Conseil international des grands réseaux électriquesInternational council on large electric systems
STUDY COMMITTEE D2: Information Systems and Telecommunication 2015 Colloquium Lima – PERU

OPTICAL FIBER TRANSMISSION MEDIA (OPGW) FOR A RELIABLE OPERATION OF THE TELECOMMUNICATION AND PROTECTION SYSTEM ON HVAC SYSTEM

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OPTICAL CABLE AS SUPPORT FOR THE FUNCTIONS OF HVAC NETWORK

>> Main link for the mission critical functions:

- **Main digital communication system**
- **Differential protection system (main protection function)**
- **Digital teleprotection system (back up protection function)**
- **SCADA and Control System**
- **Stabilization resources system for Extra High Voltage Network (DAG/DAC)**

>> Main link for the non-mission critical functions:

- **VoIP telephony system (trunk links; remote subscribers; hybrid system PABX + + IP/PABX)**
- **LAN/Ethernet networks**
- **Monitoring of electrical equipment located in the switchyard**
- **Video surveillance for SS control building, for isolated repeater stations, etc**
- **Remote management system (NMS) for:**
  - ***communication system**
  - ***protection system**
  - ***telephony system**
  - ***teleprotection system**
  - ***optical cable**
  - ***others**

REALIBILITY AND AVAILABILITY (part #1)

CRITERIA FOR SYSTEMS

- **Projecting Communication Systems with high Availability (Ai) values**
- **Using schemes with redundancy for the critical modules that are part of the equipment**
- **Implementing duplicated way for the digital communication systems through separated optical fibres**
- **Implementing redundancy schemes through different paths:**
  - ***main communication system through different optical cables (OPGW#1; OPGW#2)**
  - ***backup communication system through SHF digital radiolink**
  - ***backup communication system through dPLC system**
- **Implementing the protection system by:**
  - ***differential protection system (as the main system)**
  - ***impedance protection system (as the backup protection system)**
- **Using modules with elements with certified low rate of failure (λ) and its consequent high values of MTBF in the module**
- **Assuring very low time to repair (MTTR) that will be effectively possible to get (set or spare parts; set of instruments; people for maintenance tasks close to the installation area; etc)**

RELIABILITY AND AVAILABILITY (part #2)

CRITERIA REFERRED TO THE OPTICAL CABLE

- **To assure the optimal functioning of the communication system, as well as the whole information that is transported by it**
- **The optimal functioning must be assured along the useful period of time of the optical cable and not only in the commissioning period**
- **To be sure the optical cable does not imply a "non-availability node" in the whole chain of the transmission of information**
- **The OPGW must not be considered as a conventional guard wire of the HV Line.**

  It implies to take maximum precautions from the mechanical, electrical and optical features in comparison with a guard wire
- **It is necessary to take particular criteria that are specific and particular for optical cables. It is necesary to pay attention in all stages:**

  ***during the design and detailed project (requeriments, specifications, etc)**

  ***during the selection of the manufacturer, model of cable, etc, in order to assure compliance with the specifications**

