Naming Installed Intelligent Electronic Devices (IEDs)

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Abstract: The H10 working group was assigned the task of writing a report to the Communications Subcommittee of the IEEE Power System Relaying Committee. This paper discusses the need for a standard convention for uniquely naming installed IEDs and recommends such a convention.

Working Group Members:

Rick Cornelison, ***Chair***
Jim Hackett, ***Vice-chair***
Amir Makki, ***Secretary***

Alex Apostolov
Lars Frisk
Tony Giuliante
Jim Ingleson
Stan Klein
Ken Martin
Krish Narendra
Jeff Pond
Mark Taylor
John Tengdin
Tom Wiedman

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1. Introduction

While configuring an IED, the user has to compose and enter a number of electronic names or designations that uniquely identify the IED and each channel within it. The same is also required when manually composing COMTRADE files for use in simulation and modeling applications. Current standards such as IEEE C37.111, C37.118 and C37.232, and IEC 61850 require such designations but define them as “unformatted fields”, which means it is up to the user to compose and specify these fields without having the benefit of a standard or recommended practice. Such fields may include, and are not limited to, company, substation and IED names, installed locations, channel names, phase identifiers, monitored circuits, voltage classes, and so forth.

The above mentioned fields are essential for fault and disturbance analysis and are especially so for automated applications. For example, without knowing the voltage class it is difficult to determine whether the data are calibrated based on peak or based on RMS. And, without accurate and informative names it is impossible for an automated application to associate voltage and current phases together in order to calculate a fault location or a missing phase. Users and utilities are often faced with the problem of having to invent their own naming conventions and they do so usually to suit their own purposes. Considering the large and growing number of users today, it is clear why we now have too many types of naming conventions in circulation.

A common naming convention for specifying IED designations would help solve many of the problems that are associated with analysis, coordination, and automation. The common convention will, in turn, have a positive impact on maintenance, protection, operations, and on engineering applications. To that extent, the main objective of this working group is to address and report on the issues related to specifying IED designations. The report explains the need for having a common naming convention and provides a brief, high level, survey of current practices. The report also provides a proposed and novel method for naming IEDs. The proposed method makes references to standard IEEE device names as listed in C37.2-2008.

2. Current Industry Practices

2.1. Examples of IED naming practices

A Digital Fault Recorder (DFR) is used to monitor many devices at a substation while a relay typically monitors only one element (line, transformer, bus, etc.). The name assigned to each of these IEDs may therefore be somewhat different.

The name of a relay should include information on the equipment it protects and monitors while the name of a DFR needs to only indicate the substation and maybe some other high level entity such as a voltage level or relay house. Here are some examples of IED naming practices:

Device Type	Device Name	Examples
Substation Devices	Short unique (within substation) name	DFR#40
		DAU#150
Line Relays	Breaker Number(s) or Line Description + Function + Model	730-760 ZD SEL-311C
		SMITH 230KV ZD.S SEL-311L
Transformer Relays	Description + Function + Model	BK2 115-12KV HSOC SEL-551
Breaker Relays	Breaker Number + Function + Model	03060 BF SEL-251
Bus Relays	Description + Function + Model	NO2 12KV BUS SEL-251
All Devices (61850)	Code for sub, voltage, bay, type, device	NA138_6_M5_F60A
		NA138_3_T1_S487B
All Devices	Mfg (or common name)+serial number	mti1004
		ben707

Table 1 - Examples of IED names

2.2. Examples of channel naming practices

Since a substation device monitors many items, some reference to those items must be made in the channel naming. The information on the element for a relay is in the device name and so is not needed in the channel name. Here are some examples of channel naming practices:

Device Type	Channel Names	Examples
Substation Devices	Location (Protection) + Phase + Type	230KV P1/G POTENTIAL
		KETONA 01 AMPS
		NO4 BANK HS P1 AMPS
Relays	Type Phase	IA
		VA

Table 2 - Examples of Channel names

3. Need for Unique Naming Convention

Usually a system event such as a line trip is analyzed by examining original data from an IED record. This analysis is performed by the transmission owner of the faulted equipment. Since the August 14, 2003 northeast blackout, new sets of eyes are emerging in the analysis of events. This is especially true if the event includes the tripping of many lines and generators. In Canada and the USA, NERC and the NERC Regions are now called upon to review the event side by side with the transmission and generation owners. These new analysts do not have an intimate knowledge of the system under study nor of the naming of IEDs and their records.

