WITS Technical Bulletin #63

Application Notes Affected: AN2005-001 Rev 1.6
AN2005-002 Rev 1.7
AN2005-006 Rev 1.7
AN2007-001 Rev 1.7

WITS Device Profile version 1.6

and affects:

WITS PSA Test Specification version 3.1

Bulletin Reference: **TB0063 Iss 3**

Bulletin Type: **Design Change**

Status: **Circulated for comment ~~/ Rejected / Accepted~~**

Date Issued: **07-02-2022**

Authors: **Stephen Beadle, Mark Davison and Andrew Scott**

1 Overview

Users have requested (WITS-59) that Field Devices could be extended to support points whose value is calculated from other points on the device. These points, known as calculated points, will reduce the need to add IEC 61131-3 or automation code to the Field Device or its associated PLCs and will simplify configuration of many sites. This Technical Bulletin describes how such points will be added as standard items of WITS configuration.

The addition of calculated point support on a Field Device will be indicated in its Device Profile.

The configuration of calculated points will be performed through a new IC record (1020) in an updated IC version (6).

The value of a calculated point will be based on the values of one or more other points in the Field Device. The value is calculated using an expression. The expression contains one or more operations. operations are encoded using a bytecode which is defined in this document. An operation may have zero or more parameters. The number of parameters is fixed for each operation.

An expression and its' constituent operations are encoded in Polish Notation (PN). Calculation of the expression might normally use a Last In First Out (LIFO) stack but all implementation details are specific to the vendor, this TB only seeks to specify the coding of the expression and any rules significant to the calculation. For clarity's sake an example of the encoding and a possible calculation scheme is given later in this document.

1.1 Definition of a calculated point in IC

Each instance of the new IC record will specify a single point and how that point's calculation is to be performed. The IC record will specify the following:

a) The type of the calculated point. The type will be specified as a DNP3 Object Group and will be one of 1 (Binary Input) or 30 (Analogue Input).

b) The DNP3 point number of the calculated point. The point must not be used for any other purposes by the Field Device. The DNP3 point number will be encoded as an unsigned integer in two octets.

c) The execution strategy for the calculated point. The calculated point value will be updated on the basis of an execution strategy. One or multiple execution strategies can apply to an individual calculated point at any one time. The various strategies are as follows:

   a. Periodic. Update the calculated point on a regular timed basis.
      i. Interval - number of minutes as integer, 1-10080. This allows daily or weekly calculations.
      ii. Offset – number of minutes from start of day, 0-10079. WITS always uses offsets from start of week which begins Monday morning at 00:00.
   b. On source change. Update the calculated point when any combination of the following changes on a source point.
      i. Source point value.
      ii. Source point DNP3 object flags.
      iii. Source point state.
   c. Lazy. Update the calculated point when the value of the point is required. For example, when a Master Station requests the value or when the Field Device requires the input for logging or for assessment of a point state. Care should be taken when configuring a calculated point with only a Lazy execution strategy if the point is not logged, uses states but does not use persistence. With persistence configured the calculated point will be recalculated at no less than the persistence resolution interval and state changes will become apparent. Likewise with logging configured but no persistence configured the point will be recalculated at the logging interval and state changes will become apparent. With no persistence or logging configured then the point is only recalculated when read.

d) The expression for the calculated point. This consists of a list of bytecodes and parameters representing the expression and inputs using PN/Stack notation. The bytecodes are documented below in the form of a table, showing the bytecode, stack before, stack after and a description of the operation. Each instruction has up to four values: the bytecode, and zero to three parameters needed by that instruction. Each instruction expects up to three values to be on the stack prior to execution, and after execution these will have been replaced with a single result value on the stack.

1.2 Evaluation of a calculated point value

The calculation of a point value commences when determined by one of the execution strategies which apply to the calculated point.

After calculation a single result value will be present on the stack. An expression is not valid if this is not the case. The format of the single result of an instruction can normally be inferred from the instruction and parameter types. The result format will be given in at least the format shown in the table below. Operands A and B can appear in any order and m < n. Actual result type is implementation dependent and can be greater than the minimum in the table below.

Operand A Type	Operand B type	Minimum Result Type
signed int (m octets)	signed int (m octets)	signed int (m octets)
signed int (m octets)	signed int (n octets)	signed int (n octets)
unsigned int (m octets)	unsigned int (m octets)	unsigned int (m octets)
unsigned int (m octets)	unsigned int (n octets)	unsigned int (n octets)
signed int (m octets)	unsigned int (m octets)	unsigned int (m octets)
signed int (m octets)	unsigned int (n octets)	unsigned int (n octets)
Any int	float	Float

Any under or overflow in the operation will cause the DNP3 object flag OVERRANGE to be set for appropriate point types, the point value should be set as directed in Note 4 of Section 11.1.6.1.1 of the DNP3 specification (IEEE Std 1815-2010) and utilising normal WITS scaling to derive the matching engineering value.

Calculated points may be subject to limit processing as any other point of that type is, this includes the handling of persistence and hysteresis.

For logical operations a value of 0 is taken to be false and a non-zero value is taken to be true. The result of a logical operation will be 1 for true and 0 for false.

Calculated points may use the value of other points in calculation. Those point must be of the following type/Object Groups:

- Object Group 1 – Binary Input
- Object Group 3 – Double Bit Binary Input
- Object Group 10 – Binary Output
- Object Group 20 - Counter
- Object Group 30 – Analogue Input
- Object Group 40 – Analogue Output Status

For binary inputs and outputs, the value 0 or 1 will be used to represent the value.

Where logical operation results or binary values are used, the 0 or 1 will be encoded as an integer literal with value 0 or 1, respectively.

For double bit binary inputs, the values 0, 1, 2 or 3 as defined by DNP3 will be encoded as an integer literal with value 0, 1, 2 or 3 respectively.

Calculated points may not use other calculated points within their calculations.

The bytecode table suggests a simple format for expression of the calculations in the “Example Syntax” column. However, the format of the calculation language may be specific to the Master Station and/or Field Device Configuration Application provided by the vendor. For example, the calculation may be specified using Master Station point names; or may use a syntax created from the point type and point address. It is the bytecode which is common. This document defines the bytecodes to be used irrespective of any language used to express the calculation to a user.