  ***assuring the manufacturer has history of previous provisions (in operation)**

  ***assuring an integral solution "optical cable + accesories" (never as independent and separate providers)**

  ***assuring to have Type Test to an equal model of optical cable (not similar)**

  ***doing an exaustive factory tests (FAT) to the 100% of the provision**

  ***detailling the mounting and installation procedures in all stages of processes (mounting, splicing, etc)**

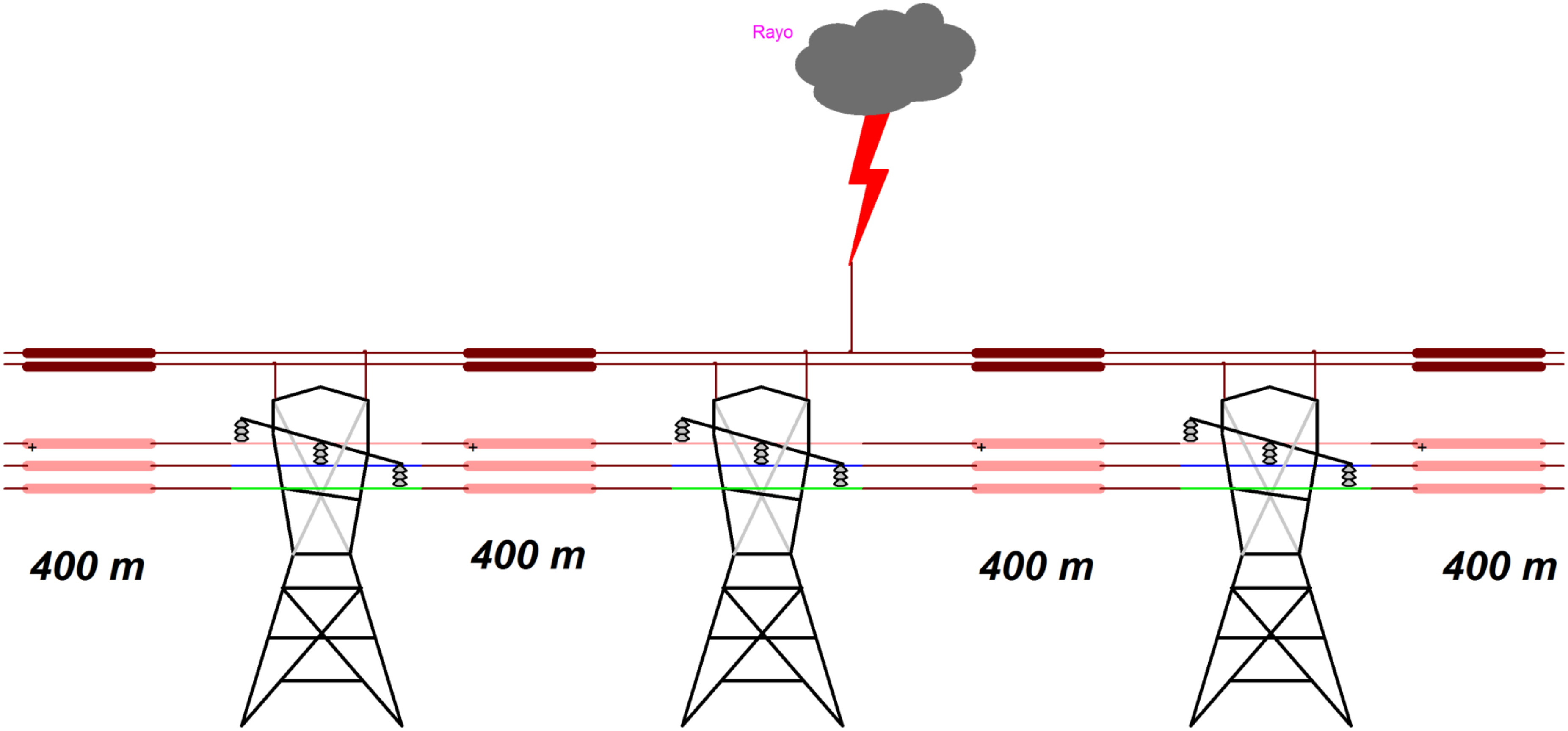
  ***doing a permanent supervision of the mounting process, with adequated tools, made by certified people, etc**