A common naming convention will vastly decrease the amount of time the analyst needs to spend identifying the records that go along with specific times during the event. The IEDs are time synchronized and a naming convention that identifies the substation and time of an event is now being supplied by some transmission owners. Now if the IEDs themselves can be uniquely identified along with their data, this will move the process ahead again.

For a given event, the time tagged data from a number of devices, whose internal clocks have been synchronized to a common clock reference, can be taken from the original multiple data sources and analyzed as a single record. Analyzed data from different time slices can be taken from original data and "strung" together to get a wider area and wider time perspective of the event. This is invaluable when having to replicate the event using wide area system models. The system is becoming more congested, newer entities are installing different types of generators, and power is traveling much greater distances. The need for a wide area view of an event is becoming that much more necessary.

4. List of Requirements for Channel Names

Consistent naming of IEDs and their channels is required to aid post fault analysis, providing an easy method for identifying what channel information is relevant for a particular operation. As an example, if a line is being monitored by a DFR or a relay with recording capability, the channels need to have a unique identifier such that the description does not conflict with the identification of any other analog or digital channel being monitored. This is particularly important when microprocessor relays are used because a relay typically defaults to phasor information only; i.e. Va, Vb, Vc, Ia, Ib, Ic, etc. Using default labels from multiple relays would not provide clear identification as to what transmission line the channel data are related to.

IEDs may have character length limitations - therefore an abbreviated description may be required. Tables 3 and 4 provide examples of long and short channel descriptors that can be used.

CIRCUIT ID LONG NAME	CIRCUIT ID SHORT NAME
LINE 1 Van	L1 Van
LINE 1 Vbn	L1 Vbn
LINE 1 Vcn	L1 Vcn
LINE 1 Ia	L1 Ia
LINE 1 Ib	L1 Ib
LINE 1 Ic	L1 Ic
LINE 1 In	L1 In
LINE 2 Van	L2 Van
LINE 2 Vbn	L2 Vbn
LINE 2 Vcn	L2 Vcn
LINE 2 Ia	L2 Ia
LINE 2 Ib	L2 Ib

LINE 2 Ic	L2 Ic
LINE 2 In	L2 In

Table 3 - Examples of Analog Channel Description

LONG NAME	SHORT NAME
LINE 1 BUS OCB STATUS	L1 CB
LINE 1-2 TIE OCB STATUS	L1-2 CB
LINE 2 OCB STATUS	L2 CB
LINE 1 SYSTEM 1 DCB RELAY TRIP	L1 S1 TRIP
LINE 1 SYSTEM 2 DTT RELAY TRIP	L1 S2 TRIP
LINE 2 SYSTEM 1 DCB RELAY TRIP	L2 S1 TRIP
LINE 2 SYSTEM 2 DTT RELAY TRIP	L2 S2 TRIP
LINE 1 S1 CARRIER START	L1 S1 CR STRT
LINE 1 S1 CARRIER STOP	L1 S1 CR STOP
LINE 1 S1 CARRIER RECEIVED	L1 S1 CR RCV
LINE 2 S2 DTT CH 1 SENT	L2 S2 DTT-1
LINE 2 S2 DTT CH 2 SENT	L2 S2 DTT-2
LINE 2 S2 DTT CH 3 & 4 RECEIVED	L2 S2 DTT-RCV
LINE 1 OCB BFI-1	L1 CB BFI
LINE 2 OCB BFI-1	L2 CB BFI
LINE 1-2 TIE OCB BFI-1	L1-2 CB BFI

Table 4 - Examples of Digital Channel Description

5. Proposed Unique Convention

Theoretically, an IED can be composed of one channel (such as a temperature monitor) or can contain multiple channels (such as a numerical relay used for feeder or transformer protection). In the limit, an IED can contain an unlimited number of channels (such as a data concentrator used to combine channels from multiple IEDs and form large composite records for a specific substation or even region). To that extent, the IED name may become far removed from the physical locations of its channels. The IED name may become as broad as a single attribute or field (such as company name) which means the burden is then on the channel name to specify all of the remaining fields needed for the user to identify the actual system component that is being sensed or monitored.

The relationship between the IED name and the channel name is dynamic, however, the combination “IED name + channel name” must always compose a unique sequence that identifies the specific component being monitored.