1.3 The Calculation Bytecode

Byte Code	Example Syntax	Type	Parameter 1	Parameter 2	Parameter 3	3rd down on stack	2nd down on stack	Top of stack	Result on stack	Description
0	-1337	Integer Literal	Integer value (signed 4 octets)						Number	Integer literal left on top of the stack
1	3.14	Floating point literal	Floating point value (4 octets IEEE)						Number	Floating point literal left on top of the stack
10	"AI1"	Source point value	DNP3 OG number (unsigned 1 octet)	Point Number (unsigned 2 octets)					Number	Point value is read and placed on top of the stack. If the point has never been read, 0 is used
11	Q("AI1",3)	Source point DNP3 object flag	DNP3 OG number (unsigned 1 octet)	Point Number (unsigned 2 octets)	Bit number (0-7) within DNP3 object flags (unsigned 1 octet)				Number	Point DNP3 object flag value is read and placed on top of the stack as 0 or 1.
12	T("AI1")	Source point timestamp	DNP3 OG number (unsigned 1 octet)	Point Number (unsigned 2 octets)					Number (unsigned 6 octets)	Epoch time (seconds since 1/1/1970 as per DNP3) of last point update is placed on top of the stack. If never processed, 0 is used
20	-	Unary minus						Number	-Number	Negate number on top of stack
30	+	Add					Number1	Number2	Number1 + Number2	Add two numbers and place on top of stack
31	-	Subtract					Number1	Number2	Number1 - Number2	
32	*	Multiply					Number1	Number2	Number1 * Number2	

Byte Code	Example Syntax	Type	Parameter 1	Parameter 2	Parameter 3	3rd down on stack	2nd down on stack	Top of stack	Result on stack	Description
33	/	Divide					Number1	Number2	Number1 / Number2	
34	**	Power					Number1	Number2	Number1 ** Number2	
35	MOD	Modulo					Number1	Number2	Number1 MOD Number2	Remainder after division
40	NOT	Logical NOT						Number	Not Number	All logical operators treat zero as false and non-zero as true. The NOT value of a number will be 0 or 1
50	OR	Logical					Number1	Number2	Number1 OR Number2	
51	AND	Logical					Number1	Number2	Number1 AND Number2	
52	XOR	Logical					Number1	Number2	Number1 XOR Number2	
53	XNOR	Logical					Number1	Number2	Number1 XNOR Number2	
60	IIF	Immediate If				Condition	Number1	Number2	Number	If Condition is true, result is Number1, else Number2
70	ABS	Absolute Value						Number1	Number	If Number1 is negative, return -Number1
71	INT	Integer						Number1	Number	The integer version of Number (truncation)

Byte Code	Example Syntax	Type	Parameter 1	Parameter 2	Parameter 3	3rd down on stack	2nd down on stack	Top of stack	Result on stack	Description
80	MAX	Return largest of two numbers					Number1	Number2	Number	The result is the largest of the two parameters
81	MIN	Return smallest of two numbers					Number1	Number2	Number	The result is the smallest of two parameters
90	=	Equal to					Number1	Number2	Number	Result is Boolean evaluation of Number1 = Number2 (false is zero, true is one)
91	!=	Not equal to					Number1	Number2	Number	Result is Boolean evaluation of Number1 != Number2 (false is zero, true is one)
92	>	Greater than					Number1	Number2	Number	Result is Boolean evaluation of Number1 > Number2 (false is zero, true is one)
93	>=	Greater than or equal to					Number1	Number2	Number	Result is Boolean evaluation of Number1 >= Number2 (false is zero, true is one)
94	<	Less than					Number1	Number2	Number	Result is Boolean evaluation of Number1 < Number2 (false is zero, true is one)
95	<=	Less than or equal to					Number1	Number2	Number	Result is Boolean evaluation of Number1 <= Number2 (false is zero, true is one)
100	TimeWeekDay(z)	Day of week						Number1 (epoch seconds)	Number (day of week)	Get the day of week from the Epoch in WITS format 1-7 (Mon-Sun)

Byte Code	Example Syntax	Type	Parameter 1	Parameter 2	Parameter 3	3rd down on stack	2nd down on stack	Top of stack	Result on stack	Description
101	TimeHour(z)							Number1 (epoch seconds)	Number	0-23
102	TimeMin(z),							Number1 (epoch seconds)	Number	0-59
103	TimeSec(z),							Number1 (epoch seconds)	Number	0-59
104	TimeDay(z)							Number1 (epoch seconds)	Number	1-31
105	TimeMonth(z)							Number1 (epoch seconds)	Number	1-12
106	TimeYear(z)							Number1 (epoch Seconds)	Number	Year e.g. 2022
107	TimeEpoch								Number (unsigned 6 octets)	Count of seconds since Jan 01 1970 UTC as per DNP3
120	Previous()								Number	Get the value of this calculated point which is about to be overwritten

Note 1: A bytecode is defined as an unsigned 1-octet integer.

Note 2: All unused bytecodes are reserved for future WITS use.

1.4 Point DNP3 object flag handling

All calculated points will have DNP3 object flags as per any other DNP3 point. The rules for calculation of those flags are given below:

- If a calculated point is not ONLINE or its RESTART flag is set then no calculation need be performed for that point.
- ONLINE for a calculated point will be the logical AND of all ONLINE flags for every point in the calculation together with the On Scan status of the calculated point. Therefore, if any of the contributing points are not ONLINE/On Scan then the calculated point will not be ONLINE, also, if the calculated point is set to Off Scan then it will not be ONLINE.
- RESTART for a calculated point will be the logical OR of all RESTART flags for every point in the calculation. If any point in the calculation has not had RESTART reset then RESTART will be set for the calculated point and hence the value should be disregarded.
- COMMS_LOST, REMOTE_FORCED and LOCAL_FORCED for a calculated point will be the logical OR of the same flags for every point in the calculation. It is not possible to set these for any other reason for the calculated point, they are dependent entirely on the source points.
- CHATTER_FILTER, ROLLOVER, DISCONTINUITY, OVERRANGE and REFERENCE_ERR share bits 5 and 6 of the DNP3 object flags. Calculated points are either a binary or analogue point, hence the following rules will be used.
    - For a binary calculated point CHATTER_FILTER will be the logical OR of the same flag for all binary points used in the calculation.
    - For an analogue calculated point OVERRANGE will be the logical OR of the same flag in all analogue points used in the calculation, OR'd with the overrange indication resulting from the calculation. So, for instance, if a calculation multiplies two source numbers together and gets an answer out of range then the OVERRANGE flag would be set irrespective of the state of the source points.
    - For an analogue calculated point REFERENCE_ERR will be set to the logical OR of the same flag for all analogue points used in the calculation.
    - ROLLOVER and DISCONTINUITY will never be used.
- STATE (for a binary only) occupies bit 7 of the DNP3 object flags. The STATE flag for a calculated binary point will be the calculated value of the point.
- At startup and before any calculation is performed, the default value of all flags will be 0, apart from RESTART which will be set to 1.
- Where a calculation uses source points which have a different point type to the calculated point, the flags of the calculated point will be determined only from those flags in the source points which match those in the calculated point. Where appropriate, it is recommended that calculations separately deal with non-matching DNP3 object flags.

