BE437 CONTACT TESTING MODULE

Technical specification and user manual

References :

- BE432 Contact testing module technical specification : BE432Brev9 & BE432B_TPrev5
- Bilt system complete technical documentation

review :

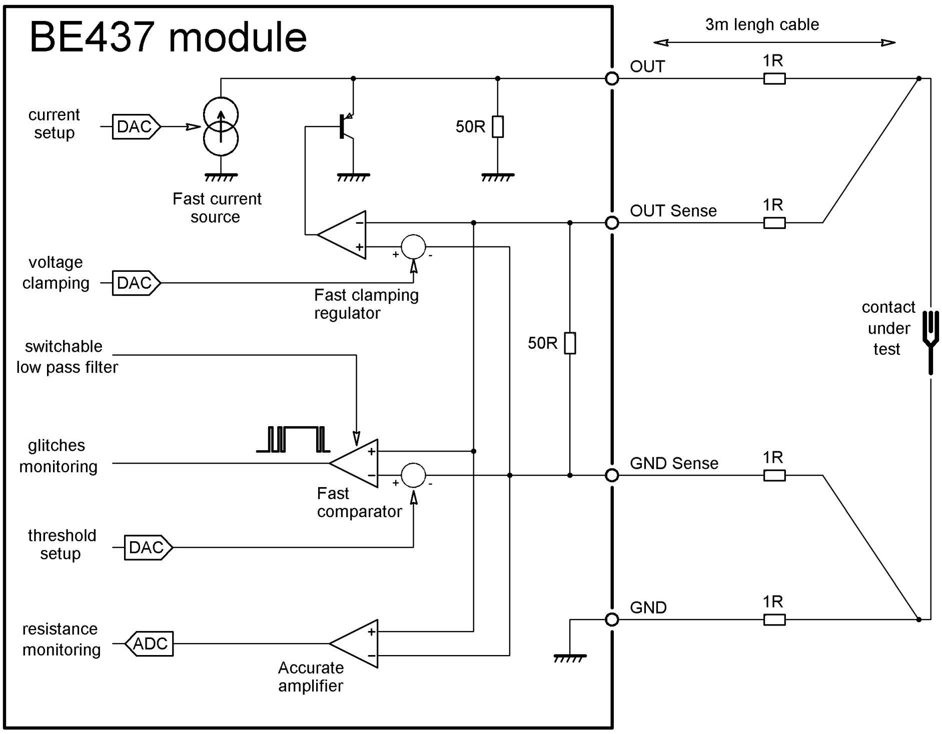
- option A rev. 1 , dated 17/11/2008 : initial review
- option A rev. 2 , dated 10/02/2009 : development completed
- option A rev. 3 , dated 27/02/2009 : calibration software completed
- option A rev. 5 , dated 13/03/2009 : resistance trigger level update
- option A rev. 6 , dated 29/04/2009 : accuracy test update
- option A rev. 7 , dated 26/07/2012 : simulator box TE437C update

Contents

1 Main features

The module BE437 is designed for testing at the same time contact interruption and contact resistance drift.

The module incorporates all the functions necessary for the test of one contact :
- a fast and accurate linear source provides:
  - –the constant current requested to bias the contact under test.
  - –the constant voltage clamping requested when the contact opens
- a fast comparator followed by a synchronous logical circuit provides:
  - –minimum pulse width control in order to reject too short pulses.
  - –number of pulse counting
  - –pulse duration measurement
- a low level amplifier provides accuracy for DC measurement of the contact resistance

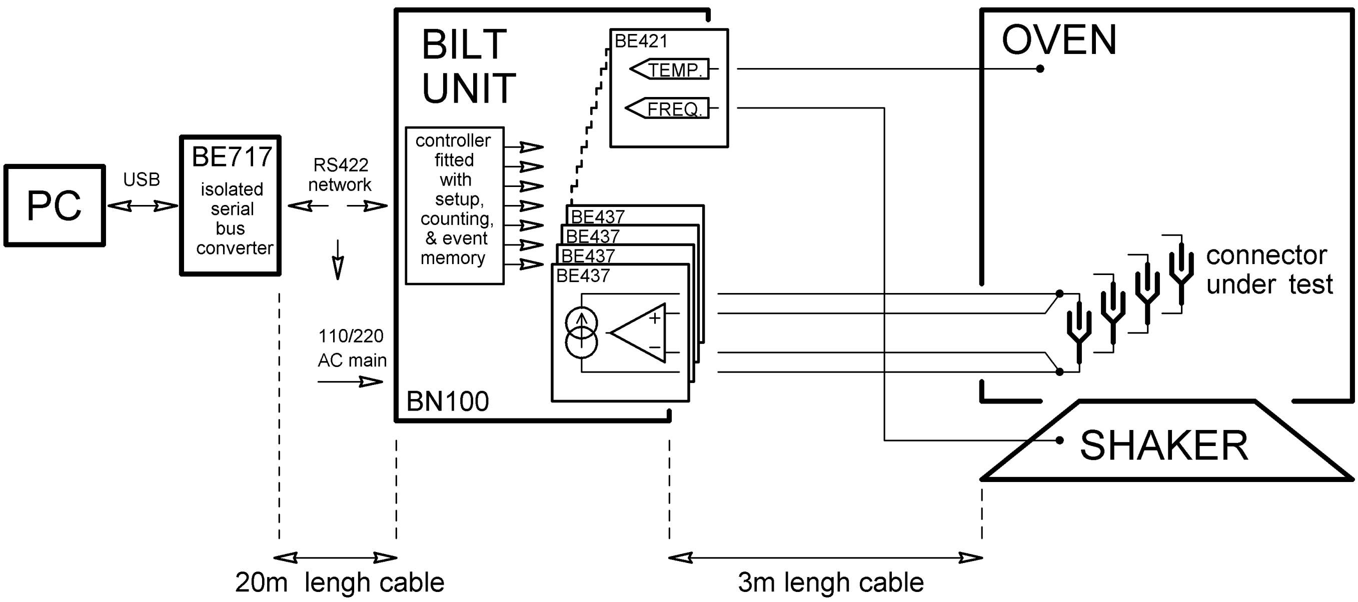


The module BE437 comes in replacement of the previous BE432 module, while providing compatible SUBD connection and software driver. The main performance improvements are:

–**Event monitoring bandwidth** : The new time resolution is 10ns.
–**Wide bandwidth connections** : Internal circuitry includes 2 terminal 50Ω loads and fully differential monitoring at sense terminal; The front panel is both fitted with general purpose SUBD connector and two additional SMB coaxial connectors useful for high bandwidth & low voltage installation.
–**Clamping accuracy** is 2mV, and minimum available level is lower down to 20mV, which is useful for dry contact testing. Using a fast linear regulator, the clamping action operates with respect to the remote voltage level, within a response time shorter than 1µs.
–**Fast comparator threshold accuracy** is 2mV, with respect to the remote voltage level , and minimum available level is lower down to 5mV. The trigger level is setup using the resistance value, ranging from 50mΩ up to 15Ω. Then, voltage level is computed according to the current level and the load resistor.
–**Bandwidth limitation for very low voltage level** : In order to operate down to 10mV levels without using coaxial cables, a switchable filter is available at the input of the fast comparator (100ns or 1µs).
–**Typical resistance measurement accuracy of 0,1mΩ** is maintained while using both long cables and 50Ω load resistors.

2 Application

Endurance test bench for connectors mounted on a shaker unit under thermal stress



Stand alone multichannel system:
A Bilt unit fitted with 12 BE437 modules and one BE421 module can monitor 12 contacts.
The embedded micro-controller unit performs reliable memorization of the test, whatever the state of the remote computer which is running the dedicated Bilt EasyStress software.
The software allows either independent or synchronised channel operation.
Several units can be controlled simultaneously by the same PC using an RS422 isolated network.

Stress conditions monitoring:
Temperature and vibration patterns are performed by equipment that is independent of the Bilt system.
The additional BE421 acquisition module performs only temperature and vibration frequency recording.
It needs a thermocouple K and a trigger signal delivered by the shaker.
As recording is performed using the same time base, occurrences of contact failure can be correlated with stress conditions.

Wiring precautions:
A four wire cable is requested in order to compensate wire resistance.
The rapid detection of low amplitude pulses requires the use of coaxial or twisted-pair cables.
In order to reduce the oscillations resulting from the length of the cables, which deform the signal observed during glitches, two 50Ω resistances connected in parallel are included: one at at the sense input and one at the force output of the module.

Although the BILT unit is fitted with many computer interfaces (RS422, RS232, GPIB, USB and Ethernet), the first one, RS422, is well suited to provide isolated interface between each Bilt unit and the computer.
Close to the shaker, this will prevent any disturbance around multiple ground connections from introducing noise into fast comparator inputs.

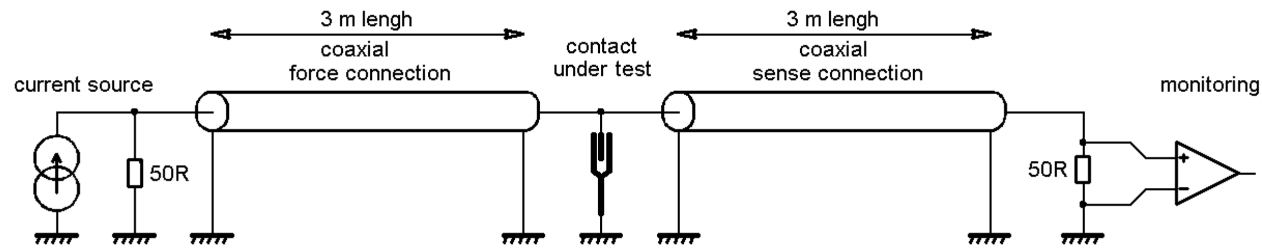
3 Specification table

	Parameter	conditions	Min.	Typ.	Max.
Current source	Setup range		**10mA**		100mA
	resolution			6,3µA	
	accuracy	Load resistance < 25mΩ	±(10µA + 0,1% of the value)		
	Response time	Transition 0,1Ω / 20Ω @100mA			**100ns**
Voltage clamping	setup		**20mV**		2,5V
	resolution			**0,16mV**	
	accuracy			**2mV**	
	Response time	Transition 0,1Ω / 20Ω @100mA			**1µs**
	overshoot	With respect to the clamping level			**+0,5V**
Trigger level comparator	Resistance setup		**50mΩ**		**16Ω**
	Resistance accuracy	1Ω @100mA		**20mΩ**	
	Voltage setup		**5mV**		**1000mV**
	Voltage resolution			**0,32mV**	
	Voltage accuracy			**2mV**	
	Voltage hysteresis			**6mV**	
Glitches monitoring	resolution			**10ns**	
	time measurement		**10ns**		**650µs**
	Minimum pulse width setup		**0ns**		**40µs**
	Time meas. Hold off			1s	
	Pulse counting		0		**65535**
	Comparator response time	No input filter		**5ns**	**10ns**
	63% RC time constant	Medium input filter		**100ns**	
	63% RC Time constant	Slow input filter		**1µs**	
DC resistance monitoring	Voltage range	At differential sense input	0		**100mV**
	Voltage resolution			**3µV**	
	Voltage accuracy		**± (5µV+0,1% of the value)**		
	Saturation resistance value	Whatever the current setup value		**1Ω**	
	Resistance accuracy	10 mΩ @100mA (see table 4,2)		**0,05mΩ**	**0,5mΩ**
	Response time			**1s**	
	DC Force voltage	At module output / GND	0		**300mV**
Bias resistors	Internal resistance both at sense input and force output			**50 Ω**	
	External cable resistance, per lead			300m Ω	**1Ω**

