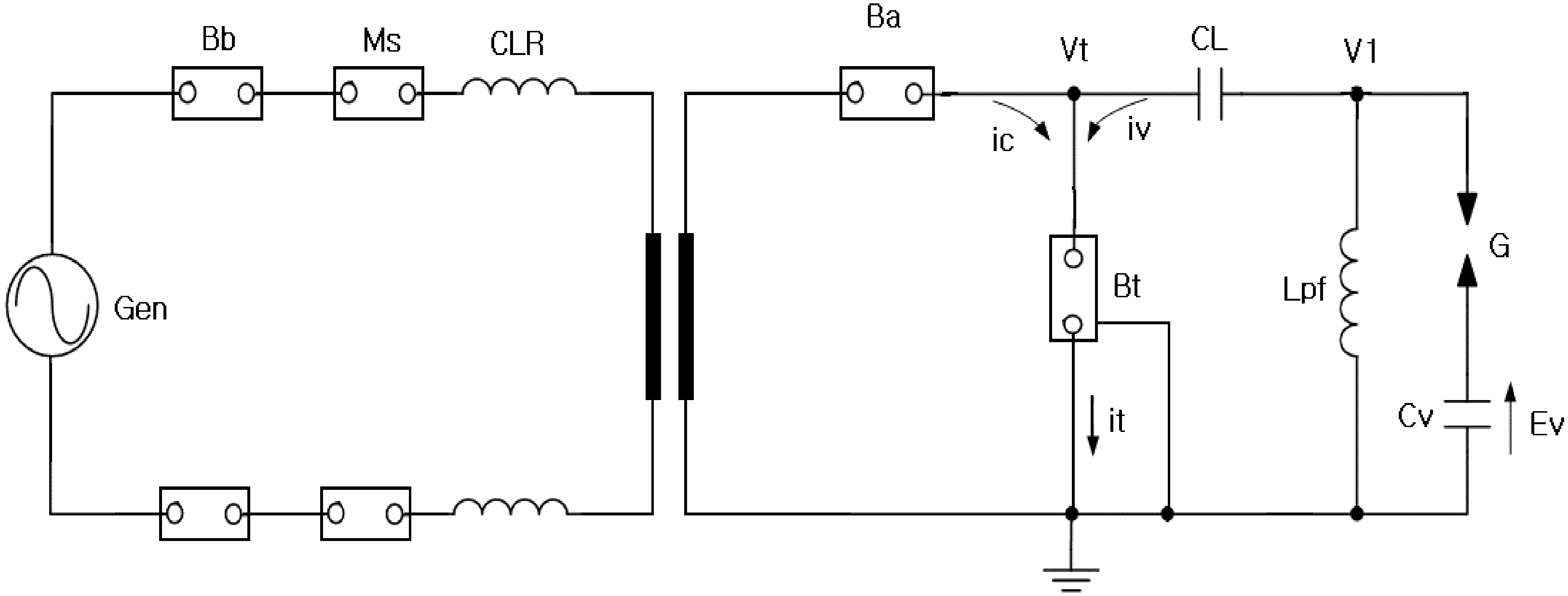
    K_c: Capacitive voltage factor(1.2: line charging current switching for earthed-neutral system)

    K_d: voltage distribution factor for half-pole unit testing (0.55)