1.5 IC action on calculated points

All calculated points can be the subject of IC record types as defined below and as appropriate given the capabilities specified in the Device Profile of the Field Device.

- The following point scope IC record types will operate successfully against a calculated point (if supported for the calculated point type in the device profile):
    - Record Type 1000 – Point On/Off Scan
    - Record Type 1002 – Analogue Range/Scaling (analogue calculated points only).
    - Record Type 1003 – Analogue Limits (analogue calculated points only)
    - Record Type 1005 – Point Archives
    - Record Type 1006 – Binary States (binary calculated point only)
    - Record Type 1007 – Profile (analogue calculated points only)

- Record Type 1008 – Rate of Change (analogue calculated points only)
- Record Type 1009 – DNP3 Object Flag Actions
- Record Type 1010 – Minimum (analogue calculated points only)
- Record Type 1011 – Maximum (analogue calculated points only)
- Record Type 1012 – Mean (analogue calculated points only)
- Record Type 1013 – Integral (analogue calculated points only)
- Record Type 1014 – State Counter
- Record Type 1015 – State Runtime
- Record Type 1017 – High Speed Sampled Data (analogue calculated points only)
- Record Type 1018 – Incident Logs
- Record Type 1019 – Significant Change Values

- Use of any other IC record types will result in a failure of that specific IC record and hence of the whole IC file. A specific error message will be allocated for such a failure.
- Only 1 to 1 scaling will be accepted for analogue points, anything else will result in an error with code 17. This Record Type (1002) is preserved for configuring the over and under range values only for the calculated point.

1.6 Limits

The Device Profile for a Field Device shall be updated to show:

- Whether a Field Device supports Calculated Points and if so:
  - The maximum number of bytes that can be used to represent any single calculation.

1.7 Other supporting information

The bytecodes do not support any bitwise operators.

The bytecodes do not support parentheses as the Polish Notation takes care of this.

There is no support for local time. All times are based on UTC as defined in both DNP3 and WITS.

1.8 Example

This section presents an example of a calculation, how it is encoded and how it could be calculated. Please note that the method of calculation is vendor dependent and need not follow the example shown here.

The example calculation expression takes the average of two analogue points (AI1 and AI2) using the calculation below:

Calculated Point Value = (AI1 + AI2) / 2

This expression would be encoded as follows:

Instruction	Bytecode	Syntax	Type	Parameter 1	Parameter 2
1	33	/	Divide	Instruction 2	Instruction 5
2	30	+	Add	Instruction 3	Instruction 4
3	10	AI1	Source Point Value (SPV)	30 (Object Group)	1 (DNP3 point number)
4	10	AI2	Source Point Value (SPV)	30 (Object Group)	2 (DNP3 point number)
5	0	2	Integer Literal (IL)	2	

Within the IC this would appear as shown in the “Encoded value in IC” column below. The interpretation to the right shows how the eventual calculation would be performed.

<table>
<tr><td rowspan="2">Bytes in IC</td><td rowspan="2">Encoded value in IC</td><td colspan="3">Results of</td></tr>
<tr><td>Instructions 3, 4 & 5</td><td>Instruction 2</td><td>Instruction 1</td></tr>
<tr><td>33 (0x021)</td><td>/</td><td colspan="2">/</td><td rowspan="15">(AI1 + AI2) / 2</td></tr>
<tr><td>30 (0x01E)</td><td>+</td><td>+</td><td rowspan="8">AI1 + AI2</td></tr>
<tr><td>10 (0x0A)</td><td>SPV</td><td rowspan="4">AI1</td></tr>
<tr><td>30 (0x01E)</td><td>30</td></tr>
<tr><td>1 (0x01)</td><td rowspan="2">1</td></tr>
<tr><td>0 (0x0)</td></tr>
<tr><td>10 (0x0A)</td><td>SPV</td><td rowspan="4">AI2</td></tr>
<tr><td>30 (0x01E)</td><td>30</td></tr>
<tr><td>2 (0x02)</td><td rowspan="2">2</td></tr>
<tr><td>0 (0x0)</td></tr>
<tr><td>0 (0x0)</td><td>IL</td><td colspan="2" rowspan="5">2</td></tr>
<tr><td>2 (0x02)</td><td rowspan="4">2</td></tr>
<tr><td>0 (0x0)</td></tr>
<tr><td>0 (0x0)</td></tr>
<tr><td>0 (0x0)</td></tr>
</table>

Which is equivalent to the following hex byte encoding in IC:

```
21 1E 0A 1E 01 00 0A 1E 02 00 00 02 00 00 00
```

NB. In section 2 onwards, text that is shown in red represents words to be removed from the application notes and text in blue represents words to be inserted into the notes. Table boxes highlighted in red are showing formatting details and have no relevance for text changes.

2 Changes to the Application Notes

2.1 AN2005-001

Make the following changes to AN2005-001.

2.1.1 Change the "Title Page" as shown:

Revision 1.67

March 2016February 2022

2.1.2 Add to the "Change History" as shown:

Date	Revision	WITS-DNP3 Version	Details
March 2016	1.6	3.0	Merged SAv2 and SAv5 streams back together. Update table 2.1 to include details of IC records for extended logging.
February 2022	1.7	3.1	Table 2.1 updated to include details of IC record for calculated points

2.1.3 Modify Table 2.1 entry as shown

WITS AN2005-006	WITS Incremental Configuration	It is recognised that Bulk Configuration of a Field Device for every small parameter change is not a suitable mechanism, especially for medium and large devices. This Application Note describes the use of file transfer to provide Incremental Configuration updates to Field Devices through a WITS defined file format. Each of the following Incremental Configuration items are described in detail in the Application Note: • Device on/off scan • Connection details • Scheduled connection • Point on/off scan • Override point • Analogue range/scaling • Analogue Limits • Counter Limits • Point archives • Binary States • Profiles • Rate of change calculations • DNP3 object flag Actions • Minimum • Maximum • Mean • Integral • State Counter • State Runtime • Profile Control Value [1] • High speed sampled data [2] • Incident Logs [3] • Significant change of value [3] • Calculated point[4]

[1] Protocol versions 1.2 / 2.0 and higher

[2] Protocol versions 1.3 / 2.1 and higher

[3] Protocol versions 3.0 and higher

[4] Protocol versions 3.1 and higher

2.2 AN2005-002

Make the following changes to AN2005-002.