The convention described here attempts to identify, in a priority order, the fields required to uniquely name an installed IED and its channels (both analog and digital). Information from IEEE C37.2-2008 (as summarized in Annex B), IEC 61850/ 61346 (as summarized in Annex C), and IEEE C37.111-1999 (as summarized in Annex D) were used in arriving at this proposed naming convention. The format is composed of a sequence of fields using the underscore "_" character as the main delimiter between consecutive fields. The sequence is as follows:

Company ID _ Station ID _ IED Type _ Voltage Level _ Equipment Type _ Relay Panel _ Relay House _ Function Type _ Phase ID _ Input Type

Where:

- ***Company ID*** is the identification of the company owning the substation.
- ***Station ID*** is the identification of the substation containing the IED.
- ***IED Type*** is the type of the IED (such as a numerical relay, DFR, or data concentrator). It should be unique within the substation or protection scheme. For instance, if two SEL421 relays are used to protect a feeder, one IED Type could be SEL421-A, the other SEL421-B.
- ***Voltage Level*** is the kV or company identifier for the voltage level(s) of the item(s) being monitored by the IED channels.
- ***Equipment Type*** is the item being protected or monitored by the IED or channel. This is typically a feeder, breaker, transformer, or generator name.
- ***Relay Panel*** identifies the relay panel where the IED or channel is located. This is a physical location and is useful for protection and maintenance engineers.
- ***Relay House*** identifies the relay house where the IED or channel is located. This is a physical location and is useful for protection and maintenance engineers.
- ***Function Type*** is the C37.2 function designation for the protection scheme and may also include additional information such as first or second line protection (primary or backup).
- ***Phase ID*** is the identification of the phase(s) or could be the identification of the control circuit being monitored.
- ***Input Type*** is formatted as follows: **A** = alternating input such as three phase currents and voltages, and **D** = direct input such as frequency, temperature, and trip signatures.

In general, and depending on the type of IED being named, the IED name may contain the first three fields or may contain the first seven fields (this is because of the mentioned dynamic relationship between the IED and channel names). The remaining fields are designated for the channel name.

For IEDs such as DFRs that monitor many items in the substation, fields after the IED Type field should not normally be used in the IED name. The IED name portion is used to name the logical and physical device. The first part of the IED name is the logical part with panel and house available if the physical location is needed.

The proposed convention is being piloted by a number of utilities in the United States with hundreds of IEDs and thousands of channels already named in compliance with the proposed convention. Examples are provided in the next subsections.

5.1. IED name examples

All of the fields for the IED name are free formatted but the name should be limited to 32 characters in total. For example:

CoA_Stn42_321_345_Fdr42_12_A
(Company A, Station 42, 321 relay, 345kV, Feeder 42, Panel 12, House A)

CoA_Stn42_DFR72_345
(Company A, Station 42, DFR number 72. 345kV)

More examples are given in Annex A.

5.2. Channel name examples

All of the fields for the channel name are free formatted but the name should also be limited to 32 characters in total. Here are a few examples:

85-1_IB_A
(Carrier current receiver relay - first line, Phase-IB, alternating input)

85-2_IC_A
(Carrier current receiver relay - second line, Phase-IC, alternating input)

85-1_IABC_D
(All current phases in one relay with one initiate contact, direct input)

T1_7_C_87-1_IA_D
(Transformer 1, Panel 7, House C, Differential trip, Phase-IA contact, direct input)

F12_4_F_86-1_Bkr11E_D
(Feeder 12, Panel 4, House F, LOR trip, to breaker 11E, direct input)

6. Conclusions

The need for a standard naming convention for IEDs and other substation equipment has existed for many years. However, asset owners have tended to prefer using their own individual naming schemes and numerous workarounds have been found to solve specific instances of the issue without developing a general solution.

This report takes a needed first step at developing a general solution to the IED naming issue. The report takes a survey of existing practices, identifies the need for a standard convention for naming installed IEDs and provides a suggested solution. In the process of preparing the report a number of factors affecting the issue were identified and debated. These include:

- The differing aspects of the actual need for a naming convention. For example, the report includes channel naming as one of its recommendations. In IEC-61850, there is no need for such a naming approach because the standard already provides the equivalent of channel names within its naming scheme. However, other standards do not provide channel names, so that recommendation is relevant to situations in which those standards are being used. IEC-61850 does benefit from the recommendation for IED names.