4 Electrical performances

4.1 Impedance balancing, cable effect

The equivalent schematic of BE437 module connected to the contact through the cables can be simplified as following:

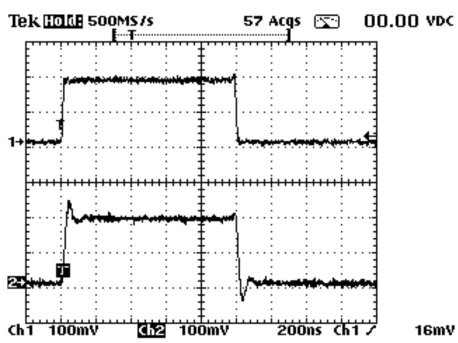


The signal to be monitored starts from the middle of the transmission line, and both terminations of the line can produce reflexions which will degrade the signal shape at the amplifier input.

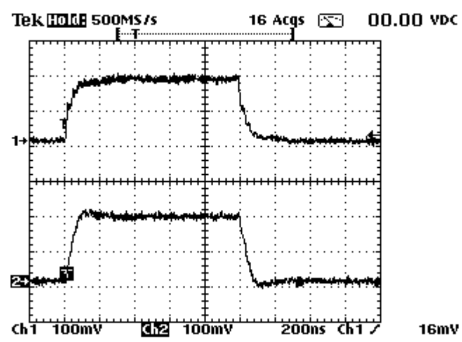
As the contact resistance ranges from zero to infinite, the only way to reduce oscillations is to use properly terminated transmission lines : 50Ω internal load resistors are integrated into the BE437 module, both at current source output and monitoring amplifier input.

Using a squared calibrated pulse simulator, it is possible to highlight the cable effect onto the transmitted signal. The 50Ω coaxial cable insures accurate shape monitoring at sense input, while the twisted pair slows down:

2 coaxial SMB cable, 1 m length
transition 0,1Ω to 2Ω @100mA
Chan1: sense input Chan2: force output



Twisted pairs cable, 3 m length
transition 0,1Ω to 2Ω @100mA
Chan1: sense input Chan2: force output



Coaxial cables are useful for both high speed performances and low voltage & low noise performances.

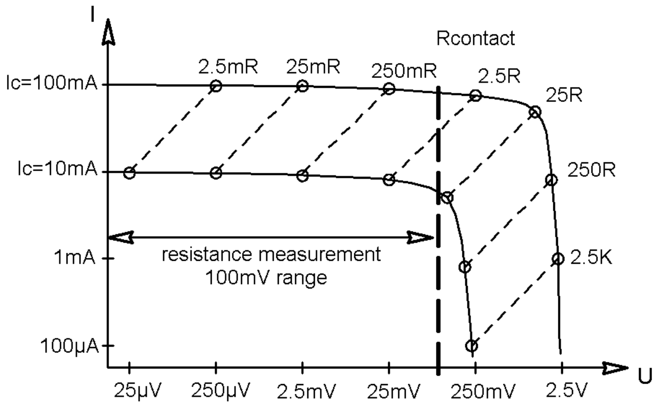
General purpose twisted pair cables feature impedance within the range of 90Ω up to 120Ω.
Then, 50Ω loads will provides additional attenuation of the signal rise time, which is not so bad because the noise level will be slightly higher than the coaxial's level.
Nevertheless, twisted pair cable features the minimum level of noise immunity and signal integrity required for the purpose of this equipment.

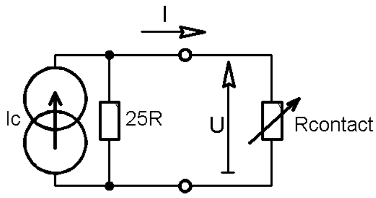
Using separated and individual wires, without any ground screen, do not comply with this system requirements.

4.2 DC characteristic, resistor measurement

➢ Internal parallel 50Ω load resistors effect

This DC characteristic plot shows the actual current and voltage when the resistance of the contact varies from 2,5mΩ up to 2,5kΩ.
The working point is plotted depending on the current source setup value Ic,
using the maximum value Ic=100mA, and the minimum value Ic=10mA.



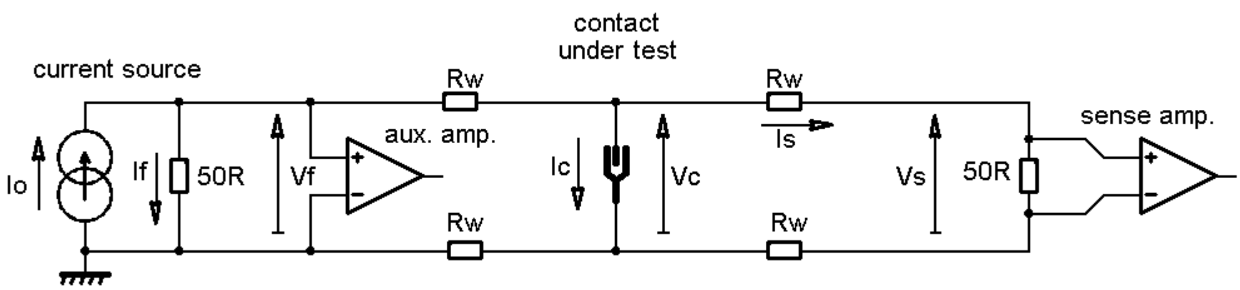


As the DC source is internally biased by the two 50Ω load resistors, the current remains nearly constant into the contact as long as it remains closed.
The software keeps accuracy of the resistance measurement by subtraction of the current bias into the two internal 50Ω resistors.

When the resistor increases above 1Ω, the voltage saturates up to the value [Ic . 25Ω].

➢ External cable resistor effect

The external maximum cable resistance, per lead, is specified up to Rw = 1Ω.
This serial resistance combined to the 50Ω load at the amplifier input introduces a gain error.



The software keeps accuracy of the resistance measurement by measuring the force output voltage Vf with an auxiliary measurement amplifier, computing the actual value of Rw, and at last compensating of the gain error.

For this purpose, it is requested to use the same length and the same size of cables for both force and sense connections.
The computed wire resistor value Rw is displayed onto the BE437 control window.

➢ Resistance over range values

In order to prevent displaying and memorization of corrupted values,
the computed resistance value is forced to 1Ω when either:

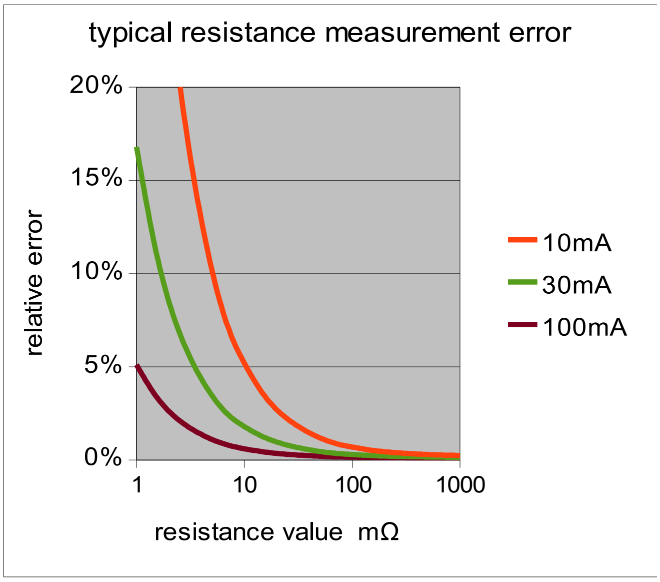
- the sense voltage Vs exceeds the 100mV measurement range.
- the force voltage Vf exceeds 300mV.
  (= 100mV maximum sense voltage + 200mV maximum wire resistance : 1Ω per led @ 100mA)
- the computed resistance value is greater than 1Ω

When outputs are shorted , giving voltage measurement lower than 10µV or slightly negative, the computed resistance value is forced to 0Ω.

➢Resistance measurement accuracy versus current source set up

At last, accuracy of the resistance measurement is strongly limited when using low current values.

Example:
Measuring of a 10mΩ contact resistance using a 10mA current will introduce an error up to 5% of the value.
According to the hereafter plot, a 100mA current will reduce the error down to 0,5% of the value.



This plot is obtained using typical maximum error amplitudes:
ΔU = 5µV + 0,05% of the measured value
ΔI = 10µA + 0,05% of the measured value

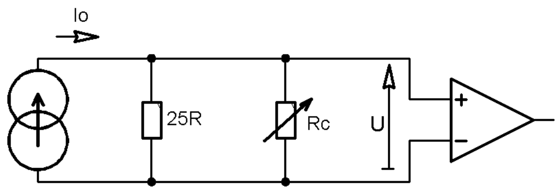
➢Resistance measurement accuracy test

The simplest way to check the accuracy of resistance measurement is to connect a 4 terminal precision shunt onto the SUBD connector. Then, using different current level and/or length/resistance of the cable, it is easy to highlight the accuracy limits. Example using a 2m length cable, with 330mΩ per lead :

Current setup	**measurement of a 10mΩ shunt**	**measurement of a 2mΩ shunt**
100mA	10,02mΩ	2,05mΩ
33mA	10,12mΩ	2,12mΩ
10mA	10,31mΩ	2,36mΩ

4.3 Contact interruption trigger level

➢ Actual resistance and voltage trigger levels



The trigger level is defined using Rc, the resistor value when the contact opens, ranging from 50mΩ up to 15Ω.