2.2.1 Change the title page as shown

Revision 1.78

March 2016February 2022

2.2.2 Add to the "Change History" as shown:

Date	Revision	WITS-DNP3 Version	Details
March 2016	1.7	3.0	Merged SAv2 and SAv5 streams back together. Introduced concepts of extended logging Added section 2.7 – optimised use of the protocol
February 2022	1.8	3.1	Added Calculated Point IC record to list in Section 2.5.2 Added Section 2.6.11 to explain Calculated Points

2.2.3 Add to Incremental Configuration list in Section 2.5.2

- Significant changes [6]. Allows a Field Device to be configured with a deadband value to be used to determine if a significant change of value has occurred, as well as configuring the action to take when a change does occur.
- Calculated point[7]. Allows a specified point to be calculated from the values of other points.

Note, also add footnote 7 which should say: "[7] Protocol versions 3.1 and higher"

2.3 AN2005-006

Make the following changes to AN2005-006, in addition to those made by TB#62.

Note that section numbers in version 3 of this Application Notes are corrupt in section 2.1.2. The following sections refer to the "corrected" section numbers.

2.3.1 Change the "Title Page" as shown:

Revision 1.78

March 2016February 2022

2.3.2 Add to the "Change History" as shown:

Date	Revision	WITS-DNP3 Version	Details
June 2017	1.8	all	Added notes about extended data points when the source point is invalid for the whole calculation period.
July 2017		3.0	Corrected table in the heading pages and added references to records 1018 and 1019

			in section 1 (correcting the other reference numbers).
		3.1	Corrected the inconsistency in the notes at the end of section 2.1.2.2 (functionality to be mandated in WITS-DNP3 V3.1). Added notes to 2.1.2.17 (functionality to be mandated in WITS-DNP3 V3.1).
February 2022			Addition of Calculate point IC message to Section 1. Addition of Section 2.1.2.21 to explain the Calculated Point IC record. Addition of appropriate error messages to Section 2.2.

2.3.3 Overview topic 1, add to the table preceding section 1:

6	3.1	2020	Calculated Point	Introduced

2.3.4 Overview topic 1, add the following to the list items in section 1:

- Calculated Point [29] (see section 2.1.2.21)

Also add footnote 29 to read "[29] Protocol versions 3.1 and higher"

2.3.5 Add new Section 2.1.2.21 as shown:

2.1.2.21 Record Type 1020 – Calculated Point

This record is only defined in protocol versions 3.1 and higher.

This configuration record defines a point whose value is calculated using instructions which are also defined in the record. The calculation may use the values, object flags or states of other points on the Field Device.

This is a new record that is defined in Incremental Configuration file format version number 6. The record is defined using the following format:

Table 2-29, Record Type 1020 – Calculated Point

Element No.	Information	Type	Size	Description
1	Record Type	Unsigned Integer	2 bytes	Unique type identifier for this record type, always 1020.
2	Byte Count	Unsigned Integer	2 bytes	Number of bytes remaining in this record, 4+n.
3	Point Type	Unsigned Integer	1 byte	Point type defined as DNP3 group types.
4	Point Number	Unsigned Integer	2 bytes	Point Number.
5	Execution Strategy	Unsigned integer	1 byte	The execution strategy for the calculated point.
6	Period	Unsigned integer	2 bytes	Period in minutes.
7	Offset	Unsigned integer	2 bytes	Offset in minutes.
8	Expression	Unsigned Integer	n bytes	The calculation expression.
			8+n or 12+n bytes	**Total size.**

Point Type (Element 3)

The point type is the type of point using standard DNP3 group types. Supported groups are 1 or 30.

Point Number (Element 4)

The point number must represent a valid point within the Field Device. This is the point whose value will be calculated using the defined expression.

Execution Strategy (Element 5)

The execution strategy for the calculated point. The calculated point value is updated whenever called for by an execution strategy. One or more execution strategies can apply to an individual calculated point at any one time. The various strategies are specified as a byte of "flag" bits, with 1 meaning the execution strategy applies and 0 that it does not:

- Bit 0: Periodic. Update the calculated point on a regular timed basis. The period and offset of the periodic calculation are specified in the period and offset elements, which are only present if this bit is set.
- Bit 1: Source value change. Update the calculated point when the value of any point referenced in the calculation changes.
- Bit 2: Source DNP3 object flags change. Update the calculated point when the DNP3 object flags of any point referenced in the calculation changes.
- Bit 3: Source state change. Update the calculated point when the state of any point referenced in the calculation changes.
- Bit 4: Lazy. Update the calculated point when the value of the point is required. For example, when a Master Station requests the value or when the Field Device requires the input for logging or for assessment of a point state.
- Bits 5 – 7: reserved

Period (Element 6)

The period defines the period (in minutes) between successive calculations of the point value. The value must be in the range 1-10080 (inclusive). This allows a minimum period of 1 minute and a maximum period of 1 week.

This element is only present if the Execution Strategy includes Periodic (bit 0 is set to 1).

Offset (Element 7)

The offset defines the offset (in minutes) from the start of the week to which the periodic calculations should be aligned. WITS always uses offsets from the start of the week which begins on Monday morning at 00:00. The value must be in the range 0-10079 (inclusive).

This element is only present if the Execution Strategy includes Periodic (bit 0 is set to 1).

Expression (Element 8)

The expression to be used in calculating the value for the point. The entire expression is encoded using Polish Notation (operators precede operands, also known as prefix notation). In the descriptions in this document operators are known as bytecodes, operands are known as parameters and an individual part of an expression (bytecode together with zero or more parameters) is termed an instruction. It is possible for a parameter within an instruction to be a further instruction with its own bytecode and parameters, allowing for complex expressions.

The bytecodes are documented below in the form of a table, showing the bytecode, stack before, stack after and a description of the operation. Each instruction has up to four values: the bytecode, and zero to three parameters needed by that instruction. Each instruction expects up to three values to be on the stack prior to execution, and after execution these will have been replaced with a single result value on the stack.

Byte Code	Example Syntax	Type	Parameter 1	Parameter 2	Parameter 3	3rd down on stack	2nd down on stack	Top of stack	Result on stack	Description
0	-1337	Integer Literal	Integer value (signed 4 octets)						Number	Integer literal left on top of the stack
1	3.14	Floating point literal	Floating point value (4 octets IEEE)						Number	Floating point literal left on top of the stack
10	"AI1"	Source point value	DNP3 OG number (unsigned 1 octet)	Point Number (unsigned 2 octets)					Number	Point value is read and placed on top of the stack. If the point has never been read, 0 is used
11	Q("AI1",3)	Source point DNP3 object flag	DNP3 OG number (unsigned 1 octet)	Point Number (unsigned 2 octets)	Bit number (0-7) within DNP3 object flags (unsigned 1 octet)				Number	Point DNP3 object flag value is read and placed on top of the stack as 0 or 1.
12	T("AI1")	Source point timestamp	DNP3 OG number (unsigned 1 octet)	Point Number (unsigned 2 octets)					Number (unsigned 6 octets)	Epoch time (seconds since 1/1/1970, as per DNP3) of last point update is placed on top of the stack. If never processed, 0 is used
20	-	Unary minus						Number	-Number	Negate number on top of stack
30	+	Add					Number1	Number2	Number1 + Number2	Add two numbers and place on top of stack
31	-	Subtract					Number1	Number2	Number1 - Number2	
32	*	Multiply					Number1	Number2	Number1 * Number2	
33	/	Divide					Number1	Number2	Number1 / Number2	
34	**	Power					Number1	Number2	Number1 ** Number2	
35	MOD	Modulo					Number1	Number2	Number1 MOD Number2	Remainder after division
40	NOT	Logical NOT						Number	Not Number	All logical operators treat zero as false and non-zero as true. The NOT value of a number will be 0 or 1
50	OR	Logical					Number1	Number2	Number1 OR Number2	

