

Protocol Implementation eXtra Information for Testing (PIXIT)

for
“Ekip Com IEC 61850”

Based on IEC 61850-10

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Document Versions

| Version | Ekip COM IEC 61850 SW version | Modifications | Release Date | Author |
|---------|-------------------------------|--|--------------|------------|
| 1.0 | 2.01 | First emission | 11 Sep, 2014 | M. Stucchi |
| 1.1 | 2.02 | Adapted to new SW version | 13 Oct, 2014 | M. Stucchi |
| 1.2 | 2.02 | Corrections after initial Baden test: <ul style="list-style-type: none"> Ct16 (DOs) unsupported, Improved Tm2, Tm3 explanation | 15 Jan, 2015 | M. Stucchi |
| 1.3 | 2.05 | Further corrections after Baden test: <ul style="list-style-type: none"> GOOSE disabled with destination MAC address 01:0C:CD:01:00:00 (default value in .icd file) | 23 Jan, 2015 | M. Stucchi |
| 1.4 | 2.06 | Updated Time synchronization model (Tm1, Tm2, failure management) | 4 Feb, 2015 | M. Stucchi |
| | | GOOSE retransmission scheme documented | | |
| | | Changed quality (q) management from XCBRI to CSWI (belonging to UR by default) | | |
| | | Rp1: Added integrity and DataUpdate as Report trigger options | | |
| | | Rp2: Supported data-reference and conf-rev | | |
| 1.5 | 2.07 | Specified Timeout delay for commands (Ct6) | 30 Mar, 2015 | M. Stucchi |
| | | Fixed Rp1 description | | |
| | | Adjusted "Maximum number of supported simultaneous clients" from 5 to 3 | | |
| | | Added Ct22, Ct23, Ct24 from TPCL 1.7.7 | | |
| 1.6 | 2.09 | Added timeAllowedToLive calculation description | 3 Jun, 2015 | M. Stucchi |
| | | Moved Control Time delay for commands from Ct6 to Ct25. | | |
| | | Completed Association model parameters | | |
| 1.7 | 2.10 | Moved to integral deadbanded filtering for MMXU DOs | 15 Jul, 2015 | M. Stucchi |
| | | Improved Association model parameters (As6) | | |
| | | Improved Control model (Ct14) | | |
| 1.8 | 3.00 | Improved Reporting model parameters (Rp9) | 12 Jan, 2017 | M. Stucchi |
| | | "Test" Quality bit supported by (MX) (Sr1) | | |
| | | Specified GOOSE Performance settings: GOOSE ping-pong processing method (Gf2) and "Application logic scan cycle" (Gf3) | | |
| | | Data types in GOOSE dataset (Gf6) | | |
| 1.8 | 3.00 | Fixed-length support (Gf7) | 12 Jan, 2017 | M. Stucchi |
| | | Increased "Maximum number of supported simultaneous clients" from 3 to 4 (As1) | | |

| | | | | |
|------|--------------|--|--------------|------------|
| 1.9 | 3.01 | Specified "Maximum number of GOOSE to be subscribed" (Gf5) and Maximum number of data attributes in GOOSE dataset (Gf4) | 27 Jan, 2017 | M. Stucchi |
| 1.10 | 3.01 | Fixed Ct1: "Direct with enhanced security" | 11 May, 2017 | M. Stucchi |
| | | Added INT32 to Gp3 supported types | | |
| | | Added "PIXIT for GOOSE subscribe model" | | |
| | | Specified in Gf4 that maximum attributes is referred to Input DAs | | |
| | | Increased startup time (As8) in order to comply with DNV test | | |
| 1.11 | 3.02 | Removed references to Emax2, transformed into references to Ekip Com IEC 61850 module instead | 21 Nov, 2017 | M. Stucchi |
| 1.12 | 3.02 | Specified maximum size of cid configuration file (Gf8). Added "Application Logic Scan cycle" for more powerful Cortex M4 based protection Unit (Gf3). | 9 Jan, 2018 | M. Stucchi |
| 1.13 | 3.02 | Modified behavior specification for "Mechanism on second internal data change notification..." (Rp4) | 16 Jan, 2018 | M. Stucchi |
| | 3.04 | Adapted to different GOOSE performance class definition between Ed.1 and Ed.2. (Gf1) | 18 Jan, 2018 | M. Stucchi |
| | 3.05 3.06 | Added out-of-order DataSet members observance according to newest PIXIT template (Gs1) | 18 Jan, 2018 | M. Stucchi |