- The complexities surrounding selection of separators in names. These turn out to be dependent on a combination of choices made within standards and constraints imposed by computer operating systems (especially if files need to be named according to their relationships to IEDs). Examples of these complexities include limitations on name length, significance of particular characters within different operating systems, use of spaces within names (that for important purposes in some systems is treated not as one name but as a list of names), use of capitalization as a separator (names in some systems are case-sensitive and others are case-insensitive).

Overall, this report should be treated as a first step. In the era of the Smart Grid, the need for a common naming convention will grow and not diminish. It is the hope of the Working Group that this report will contribute to the eventual resolution of this important issue.

Annex A: Examples of IED Names

Examples of sample IEDs modified to proposed format			
Device Type	**Original Device Name Format**	**Original Examples**	**Device Examples in Proposed Format (COid_STAid_IEDid_Voltage_Protection_Panel_House)**
Substation Devices	Short unique name	DFR#40	CO A_HOLT TS_DFR40
Line Relays	Breaker Number(s) or Line Description+Function+Model	730-760 SEL-311C	CO A_HOLT TS_311C_115_GREENVILLE-HOLT_730-760
		SMITH 230KV SEC SEL-311L	CO A_HOLT TS_311L-B_230_HOLT-SMITH
Transformer Relays	Description+Function+Model	NO2 115-12KV HSOC SEL-551	CO A_HOLT TS_551-A_115_NO2 115-12KV_HSOC
Breaker Relays	Breaker Number+Function+ Model	03060 BF SEL-251	CO A_HOLT TS_251_115_03060BF
Bus Relays	Description+Function+Model	NO2 12KV BUS SEL-251	CO A_Carter Hill Road DS_251_12_NO2 12KV BUS
All Devices (61850)	Code for sub, voltage, bay, type, device	NA138_6_M5_F60A	CO B_NA138_F60A_6_M5
		NA138_3_T1_S487B	CO B_NA138_S487B_3_T1
All Devices	Mfg (or common name)+serial number	mti1004	CO C_SUB A_mti1004
		ben707	CO C_SUB A_ben707

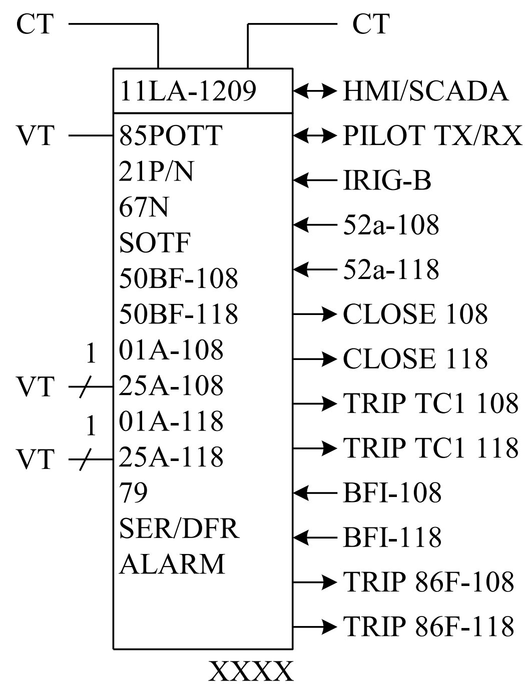
Annex B: IEEE C37.2 – 2008 Standard Electrical Power System Device Function Numbers, Acronyms and Contact Designations

The primary objective is to identify, by its name, an installed IED's location and the element of the power system to which it is connected. This is essential for effective post event analysis. The fundamental IED naming approach (with its extensions) in IEEE C37.2 should be the prime candidate for this naming convention. Essentially all IEDs that may be a source of data for post event analysis are multifunction devices. In IEEE C37.2 these are individually known as a Device 11 – multifunction device. That standard also uses the first suffix letter to define the power system element: L (line), B (bus), G (generator), T (transformer), etc. being monitored or controlled. An addition alpha-numeric suffix is used to define the specific power system element, and the final letter, if any (A, B, C etc.) defines the IED's position in a redundant scheme. Thus, 11L1209A is a multifunction device controlling Line 1209 and is the A element in a redundant scheme.