Byte Code	Example Syntax	Type	Parameter 1	Parameter 2	Parameter 3	3rd down on stack	2nd down on stack	Top of stack	Result on stack	Description
51	AND	Logical					Number1	Number2	Number1 AND Number2	
52	XOR	Logical					Number1	Number2	Number1 XOR Number2	
53	XNOR	Logical					Number1	Number2	Number1 XNOR Number2	
60	IIF	Immediate If				Test	Number1	Number2	Number	If Test is true, result is Number1, else Number2
70	ABS	Absolute Value						Number1	Number	If Number1 is negative, return -Number1
71	INT	Integer						Number1	Number	The integer version of Number (truncation)
80	MAX	Return largest of two numbers					Number1	Number2	Number	The result is the largest of the two parameters
81	MIN	Return smallest of two numbers					Number1	Number2	Number	The result is the smallest of two parameters
90	=	Equal to					Number1	Number2	Number	Result is the Boolean evaluation of Number1 = Number2 (false is zero, true is one)
91	!=	Not equal to					Number1	Number2	Number	Result is the Boolean evaluation of Number1 != Number2 (false is zero, true is one)
92	>	Greater than					Number1	Number2	Number	Result is the Boolean evaluation of Number1 > Number2 (false is zero, true is one)
93	>=	Greater than or equal to					Number1	Number2	Number	Result is the Boolean evaluation of Number1 >= Number2 (false is zero, true is one)
94	<	Less than					Number1	Number2	Number	Result is the Boolean evaluation of Number1 < Number2 (false is zero, true is one)
95	<=	Less than or equal to					Number1	Number2	Number	Result is the Boolean evaluation of Number1 <= Number2 (false is zero, true is one)
100	TimeWeekDay (z)	Day of week						Number1 (epoch seconds)	Number (day of week)	Get the day of week from the Epoch in WITS format 1-7 (Mon-Sun)

Byte Code	Example Syntax	Type	Parameter 1	Parameter 2	Parameter 3	3rd down on stack	2nd down on stack	Top of stack	Result on stack	Description
101	TimeHour(z)							Number1 (epoch seconds)	Number	0-23
102	TimeMin(z),							Number1 (epoch seconds)	Number	0-59
103	TimeSec(z),							Number1 (epoch seconds)	Number	0-59
104	TimeDay(z)							Number1 (epoch seconds)	Number	1-31
105	TimeMonth(z)							Number1 (epoch seconds)	Number	1-12
106	TimeYear(z)							Number1 (epoch seconds)	Number	The year e.g. 2022
107	TimeEpoch								Number (unsigned 6 octet)	Count of seconds since Jan 01 1970 UTC, as per DNP3
120	Previous()								Number	Get the value of this calculated point which is about to be overwritten

Note 1: A bytecode is defined as an unsigned 1-octet integer.

Note 2: All unused bytecodes are reserved for future WITS use.

The length of the expression must be at least 1 byte and must not exceed n bytes, where n is defined in the Device Profile as 1.17.2 Maximum number of bytes per calculation.

Notes on calculation

Support for this IC record is optional for a Field Device, the Field Device's Device Profile indicating support or not.

The calculation of a point value commences when determined by one of the execution strategies which apply to the calculated point.

After calculation a single result value will be present on the stack. An expression is not valid if this is not the case. The format of the single result of an instruction can normally be inferred from the instruction and parameter types. The result format will be given in at least the format shown in the table below. Operands A and B can appear in any order and m < n.

Operand A Type	Operand B type	Minimum result type
signed int (m octets)	signed int (m octets)	signed int (m octets)
signed int (m octets)	signed int (n octets)	signed int (n octets)
unsigned int (m octets)	unsigned int (m octets)	unsigned int (m octets)
unsigned int (m octets)	unsigned int (n octets)	unsigned int (n octets)
signed int (m octets)	unsigned int (m octets)	unsigned int (m octets)
signed int (m octets)	unsigned int (n octets)	unsigned int (n octets)
Any int	float	float

Any under or overflow in the operation will cause the DNP3 object flag OVERRANGE to be set for appropriate point types, the point value should be set as directed in Note 4 of Section 11.1.6.1.1 of the DNP3 specification (IEEE Std 1815-2010) and utilising normal WITS scaling to derive the matching engineering value.

Calculated points may be subject to limit processing as any other point of that type is, this includes the handling of persistence and hysteresis.

For logical operations a value of 0 is taken to be false and a non-zero value is taken to be true. The result of a logical operation will be 1 for true and 0 for false.

Calculated points may use the value of other points in calculation. Those point must be of the following type/Object Groups:

- Object Group 1 – Binary Input
- Object Group 3 – Double Bit Binary Input
- Object Group 10 – Binary Output
- Object Group 20 – Counter
- Object Group 30 – Analogue Input
- Object Group 40 – Analogue Output Status

For binary inputs and outputs, the value 0 or 1 will be used to represent the value.

Where logical operation results or binary values are used, the 0 or 1 will be encoded as an integer literal with value 0 or 1, respectively.

For double bit binary inputs, the values 0, 1, 2 or 3 as defined by DNP3 will be encoded as an integer literal with value 0, 1, 2 or 3 respectively.

Calculated points may not use other calculated points within their calculations.

Care should be taken when configuring a calculated point with only a Lazy execution strategy if the point is not logged, uses states but does not use persistence. With persistence configured the

calculated point will be recalculated at no less than the persistence resolution interval and state changes will become apparent. Likewise with logging configured but no persistence configured the point will be recalculated at the logging interval and state changes will become apparent. With no persistence or logging configured then the point is only recalculated when read.

Irrespective of the execution strategy, the value of the calculated point and its DNP3 object flags will be updated once on the application of any IC containing the Calculated Point (1020) record for this point.