Introduction

This document specifies the Protocol Implementation eXtra Information for Testing (PIXIT) of the Ekip Com IEC 61850 communication module with the latest firmware specified in the Document Versions table above.

Together with the PICS (Protocol Implementation Conformance Statement) and the MICS (Model Implementation Conformance Statement), the PIXIT forms the basis for a conformance test according to IEC 61850-10.

Content of this document

Each of the following chapters specifies the PIXIT for applicable ACSI service model as structured in IEC 61850-10. The “Ed” column indicates if the entry is applicable for IEC 61850 Edition 1 and/or Edition 2.

PIXIT for Association model

Table 1 - PIXIT for Association Model

| Id | Ed. | Extra Information | Value |
|-----|-----|---|---|
| As1 | 1,2 | Maximum number of supported simultaneous clients | 4 |
| As2 | 1,2 | TCP Keep-Alive according to RFC1122 | Implemented, Keep-Alive Idle time = 5s Keep-Alive Interval = 5s |
| As3 | 1,2 | Maximum time before a lost connection is detected | 20 s |
| As4 | - | Authentication support | No |
| As5 | 1,2 | What Association parameters are necessary for successful association | Transport selector N Session selector N Presentation selector N AP Title N AE Qualifier N |
| As6 | 1,2 | If association parameters are necessary for association, describe the correct values, | Transport selector - Session selector - Presentation selector - AP Title - AE Qualifier - |
| As7 | 1,2 | Maximum PDU size (bytes) | 16384 |
| As8 | 1,2 | Typical startup time after power on | 25 s |

PIXIT for Server Model

Table 2 - PIXIT for Server Model

| Id | Ed. | Extra Information | Value |
|-----|-----|--|---|
| Sr1 | 1,2 | Quality bits supported by (MX) | Validity Good Y Invalid Y Reserved N Questionable Y Overflow N OutofRange Y BadReference N Oscillatory N Failure Y OldData N Inconsistent N Inaccurate N Source Process Y Substituted N Test Y OperatorBlocked N |
| Sr2 | 1,2 | Quality bits supported by (ST) Note: ¹ CSWI1.Pos, XCBR1.Pos, ² PTRC.Tr, PTRC.Str, RBRF.OpEx | Validity Good Y ^{1, 2} Invalid Y ¹ Reserved N Questionable N Overflow N OutofRange N BadReference N Oscillatory N Failure Y ¹ OldData N Inconsistent N Inaccurate N Source Process Y Substituted N Test N OperatorBlocked N |
| Sr5 | 1,2 | Supported Mode / Behaviour ¹ Test mode cannot be forced by IEC61850 services | On Y Blocked N Test Y ¹ Test/Blocked N Off N |

PIXIT for Reporting Model

Device supports only Unbuffered Reports.

