DLMS TECHNICAL MANUAL

GENERAL DESCRIPTION

DLMS is the family name of DigiCell/DigiTerm devices and DLMS software. DLMS is the abbreviation of **D**igital **L**oad **M**easurement **S**ystem.

COMMUNICATION

Physical Layer

There are two implementations devised for communicating in DLMS system;

1- RS232C compatible 3 wire communications (implemented to be used in Half-Duplex mode)
2- RS485 compatible 2 wire communications (Half-Duplex)

PC compatible devices has single or multiple RS232C ports
DigiTerm has 2 ports (RS232C as slave, RS485 as master)
DigiCell has 1 RS485 port

Universal RS232C/RS485 Converters must be devised for signal conversion between these protocols.

DIGICELL RS485 SPECIFICATIONS

Media	RS-485 (2 wired half duplex)
Protection	Automotive class Protection of A & B Lines via varistors.
Isolation	Communication lines are not isolated from supply voltage. Isolation between supply voltage and the internal power supply.
Termination	No internal termination or polarization (End-Device Must be terminated externally).

DIGITERM RS485 SPECIFICATIONS

Media	RS-485 (2 wired half duplex)
Protection	Automotive class Protection of A & B Lines via varistors.
Isolation	No isolation.
Termination	Review

Data Layer

RS232C Framing deviced for communications.

Baudrates	1200,2400,4800,9600
Parity	None,Odd,Even
Data Bits	7,8
Stop Bits	1,2
Limitations of communications Setup	Combination 2 stop, 8 bit, parity is not allowed Combination 1 stop, 7 bit, no parity is not allowed

Application Layer

SLAVE SPECIFICATIONS (DigiTerm Slave Port & DigiCell devices)

Protocol	MODBUS SLAVE ASCII or MODBUS SLAVE RTU
Response time	**Additional delay before response:** 0-31.5ms Selectable 500uS steps in 9600BPS 0-63.5ms Selectable 500uS steps in 4800BPS 0-127ms Selectable 500uS steps in 2400BPS 0-255ms Selectable 1mS steps in 1200BPS
Timeout	**Timeout utilized as reply timeout in RTU protocol (slave replies after the timeout specified) Utilized as cancel/error timeout for ASCII protocol (slave terminates communication if there is no EOL character received after last character reception)** 1.5ms-31.5ms Selectable 500uS steps in 9600BPS 3ms-63.5ms Selectable 500uS steps in 4800BPS 6ms-127ms Selectable 500uS steps in 2400BPS

	12ms-255ms Selectable 1mS steps in 1200BPS
Reply Timing Error	+2mS maximum

MASTER SPECIFICATIONS (DigiTerm Master Port)

Protocol	MODBUS MASTER ASCII or MODBUS MASTER RTU
Response time	**Initial delay before any transmission after last reception:** 0-31.5ms Selectable 500uS steps in 9600BPS 0-63.5ms Selectable 500uS steps in 4800BPS 0-127ms Selectable 500uS steps in 2400BPS 0-255ms Selectable 1mS steps in 1200BPS
Timeout	**Time-out for valid reception after the last data sent** 1.5ms-31.5ms Selectable 500uS steps in 9600BPS 3ms-63.5ms Selectable 500uS steps in 4800BPS 6ms-127ms Selectable 500uS steps in 2400BPS 12ms-255ms Selectable 1mS steps in 1200BPS

AVAILABLE MODBUS COMMANDS

3	Read holding registers
6	Preset single register
16	Preset multiple registers

LIMITATIONS FOR MODBUS

DigiCell Buffer Size	**30 bytes can be written or read in one ModBus cycle** Each ASCII number (2 chars) treated as 1 byte Each byte of RTU byte trated as 1 byte
DigiTerm Buffer Size	**100 bytes either for slave and master** (Totally 4 x 100 bytes for internal proxy server) Each byte input to the device our output treated as 1 byte.

Communication when parameters are unknown in DigiCell

Forced Initialization of communications: When device is powered on, the communications will be in the communications state as read form EEPROM. In first power-up; The device will be automatically go to a fixed state, but if any hardware problem occurs during the first power-up, it may be initialized to a unknown state.. If the communications are in an undetermined state due to any reason; in order to communicate with the device the following procedure must be applied.