The bytecode table suggests a simple format for expression of the calculations in the “Example Syntax” column. However, the format of the calculation language may be specific to the Master Station and/or Field Device Configuration Application provided by the vendor. For example, the calculation may be specified using Master Station point names; or may use a syntax created from the point type and point address. It is the bytecode which is common. This document defines the bytecodes to be used irrespective of any language used to express the calculation to a user.

The bytecodes do not support any bitwise operators.

The bytecodes do not support parentheses as the Polish Notation takes care of this.

There is no support for local time. All times are based on UTC as defined in both DNP3 and WITS.

Notes on point DNP3 object flag handling

All calculated points will have DNP3 object flags as per any other DNP3 point. The rules for calculation of those flags are given below:

- If a calculated point is not ONLINE or its RESTART flag is set then no calculation need be performed for that point.
- ONLINE for a calculated point will be the logical AND of all ONLINE flags for every point in the calculation together with the On Scan status of the calculated point. Therefore, if any of the contributing points are not ONLINE/On Scan then the calculated point will not be ONLINE, also, if the calculated point is set to Off Scan then it will not be ONLINE.
- RESTART for a calculated point will be the logical OR of all RESTART flags for every point in the calculation. If any point in the calculation has not had RESTART reset then RESTART will be set for the calculated point and hence the value should be disregarded.
- COMMS_LOST, REMOTE_FORCED and LOCAL_FORCED for a calculated point will be the logical OR of the same flags for every point in the calculation. It is not possible to set these for any other reason for the calculated point, they are dependent entirely on the source points.
- CHATTER_FILTER, ROLLOVER, DISCONTINUITY, OVERRANGE and REFERENCE_ERR share bits 5 and 6 of the DNP3 object flags. Calculated points are either a binary or analogue point, hence the following rules will be used.
    - For a binary calculated point CHATTER_FILTER will be the logical OR of the same flag for all binary points used in the calculation.
    - For an analogue calculated point OVERRANGE will be the logical OR of the same flag in all analogue points used in the calculation, OR’d with the overrange indication resulting from the calculation. So, for instance, if a calculation multiplies two source numbers together and gets an answer out of range then the OVERRANGE flag would be set irrespective of the state of the source points.
    - For an analogue calculated point REFERENCE_ERR will be set to the logical OR of the same flag for all analogue points used in the calculation.
    - ROLLOVER and DISCONTINUITY will never be used.
- STATE (for a binary only) occupies bit 7 of the DNP3 object flags. The STATE flag for a calculated binary point will be the calculated value of the point.

- At startup and before any calculation is performed, the default value of all flags will be 0, apart from RESTART which will be set to 1.
- Where a calculation uses source points which have a different point type to the calculated point, the flags of the calculated point will be determined only from those flags in the source points which match those in the calculated point. Where appropriate, it is recommended that calculations separately deal with non-matching DNP3 object flags.

Notes on IC actions on calculated points

All calculated points can be the subject of IC record types as defined below and as appropriate given the capabilities specified in the Device Profile of the Field Device.

- The following point scope IC record types will operate successfully against a calculated point (if supported for the calculated point type in the device profile):
    - Record Type 1000 – Point On/Off Scan
    - Record Type 1002 – Analogue Range/Scaling (analogue calculated points only).
    - Record Type 1003 – Analogue Limits (analogue calculated points only)
    - Record Type 1005 – Point Archives
    - Record Type 1006 – Binary States (binary calculated point only)
    - Record Type 1007 – Profile (analogue calculated points only)
    - Record Type 1008 – Rate of Change (analogue calculated points only)
    - Record Type 1009 – DNP3 Object Flag Actions
    - Record Type 1010 – Minimum (analogue calculated points only)
    - Record Type 1011 – Maximum (analogue calculated points only)
    - Record Type 1012 – Mean (analogue calculated points only)
    - Record Type 1013 – Integral (analogue calculated points only)
    - Record Type 1014 – State Counter
    - Record Type 1015 – State Runtime
    - Record Type 1017 – High Speed Sampled Data (analogue calculated points only)
    - Record Type 1018 – Incident Logs
    - Record Type 1019 – Significant Change Values
- Use of any other IC record types will result in a failure of that specific IC record and hence of the whole IC file. A specific error message will be allocated for such a failure.
- Only 1 to 1 scaling will be accepted for analogue points, anything else will result in an error with code 17. This Record Type (1002) is preserved for configuring the over and under range values only for the calculated point.

Example

This section presents an example of a calculation, how it is encoded and how it could be calculated. Please note that the method of calculation is vendor dependent and need not follow the example shown here.

The example calculation expression takes the average of two analogue points (AI1 and AI2) using the calculation below:

Calculated Point Value = (AI1 + AI2) / 2

This expression would be encoded as follows:

Instruction	Bytecode	Syntax	Type	Parameter 1	Parameter 2
1	33	/	Divide	Instruction 2	Instruction 5
2	30	+	Add	Instruction 3	Instruction 4
3	10	AI1	Source Point Value (SPV)	30 (Object Group)	1 (DNP3 point number)
4	10	AI2	Source Point Value (SPV)	30 (Object Group)	2 (DNP3 point number)
5	0	2	Integer Literal (IL)	2	

Within the IC this would appear as shown in the "Encoded value in IC" column below. The interpretation to the right shows how the eventual calculation would be performed.

<table>
<tr><th rowspan="2">Bytes in IC</th><th rowspan="2">Encoded value in IC</th><th colspan="3">Results of</th></tr>
<tr><th>Instructions 3, 4 & 5</th><th>Instruction 2</th><th>Instruction 1</th></tr>
<tr><td>33 (0x021)</td><td>/</td><td colspan="2">/</td><td rowspan="14">(AI1 + AI2) / 2</td></tr>
<tr><td>30 (0x01E)</td><td>+</td><td>+</td><td rowspan="13">AI1 + AI2</td></tr>
<tr><td>10 (0x0A)</td><td>SPV</td><td rowspan="4">AI1</td></tr>
<tr><td>30 (0x01E)</td><td>30</td></tr>
<tr><td>1 (0x01)</td><td rowspan="2">1</td></tr>
<tr><td>0 (0x0)</td></tr>
<tr><td>10 (0x0A)</td><td>SPV</td><td rowspan="4">AI2</td></tr>
<tr><td>30 (0x01E)</td><td>30</td></tr>
<tr><td>2 (0x02)</td><td rowspan="2">2</td></tr>
<tr><td>0 (0x0)</td></tr>
<tr><td>0 (0x0)</td><td>IL</td><td colspan="2" rowspan="5">2</td></tr>
<tr><td>2 (0x02)</td><td rowspan="4">2</td></tr>
<tr><td>0 (0x0)</td></tr>
<tr><td>0 (0x0)</td></tr>
<tr><td>0 (0x0)</td></tr>
</table>