  ***doing an intensive set of tests on site (SAT)**

ENERGETIC SOLICITATION OF THE OPGW

FAILURE
ENERGETIC SOLICITATION
FACTORS OF INFLUENCE
MODELING AND SIMULATION
RESULTS
MAIN FACTORS
COMPARING CASES

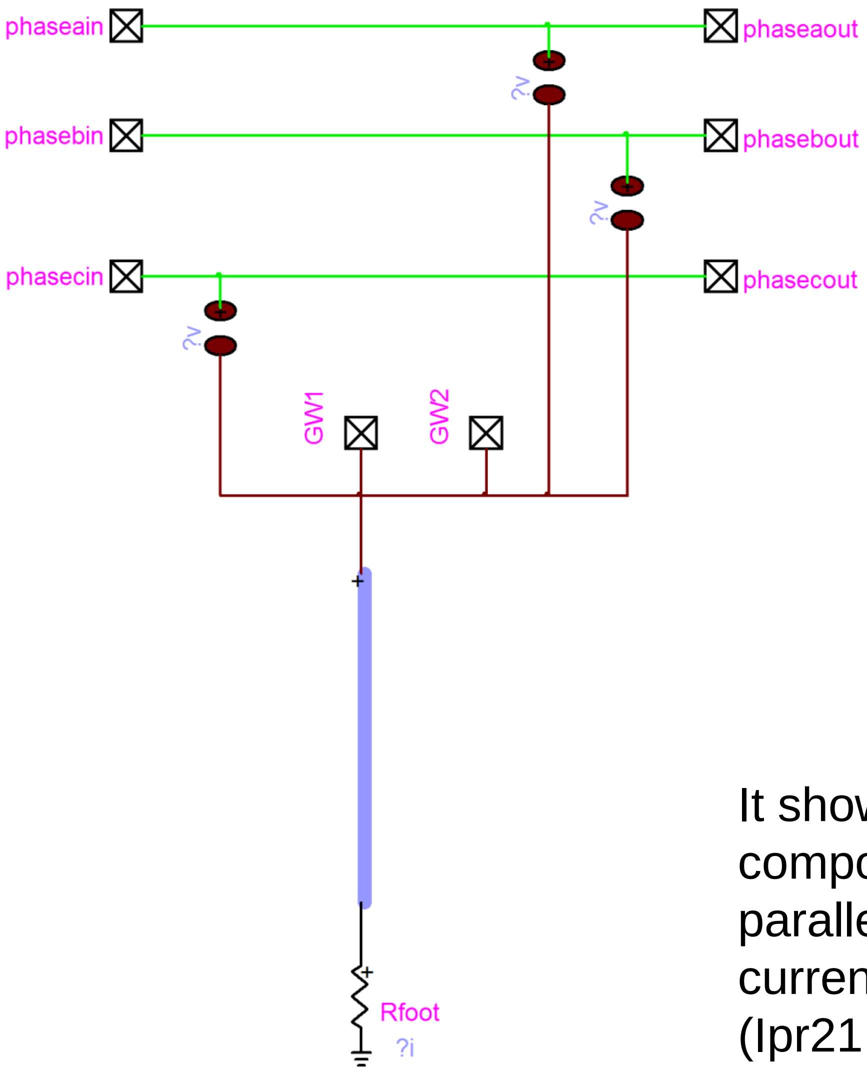
FAILURE

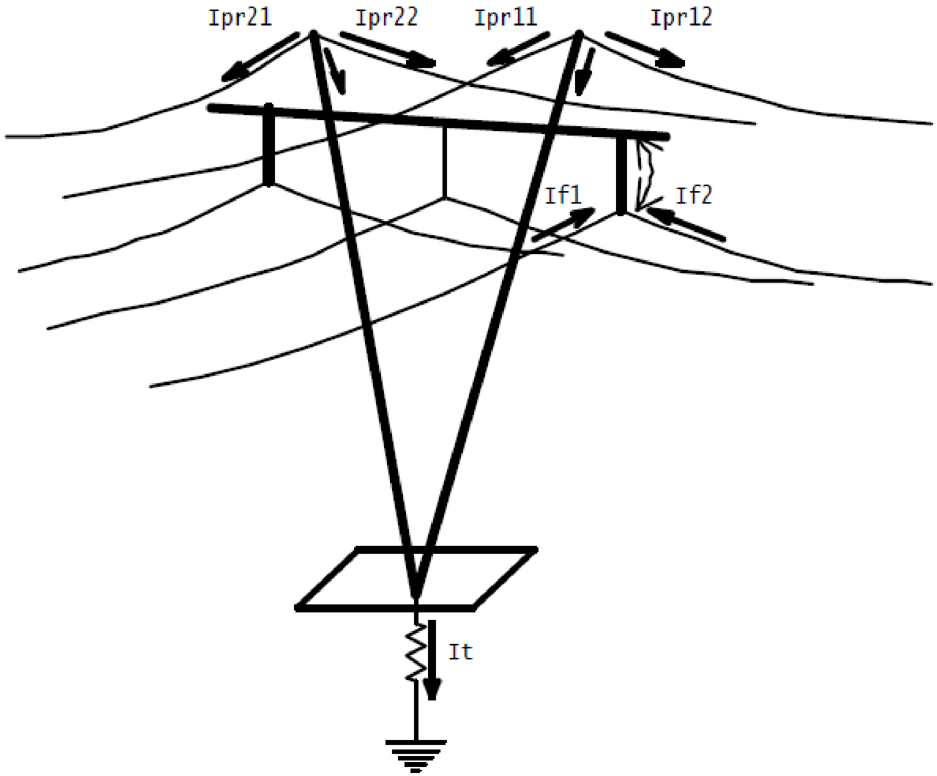


The situation presented to the lightning strike on one of the ground wires, resulting finally in a single-phase fault between a phase and structure of the tower.