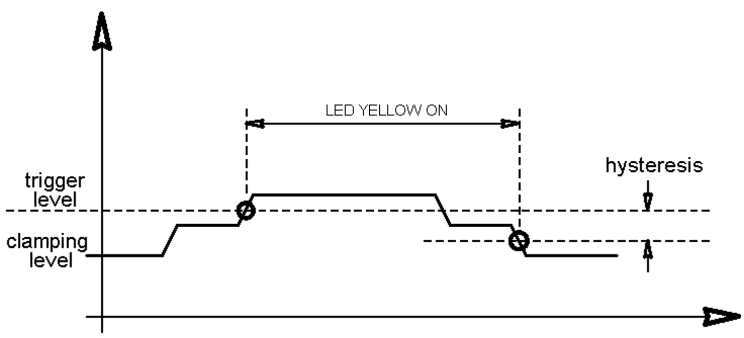
Then the software computes the corresponding actual voltage level U , as a function of both the current source setup value Io and the parallel 25Ω internal load resistor.
The result has to be a voltage within the range of 5mV up to 1V.

example:
Setup : contact resistance trigger level Rc= 7Ω, and current source Io=100mA
Then computed voltage trigger level is U = 100mA (7Ω // 25Ω) = 546mV

If the user modifies the current level Io, then the software will update the trigger voltage level:
Using Io = 10mA , the voltage trigger level U becomes 54mV, thus maintaining 7Ω constant resistance level.

➢ trigger level accuracy checking

When testing trigger level accuracy down to 1mV, care should be taken with the 6mV hysteresis gap:
The fast comparator is calibrated with respect to the rising edge of the pulse, and the accuracy of 1 mV is related to the level requested to trig at the beginning of the pulse.
But, in order to stop the time counting, at the end of the pulse, the signal have to decrease 6mV under the programmable trigger level!

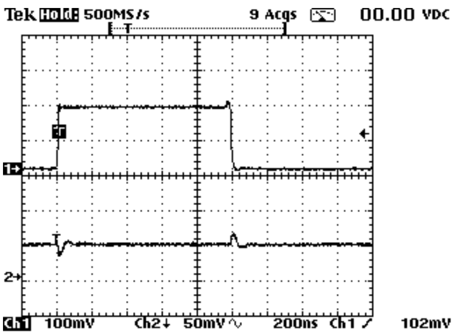


The trigger level accuracy is easy to test at any time using a DC voltage level close to the trigger level while reading the comparator state on the front panel LED.(see 7.2)
Assuming large enough contact resistor, (including open circuit), the actual output voltage will be controlled by the clamping voltage setup.
Then, tuning this setup, it is possible to go "through" the trigger voltage level, providing enough accuracy to meet the 6mV hysteresis gap.
Of course, actual noise level at sense input will be included into the decision of the comparator...

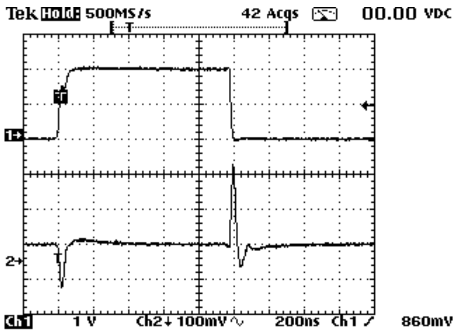
4.4 Current source performances

The current source provides fast response time during resistor / voltage transitions:
The current recovers within 50ns and 2% overshoot when a small step occurs (200mV)
The current recovers within 100ns and 20% overshoot when a large step occurs (2V)

coaxial SMB cable
transition 0,1Ω to 2Ω @100mA
Chan1: sense voltage 100mV/div.
Chan2: internal current shunt voltage 5mA/div.



coaxial SMB cable
transition 0,1Ω to 20Ω @100mA
Chan1: sense voltage 1V/div.
Chan2: internal current shunt voltage 10mA/div.



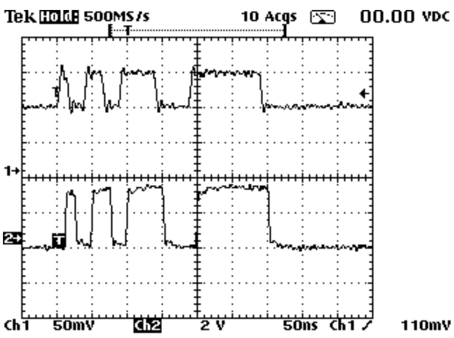
4.5 Input filter

This test is proceeded using the burst of 4 pulses with duration in progression : 12ns, 25ns, 50ns, 100ns.
The fast comparator is able to trig pulses as short as 12ns.
Then, the module is able to count and/ or to verify the duration of each pulse of the burst of 4 pulses.
The displayed values are rounded to +-10ns.

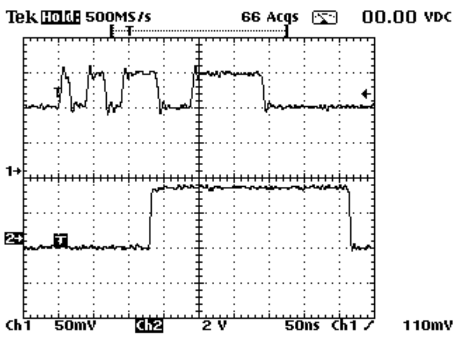
Using the medium filter, with 100ns time constant, the same burst will trig only one time, displaying a 300ns duration.

Of course when using the lower filter, with 1µs time constant, no trig will occur with such a burst.

coaxial SMB cable
Burst from 2Ω up to 3Ω @50mA
Chan1: Sense voltage 50mV/Div.
Chan2: fast comparator output, threshold = 120mV

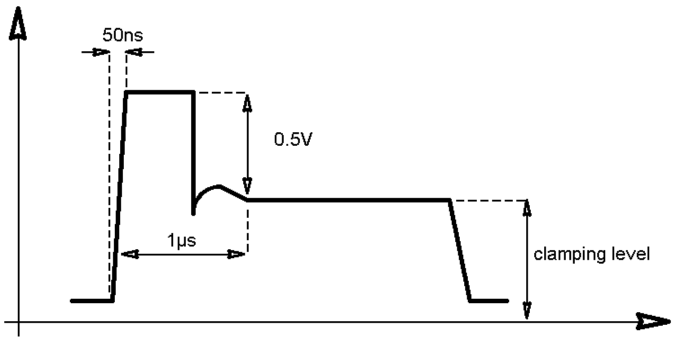


coaxial SMB cable
Burst from 2Ω up to 3Ω @50mA
Chan1: Sense voltage 50mV/Div.
Chan2: 100ns filtered comparator output, th= 120mV

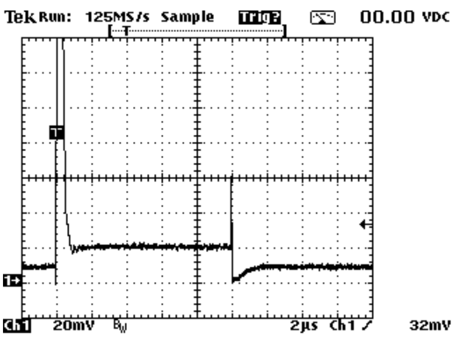


4.6 Voltage clamping performances

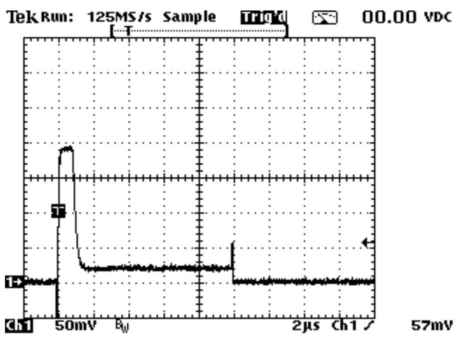
The clamping voltage regulator is able to regulate to remote voltage in the range of 2,5V down to 20mV.
But, it needs a response time of 1µs.
Meanwhile, a fast schotky diode will clamp the overshoot at 0,5V above the setup level.
When using very low clamping level, in order to avoid time measurement errors due to transient voltage, it is recommended to use filtered input (100ns) and/or min. pulse duration >1µs.



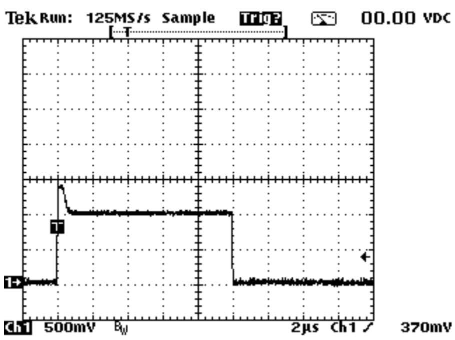
10µs pulse from 100mΩ up to 20Ω @100mA
voltage clamping = 20mV, scope 20mV/div



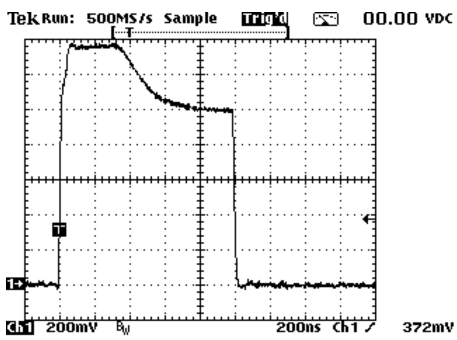
10µs pulse from 100mΩ up to 20Ω @10mA
voltage clamping = 20mV, scope 50mV/div



10µs pulse from 100mΩ up to 20Ω @100mA
voltage clamping = 1V , scope 500mV/div.



1µs pulse from 100mΩ up to 20Ω @100mA
voltage clamping = 1V, scope 200mV/div.



5 Monitoring and memorization

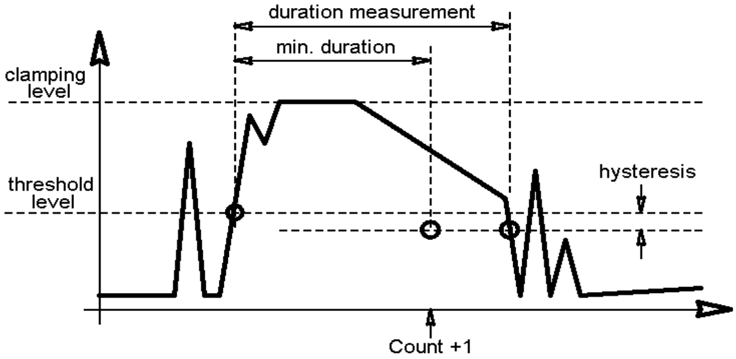
5.1 Glitches recording principle

The fast comparator trigs when the input goes above the programmable threshold level.

The comparator output is sampled each 10ns.
Each time a pulse occurs, the time counting is enabled.