If needed, IEEE C37.2-2008 includes addition suffix letters that may be used to describe the protective relay scheme implemented in the Device 11. These appear in Clause 3.5.5 of the standard and now include:

BU:	Back up
DCB:	Directional comparison blocking
DCUB:	Directional comparison unblocking
DUTT:	Direct under-reaching transfer trip
POTT:	Permissive over-reaching transfer trip
PUTT:	Permissive under-reaching transfer trip
SOTF:	Switch on to fault

Annex A.4 of C37.2 also includes the following example diagram showing how these notational methods have been used on an elementary diagram for Line 1209. The zone of protection covered by this multifunction device 11 is line 1209. The line is connected to a breaker-and-a-half substation via bus breaker 108 and mid breaker 118. This device is the System A multifunction device for line 1209. There is also a System B multifunction device 11 on line 1209 as well, and it would have its own list box. XXXX is reserved for the manufacturer's model number.



NOTES:
1. AC sensing connections are 3-Phase unless otherwise marked.
2. Functions apply to the multifunction device's designated zone of protection unless otherwise marked.
3. A/B designate System A and System B of the fully redundant system.
4. Device 01 is manual control of the designated power system element.
01A is local HMI and panel control.
01B is remote SCADA control.

Fig B1 - Example of Elementary Diagram from C37.2

Annex C: IEC 61850, 61346

C.1 IEC 61850 networks and systems for power utility automation

IEC 61850 has several options concerning how to name objects within the IED. The two main ones are product-related naming and function-related naming. The product-related naming uses by the vendor pre-defined LDevice Inst and LN Prefix attributes. This concept allows the project engineer to freely choose the IED Name.

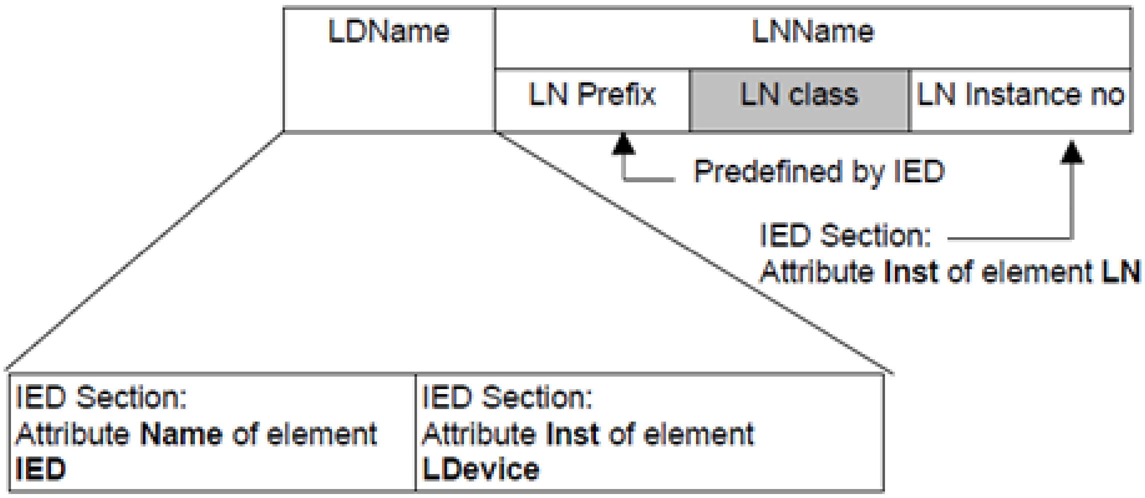


Fig C1 - Product-related naming from IEC 61850-6 Ed 2.0

The other option is function-related naming. In this concept the idea is to Name the IED and the Logical device according to its function. The IED name would in this case be created by concatenating the voltage level name, bay name and the IED's function within the bay. This concept does guarantee that the IED name is unique within the substation. The option to allow the project engineer to modify LD Inst and LN Prefix must be enabled by the tools from the IED vendor in order to allow function-related naming to be used.