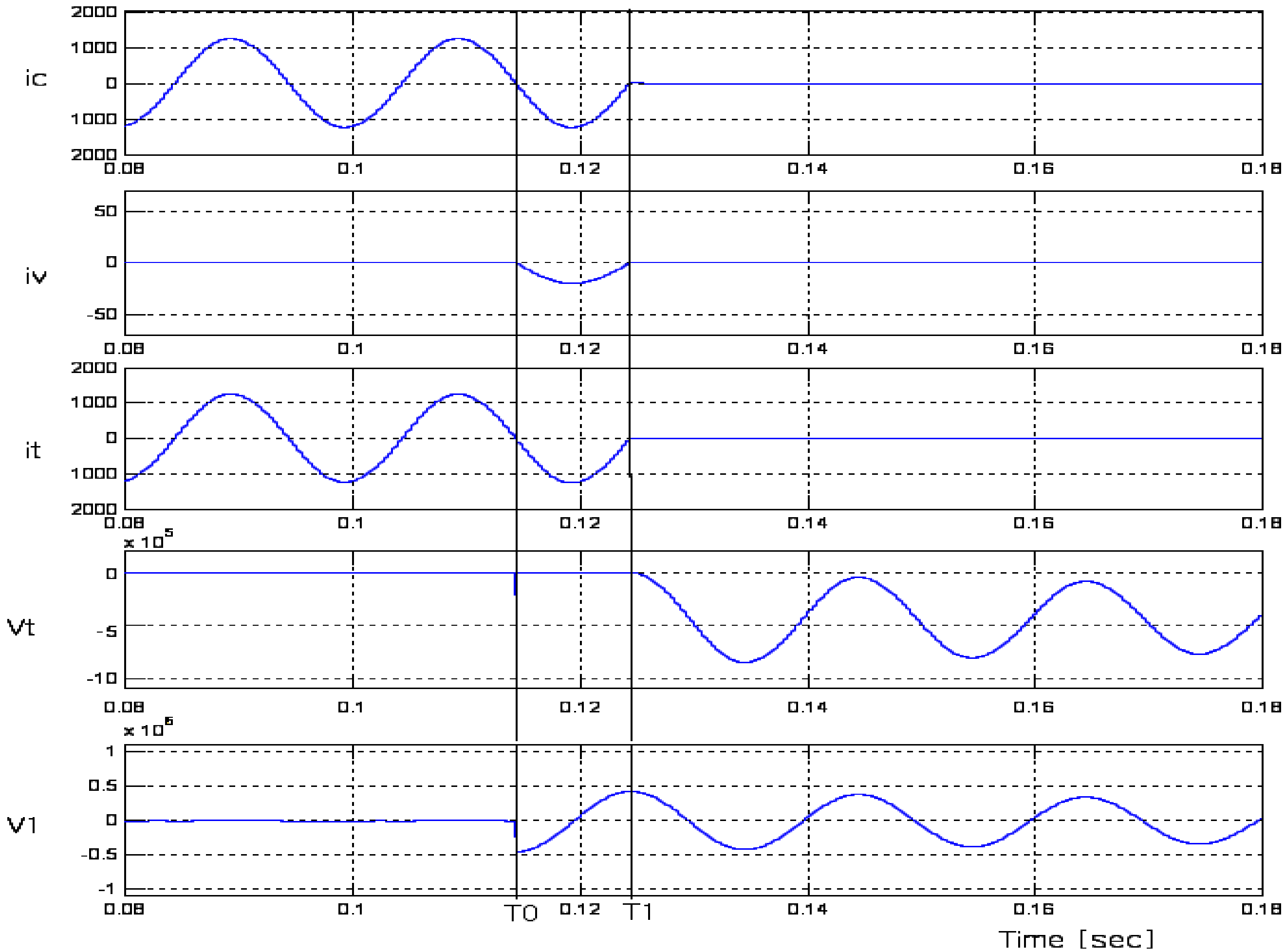
Capacitive current switching test

- Voltage application
  - DC and AC recovery voltages were superimposed to one terminal
    (*) Across contacts : Half-pole test voltage
    (*) Phase-to-enclosure : Full voltage
- Even if half-pole testing, full voltage was applied on phase-to-enclosure : $(800/\sqrt{3})*\sqrt{2}*kc=784kV$