Apply valid 0 signal (mark) to RS-485 port more than 3 seconds. The device will go into the fixed state after this hardwiring. As an easier way you can reverse A-B lines on communication bus (while devices not communicationg via this bus). This operation does not effect the communication parameters stored in devices non-volatile memory (EEPROM). It only fixes the communication temporarily to a known (fixed) state. The master software must write communication parameters to the EEPROM and the device must be reset (powered off an powered on) to operate with the new parameters in EEPROM.
The fixed state of the communication is **RTU, 1200 BPS, 8 bit Data, NoParity, One Stop**

Some specific conditions for EEPROM: All parameters are read from EEPROM and device operates due to these values with the following exceptions:

- Only communication will operate if an empty (All locations are FF) EEPROM is used. The reference value enabling measurement read and performing calculations is the filter size. All measurement functions are skipped if it is set to 255 (FF); as the first power up. Any other value enables the system for read & calculate.
- EEPROM cannot be written for 500mS after power-up.
- EEPROM cannot be written unless Program key is pressed or its input shorted to ground by the jumper on the PCB. If program key is used it functions as toggle for enable/disable.

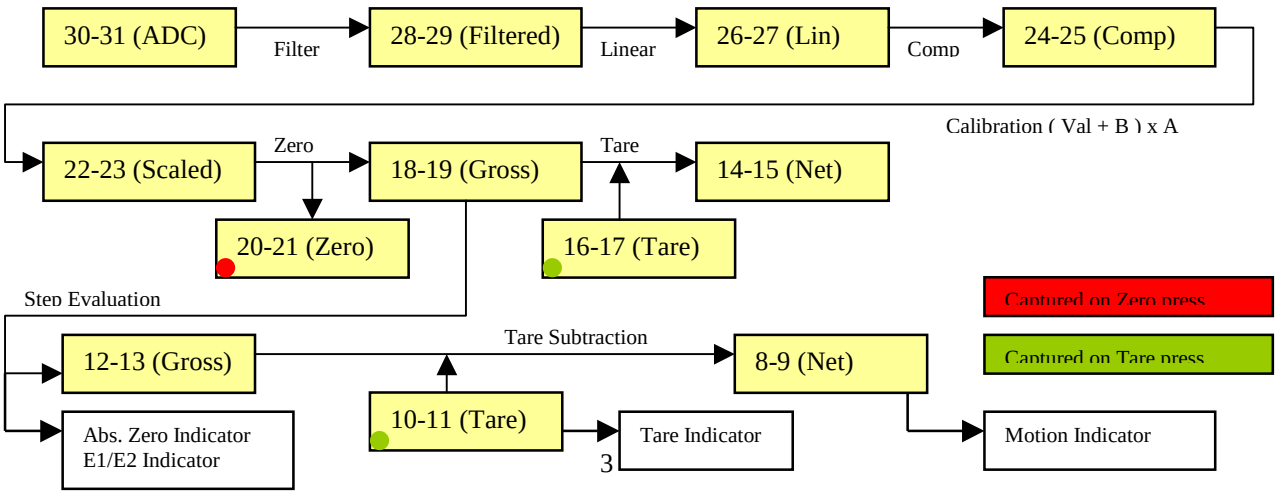
Memory Map

Only RAM can be accessed by any ModBus Master. Non-Volatile Memory (EEPROM) can only be accessed indirectly thru Command, RegA & RegB registers using procedures devised.