FAILURE

Tower model





It shows the fault current (It) and its components, the current through the parallel circuit of guard wires (If1+If2), the current through the companion ground wire (Ipr21 o Ipr22), the current conducted by the OPGW (Ipr11 o Ior12)

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ENERGETIC SOLICITATION (SE)

$$SE = \int_0^{T\,despeje} Icc(t)^2.dt$$

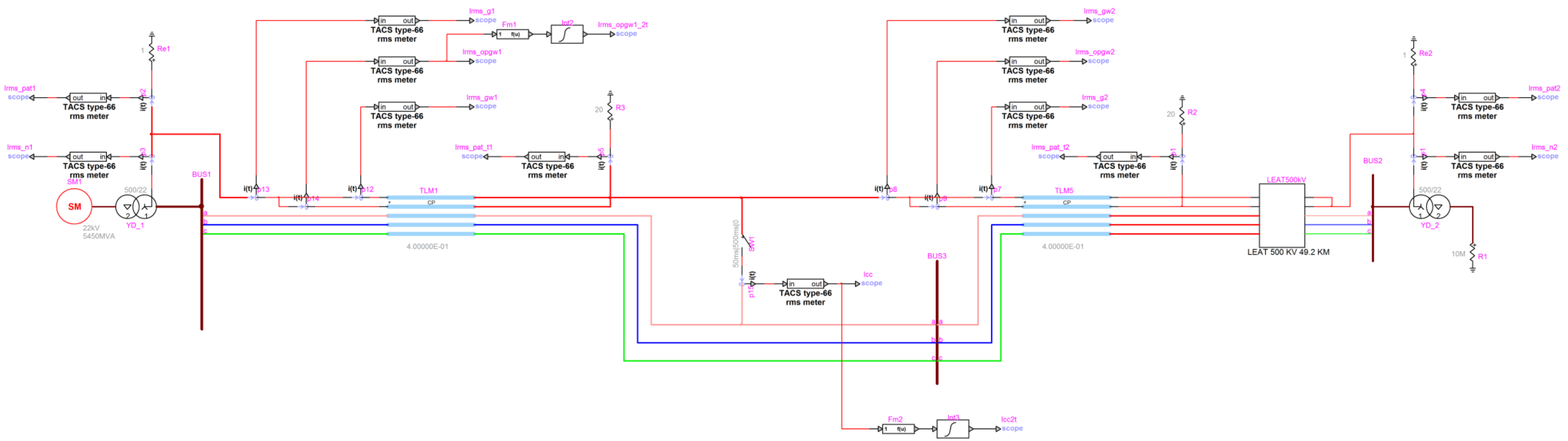
Icc(t) **is the RMS of the monophasic current of failure (kA)**

t **is the duration of the failure up to the clearance of the failure (seg)**

SE **is indicated in (kA^2s).**

FACTORS THAT INFLUENCE IN THE SE OF OPGW CABLE

1. **The short circuit power of the design**
2. **The damping of the failure current**
3. **The location of the failure in the HV Line**
4. **The time of clearance of the failure**
5. **The resistance of the failure**
6. **The earthing of the substations**
7. **The earthing of the HV Towers**
8. **The impedance of the guard wire that are companion of the OPGW**