Table 3 - PIXIT for Reporting Model

| Id | Ed. | Extra Information | Value |
|------|-----|---|---|
| Rp1 | 1 | The supported trigger conditions are Note: ¹ CSW11.ST.Pos, PTRC1.ST.Tr, PTRC1.ST.Str, MMXU | integrity Y data change Y quality change Y ¹ data update Y general interrogation Y |
| Rp2 | 1 | The supported optional fields are | sequence number Y report-time-stamp Y reason-for-inclusion Y data-set-name Y data-reference Y buffer-overflow Y entryID Y conf-rev Y segmentation N |
| Rp3 | 1,2 | Can the server send segmented reports | N |
| Rp4 | 1,2 | Mechanism on second internal data change notification of the same analogue data value within buffer period | Events will not be discarded |
| Rp5 | 1 | Multi-client URCB approach | Each URCB is visible to all clients |
| Rp9 | 1 | May the reported data set contain: - Structured data objects - Data attributes | Y N |
| Rp10 | 1,2 | Scan cycle for binary events: - GOOSE objects - Status Is this fixed, configurable | sniff from local bus (<1ms) 100 ms Fixed |
| Rp11 | 1 | Does the device support to pre-assign a RCB to a specific client in the SCL | N |
| Rp12 | 2 | After restart of the server is the value of ConfRev restored from the original configuration or retained | N ConfRev field is not included in the report |

PIXIT for GOOSE publish model

Table 4 - PIXIT for GOOSE publish Model

| Id | Ed. | Extra Information | Value |
|-----|-----|---|---|
| Gp1 | 1,2 | Can the test (Ed.1) / simulation (Ed.2) flag in the published GOOSE be set | N |
| Gp2 | 1 | What is the behaviour when the GOOSE publish configuration is incorrect | GOOSE configuration is fixed |
| Gp3 | 1,2 | Published FCD supported common data classes | DPC, ACT, ACD, INT32 GOOSE configuration is fixed anyway |
| Gp4 | 1,2 | What is the slow retransmission time Is it fixed or configurable | Interlock = 1s Protection = 2s Brftrip = 5s These values can be increased by changing MaxTime from within the communication portion of the .icd SCL file. |
| Gp5 | 1,2 | What is the fastest retransmission time Is it fixed or configurable | Interlock, Protection = 4ms Brftrip = 10ms These values can be increased by changing MinTime from within the communication portion of the .icd SCL file. Decreased is not advised. |
| Gp6 | - | Can the GOOSE publish be turned on/off by using SetGoCBValues(GoEna) | Y Another way to disable GOOSE is setting MAC address equal to 00:00:00:00:00:00 or equal to 01:0C:CD:01:00:00. The latter is the initial value suggested by the .icd file. |
| Gp7 | 1,2 | What is the initial GOOSE sqNum after restart | sqNum = 0 |
| Gp8 | 1 | May the GOOSE data set contain: - Structured data objects - Timestamp data attributes | N N |

PIXIT for GOOSE subscribe model

Table 5 - PIXIT for GOOSE subscribe Model

| Id | Ed. | Extra Information | Value |
|------|-----|---|--|
| Gs1 | 1,2 | <p>What elements of a subscribed GOOSE header are checked to decide the message is valid and the allData values are accepted? If yes, describe the conditions.</p> <p>Notes:</p> <ul style="list-style-type: none"> VLAN tag may be removed by an Ethernet switch and shall not be checked stNum different from the previous value triggers allData acceptance for a correct GOOSE sqNum is used to determine if the message is valid, but does not prevent allData assignment timeAllowedToLive equal to 0 prevents GOOSE decoding | <p>Destination MAC address Y</p> <p>APPID N</p> <p>gocbRef Y</p> <p>timeAllowedToLive Y</p> <p>datSet¹ Y</p> <p>gold Y</p> <p>t N</p> <p>stNum Y</p> <p>sqNum Y</p> <p>simulation / test N</p> <p>confRev Y</p> <p>ndsCom¹ N</p> <p>numDatSetEntries¹ N</p> <p>out-of-order DataSet memb. Y</p> <p>¹: validated at startup</p> |
| Gs2 | 1,2 | When is a subscribed GOOSE marked as missing | GOOSE is considered missing after 2 x Time Allowed to Live from last received GOOSE |
| Gs3 | 1,2 | What is the behaviour with a missing GOOSE | "Missing GOOSE" error issued. Internal data is set to 0. |
| Gs4 | 1,2 | What is the behaviour when a subscribed GOOSE has a confRev element mismatch | GOOSE is ignored. Internal data is set to 0. |
| Gs5 | 1,2 | What is the behaviour when a subscribed GOOSE message is out of order (sqNum) | GOOSE is ignored. "Out of order error" is issued. |
| Gs6 | 1,2 | What is the behaviour when a subscribed GOOSE message is duplicated | GOOSE is ignored. "Out of order error" is generated. |
| Gs7 | 1,2 | Does the device subscribe to GOOSE messages with/without the VLAN tag | <p>With the VLAN tag Y</p> <p>Without the VLAN tag Y</p> |
| Gs8 | 1,2 | May the GOOSE data set contain: <ul style="list-style-type: none"> Structured data objects Timestamp data attributes | <p>N</p> <p>N</p> |
| Gs9 | 1,2 | Subscribed FCD supported common data classes | - |
| Gs10 | 1,2 | Are subscribed GOOSE with test=T (Ed1) /simulation=T (Ed2) accepted in test/simulation mode | <p>Y</p> <p>note: only applicable for Ed2</p> |