Which is equivalent to the following 15 byte hex sequence in IC:

```
21 1E 0A 1E 01 00 0A 1E 02 00 00 02 00 00 00
```

2.3.6 Add the following rows and notes to the end of Table 2-30 in Section 2.2

71	1018 (note 3)	Invalid duration (e.g. zero seconds).
72	1018 (note 3)	Field Device does not support remote setting of incident log parameters.
73	1019 (note 3)	Invalid significant change value (e.g. a negative value).
74	1019 (note 3)	Field Device does not support remote setting of significant change parameters.
75	1020 (note 4)	Invalid calculation point point number. Point number is already in use, not configured or is not a virtual point in this Field Device.
76	1020 (note 4)	Source point in calculation does not exist
77	1020 (note 4)	Invalid period
78	1020 (note 4)	Invalid offset
79	1020 (note 4)	Invalid expression
80	1020 (note 4)	Expression is too long
81	1020 (note 4)	IC record does not apply to calculated point
82	1020 (note 4)	Field Device does not support calculated points

Notes:

1. Protocol versions 1.2 / 2.0 and higher
2. Protocol versions 1.3 / 2.1 and higher
3. Protocol versions 3.0 and higher
4. Protocol versions 3.1 and higher

2.4 AN2007-001

Make the following changes to AN2005-004, in addition to those made by TB#62.

2.4.1 Change the "Title Page" as shown:

Revision 1.78

March 2016February 2022

2.4.2 Add to the "Change History" as shown:

Date	Revision	WITS-DNP3 Version	Details
March 2016	1.7	3.0	Merged SAv2 and SAv5 streams back together. Added a section to 4.8, detailing an optimised use of the protocol. Added IC records 1018 and 1019 to table 4-1
July 2017	1.8	3.1	Added a note about BCF file names and use of underscore and period characters to section 3.1.1.
February 2022			Update Table 4-1 in Section 4.4 to include Calculated Points

2.4.3 Modify Table 4-1 in Section 4.4 as shown:

Record Type	Conditions under which a record of this type may be omitted
1019 - Significant change of value [34]	This point is not configured for significant change of value processing
1020 - Calculated Point [35]	This point is not configured as a calculated point

Note that a footnote should be added with the following text "[35] Protocol versions 3.1 and higher".

2.5 Device Profile

Make the following changes to the WITS Device Profile and the supporting XML suite.

2.5.1 Change the "Title Page" as shown:

Protocol Version	XML suite version
1.1	1.3
1.2 / 2.0	1.4
1.3 / 2.1	1.5
3.0	1.6
3.1	1.7

2.5.2 Add new section as shown:

This section of the Device Profile is only supported in protocol versions 3.1 and higher.

1.17 CALCULATED POINTS	Capabilities
1.17.1 Supports calculated points:	☐ Yes ☐ No
1.17.2 Maximum number of bytes per calculation: *Indicates the maximum number of bytes that may be used to represent a single calculation. The number includes the bytecodes for each instruction and all bytes used to encore the instructions parameters.* *Enter zero if calculated points are not supported.*	

3 Changes to the Test Specification

Make the following changes to version 3.1 of the Test Specification, in addition to those made by TB#61 and TB#62:

3.1 Housekeeping

3.1.1 Change the "Title Page" as shown:

Revision 3.12

June 2016 February 2022

3.1.2 Change the revision history as shown:

June 2017	3.2	All	Added more details of expected results to extended data points for the case when there are no valid source point values.
July 2017		All	Corrected the expected result of test 2.5.11.13 Added tests to 2.12 to ensure comms sessions start with a NULL unsolicited message from a FD.
		3.1	Added tests 2.5.9.15 to 2.5.9. (point overrides)
February 2022		3.1	Updated with tests for calculated points (TB#63.3)

3.2 Add Section 2.17 as shown

2.17 Calculated point

This section if for protocol versions 3.1 and higher.

The support for calculated points is optional in WITS devices, the support being indicated by the device's WITS Device Profile. If the Device Profile shows that calculated points are not supported then skip this section of the test specification.

2.17.1 Periodic calculation

Purpose of tests:

To verify that the Master Station can configure the Field Device with a periodically calculated point.

References in WITS Application Notes:

Application Note	Section
AN2005-006	2.1.2.21 (Record Type 1020 – Calculated Point)

Initial conditions:

These tests require the Field Device and Master Station to have suitable configuration to start communications.

These tests require two analogue inputs (DNP3 object group 30) to be configured on the device, where the value of each can be set during the test. AI0 and AI1 are used as inputs to the calculation during this test description.

Test procedures:

Test	Test procedure	Expected result	MS result	FD result
2.17.1.1	Download and activate an incremental configuration file to configure a calculated point, based on the two available analogue inputs which calculates their sum, using record type 1020. In these records, set the parameters to be as follows: • Any valid unused "analogue input point number" • An execution strategy of periodic • A period of 3 minutes and offset of 0 minutes • An expression of AI0 + AI1	The IC is downloaded, and the activate request is successful.		

Test	Test procedure	Expected result	MS result	FD result
2.17.1.2	Poll the point values on the FD.	The Calculated point values is the sum of AI0 and AI1.		
2.17.1.3	Change the value of points AI0 and AI1 so that the sum AI0 + AI1 will be different to the previous sum. Wait a further three minutes. Poll the point values on the FD	The calculated point value is the new sum of AI0 and AI1		
Notes:				
Tested by:		Date:		

2.17.2 Source state change calculation

Purpose of tests:

To verify that the Master Station can configure the Field Device with a calculated point which is updated when its source state changes.

References in WITS Application Notes:

Application Note	Section
AN2005-006	2.1.2.21 (Record Type 1020 – Calculated Point)

Initial conditions:

These tests require the Field Device and Master Station to have suitable configuration to start communications.

These tests require two analogue inputs (DNP3 object group 30) to be configured on the device. Each analogue input should have at least one point limit configured to allow for two states to be entered. The action on entering any state should be set to 2 (create an Analogue Event Data Set). The points, AI0 and AI1 are used as input to the calculation during this test description.