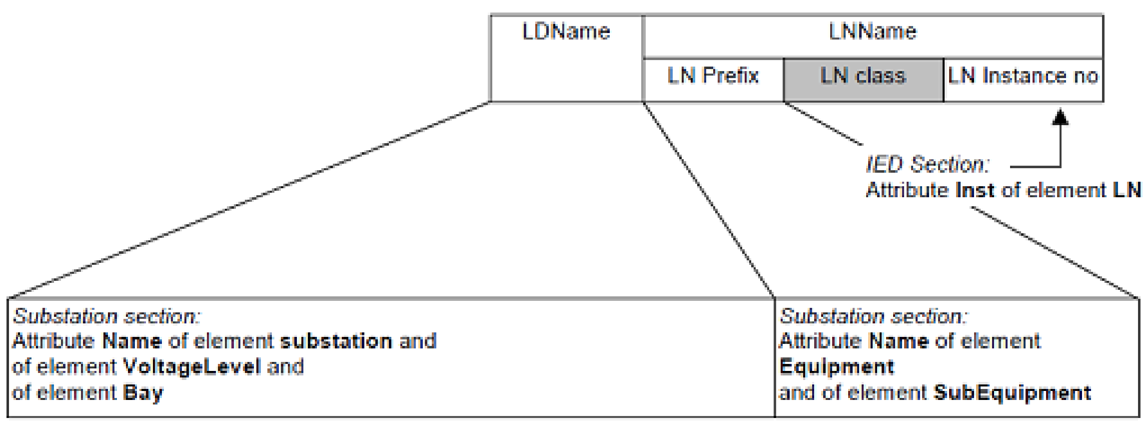


Fig C2 - Function-related naming from IEC 61850-6 Ed 2.0

IEC 61850 does not define how to name voltage levels, bays or IED's. The standard refers to IEC 81346 (formerly IED 61346) for naming of the different levels and objects within the substation

Figure 4 shows an example of an IED with LNs, which control a circuit breaker QA1 of bay Q1 at voltage level E1. The naming is chosen according to the IEC 81346 series. In this example, the IED as a product has the same higher-level product designation part according to the bay (-E1Q1) as the controlled circuit breaker QA1 has in its functional designation (=E1Q1QA1). Figure 4 shows the resulting references within different structures, and the resulting LNreference for communication.

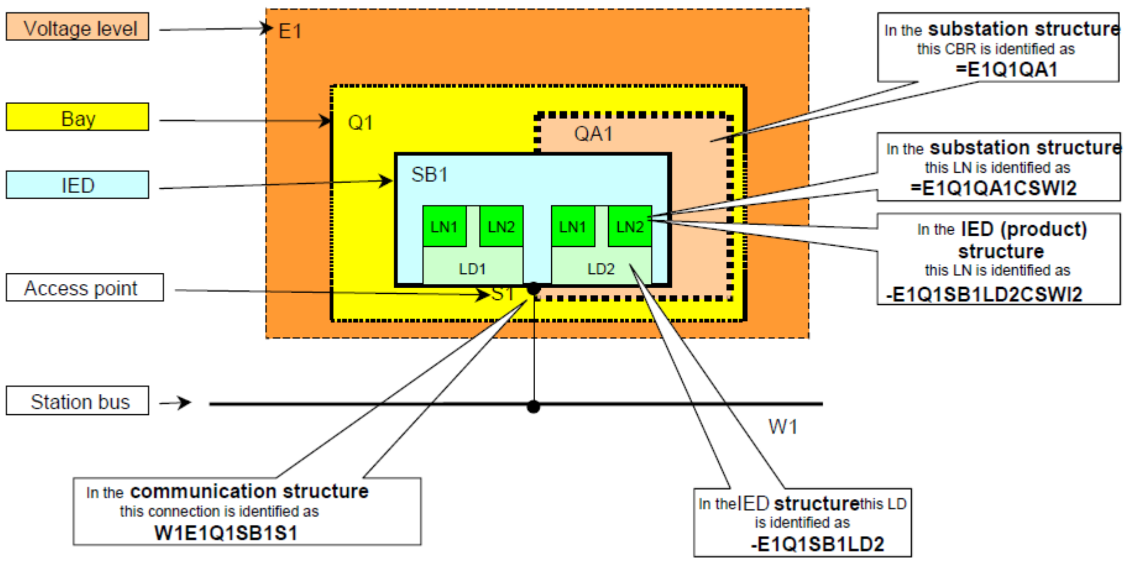


Fig C3 - Example of IED naming from IEC 61850-6 Ed 2.0

In IEC 61850, MMS is used for client-server communication.

MMS objects can be organized using the different scopes. The object names (with or without domain scope) can be compounded from the following character set:
A | a | B | b | C | c | D | d | E | e | F | f | G | g | H | h | I | i | J | j | K | k | L | l | M | m | N | n | O | o | P | p | Q | q | R | r | S | s | T | t | U | u | V | v | W | w | X | x | Y | y | Z | z | $ | _ | 0 | 1 | 2 | 3 | 4 | 5 | | 7 | 8 | 9
The identifiers can contain 1 to 32 characters and they must not start with a number.