PIXIT for GOOSE performance

Table 6 - PIXIT for GOOSE performance

| Id | Ed. | Extra Information | Value |
|-----|-----|---|--|
| Gf1 | 1 | IEC 61850-5 Performance class | P1 (10ms Max for trip) |
| | 2 | | P2 (10ms Max for trip) |
| Gf2 | 1,2 | GOOSE ping-pong processing method | Scan cycle based |
| Gf3 | 1,2 | Application logic scan cycle | 3.3ms / 1.66ms based on Protection Unit hardware (Cortex M3 based or Cortex M4 based) |
| Gf4 | 1 | Maximum number of data attributes in GOOSE dataset (value and quality has to be counted as separate attributes) | Configuration is fixed for output GOOSE, can vary for input GOOSE. Total input attributes approximately 750. |
| Gf5 | 1,2 | Maximum number of GOOSE to be subscribed | 10, including Input and Output GOOSE |
| Gf6 | 1,2 | Data types in GOOSE dataset for subscribed GOOSEs | Boolean, Double Point, Integer32, Quality |
| Gf7 | 1,2 | Support fixed length encoding to improve performance | N |
| Gf8 | 1,2 | Maximum configuration file size (.cid file) | 256 kB |

PIXIT for Control model

Table 7 - PIXIT for Control Model

| Id | Ed. | Extra Information | Value |
|-----|-----|--|--|
| Ct1 | - | What control models are supported | Direct with enhanced security |
| Ct2 | 1,2 | Is the control model fixed, configurable and/or dynamic | Fixed |
| Ct3 | - | Is TimeActivatedOperate supported (compare PICS or SCL) | N |
| Ct4 | - | Is the "operate-many" supported (compare sboClass) | N |
| Ct5 | 1 | Will the DUT activate the control output when the test attribute is set in the SelectWithValue and/or Operate request | Y |
| Ct6 | - | What are the conditions for the time (T) attribute in the SelectedWithValue and/or Operate request | - |
| Ct7 | - | Is pulse configuration supported (compare pulseConfig) | N |
| Ct8 | 1 | What is the behaviour of the DUT when the check conditions are set Is this behaviour fixed, configurable, online changeable | Synchrocheck N interlock-check N Fixed |
| Ct9 | 1,2 | Which additional cause diagnosis are supported | Unknown N Not-supported Y Blocked-by- |