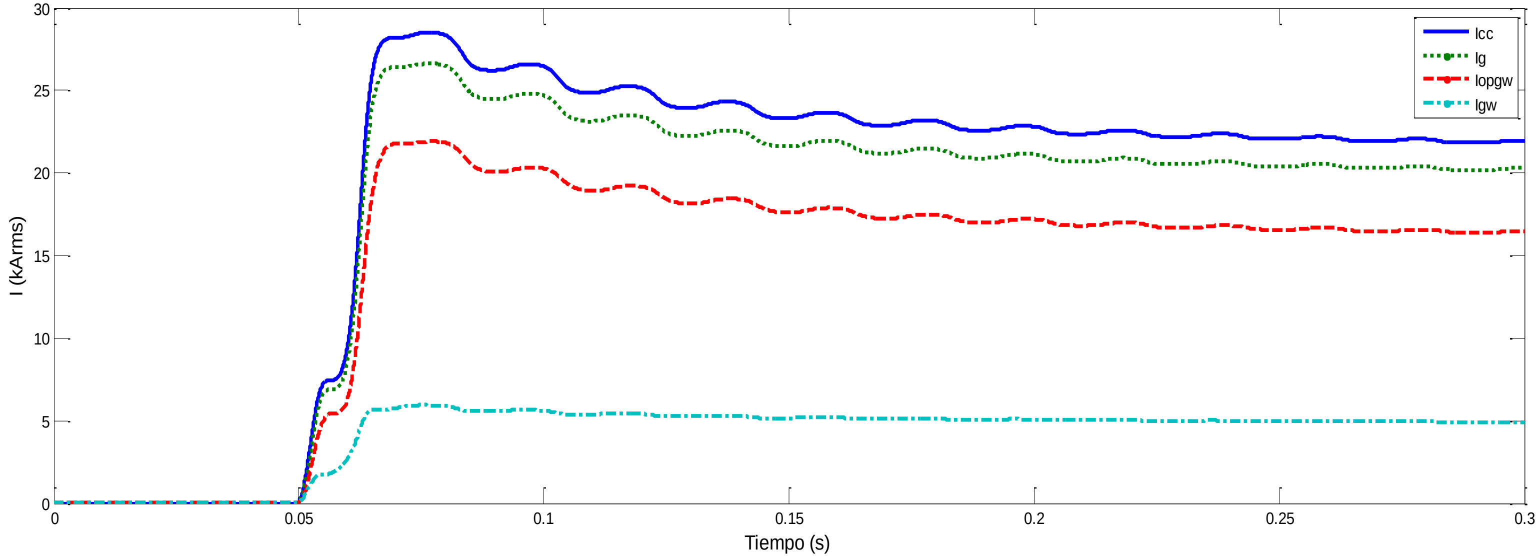


Benchmark

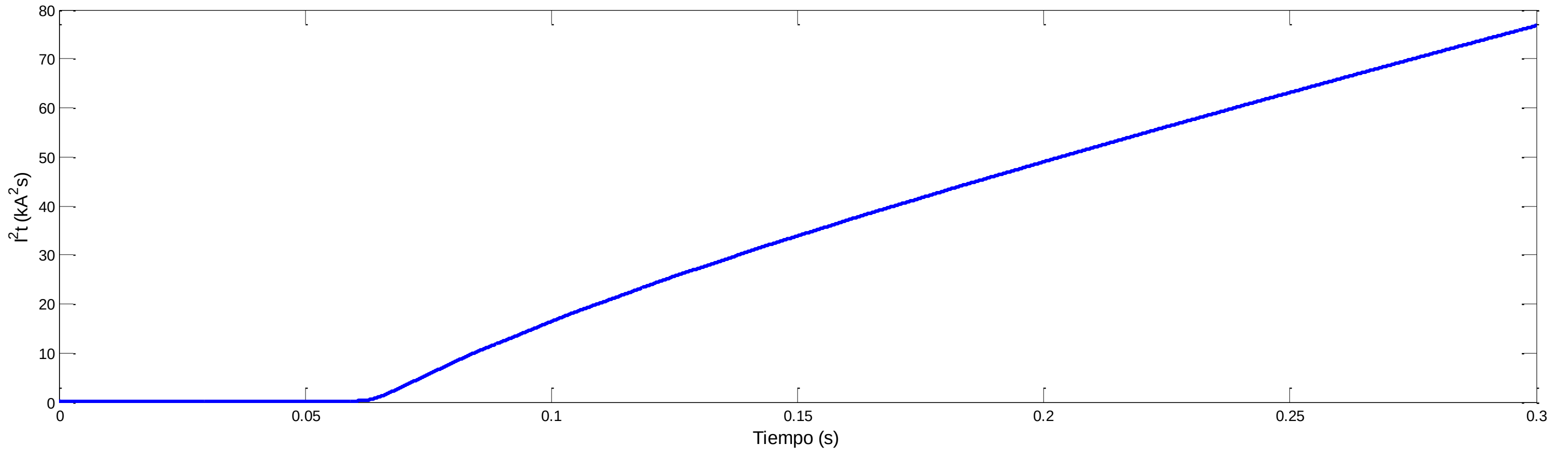
The benchmark corresponds to the situation presented to the lightning strike on one of the ground wires, resulting finally in a single-phase fault between a phase and structure of the tower. The assumption applied in this failure is that being applied phase fault near the tower there is direct contact with the ground line.