MODBUS DIRECT ACCESSIBLE MEMORY MAP

Register Location (16 Bits each)	Function	Device
0 (RW)	Command Register (for special functions, used with RegA &RegB)	All
1 (RW)	RegA: General purpose data register A.	All
2 (RW)	RegB: General purpose data register B.	All
3 (RO)	Temperature (Actual x 16) (Read only)	Digicell Only
4 (R/W)	Port DDR (H) /Value (L)	Digicell Only
5 (See Table)	**Status A**	All
6 (See Table)	Status B	All
7 (See Table)	Status C	All
8 (RO)	**Display value high (As displayed)**	All (2)
9 (RO)	Display value low (As displayed)	All (2)
10 (RO)	**Tare value high (As displayed)**	All
11 (RO)	Tare value low (As displayed)	All
12 (RO)	**Gross value high (As displayed)**	All (2)
13 (RO)	Gross value low (As displayed)	All (2)
14 (RO)	**Display value high (256 x load value w/o stepping)**	All (2)
15 (RO)	Display value low (256 x load value w/o stepping)	All (2)
16 (RO)	**Tare value high (256 x load value w/o stepping)**	All
17 (RO)	Tare value low (256 x load value w/o stepping)	All
18 (RO)	**Gross value high (256 x load value w/o stepping)**	All (2)
19 (RO)	Gross value low (256 x load value w/o stepping)	All (2)
20 (RO)	**User-Zero offset high**	All
21 (RO)	User-Zero offset low	All
22 (RO)	**Scaled Count high (256 x load value w/o step and Zero)**	All (1)(2)
23 (RO)	Scaled Count low word (256 x load value w/o step and Zero)	All (1)(2)
24 (RO)	**Internal Count (Lin, Comp., not scaled) High**	DigiCell Only (2)
25 (RO)	Internal Count (Lin, Comp., not scaled) Low	DigiCell Only (2)
26 (RO)	**Internal Count (Lin, not Comp., not scaled) High**	DigiCell Only
27 (RO)	Internal Count (Lin, not Comp., not scaled) Low	DigiCell Only
28 (RO)	**Internal Count (not Lin, not Comp., not scaled) High**	DigiCell Only
29 (RO)	Internal Count (not Lin, not Comp., not scaled) Low	DigiCell Only
30 (RO)	**Internal Count (ADC) High**	DigiCell Only
31 (RO)	Internal Count (ADC) Low	DigiCell Only

(RW) Read and Write enabled
(RO) Read Only, do not write
(1) DigiTerm: The Mean of gross values of connected DigiCells before DigiTerm Zero operation
(2) Returns 70 00 00 00 H on measurement failure in DigiCells



STATUS A (16 Bit, LSB to MSB)

BIT(s)	Function	Device
0-7	Percent indicator	DigiTerm only
8	Temperature disabled	Digicell Only
9	ADC Conversion failure occured (ADC Could not perform conversion in time-out interval). Must be manually cleared by user.	DigiTerm only
10	ADC Input voltage difference it too high. Must be manually cleared by user.	
11	Temperature failure occured (Sensor could not perform measurement in time-out interval). Must be manually cleared by user.	
12	ADC Input voltage difference it too high. Cleared when condition is resumed. (Has no effect when user sets to a value).	
13(RW)	Abnormal system operation flag. It is set to 1 if errornous operation occured. It means; the system restarted due to electrical problems.	
14-15	N/A	All

STATUS B (16 Bit, LSB to MSB)

BIT(s)	Function	Device
0-6	Current Step Value	All
7	Relay 1 energizing status	All
8-10	Decimal Point position (0: NoDp, 1: one from right)	All
11-14	Unit indicator (0:Kg, 1:lb, 2:t)	
15	Relay 2 energizing status	All

STATUS C (16 Bit, LSB to MSB)

BIT(s)	Function	Device
0-2 (RW)	Device ADC Gain Flags	DigiCell Only
3 (RW)	N/A	
4 (RW)	Comm. Error with connected devices.	Digiterm Only
5 (RO)	Device is in error state	Digicell Only
6 (RO)	Programming key is on on device.	All
7 (RO)	Parameter Gateway flag. It is set to 1 if gateway is open	All
8 (RO)	Device is being programmed locally	All
9 (RO)	Absolute zero flag	All
10 (RO)	No-Motion Flag	All
11 (RO)	Maximum flag	All
12 (RO)	E2 is being used	All
13-14 (RO)	N/A	
15 (RW)	Multimode (When scale type is multimode(multi-range or multi-interval)	

(RW) Read and Write enabled

(RO) Read Only, has no effect on any write

(1) For DigiTerm; Flag set if any of connected DigiCell's have failure

(2) For DigiTerm; Flag set if any of connected DigiCell's or DigiTerm itself have failure