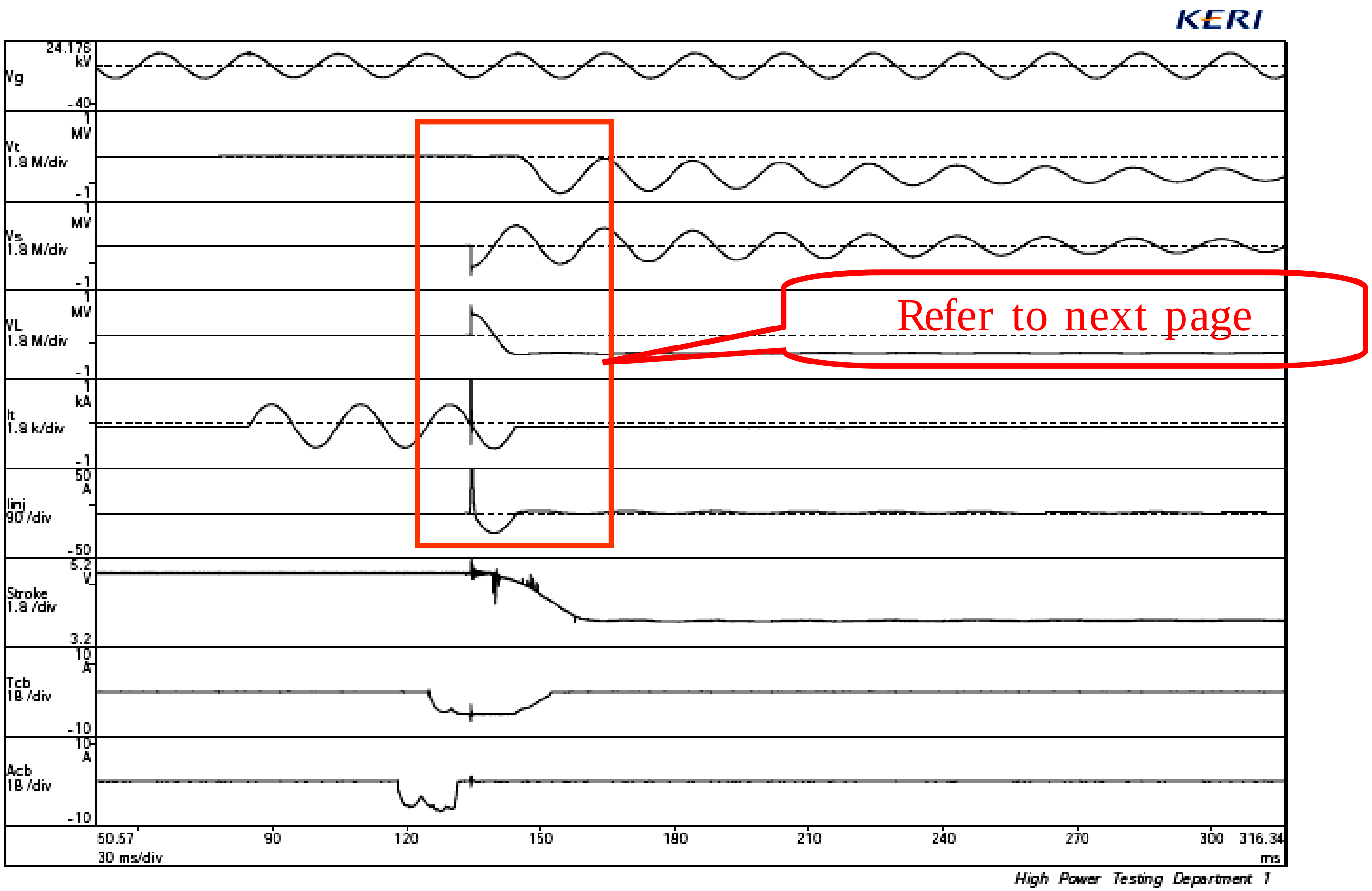
Capacitive current switching test



Capacitive current switching test

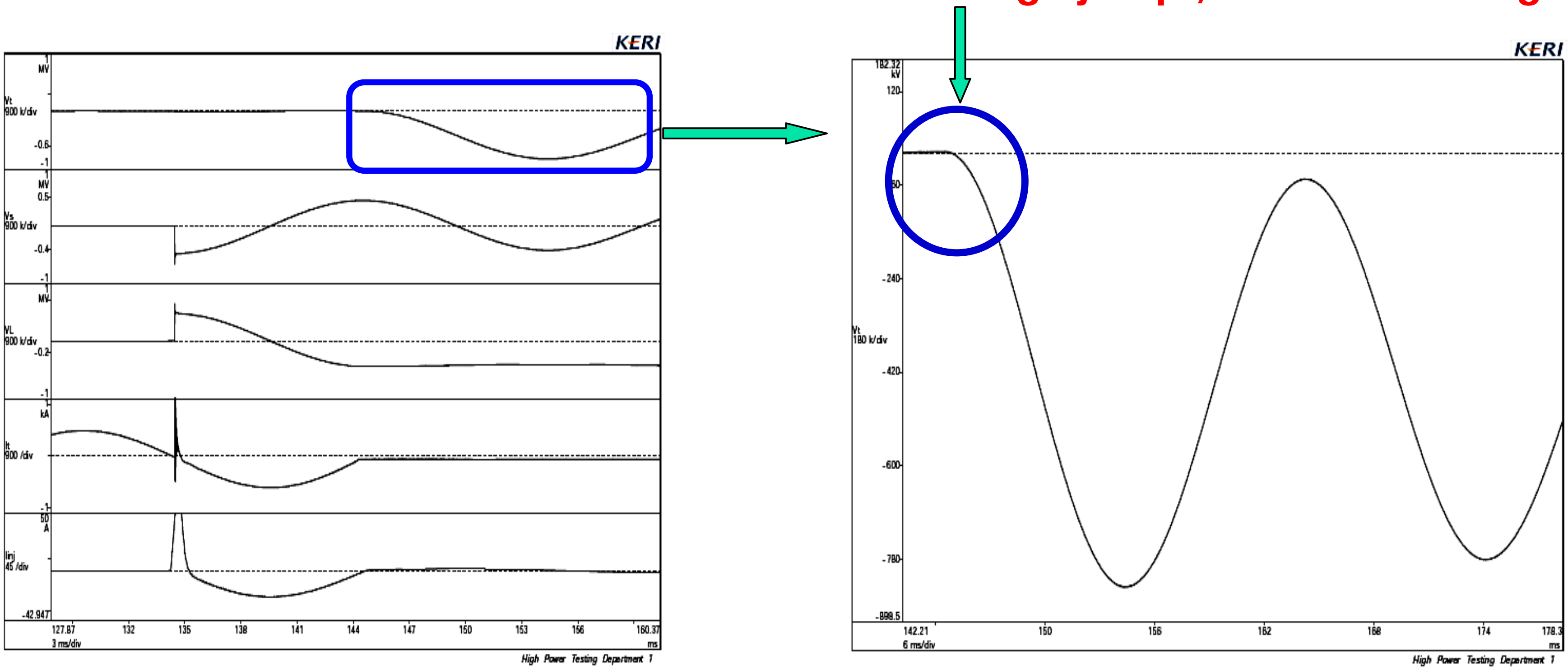


Capacitive current switching test



Capacitive current switching test

No voltage jump ; No initial voltage



Capacitive current switching test

- What are the the advantages of this method

  - Verification of full insulation on phase-to-enclosure

  - No initial voltage jump(U1, t1)