Test procedures:

Test	Test procedure	Expected result	MS result	FD result
2.17.2.1	Download and activate an incremental configuration file to configure a calculated point, based on the two available analogue inputs which computes their sum, using record type 1020. In these records, set the parameters to be as follows: • Any valid unused “analogue input point number” • An execution strategy of on state change • An expression of AI0 + AI1	The IC is downloaded, and the activate request is successful.		
2.17.2.2	Poll the point values on the FD.	The calculated point value is the sum of AI0 and AI1.		
2.17.2.3	Change the value of point AI0 so that it does not cross any limit. Poll the FD.	There should be no events and the calculated point value should be the same as before and not the sum of the new AI0 and AI1 values.		
2.17.2.4	Change the value of the point AI0 so that it does cross a limit. Poll the FD.	There should be an event for the AI0 state transition and the calculated point value should have changed. The new value may not be the sum of AI0 and AI1 depending upon what changes were made to the AI0 value after state transition, but the value should reflect AI0 being the appropriate side of the limit.		
2.17.2.5	Change the value of the point AI1 so that it does not cross a limit. Poll the FD.	There should be no events and the calculated point value should be the same as before and not the sum of the new AI0 and AI1 values.		
2.17.2.6	Change the value of the point AI1 so that it does cross a limit. Poll the FD,	There should be an event for the AI1 state transition and the calculated point value should have changed. The new value may not be the sum of AI0 and AI1 depending upon what changes were made to the AI1 value after state transition, but the value should reflect AI1 being the appropriate side of the limit.		

Test	Test procedure	Expected result	MS result	FD result
Notes:				
Tested by:		Date:		

2.17.3 Lazy calculation

Purpose of tests:

To verify that the Master Station can configure the Field Device with a lazily calculated point.

References in WITS Application Notes:

Application Note	Section
AN2005-006	2.1.2.21 (Record Type 1020 – Calculated Point)

Initial conditions:

These tests require the Field Device and Master Station to have suitable configuration to start communications.

These tests require a single binary input (DNP3 object group 1) to be configured on the device, where the value of that point can be set during the test. DI0 is used as the input to the calculation during this test description.

Test procedures:

Test	Test procedure	Expected result	MS result	FD result
2.17.3.1	Download and activate an incremental configuration file to configure a calculated point, based on the available binary inputs which calculates the inverse, using record type 1020. In these records, set the parameters to be as follows: • Any valid unused “binary input point number” • An execution strategy of lazy • An expression of !DI0	The IC is downloaded, and the activate request is successful.		

Test	Test procedure	Expected result	MS result	FD result
2.17.3.2	Poll the point values on the FD.	The calculated point values is the inverse of DI0.		
2.17.3.3	Change the value of point DI0 Poll the point values on the FD	If it is possible to view the value of the calculated point on the FD without it changing, then observe that it has not changed prior to the FD being polled. The calculated point value is the inverse of DI0		
Notes:				
Tested by:		Date:		

2.17.4 Multiple execution strategy calculation

Purpose of tests:

To verify that the Master Station can configure the Field Device with a calculated point which uses multiple execution strategies.

References in WITS Application Notes:

Application Note	Section
AN2005-006	2.1.2.21 (Record Type 1020 – Calculated Point)

Initial conditions:

These tests require the Field Device and Master Station to have suitable configuration to start communications.

These tests require two analogue inputs (DNP3 object group 30) to be configured on the device. Each analogue input should have at least one point limit configured to allow for two states to be entered. The action on entering any state should be set to 2 (create an Analogue Event Data Set). The points, AI0 and AI1 are used as input to the calculation during this test description.

Test procedures:

Test	Test procedure	Expected result	MS result	FD result
2.17.4.1	Download and activate an incremental configuration file to configure a calculated point, based on the two available analogue inputs which computes their sum, using record type 1020. In these records, set the parameters to be as follows: • Any valid unused “analogue input point number” • An execution strategy of periodic and on state change • A period of 3 minutes and offset of 0 minutes • An expression of AI0 + AI1	The IC is downloaded, and the activate request is successful.		
2.17.4.2	Poll the point values on the FD.	The calculated point value is the sum of AI0 and AI1.		
2.17.4.3	Change the value of point AI0 so that it does not cross any limit and within the aligned three minute period poll the FD.	There should be no events and the calculated point value should not have changed.		
2.17.4.4	Wait for the three minutes. Poll the FD	There should be no events but the calculated point values should have changed to be the sum of AI0 and AI1.		
2.17.4.5	Change the value of the point AI0 so that it does cross a limit and within the aligned three minute period poll the FD.	There should be an event for the AI0 state transition and the calculated point value should have changed. The new value may not be the sum of AI0 and AI1 depending upon what changes were made to the AI0 value after state transition, but the value should reflect AI0 being the appropriate side of the limit.		
2.17.4.6	Wait for three minutes. Poll the FD.	There should be no events and the calculated point value should be the sum of the AI0 and AI1 values.		
Notes:				
Tested by:		Date:		

2.17.5 Expression too long

Purpose of tests:

To verify that the Master Station fails to configure the Field Device with calculated points when an expression is too long.

This test may only be possible using a test harness if the Master Station does not permit such a message to be sent.

References in WITS Application Notes:

Application Note	Section
AN2005-006	2.1.2.21 (Record Type 1020 – Calculated Point)

Initial conditions:

These tests require the Field Device and Master Station to have suitable configuration to start communications.

These tests require two analogue inputs (DNP3 object group 30) to be configured on the device, where the value of each can be set during the test. AI0 and AI1 are used as inputs to the calculation during this test description.

Test procedures:

Test	Test procedure	Expected result	MS result	FD result
2.17.5.1	Download and activate an incremental configuration file to configure a calculated point, based on the two available analogue inputs which calculates their sum, using record type 1020. In these records, set the parameters to be as follows: • Any valid unused “analogue input point number” • An execution strategy of periodic • A period of 3 minutes and offset of 0 minutes • An expression of AI0 + AI1 + 1 … + 1. Keep adding literal addition until the size of the expression exceeds the maximum permitted length of expression in the Device Profile.	The IC is downloaded, and the activate request fails showing the error 80.		

Test	Test procedure	Expected result	MS result	FD result
Notes:				
Tested by:		Date:		

2.17.6 Invalid point in expression

Purpose of tests:

To verify that the Master Station fails to configure the Field Device with a calculated point when an expression uses a non-existing point.

This test may only be possible using a test harness if the Master Station does not permit such a message to be sent.

References in WITS Application Notes:

Application Note	Section
AN2005-006	2.1.2.21 (Record Type 1020 – Calculated Point)

Initial conditions:

These tests require the Field Device and Master Station to have suitable configuration to start communications.

Test procedures:

Test	Test procedure	Expected result	MS result	FD result
2.17.6.1	Download and activate an incremental configuration file to configure a calculated point, based on a non-existing analogue input, using record type 1020. In these records, set the parameters to be as follows: • Any valid unused “analogue input point number” • An execution strategy of periodic • A period of 3 minutes and offset of 0 minutes • An expression of AIx + 1 where x is an undefined point on the FD.	The IC is downloaded, and the activate request fails showing the error 76.		

Test	Test procedure	Expected result	MS result	FD result
Notes:				
Tested by:		Date:		