(3) Unused flags are always zero, Do not write these bits for future compatibility

Command Register Functions

Command	Function	Device
-2	**No operation**, used for feedback of operation. Meaning: Last command refused (the operation cannot be done in current status)	All
-1	**No operation**, used for feedback of operation. Meaning: Last command failed (the operation cannot be done in current status)	All
0	**No operation**, used for feedback of operation. Meaning: Last operation was **successful**.	All
1	**Security protection key unlock.** Set Register A to **1357h** and Register B to **2192h** to unlock before executing this command. Locations 0,1 and 2 can be set within one write cycle. Key automatically relocked within 3 seconds after executing a successful key unlock command.	All
2	**Write EEPROM,** address must be placed in Register A and data in Register B. Command Register turns to 0 after write session completed (Nearly 11mS's). Command, A & B registers can be written in the same cycle. Attention!: The Keylock gateway must be unlocked by Command 1 before EEPROM write.	All
3	**Read EEPROM;** Address must be placed in Register A. Command register turns to 0 and data is placed in Register B after a successful read session completed.	All
4	**Initialize communications with loading parameters form EEPROM;** Command register turns to 0 after a successful initialization. Since the communication parameters may change after completion. The MODBUS response may be undetermined. It is suggested that the user waits 300mS's after the execution of this command, and checks if the result is satisfactory.	All
5	**Set User Zero** Accepts current value as zero if it is within the zero range.	All
6	**Set Tare** Accepts current value as Tare if tare is zero, otherwise sets the Tare to zero.	All
7	**Get Security Gateway codes** Variables will be returned in reverse order in Register A and B. The value that Will be placed in Register A is in Register B, the value that will be placed in Register B is in Register A. The user may read this values and exchange them and send as a code to unlock the protection easily.	All
8	**Get device type** Returns in RegisterA 1801: Digicell Family, 1851:DigiTerm	All
9	**Gets version number of software installed in**. Returns in RegisterA	All
10	**Transfer Operating Parameters from EEPROM to RAM.** Register A and Register B has no effect Attention! Linearity table, compensation table and Communication Parameters exluded in this function.	All
11	**Transfer tables in locations 64-141 (Linearization Table and Temperature compansation Table) from EEPROM to RAM.** Register A and Register B has no effect. Attention! Operating Parameters and Communication Parameters	DigiCell only

	exluded in this function).	
12	**Clear Failure**	All

Non-Volatile Memory Map

EEPROM can only be read or written into or updated using the procedures below;

Non-Volatile Memory Read

1- Command=3, RegA=Address to be read (Can be done within Multiple Register Write command of ModBus)
2- Check Command register (it is read as 0 if EEPROM location succesfully read)
3- Read RegB (which is the value of specified EEPROM location)

Non-Volatile Memory Write

1- Command=1, RegA=1357h, RegB=2192h (Can be done within Multiple Register Write command of ModBus)
2- Command=2, RegA=Address to be read, RegB=Data to be written into (Can be done within Multiple Register Write command of ModBus)
3- Check Command register (it is read as 0 if data is succesfully written into the EEPROM location)

Note: Step 1 opens the gateway for about 3 seconds. The user may execute this command only once if any it is obvious that arbitrary write operations can be completed in this interval.

EEPROM PARAMETER LOCATIONS (Written or read by Command register functions)