| | | | |
|------|-----|---|---|
| | | | switching-hierarchy Y Select-failed N Invalid-position N Position-reached Y Parameter-change-in-execution N Step limit N Blocked-by-Mode Y Blocked-by-process N Blocked-by-interlocking N Blocked-by-synchrocheck N Command-already-in-execution N ¹ Blocked-by-health N 1-of-n-control N Abort-by-Cancel N Time-over-limit Y Abortion-by-trip N Object-not-selected Y Ed.2 special values: No access authority N Ended-with-overshoot N Abort-due-to-deviation N Abortion-by-communication-loss N Blocked-by-command N None N Inconsistent-parameters N Locked-by-other-client N |
| | | ¹ Only supported by library for Sbo controls | |
| Ct10 | 1,2 | How to force a “test-not-ok” respond with SelectWithValue request | - |
| Ct11 | 1,2 | How to force a “test-not-ok” respond with Select request | - |
| Ct12 | 1,2 | How to force a “test-not-ok” respond with Operate request | - |
| Ct13 | 1,2 | Which origin categories are supported / accepted | bay-control Y station-control Y remote-control Y automatic-bay Y automatic-station Y automatic-remote Y maintenance Y process Y |
| Ct14 | 1,2 | What happens if the orCat value is not supported or invalid | Command fails. In case of orCat not supported, the related error code (“not supported”) is returned |

| | | | |
|------|-----|--|--|
| Ct15 | 1,2 | Does the IED accept a SelectWithValue / Operate with the same control value as the current status value Is this behaviour configurable | Command is rejected and “Position-reached” error code is returned N |
| Ct16 | 1,2 | Does the IED accept a select/operate on the same control object from the 2 different clients at the same time | DOns - SBOns - DOes Y SBOes - |
| Ct17 | 1,2 | Does the IED accept a Select/ SelectWithValue from the same client when the control object is already selected | SBOns - SBOes - |
| Ct18 | 1,2 | Is SBOes the internal validation performed during the SelectWithValue and/or Operate step | - |
| Ct19 | - | Can a control operation be blocked by Mod=Off or [On-]Blocked (Compare PIXIT Sr5) | N |
| Ct20 | 1,2 | Does the IED support local/remote operation | Y |
| Ct21 | 1,2 | Does the IED send an InformationReport with LastApplErr as part of the Operate response- for control with normal security | DOns - SBOns - |
| Ct22 | 1,2 | How many SBOns/SBOes control objects be selected at the same time? | SBOns “N/A” SBOes “N/A” |
| Ct23 | 1,2 | Can a controllable object be forced to keep its old state e.g. Internal Controllable Objects may not be accessible to force this, whereas a switch like Circuit Breaker outside the DUT can? | N |
| Ct24 | 1,2 | When CDC=DPC is supported, is it possible to have DPC (Controllable Double Point) go to the intermediate state? (00) | N |
| Ct25 | 1,2 | Control Time period | 1.5s (fixed) |

PIXIT for Time synchronization model

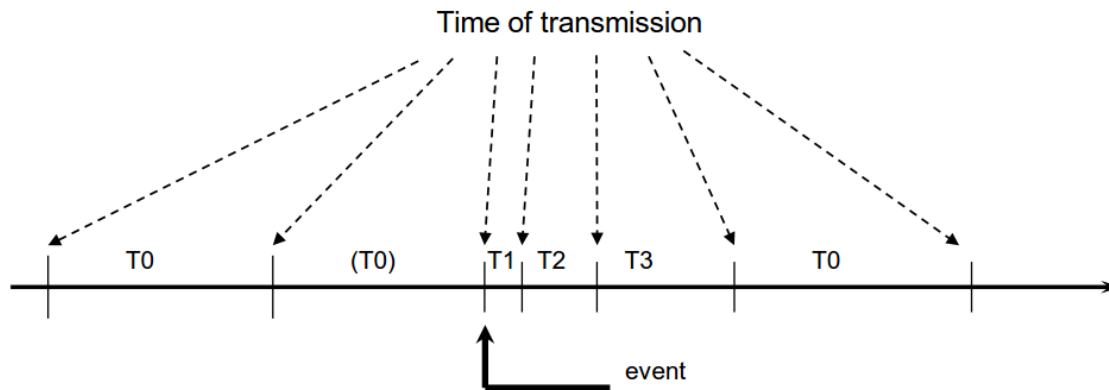
Table 8 - PIXIT for Time synchronization Model