  - Increase the testing capacity

Capacitive current switching test

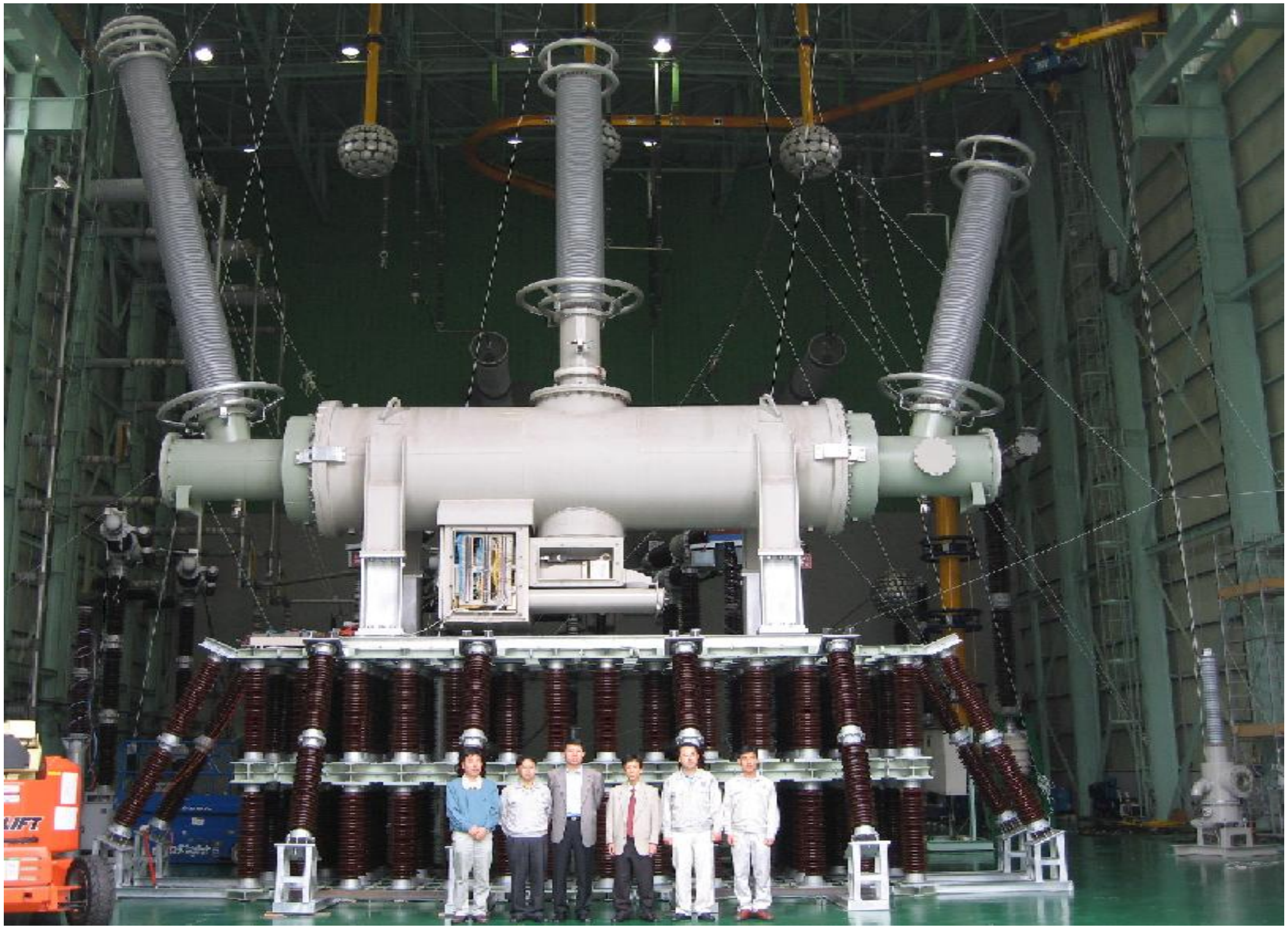
- What are the disadvantages of this method

  - Over charging due to the voltage decay
  (Approximately 15-20% at 75ms(time constant) of LPF)

  - Impossible to maintain the power frequency oscillating
  voltage during 0.3s (Needed additional voltage test)

  - Frequency difference between injected current (iv(t))
  and recovery voltage (v(t))

Photographs after test



Conclusion

- Type-test for full-insulation performance has successfully been completed
  - Short-circuit performance
  - Capacitive current switching performance

- Next challenge
  - Full insulation test of 1100kV circuit breaker

Thank you!!

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