Location (8 Bits each)	**Function**	**Device**
0	**Slave Communication setup flags (LSB to MSB)** Bit 0 Device operates in fixed values if 1 Bit 1 0: RTU, 1:ASCII Bit 2 Parity enabled if 1 Bit 3 0: Even, 1:Odd, (has no effect if Bit 2 is 0) Bit 4,5 Baudrate; Bit 5,Bit 4 corresponds the baudrates: 00:1200BPS, 01:2400BPS, 10:4800BPS, 11:9600BPS Bit 6 0: One stop, 1: Double stop (2 stops) Bit 7 0: 7 bit data, 1: 8 bit data	All
1	Device ModBus number (ID)	All
2	ModBus Slave response delay (0-255); for 1200 BPS: Delay Time (mS) = Value for 2400 BPS: Delay Time (mS) = Value/2 for 4800 BPS: Delay Time (mS) = Value/4 for 9600 BPS: Delay Time (mS) = Value/8	All
3	**ModBus response timeout** (12-255); Depends on baudrate, calculated as the same that specified in **Location 2**.	All (1)
4	**Customer specific operation**, Leave always 255 unless otherwise specified by the manufacturer.	All
5	**Filter size**; Specifies the number of samples to be averaged. The value is given in 2n form; thus assigning 2 to this value means 4 samples will be avaraged and assigning 5 to this value means 32 samples will be avaraged.	DigiCell Only
6	**Filter Escape Tolerance**; value between 0-255. The content of value results as follows: Tolerance(in internal counts) = 2^(Location6+3); The tolerance ranges from 8 to 65,536.	DigiCell Only
7	**Filter Escape (reset) Counts**; if this number of samples are detected as out-of-range of tolerance, the filter will be automatically reset.	DigiCell Only
8-11*	Production date (Day, Month, YearL,YearH)	All
12*	**Full capacity (For ID only);** Actual weight in Kg's = (Lower 5 bits) x 10^(Higher 3 bits) 0 in lower bits means N/A for device	DigiCell Only
13-16*	Serial number Low to High	All
17*	Calibration software version. (Major)	All
18*	Calibration software version. (Minor)	All

19*	Calibrating Software	All
20-23*	Calibration Date (Day, Month, YearL,YearH)	All
24*	Calibration counts (Scaling)	All
25*	Input Gain, (unused bits masked) 0:Gain 200 (For gages upto 1.25mV/V) 1:Gain 100 (For gages upto 2.5mV/V) 2:Gain 50 (For gages upto 5 mV/V) 3:Gain 25 (For gages upto 10 mV/V)	DigiCell Only
26-29*	**Gain of scaled output;** (x256 gain) 0 (00000000h)<=gain<=255.9999 (FFFFFFFFh) Gain is unsigned.	DigiCell Only
30-33*	**Offset of scaled output** (4 bytes signed) Output = (input + B) x A where B is offset and A is gain of scale.	DigiCell Only
34*	**Step range type** 0: Step1 used for all operations (Single interval) 1: Multi interval (step1 below level, step2 above level) 2: Multi Range (step2 above level), reset to step1 on zero all other value accepted as 0	All
35*	Number of display steps for e1	All
36*	Number of display steps for e2	All
37-39*	Range Change Value	All
40-43*	Relative Zero	All
44*	Decimal point location for LCD (from right). Zero means no point.	All
45-47*	Maximum range for LCD (Number that will be compared with the value on LCD for MAX indication).	All
48*	Display Unit	All
49-51*	Reserved for future use	All
52-54	Relay 1 Setpoint	DigiCell Only
55-57	Relay2 Setpoint	DigiCell Only
58-59	Analog output minimum value (0-32 mA)	All
60-61	Analog output max value (0-32 mA)	All
62	Relay Energizing delay (Time is in 100^{th} of seconds, i.e. 10 is 1.1s)	DigiCell Only
63	Reserved for future use	All
64	Bus communication setup flags (Flag locations are as the same of Parameter 0)	DigiTerm Only
65	**BUS initial delay (0-255);** Delay between any reception from bus and a new transmit to the bus (calculated same as in other bus timings).	DigiTerm Only
66	**BUS response timeout** (12-255); calculated same as in other bus timings Time-out value for EOF signal in RTU mode Time-out for interval between characters before data-burst failure in ASCII mode. (except the reception of first character).	DigiTerm Only
67	Retry counts for same device on BUS before error message displayed.	DigiTerm Only
68	LCD Contrast	DigiTerm Only
69	232 port operation; Printer/Modbus	DigiTerm Only
70-81	BUS device address list (0:No device)	DigiTerm Only
82	Analog output (20mA) on gross value (0:Net, o/w:Gross)	DigiCell Only
83*	Temperature measument Disabled if nonzero	DigiCell Only
84	SetPoint1 on gross value (0:Net, o/w:Gross)	All
85	SetPoint2 on gross value (0:Net, o/w:Gross)	All
86	SetPoint1 Reversed if nonzero	All
87	SetPoint2 Reversed if nonzero	All
88*	Device has an LCD panel if nonzero	All
89-99*	Reserved for future use	All
100-135*	Linearity correction table in 6 regions as descriebed in calibration section.	DigiCell Only
150-191*	Temperature compansation table in 3 regions as descriebed in	DigiCell Only