In each simulation case are determined the total current single phase fault, the current through the parallel circuit of guard wires, the current through the companion ground wire, the current conducted by the OPGW and finally the calculated I2t value. I2t value obtained by simulation with the provided by the manufacturer of OPGW cable is then compared; accepting the OPGW cable if the simulated value is below the manufacturer's specification limit

RESULTS



30
25
20
15
10
5
0
I (kArms)
0
0.05
0.1
0.15
0.2
0.25
0.3
Tiempo (s)
Icc
Ig
Iopgw
Igw



80
70
60
50
40
30
20
10
0
I2t (kA2s)
0
0.05
0.1
0.15
0.2
0.25
0.3
Tiempo (s)

RESULTS

Case OPGW + GW of GS

Distance (km)	Time of failure (s)	Icc (kArms)	Ig (kArms)	Igw (kArms)	Iopgw (kArms)	I^2t (kA^2s)
0.4	0.25	21.939 (1)	20.286 (1)	4.926 (1)	16.482 (1)	77.0 (2)
3.2	0.25	19.721	15.482	3.625	12.751	43.0

Case OPGW + GW Alumoweld

Distance (km)	Time of failure (s)	Icc (kArms)	Ig (kArms)	Igw (kArms)	Iopgw (kArms)	I^2t (kA^2s)
0.4	0.25	22.013	20.450	8.283	12.810	47.0
3.2	0.25	19.995	16.077	6.471	10.165	28.0

The following Table I shows the case of one phase failure, with conventional guard wire..
(1) Valores ilustrados en Figura 2 (2) Valor ilustrado en Figura 3
In the following Table 2 is showed the case of one phase failure, with guard wire of Alumoweld

DETERMINANTS AND COMPARISON OF CASES

Under the hypotesis that were assumed in this study, is important to mention the influence of the following factors, in the determination of the energectic solicitation of the OPGW cable:

>Damping of the failure current

>Earthing in SSEE and Towers

>Guard wire companion of the OPGW

It is evidenced the difference with the quick calculation

Related to 500 kV Lines

Under tha hypotesis that are assumed in this study (short circuit power of 25 GVA; action of protection system of 250 msec) the guard wire companion (70 mm^2 of Galvanised Steel) in

the failure more severe, it is not necessary to increase the energetic capacity of the OGW (i^2t) beyond of 120 kA^2s.

The companion guard wires of Alumoweld (Aluminium clad Steel wire) show re insurance that can permit reduce the portion of failure current that flows through the OPGW with no-modification of the section of the companion cable of GS, and can resist the impact of lightning

This type of companion cable would be justificable in face an increase of short circuit power of design greater than 25 GVA

QUESTION AND ANSWERS (special reporter)

Questions about Paper D2-01_03

Q1-5. According to your experience, what are the best practices to monitor and maintain the quality of the existing OPGW?

ANSWER:

**THE BEST WAY TO ENSURE AND MAINTAIN THE QUALITY OF THE OPGW CABLES IS BY THE INSTALLATION OF A SYSTEM FOR THE REMOTE MANAGEMENT OF THE OPTICAL CABLES (ON REAL TIME) , ACCORDING TO ITU-T RECOMMENDATION L.40, L.41*

**THE CIGRE SCD2-COLLOQUIUM DEVELOPED IN 2011 HAS A DETAILED TECHNICAL PAPER ABOUT THIS TOPIC (D2-01-A07)*

QUESTION AND ANSWERS (special reporter)

Q1-6. Impact of electrical and mechanical constrains are often underestimated. How can this possibly impact the continuity of the telecommunication services?

ANSWERS:

****TO UNDERESTIMATE THE ELECTRICAL ASPECTS AS WELL AS THE MECHANICAL ONES, CAN AFFECT SERIOUSLY THE USEFUL LIFE PERIOD OF THE OPTICAL CABLE (FROM EXPECTED 25 YEARS, TO AN EFFECTIVE 10 YEARS)***

****CONSEQUENTLY, THE TELECOMMUNICATION SERVICES CAN BE AFFECTED IN AN IMPORTANT MANNER (MAINLY FOR FUNCTIONS OF MISSION CRITICAL)***

****THIS IS A REASON WHY IS SO IMPORTANT TAKE INTO ACCOUNT ALL ASPECTS IN ALL THE STAGES OF THE PROJECT OF AN OPTICAL CABLE SYSTEM: DESIGN CRITERIA, DETAILED ENGINEERING, FACTORY TESTS, INSTALLATION PROCEDURES, FIELD TESTS, COMMISSIONING TASKS***

****IT IS FUNDAMENTAL THAT THE SOLUTION TO BE IMPLEMENTED SHOULD BE CONSIDERED AS "A WHOLE" (OPTICAL CABLE + MOUNTING ACCESSORIES)***