Then, if the pulse ends before the minimum duration value, the counter is cleared and the wait state resumes.

When the pulse remains longer than the specified minimum duration value, the "number of pulse" counter is incremented and the total pulse duration is measured, using the 10ns sample rate resolution.

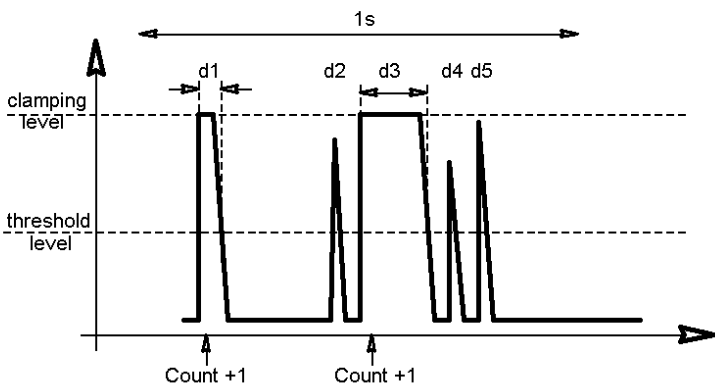


Once a pulse has been triggered, the measured duration is latched until main micro-controller asks for memory update, according to a rate of 1Hz.
Then, during the remaining time, the system is able to count any other pulses, with respect to specified minimum duration, but, it will be unable to measure a new duration.

The event memory is updated only when an event occurs.

If several pulses occurs during the same interval of 1s, the record will contains only the total number of pulse and the duration of the first one.

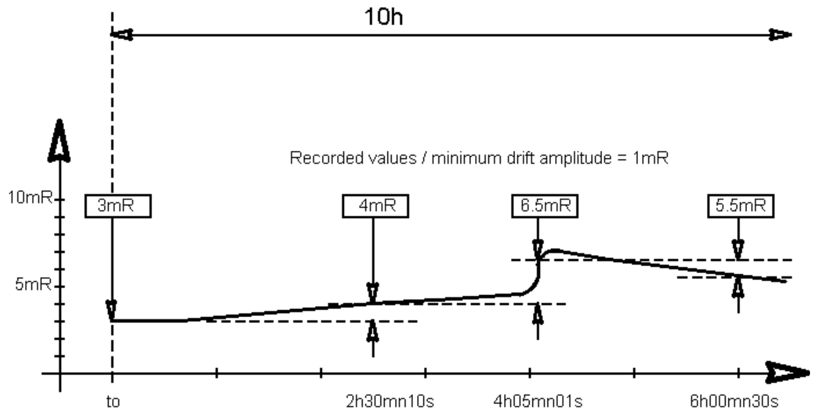
In this example, five pulses occurred within 1s.
As d2, d4 and d5 were too short, only 2 pulses were counted.
As d1 was the first pulse within this sample interval of 1 s, only the time value d1 was recorded.



5.2 Resistance variation recording principle

Moreover, the DC Resistance value is recorded together with the glitches into the event memory.
Each time the variation of the resistance is greater than a programmable "minimum drift amplitude", a new recording is initiated.
The sampling rate is 1 Hz.

In this example, 4 recordings were initiated:
one for the initial value,
and then 3 times along the test duration, when the variation was greater than the 1mΩ "minimum drift amplitude".



5.3 Event memory principle

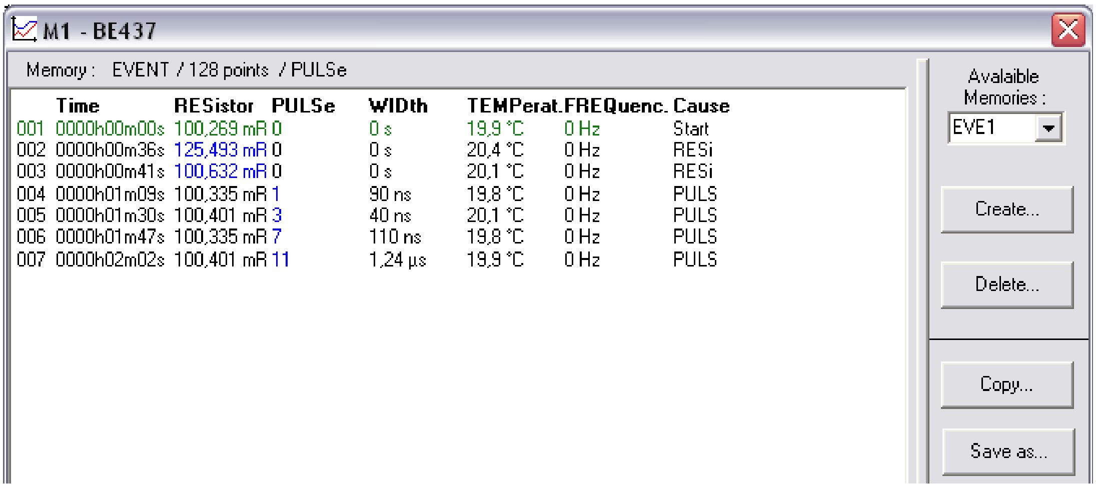
The Event memory is dedicated to BE432/BE437 contact interruption modules.

It allows three types of event to be displayed chronologically in the same table:
- -Cause = pulse : when a new glitch or a burst of glitches is detected.
- -Cause = resistance : when a DC resistance variation is detected.
- -Cause = start/stop : Initial and final values are included at the beginning and end of the table

The table can record a maximum of 128 event lines and when full, an alarm is triggered.
Temperature and Frequency recording requires that the BE421 module is installed at position 13.

Whatever the nature of the event, each line of the table contains the following information: Test time, accumulated number of glitches, duration of glitch, DC resistance, temperature, frequency and cause.

EasyStress software display window:
colour code : green=start/stop, blue = new informations, red= alarm stop



Backup memory file format:

EasyStress software allows to download the memory files onto the PC , either for single channel or for the complete system.

Using Excel compatible format, the memory file contains all the data related to the test of one channel, first including general informations:
- –channel position
- –Run/step information, duration
- –group history : list of major events related to the group of module

BILT SYSTEM 100 MEMORY FILE

Unit 02 (BILT 2)
Group 1 (1)
Module 1 (BE437)

Group properties :
Step No : 38
Step duration : 1000h00m00s
Test Time : 0h00m02s

Group History :
05/02/09 17-31-46 : 0000h00m00s Start

Memory Type : EVENT

Data Memory :

Time	RESistor	PULSe	WIDth	TEMPe	REQuer	Cause
0000h00m00s	0.100269	0	0	+19.9	0	Start
0000h00m36s	0.125493	0	0	+20.4	0	RESi
0000h00m41s	0.100632	0	0	+20.1	0	RESi
0000h01m09s	0.100335	1	9,00E-08	+19.8	0	PULS
0000h01m30s	0.100401	3	4,00E-08	+20.1	0	PULS
0000h01m47s	0.100335	7	1.1e-07	+19.8	0	PULS
0000h02m02s	0.100401	11	1.24e-06	+19.9	0	PULS

5.4 DC measurement memory principle

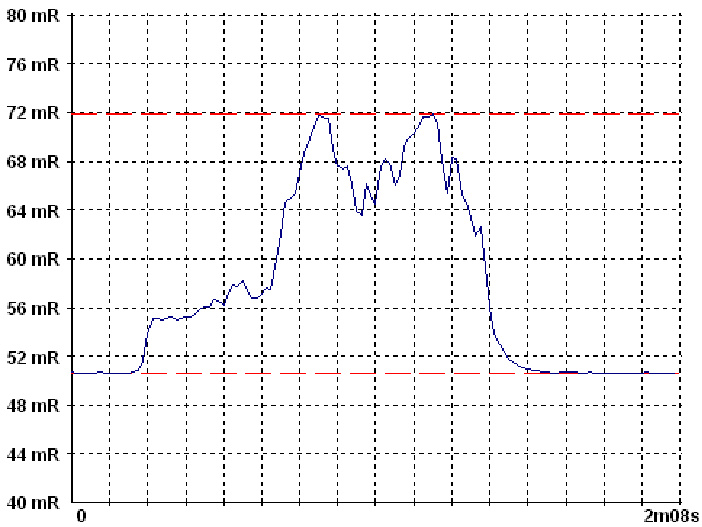
DC Resistance, temperature and frequency can be plotted using the same time scale with EasyStress general purpose memory system:

- ROLL memories allow to plot the drift within a shifting constant time interval.

- INFINITE memory allow to plot the drift within the whole test duration, using a constant number of point, thus corresponding to an extensible time interval. Data compression is performed by the software each time the test duration doubles.

Please refer to “EasyStress User Manual” for the detailed specification of these kind of memories.

Exemple of resistance measurement using a 128 point memory.



ROLL

Example for backup memory file format:

The contents of the report file is similar to the one of the event memory.

BILT SYSTEM 100 MEMORY FILE

Unit 02 (BILT 2)
Group 1 (1)
Module 1 (BE437)

Group properties :
Step No : 43
Step duration : 1000h00m00s
Test Time : 0h02m10s

Group History :
05/02/09 17-58-58 : 0000h00m00s Start
05/02/09 18-01-08 : 0000h02m10s Stop

Memory Type : ROLS
Parameter : RESistor

Data Memory :

1	0.050662
2	0.050563
3	0.050531
4	0.050563
5	0.050563
6	0.050563
7	0.050695
8	0.050563
9	0.050563
10	0.050596

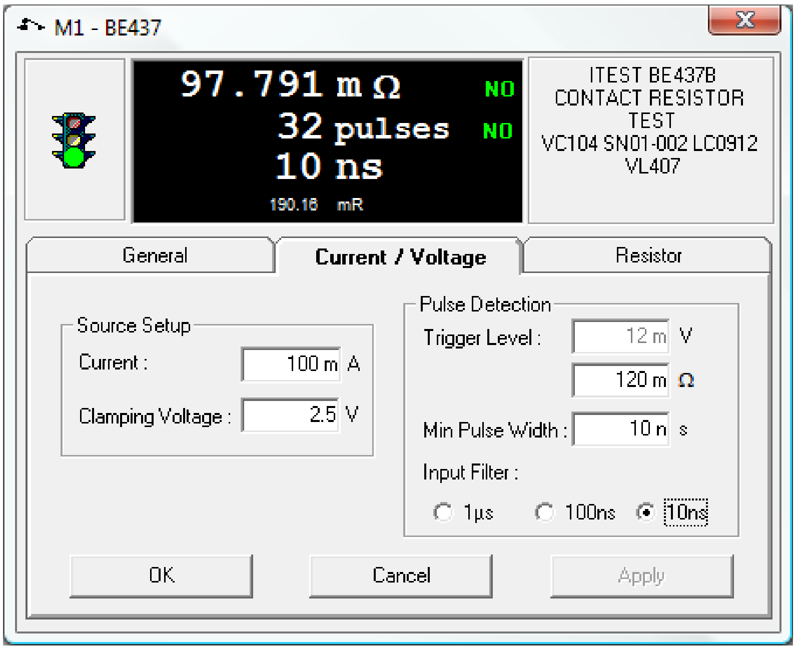
6 EasyStress user interface

As this paragraph contains only BE437 specific informations, please refer to “EasyStress User Manual” in order to find general purpose informations and tricks useful for this matter.

6.1 Dedicated BE437 control window

The black area indicates:

- the resistance measurement
- the min/max threshold state
- the pulse count
- the max. count state
- the last pulse width
- the cable resistance (per lead)



The right area indicates the complete identification of the module:

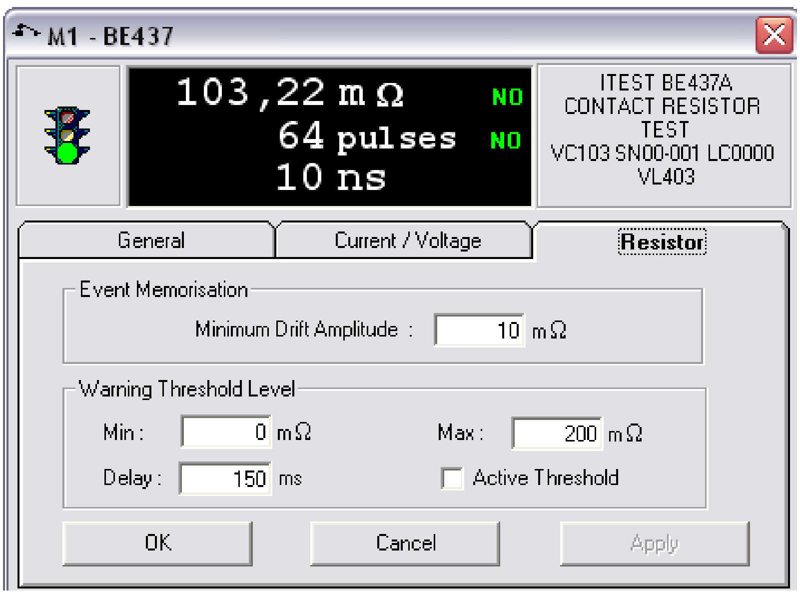
- BE437A module type + hardware revision letter
- VC101: FPGA revision
- SN01-008 serial number
- LC08-52: last calibration date
- VL1,01 : software revision

Current/voltage setup tab:

- current
- clamping voltage
- computed voltage trigger level (display value only)
- resistance trigger level (setup value)
- min pulse duration
- input filter

Resistor setup tab:

- minimum drift amplitude
- min threshold level
- max threshold level
- threshold activation delay after start
- activation of threshold control



6.2 Creating your own software setup

Before defining a test setup, the user has to identify the following basic test conditions:

parameter	general purpose value	comment
contact resistor typical value	2mΩ	
cable bandwidth	10MHZ	using general purpose twisted pairs
cable resistor, per lead	300mΩ	3 m length
Shaker frequency range	5Hz / 500Hz	synchro signal available, logic level, connection?
Oven temperature range	20°C / 85°C	thermocouple K

The complete setting of the first module has to be performed and tested:

parameter	value at reset	general purpose value	comment
signal name	BE437	connector pin number	
current	1mA	100mA	
clamping voltage	20mV	2V	
resistance trigger level	6,25Ω	100mΩ	
min pulse duration	20ns	1µs	
input filter	10ns	100ns	
min. drift amplitude	500mΩ	0,1mΩ	
min. threshold level	0Ω	0Ω	
max. threshold level	0Ω	10mΩ	
active threshold	no	yes	

Then, a major choice has to be discussed:

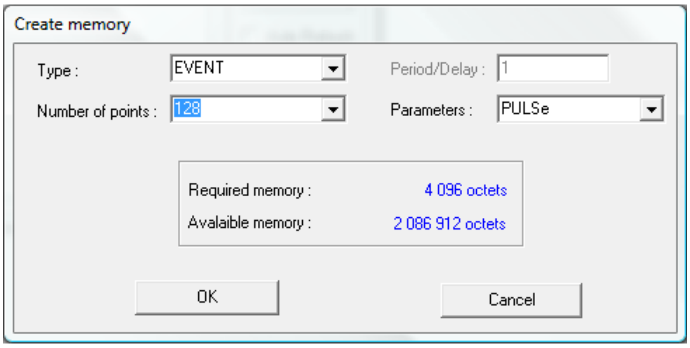
- The use of individual group for each contact under test will allow to drive independent tests... Then time base can be mismatched between the different samples of the batch.
- The use of groups of several contacts, (up to 12 within one group), will allow to drive synchronous test... Then the reports will use the same time base.

If separated groups are uses, BE421 temperature and frequency module has to be duplicated in each of them.

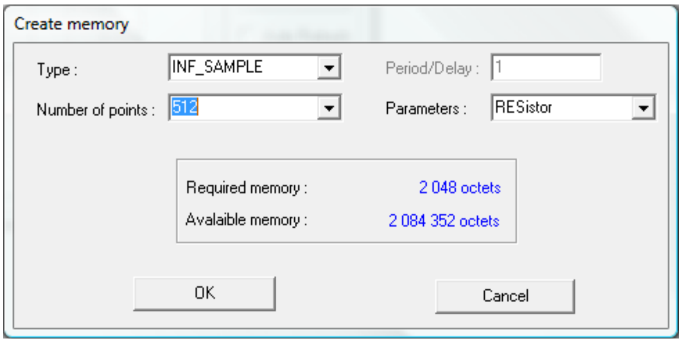
When the groups are formed, it's time to create the memories associated to each module.

6.3 Memory configuration

The **event** memory has to be created in order to enable contact interruption monitoring:



Then, DC **Resistor** monitoring can be created using either ROLL_SAMPLE or INF_SAMPLE with resolution from 128 points up to 4096 points.



Then, for future comparison and data compilation, **Temperature** memories have to be created in the BE421 module using same type and same resolution memories as for BE437- Resistor.

The recommended memory setup for BE437 module associated to common BE421 module is :

Module	Module Name	Memory Name	Type	Nb Points	Period	Param
M4	BE437	EVE1	EVENT	128	1	PULSe
M4	BE437	ROL1	ROLS	128	1	RESistor
M4	BE437	INF1	INFS	512	1	RESistor
M8	BE421	ROL1	ROLS	128	1	TEMPerat...
M8	BE421	INF1	INFS	512	1	TEMPerat...

7 Miscellaneous information

7.1 Software threshold control on resistance value and maximum count

As others Bilt instruments, the BE437 module software proceeds to a min / max threshold control with the actual resistance measurement value. This control operates at 1Hz rate, and trigs only with DC events.

- If required, this control has to be activated at the module level (option “active threshold”).
  Then, when the actual resistance values goes outside the range [MIN - MAX], a warning message is delivered at the group level, but the test is not interrupted.
- If an emergency stop is required, the threshold control has to be activated at the group level. (button “activate/desactivate threshold”).
  The emergency stop is proceeded for all the modules includes in the same group.

In addition, a threshold control is proceeded on the force output voltage, which must stays under 300mV.

The BE437 module can produce 4 different alarm messages:

mnemonic	event	Enable/disable	action
LOW	Resistor Min software threshold occurred.	at module level and at group level	warning or emergency stop, (depending on group level activation)
HIGH	Resistor Max software threshold occurred.		
OVER	DC voltage at force output over 300mV	only at group level	
FULL	pulse count is over 65 535	no	only warning

The first alarm which occurs is latched into the alarm memory buffer.
This buffer is readable when recovering from abnormal state.
Clearing of the buffer is requested before restarting.
In addition, a programmable delay can be added after the start of the module, before activation of the threshold control.

7.2 Front panel features

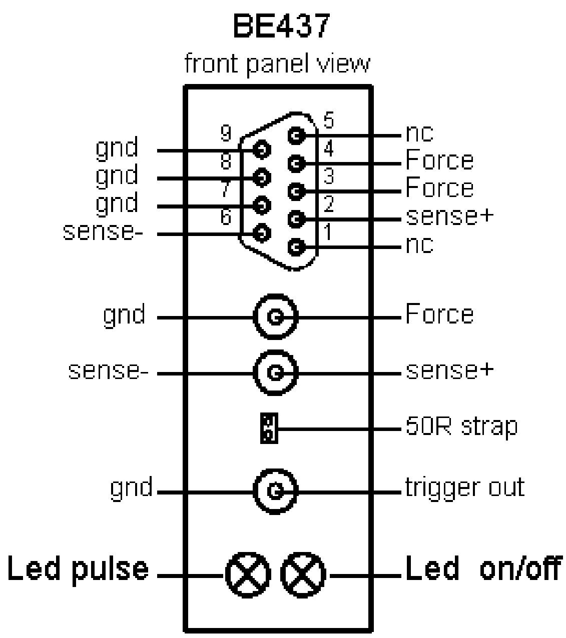
The force output signal and the sense input signals are available on both SubD9 and 2 coaxial SMB connectors.

A third SMB connector provides a 200ms logic level pulse each time a valid contact interruption is counted. This pulse is intended for oscilloscope triggering.

The right LED indicates the on/off state of the module.

The left LED indicates 3 different states:

– When OFF, the input level is lower than the setup voltage threshold level.
– When ON and YELLOW continuously, the input level is continuously greater than the setup voltage threshold level.
– Each time a valid contact interruption is counted, this LED blinks GREEN during 200ms



7.3 External 50Ω load connection

For the purpose of displaying on the oscilloscope the actual sense input signal, the internal 50Ω load can be removed, using a strap located closed to the SMB connector.

Then, the 50Ω load requested at sense input will be located at the scope input, providing full bandwidth.

If omitted, there will be no damage running the BE437 module without the sense input 50Ω load, except a loss of accuracy.

7.4 Temperature and frequency monitoring

For the purpose of monitoring temperature and frequency , the 13th position of the BILT unit has to be fitted with a BE421 module.

- **Measuring temperature**

Sensor: type K thermocouple
Range: from -50°C to +250°C
Resolution: ±0.1°C with typical accuracy of ±1°C (maximum ±3°C over the entire range)
Connector: standard K type thermocouple.

- **Measuring the frequency of the shaker unit**

The shaker unit should deliver a trigger signal synchronous of its power output.
Typical input logic level: 3,3V to 5V
The BE421 module performs a simple counting within a 1s window.
Measurement range: from 2Hz to 3KHz, with resolution and accuracy ±1Hz.
Filter limiting input signal frequency to 3.5KHz.
Connector: SUBD 9. pin 3 = input, pin 7&8 = GND
BNC adaptor is available.

This two measurements are to be memorized together with the resistance measurement of each BE437 module, using their own time base.
For this purpose, the BE421 module will be "duplicated" into each "group" of BE437 module.
Please refer to “EasyStress User Manual” for the detailed operation of the group function.

8 Test tools

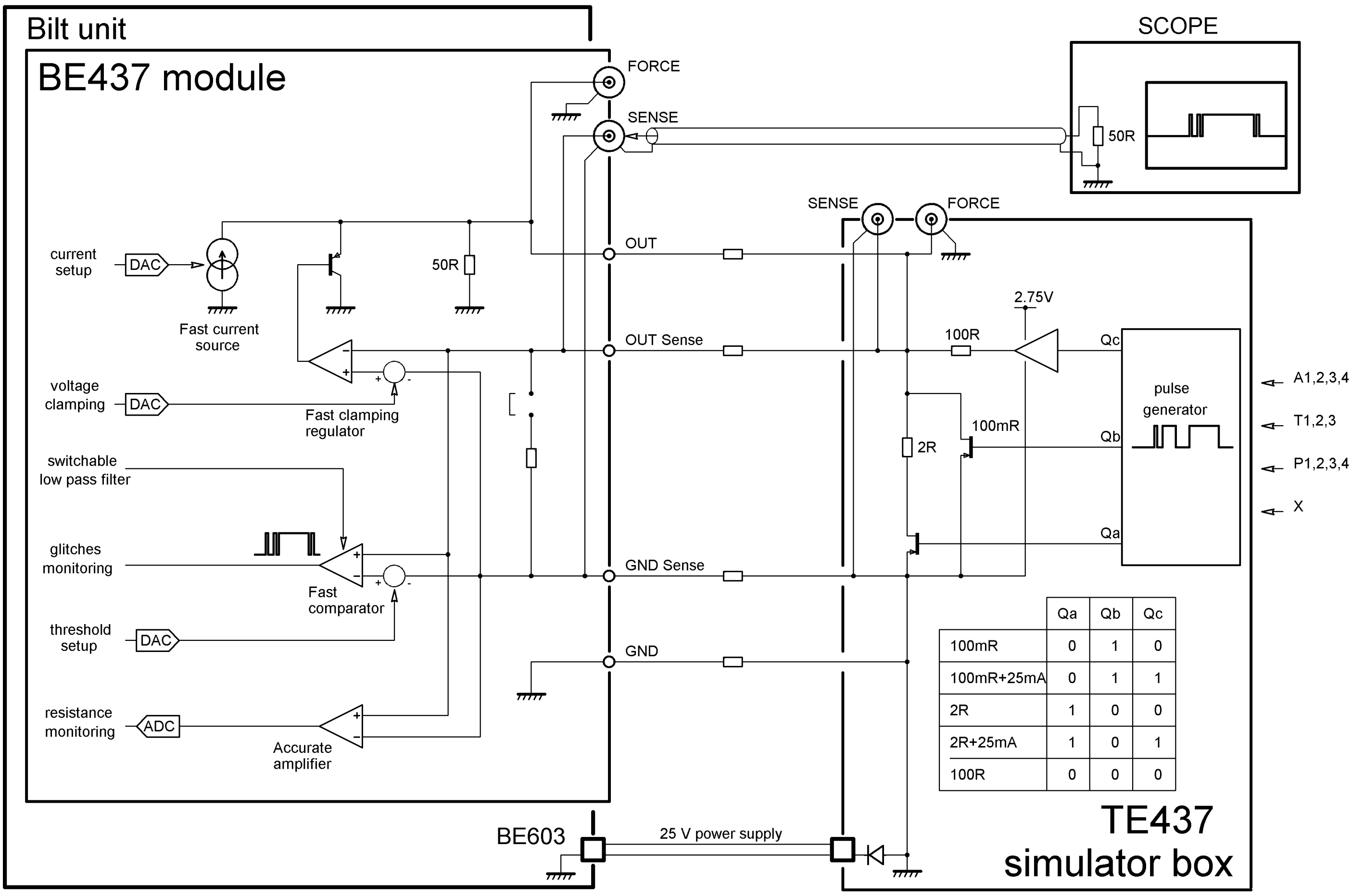
8.1 Operating test using the TE437 simulator box

The TE437 simulator box is designed for the purpose of BE437 module operating test.
Connected straight to the module with a short SUBD9 cable, it is useful for training or for on site verification.
Moreover, it will useful for the characterization of the module and the demonstration of its dynamic performances.
The TE437 simulator box is not designed for resistance measurement accuracy test, as low contact resistance is simulated by saturated transistors subject to drift.

Depending on what will be tested, it will be requested to use the proper cable:
–4 wires / twisted pairs SUBD9 cable for general purpose test.
–Maximum length 1 ohm resistive cable for sense voltage test.
–coaxial SMB cables for high frequency and/or low level test.

For the purpose of high frequency and/or low level test, the internal 50 Ω load of the BE437 module should be manually disconnected, in order to connect the scope with coaxial cable with the 50 Ω load at the scope input.

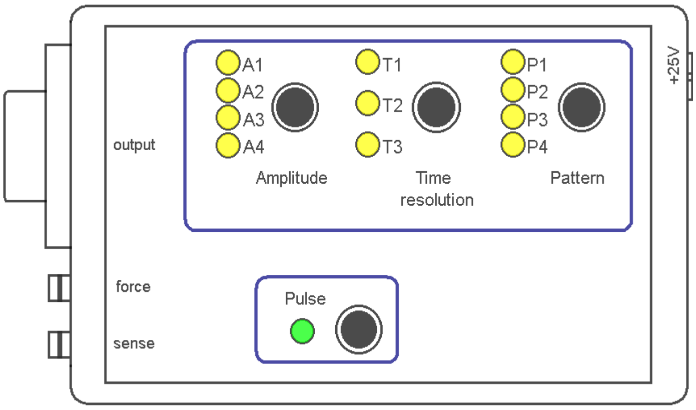
The TE437 box is supplied by the 25V voltage available into the “safety stop” connector located on the BE603 main input board front panel.



	Qa	Qb	Qc
100mR	0	1	0
100mR+25mA	0	1	1
2R	1	0	0
2R+25mA	1	0	1
100R	0	0	0

8.2 Simulator set up

The test signal is defined according to 3 parameters : amplitude low/high, time resolution, pattern.
Each parameter setup is selected with a push button: A, T & P :
Each time the button is pressed, the selected value (yellow LED) is shifted to the next position.
The output is enabled by pushing the last button, X;
The green LED blinks at each pulse.



Amplitude Low/High setup (button A & led A1,A2,A3,A4)

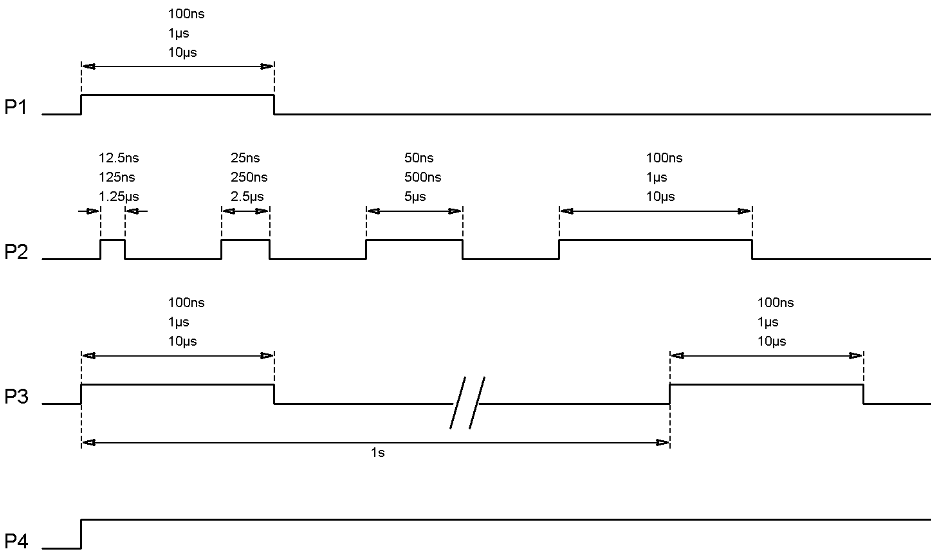
	test purpose	Low level load	Low voltage level @100mA	High level load	High voltage level @100mA
A1	**small resistance drift**	**100mΩ**	10mV	**100mΩ + 25mA**	12mV
A2	**medium step**	**100mΩ**	10mV	**2Ω**	200mV
A3	**large step**	**100mΩ**	10mV	**20Ω**	2V
A4	**small step & high speed**	**2Ω**	200mV	**2Ω + 22mA**	250mV

Time resolution setup (button T & led T1,T2,T3)

A master clock performs 3 different time resolutions: 12,5ns, 125ns & 1,25µs.
Then, according to the time setup command, the length of the main generated pulses will be:
T1 = 100ns **T2 = 1µs** **T3 = 10µs**

Pattern setup (button P & Led P1,P2,P3,P4)

P1: one shoot pulse (one clean pulse is generated each time the push button X is pressed)
P2: one shoot **burst** of 4 pulses, duration in progression (one burst / each time X is pressed)
P3: same pulse as P1, but continuously repeated at **1Hz rate** (starts/stops when push button X is pressed)
P4: steady state value at output (state toggles each time push button X is pressed)



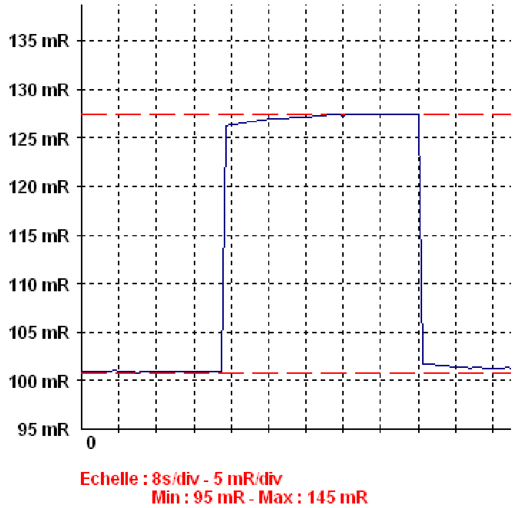
When powered on, the TE437 box is set to **A3, T3, P3** : the large step 10µs pulse at 1Hz rate is enabled.

8.3 Operating test examples

Using the TE437 simulator box allows to test all the operating conditions of the BE437 module.

DC resistance variation recording : slow step 100mΩ / 125mΩ

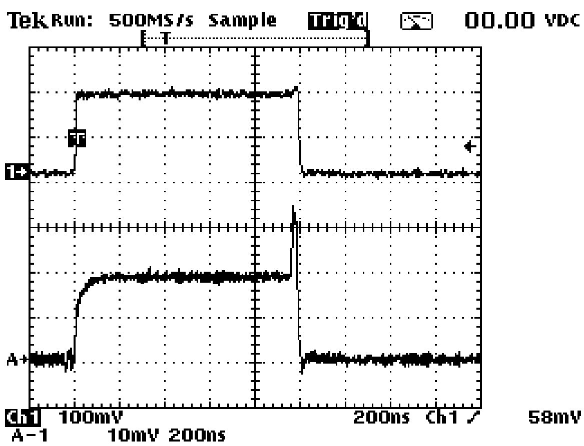
TE437 box setup	Amplitude	A1: small drift
	Time resolution	
	Pattern	P4: steady state
Connection setup		Thin 3m wire 1Ω
BE437 module setup	Current	100mA
	Clamping Voltage	2,5V
	Trigger level	120mΩ (12mV)
	Min. Width	0
	Input filter	10ns
	ΔR min.	0,01Ω



	Time	RESistor	PULSe	WIDth	TEMPe	FREQ	Cause
1	0000h00m00s	0.100929	0	0	+20.3	0	Start
2	0000h00m32s	0.12632	0	0	+20.0	0	RESi
3	0000h01m14s	0.10172	0	0	+19.9	0	RESi
4	0000h01m43s	0.101193	0	0	+19.9	0	Stop

Pulse detection : calibrated 1µs pulse 100mΩ / 2Ω at 1 Hz rate, low level detection

TE437 box setup	Amplitude	A2: medium step
	Time resolution	T2:1µs
	Pattern	P3: pulse @1Hz
Connection setup		SMB cable + scope
BE437 module setup	Current	**100mA then 10mA**
	Clamping Voltage	2,5V
	Trigger level	**1,04Ω then 100mΩ (100mV then 10mV)**
	Min. Width	50ns
	Input filter	10ns
	ΔR min.	



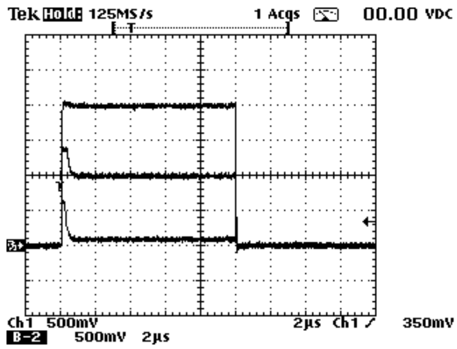
Chan1: 100mV/Div sense voltage @100mA

ChanA: 10mV/Div sense voltage @10mA

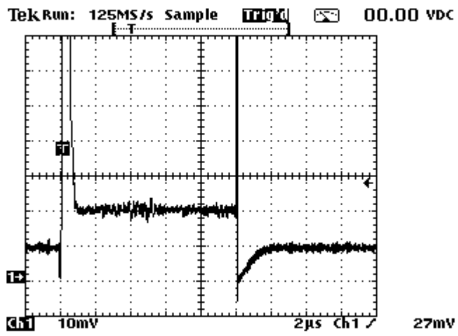
Current source with voltage clamping : 10µs pulse 100mΩ / 20Ω at 1 Hz rate

The threshold voltage is only 5mV above the steady voltage which is 10mV (100mA x 100mΩ).
Then pulses are counted properly whatever the clamping voltage, which is set to 4 different levels:

- 2,5V (no clamping, square pulse 100mA x 20Ω = 2V)
- 1V (with 1,5V overshoot, same picture)
- 100mV (with 0,5V overshoot, same picture)
- 20mV (in this case, the scope is set to 10mV)

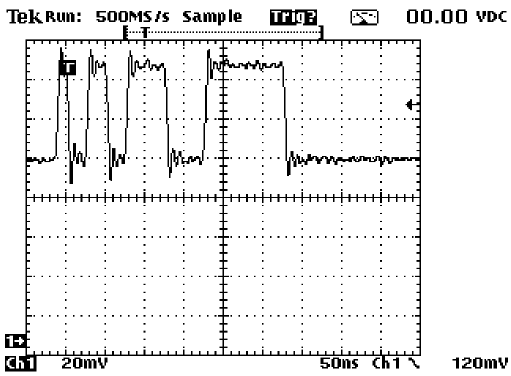


TE437 box setup	Amplitude	A3: large step
	Time resolution	T3: 10µs
	Pattern	P3: pulse @1Hz
Connection setup		SMB cable + scope
437 module setup	Current	**100mA**
	Clamping Voltage	**2,5V, 1V, 100mV, 20mV**
	Trigger level	150mΩ (15mV)
	Min. Width	1µs
	Input filter	100ns
	ΔR min.	



High speed detection : 12ns to 100ns burst , pulse 2Ω / 3Ω

TE437 box setup	Amplitude	A4: high speed
	Time resolution	T1: 100ns
	Pattern	P2: burst 4 pulses
Connection setup		SMB cable + scope
BE437 module setup	Current	**50mA**
	Clamping Voltage	2,5V
	Trigger level	2,65Ω **(120mV)**
	Min. Width	**0ns, 10ns, 20ns, 40ns, 80ns**
	Input filter	**10ns, 100ns, 1µs**
	ΔR min.	



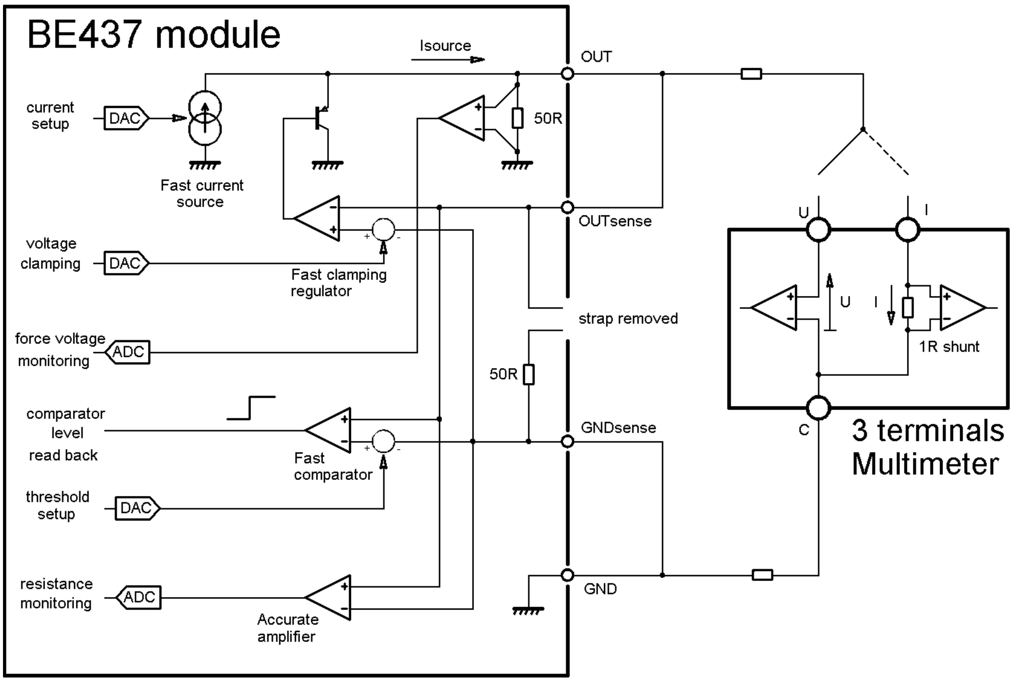
pulse acquisition using different values of "input filter"				
Filter	Time	RES	PULS	WIDth
start	1 0000h00m00s	1	0	0
no	2 0000h00m19s	1	4	2,00E-08
no	3 0000h00m25s	1	8	1,00E-08
100ns	4 0000h00m34s	1	9	9,00E-08
100ns	5 0000h00m39s	1	10	8,00E-08
100ns	6 0000h00m42s	1	11	9,00E-08

No event using 1µs filter

pulse acquisition using different values of "min pulse width"				
	Time	RES	PULS	WIDth
start	1 0000h00m00s	1	0	0
0	2 0000h00m04s	1	4	1,00E-08
0	3 0000h00m06s	1	8	1,00E-08
10ns	4 0000h00m18s	1	11	2,00E-08
10ns	5 0000h00m20s	1	14	3,00E-08
20ns	6 0000h00m34s	1	16	5,00E-08
20ns	7 0000h00m36s	1	18	5,00E-08
40ns	8 0000h00m50s	1	20	5,00E-08
40ns	9 0000h00m52s	1	22	5,00E-08
80ns	10 0000h01m07s	1	23	1,00E-07
80ns	11 0000h01m10s	1	24	1,00E-07

8.4 Calibration test

The calibration of the module involves testing separately voltage and current .
For this purpose, the sense connexions are shorted, and the BE437 module is connected to a general purpose digital multimeter :



The strap which connects the internal 50Ω resistor at sense input must be removed. As no current flows into external cable and connexions, the voltage displayed by the voltmeter will be equal to the amplifier input's.

Easystress control sheet displays the computed resistance value, but no the straightforward voltage input values. Then, using dedicated SCPI commands (see section 8.5), it is possible to display the voltage measurements both at force output and at sense input, the comparator state...

The complete calibration requests 4 steps:

- **The current setup** is tested while ranging from 1mA up to 100mA, with the ampere meter using a shunt lower than 1Ω. The actual source current is computed using the formula:
  Imeas = Isetup - Vforce/50Ω

- **The voltage clamping setup** is tested while ranging from 20mV up to 2,5V. The current setup is fixed to 100mA.

- **The low level voltage measurement** used for ohmmeter function is tested using the voltage clamping setup ranging from 20mV up to 100mV.

- **The comparator threshold setup** is tested using only DC levels, without any pulse.
  In order to track the toggling point, the comparator level is fixed, and the actual voltage level is raised using the clamping setup ranging from 20mV to 1V.
  The comparator output state is displayed by the front panel LED. (see section 7.2).

An automatic accuracy test bench is used by iTest for the purpose of initial test and periodical check on customer request. The next page is a partial copy of the main sheet of the Excel control file used for BE437 module test.

ACCURACY TEST

BE437 N° 01-002 Vers B,406 | Code date 09/08 | New:

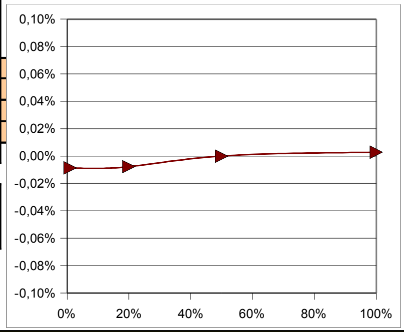
Error level : 7	marge de précision 0%	marge après correction 79%	marge de réglage

5 Current 0.1A gammeK= 1A 0,1 V

	consigne		Mesure	Ref.	mesures annexes		écart consigne	
	0,10 A		0,1 A				initial	corrigé
niveau	CI	Tstab	K1A?	Isource	MUF?	MUS?	spec:	0,10%
1%	0,001	0	9,675E-04	1,0087E-03	0,001	0,001	-0,01%	0,00%
20%	0,020	0	1,916E-02	2,0008E-02	0,022	0,020	-0,01%	0,00%
50%	0,050	0	4,789E-02	5,0000E-02	0,055	0,050	0,00%	0,00%
100%	0,100	0	9,577E-02	9,9997E-02	0,111	0,101	0,00%	0,00%
contrôle suivi +- 5%					écarts maximums :		0,01%	0,00%

a(C/K)	1,00012	b(C/K)	-8,758E-6
CGI	6,998E-6	COI	3,13E-04
CGI'	6,997E-6	COI'	3,21E-04
idéal:	6,936E-6	idéal:	0,00E+00
limite+/-	5,00%	80 LSB	5,549E-4
marge	82%	marge	42%

marge précision initiale	91%
marge précision corrigée	97%
marge de réglage	42%

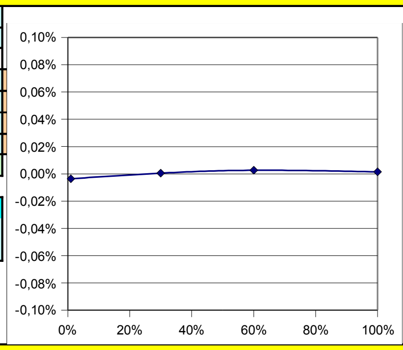


6 Voltage 0.1V Mesure sense

	consigne		Mesure	Ref.	mesures annexes		écart mesure	
	0,1 V		0,1 V				initial	corrigé
niveau	CI	Tstab	MUS?	KU?			spec:	0,06%
1%	0,001	0	1,015E-03	1,018E-03			-0,004%	-0,002%
30%	0,030	0	3,021E-02	3,021E-02			0,000%	0,001%
60%	0,060	0	6,041E-02	6,041E-02			0,003%	0,002%
100%	0,100	0	1,007E-01	1,007E-01			0,001%	-0,001%
contrôle suivi +- 5%					écarts maximums :		0,004%	0,002%

a(M/K)	1,00005	b(M/K)	-2,147E-6
MGUS	3,219E-6	MOUS	-4,999E-4
MGUS'	3,219E-6	MOUS'	-4,978E-4
idéal:	3,179E-6	idéal:	0
limite+/-	5,0%	300 LSB	9,537E-4
marge	75%	marge	48%

marge précision initiale	94%
marge précision corrigée	97%
marge de réglage	48%

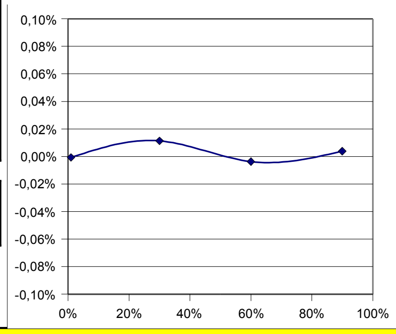


7 Voltage 2.5V clamping

	consigne		Mesure	Ref.	mesures annexes		écart consigne	
	2,5 V		2,5 V				initial	corrigé
niveau	Cumax	Tstab		KU?			spec:	0,08%
1%	0,025	0		2,502E-02			0,00%	0,00%
30%	0,750	0		7,497E-01			0,01%	0,01%
60%	1,500	0		1,500E+00			0,00%	-0,01%
90%	2,250	0		2,250E+00			0,00%	0,00%
contrôle suivi +- 50%					écarts maximums :		0,01%	0,01%

a(C/K)	0,99999	b(C/K)	7,354E-5
CGU	1,685E-4	COU	0,0
CGU'	1,685E-4	COU'	9,031E-4
idéal:	6,936E-6	idéal:	0
limite+/-	5,00%	10 LSB	6,936E-5
marge	0%	marge	0%

marge précision initiale	86%
marge précision corrigée	89%
marge de réglage	0%



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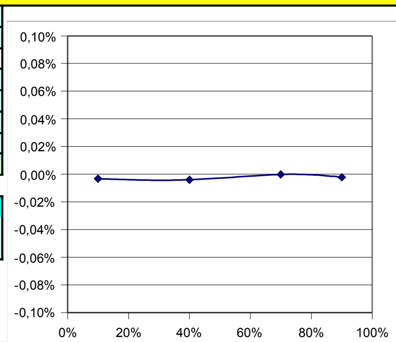
8 Voltage 0.3V force

	consigne		Mesure	Ref.	mesures annexes		écart mesure	
	0,3 V		0,3 V				initial	corrigé
niveau	Cumax	Tstab	MUF?	KU?			spec:	0,10%
10%	0,030	0	3,010E-02	3,011E-02			0,00%	0,00%
40%	0,120	0	1,200E-01	1,200E-01			0,00%	0,00%
70%	0,210	0	2,100E-01	2,100E-01			0,00%	0,00%
90%	0,270	0	2,700E-01	2,700E-01			0,00%	0,00%
contrôle suivi +- 5%					écarts maximums :		0,00%	0,00%

a(C/K)	1,00003	b(C/K)	-1,159E-5
MGUF	9,826E-6	MOUF	1,591E-3
MGUF'	9,826E-6	MOUF'	1,603E-3
idéal:	9,781E-6	idéal:	0
limite+/-	3,0%	200 LSB	1,956E-3
marge	85%	marge	18%

marge précision initiale	96%
marge précision corrigée	98%
marge de réglage	18%

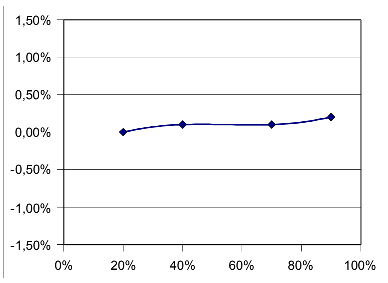


10 Voltage S_bp_H

	consigne			Mesure	V Step	0,0005		
	0,5 V		0,5		Nbre	20	initial	corrigé
niveau	CUMAX	min	max	CuL			spec:	0,20%
20%	0,100	0,090	0,110	0,100			0,00%	-0,01%
40%	0,200	0,190	0,210	0,200			0,10%	0,04%
70%	0,350	0,340	0,360	0,350			0,10%	-0,03%
90%	0,450	0,440	0,460	0,449			0,20%	0,02%
	contrôle suivi +- 100%				écarts maximums :		0,20%	0,04%

a(C/K)	1,00242	b(C/K)	-1,639E-4
CGUD1	3,595E-5	COUD1	-2,463E-3
CGUD1'	3,604E-5	COUD1'	-2,627E-3
idéal:	6,936E-6	idéal:	0,000E0
limite+/-	5,00%	150 LSB	1,040E-3
marge	0%	marge	0%

marge précision initiale	0%
marge précision corrigée	81%
marge de réglage	0%



8.5 Main SCPI commands

Command	Comments
***idn?**	Complete identification of the module: • BE437A module type + hardware revision letter • CONTACT RESISTOR TEST :function description • VC101: FPGA revision • SN01-008 serial number • LC08-52: last calibration date • VL1,01 : software revision
CURRent [val][?]	current setup. (100mA range) (including update of VOLT:LEV, providing constant RES:LEV value) Use of m,µ,n coefficient allowed , Example : curr *41.5 m* = curr *415E-4* = *curr 0,0415*
VOLTage:LEVel [val][?]	Voltage trigger level setup, (1V range) including automatic update of RES:LEV
RESistance:LEVel [val][?]	Resistance trigger level setup (10*Ω* range) including automatic update of VOLT:LEV
VOLTage:MAXimum [val][?]	Clamping voltage setup (2,5V range)
MEASure:VOLTage:SENSe ?	Reading of the voltage at sense input (100mV range)
MEASure:VOLTage:FORCe ?	Reading of the voltage at force output (300mV range)
MEASure:VOLTage ?	Reading of the voltage measurement at remote sense point, including wire resistance compensation. (100mV range)
MEASure:RESistance?	Reading of the computed DC contact resistor (1*Ω* range)
MEASure:RESistance:CABle?	Reading of the computed cable resistor, per lead, using sense and force voltage measurement (1*Ω* range)
OUTPut [on/off][?]	Enabling / Disabling output
LIMit[:STATe][on/off][?]	Enabling / Disabling of the software thresholds monitoring .
LIM:UPP[val][?] **LIM:LOW[val][?]**	Resistor High/low threshold programming Any values are accepted, without any warning message if out of range. It's then possible to disable one threshold monitoring using any inaccessible out of range value : *limit:upp 10m;low –1000;state on (set only UPP threshold to 10mΩ)*
LIM:DELay [val][?]	Setting of delay before applying thresholds. (0-60000 ms) . This delay start at OUTP ON or P:STATE ON received.
LIM:CLEar	Thresholds reset
LIM:FAIL?	Reading of alarm status related to the selected channel. "NO": No alarm "LOW" : Resistor LOWer software threshold occurred. "HIGH" : Resistor UPPer software threshold occurred. FULL : maximum pulse count OVER : maximum force voltage 300mV
PULSe:BANDwidth[val][?]	Input filter setup: 0 or H = 10ns 1 or M = 100ns 2 or L = 1µs
PULSe:COUNt[?]	Pulse counter read back, max.65535
PULSe:COUNt:CLEar	Pulse counter clear
PULSe:WIDth[val][?]	Pulse duration read back
PULSe:WIDth:MINimum[val][?]	Minimum pulse duration setup
RESistance:STEP[val][?]	Minimum resistor drift amplitude requested to trig event memorization
IDATA?	Complete data read back: N° instrument, State, Lim:Fail, Meas:res, Pulse:count, Pulse:width,meas:res:cable