	calibration section.	
192-255*	Reserved for future use	All
256*	Calibration Time pointer, always points the position of last record (not the byte position in the memory!) (Must be incremented by 1) Managed externally by PC.	DigiTerm Only
260-319*	Calibration Records (150 day,151 month, 152 year L, 153 year H, 154 Hour, 155 minutes) totally 6 bytes for each record, Total 6x10=60 bytes for all records. Maintained externally by PC.	DigiTerm Only

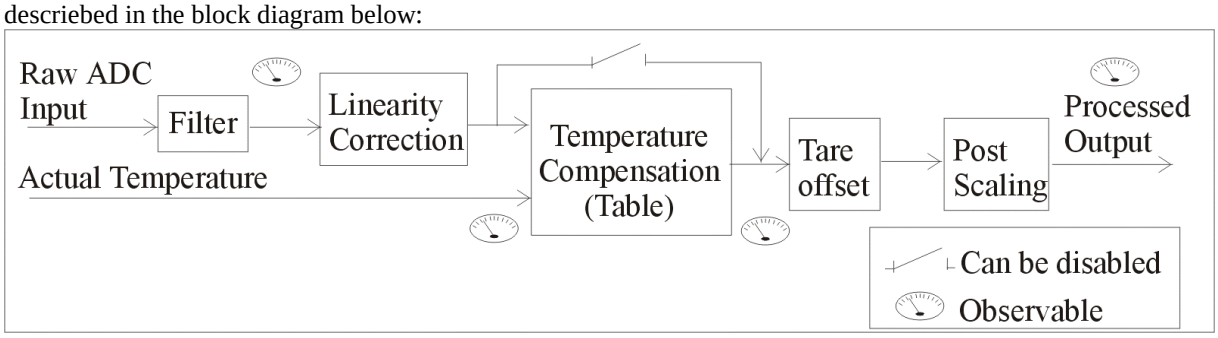
(1) Any value given below limit assumed as minimum allowed.

* Protected by calibration jumper

DIGICELL CALIBRATION NOTES

PRINCIPLES

Digicell provides multiple built-in measurement correction operations. The operations are linear and based on the correction tables given in calibration phase of production. The raw data are processed in the maner as descriebed in the block diagram below:



STAGES

1- Filter:
The row data are filtered against internal and external noise sources. The filtering algorithm is based on calculating the mean of specified number of measurements. The number of measurements those calculated to give the resultant mean must be 2,4,8,16 or 32.