C.2 IEC 81346, Industrial systems, installations and equipment and industrial products

IEC 81346 was published in 2009 it replaces the former standard IEC 61346. IEC 81346 defines naming of objects in a structured way. There are several ways to address an object, the most important ones are the Function-oriented, Product-oriented and location-oriented structures. As the names of the structures suggests, these are different ways to locate an object.

A function-oriented structure is based on the purpose of a system. A function-oriented structure shows the subdivision of the system into constituent objects with respect to the function aspect, without taking into account possible location and/or product aspects of these objects.

A location-oriented structure is based on the spatial constituents or, if sufficient, the topographical layout of an object. A location-oriented structure shows the subdivision of the system into constituent objects with respect to the location aspect without taking into account possible product and/or function aspects of these objects.

A product-oriented structure is based on the way a system is implemented, constructed or delivered using intermediate or final components. A product-oriented structure shows the subdivision of the system into constituent objects with respect to the product aspect without taking into account possible function and/or location aspects of these objects.

When using one of the ways discussed above to name an object, in general the different elements building up the complete object address are from the same structure. There are as well ways to cross over from one structure to another.

Annex D: Summary of COMTRADE Naming Convention

D.1 IED names

The first line of the COMTRADE (1999) configuration file contains the IED name which is formatted as follows:

Station Name, Recording Device ID, Revision Year

Where:

- ***Station Name*** is the name of the substation location where the IED is installed, length = 64 characters.
- ***Recording Device ID*** is the identification number or name of the recording device, length = 64 characters.
- ***Revision Year*** is the year of the standard revision, e.g. 1999, that identifies the COMTRADE version being used.

D.2 Analog channel names

The following fields contain the analog channel information. There is one line for each defined analog channel. The fields are:

An, ch_id, ph, ccbm, uu, a, b, skew, min, max, primary, secondary, PS

Where:

- ***An*** is the analog channel index number, length = 6 characters.
- ***Ch_id*** is the channel name or identifier, length = 64 characters.
- ***Ph*** is the channel phase identification, length = 2 characters.
- ***Ccbm*** is the circuit component being monitored, length = 64 characters.
- ***Uu*** is the channel unit (e.g., kV, V, kA, A), length = 32 characters.
- ***A*** is the channel data multiplier, length = 32 characters.
- ***B*** is the channel offset adder, length = 32 characters.
- ***Skew*** is the time skew (in µs) from start of sample period, length = 32 characters.
- ***Min*** is the lower limit of the data range for the channel, length = 13 characters.
- ***Max*** is the upper limit of the data range for the channel, length = 13 characters.

- ***Primary*** is the CT or PT primary ratio factor, length = 32 characters.
- ***Secondary*** is the CT or PT secondary ratio factor, length = 32 characters.
- ***PS*** is the data type in primary (P) or secondary (S), length = 1 character.

D.3 Digital channel names

The following fields contain the digital channel information. There is one line for each defined digital channel. The fields are:

Dn, ch_id, ph, ccbm, Y

Where:

- ***Dn*** is the digital or status channel index number, length = 6 characters.
- ***Ch_id*** is the channel name or identifier, length = 64 characters.
- ***Ph*** is the channel phase identification, length = 2 characters.
- ***Ccbm*** is the circuit component being monitored, length = 64 characters.
- ***Y*** is the normal state "in service" of the channel, length = 1 character (0 or 1).

Annex E: Bibliography

[E1] IEEE Standard C37.111-1999, *IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems*

[E2] IEEE Standard C37.118-2005, *IEEE Standard for Synchrophasors for Power Systems*

[E3] IEEE Standard C37.2-2008, *IEEE Standard Electrical Power System Device Function Numbers, Acronyms and Contact Designations*

[E4] IEEE Standard C37.232-2007, *IEEE Recommended Practice for Naming Time Sequence Data Files*

[E5] IEC Standard 61850, *IEC Standard Networks and Systems for Power Utility Automation*

[E6] IEC Standard 81346, *IEC Standard Industrial systems, installations and equipment and industrial products*

[E7] "Combining Digital Fault Records from Various Types of Devices (Virtual DFR)," by Makki et al, Fault and Disturbance Analysis Conference, May 2006.