| Id | Ed. | Extra Information | Value |
|-----|-----|--|--|
| Tm1 | 1,2 | What time quality bits are supported (may be set by the IED) | LeapSecondsKnown Y ClockFailure Y ClockNotSynchronized Y |
| Tm2 | 1,2 | Describe the behaviour when the time server(s) ceases to respond. What is the time server lost detection time | On one time server: 60s On all time servers: N If the SNTP time server does not respond in such a period, quality bits are affected. A single server is supported. |
| Tm3 | 1,2 | How long does it take to take over the new time from time server | 30 seconds |
| Tm4 | 1,2 | When is the time quality bit "ClockFailure" set | In case of no response (see Tm2), if SNTP client is enabled |
| Tm5 | 1,2 | When is the time quality bit "Clock not Synchronized" set | At startup and in case of no response (see Tm2), if SNTP client is enabled. It is reset when a synchronization is detected. |
| Tm6 | - | Is the timestamp of a binary event adjusted to the configured scan cycle | N |
| Tm7 | 1 | Does the device support time zone and daylight saving time | Y |
| Tm8 | 1,2 | Which attributes of the SNTP response packet are validated | Leap indicator != 3 N Mode is equal to SERVER or BROADCAST Y OriginateTimestamp is equal to value sent by the SNTP client at Transmit Timestamp Y RX/TX timestamp fields are checked for reasonableness N SNTP version 3 and/or 4 N Check Server IP address Y Check SNTP port Y SNTP message total length Y |
| Tm9 | 1,2 | Do the COMTRADE files have local time or UTC time and is this configurable | - |

Additional Information

GOOSE retransmission scheme

The following scheme describes the GOOSE retransmission scheme according to IEC 61850-8-1.



Key

- T0 retransmission in stable conditions (no event for a long time).
- (T0) retransmission in stable conditions may be shortened by an event.
- T1 shortest retransmission time after the event.
- T2, T3 retransmission times until achieving the stable conditions time.

Figure 1 - GOOSE retransmission time

The transmission scheme can be described as follows: After an event configured to trigger a GOOSE message transmission, a message is immediately generated. After that, according to the reliable transmission principle from IEC 61850-7-2, message retransmission are scheduled with an increasing interval. This retransmission scheme can be described with two parameters, a first one (MinTime) that indicates the first retransmission interval, and a second one (MaxTime) that indicates the retransmission interval in stable conditions, after a long time without triggering event. The first retransmission is scheduled MinTime interval after the first transmission. After that, each subsequent retransmission delay is twice the delay of the preceding message, until it reaches the upper limit determined by MaxTime. In short:

$$T1 = \text{MinTime} \rightarrow T2 = T1 * 2 \rightarrow T3 = T2 * 2 \rightarrow \dots \rightarrow \text{MaxTime}.$$

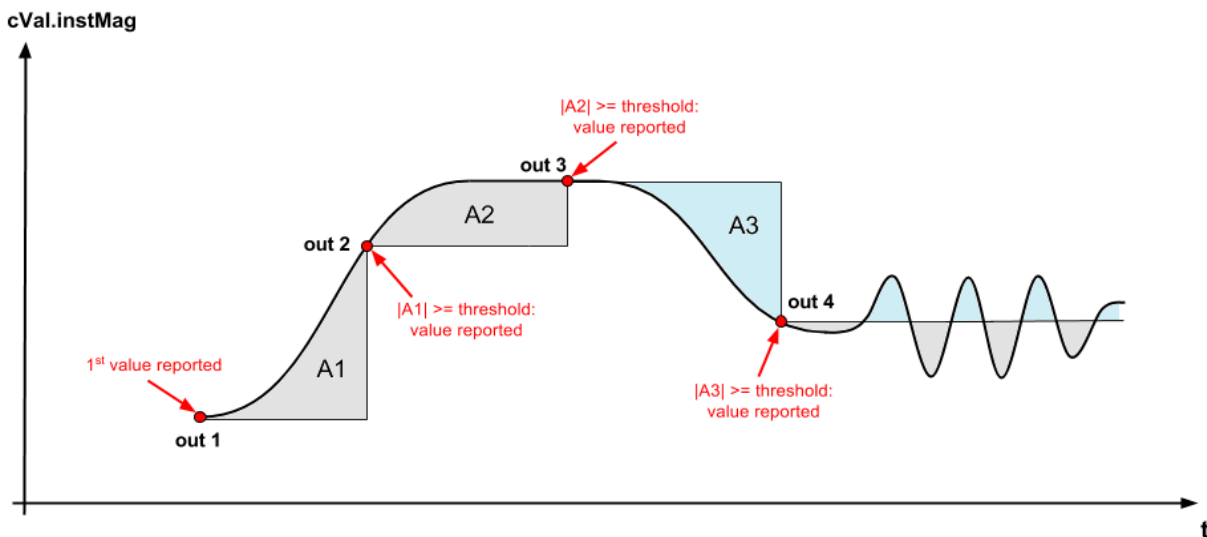
When the calculated delay result bigger than MaxTime it is limited at that value. From then on, every subsequent message is retransmitted at MaxTime delay. The two described parameters MinTime and MaxTime are specified in the SCL file for each single GOOSE. While it is possible to change such values, it is not advised to decrease MinTime.

timeAllowedToLive is calculated for each GOOSE message as the sum of the present retransmission time and the successive retransmission time. In this way two GOOSE messages can be transmitted before the GOOSE connection is to be considered lost (i.e. one message can be lost with no practical impact). E.g. the 1st GOOSE after the event will have a *timeAllowedToLive* equal to (T1 + T2), the 2nd (T2+T3). In stable conditions thus the *timeAllowedToLive* will be (T0 * 2).

Measurement deadbands

ABB SACE Emax2 supports deadbands for objects MMXU logical nodes. Instantaneous values ($cVal.instMag$) are sampled every 20ms from the protection unit are used for deadbanded values calculation ($cVal.mag$). The former values are not exposed in the object model, anyway.

In order to implement a deadbanded behaviour, thus optimizing the required bandwidth, without limiting the algorithm precision, the implemented deadband algorithm is of integral type, increasing the precision over time. This means that the long term error is zero (e.g. with a constant current, the $cVal.mag$ value will always be identical to the constant $cVal.instMag$). This behaviour is depicted in the figure below: each time the integrated difference between the last reported value and the instantaneous value reaches, as an absolute value, the predefined threshold a new report is generated. This can be seen with the transmission of out 2, out 3 and out 4. Conversely, an instantaneous value oscillating around the last reported value will not cause any new report to be transmitted, as displayed after out 4 is generated, with the $instMag$ value unable to cause a further report to be generated.



Deadband thresholds are pre-defined and cannot be changed, and their values are listed below, optimized for the type of analogue value that they manage. These values are displayed in the table on the next page.

Table 9 - Deadband predefined thresholds

| Analogue value | Predefined deadband thresholds |
|---|--|
| Phase Currents MMXU.A.phsA, MMXU.A.phsB, MMXU.A.phsC, MMXU.A.neut, | 2% I_n s Where I_n is the Circuit Breaker nominal current and current measures have a range of 0 to 16 I_n |
| Ground Current MMXU.A.net, | 0.2% I_n s |
| Voltages MMXU.PNV, MMXU.PPV | 0.2% U_n s Where U_n is the Circuit Breaker nominal voltage and voltage measures have a range of 0 to 1.3 U_n |
| Power MMXU.W, MMXU.TotW MMXU.VAr, MMXU.TotVAr MMXU.VA, MMXU.TotVA, | 1 % P_n s Where P_n is the Circuit Breaker nominal Power and power measures have a range from 0 to 5 P_n |
| Power factor MMXU.TotPF | 0.2 s MMXU.TotPF range goes from -1.000 to +1.000 |
| Frequency MMXU.Hz | 0.5 Hz s MMXU.Hz range goes from 30.00Hz to 50.00Hz |