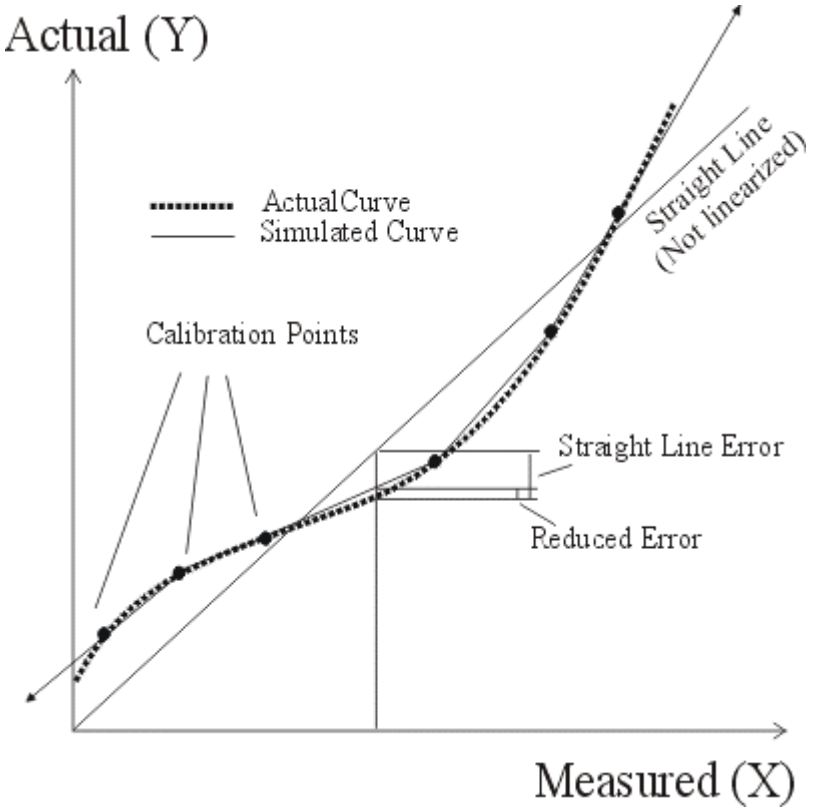
The filter has a auto-reset mechanism that provides the filter to be adaptive. Auto-reset features enables the filter act faster than a conventional filter. The filter acts as described below:

Normal Operation:
a) Escape Tolerance, Escape Counts and Filter Size are user defined parameters.
b) The filter buffer for mean calculation acts as a slot memory (like a FIFO memory, but always one-in one-out at a time). It's content dynamically changes from 1 to Filter Size due to auto-reset mechanism (named filter length here). The Filter Size (i.e. the maximum value of the filter buffer content) is given by user as 4,8,16 or 32.
c) If the filter length (number of valid values in memory) is not one of values of 2,4,8,16 or 32, the calculation of mean is skipped in this sampling, the incoming value is just stored in memory and will be ready to calculate in first 2,4,8,16,32 records sampled into memory. Thus the result remains unchanged for values between them.

Exceptions for Auto-Reset:
a) If difference of the last measurement to current mean value is greater than the escape tolerance, the last measurement is skipped.
b) If N (Escape Count) number of out-of-tolerance measurements occur, the filter is reset to the last value and starts getting values for a new mean value. The result is the mean of the values that are obtained after last reset (not greater than the selected filter size).
c) If N number of out-of-tolerance measurements does not occur (i.e. the last measurement is within the tolerance range) the last out-of-tolerance measurements are skipped and the filter continues normal operation. After a in-tolerance value detected, the out-of-tolerance counter is reset.

2- Linearity Correction:
Linearity correction is made by linear interpolation. For values those are out of range (greater than maximum reference or less than minimum reference) linear extrapolation is made. A linearity correction table is deviced (that entered in production) for obtaining the corresponding values for actual values.

The table constituted of 6 points (X & Y; Measured and Actual). If less than 6 points will be given, the empty points must be adjusted to obtain linearity (i.e. they may be midpoints between given points) manually. Linearization works as in the diagram below:



3- Temperature Compensation

Temperature compensation is the most complex behaviour of the system. It also optimized to obtain the best results. Temperature compansation is constructed in the same way as in linearity, with an exception that it has a three-dimensional feature. It also operates by linear interpolation and extrapolation.

Temperature compansation table holds three groups of values. Each group is for one reference temperature. Each group contains values below:

1- Input and Output value pair in no-load condition.
2- Input and Output value pair in full-load condition.

Input value means an uncompansated value for a condition, and the output value means the actual (desired) value for that condition. Referring to the operational block diagram the input value is the output of linearity correction stage.

In brief, compansation is made by interpolating a no-load value to a full-load value at a specified temperature. To accomplish this operation the no-load and full-load points must be calculated (also interpolated) for the actual temperature.

There are 5 interpolations those made to obtain the compansated result, each descriebed below:

a) Calculation of the no-load condition's input value at current temperature.
b) Calculation of the no-load condition's output value at current temperature.
c) Calculation of the full-load condition's input value at current temperature.
d) Calculation of the full-load condition's output value at current temperature.
e) Calculation of the result for the current load using the above value set.

The operation is describebed mathematically in the following diagram: