



Inventure

Automotive Electronics



XL Meter™

User's Manual

Inventure

XL MeterTM

Pro Gamma

Notes

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1 Introduction

Thank you for purchasing an Inventure product. Your new XL Meter™ Pro¹ is a carefully engineered, high quality durable product with modern features and elegant styling. It is designed to give you the quality and convenience you expect from an acceleration/deceleration meter.

To familiarize yourself with all the features of your instrument, please read the following instructions carefully. Retain this guide for future reference.²

Important! All the information written in this material is informative and subject to changes without any notice.

2 Warranty

There is a one-year warranty on XL Meter™ from the date of the original purchase. The warranty covers any defect in materials or workmanship. The warranty is valid only if XL Meter™ was operated under normal circumstances in regular use and the warranty sealing is not corrupted. The warranty does not include the batteries, damage from misuse or neglect.

As XL Meter™ has a well thought design, it is thoroughly tested before release and it is composed of high quality parts, there should be no need for regular maintenance of any parts of XL Meter™ during normal operation. Therefore the box screws are sealed. Should the seal be missing, damaged or corrupted, the warranty for XL Meter™ is no longer valid.

Remember to save your sales receipt (invoice) in case you ever need warranty service. Please refer to the serial number of your XL Meter™ in case of any problems. The serial number can be found on a label inside the battery compartment or can be displayed in *Settings* mode.

In case of warranty claims contact your local dealer or directly Inventure, Inc. (See Section 9)

3 Parts check list

Check this list to be certain all components are included.

- XL Meter™ base unit
- Special bag
- RS-232 link cable

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² Information contained in this publication regarding the device applications and the like is intended through suggestion only and may be superseded by updates.

- Set of AA type batteries (4 pieces)
- CD with XL Vision™ software

3.1 Optional complementary

The XL Meter™ universal acceleration and deceleration set contains everything that necessary for normal usage. With the help of the optional complementary, which are not included, the usage of the instrument can be even more comfortable. The list of the optional complementary can be read on the homepage of Inventure Automotive. Among them are the followings:

- Brake pedal switch – for brake delay examination
- USB cable kit – for perfect USB connection
- Cigar-lighter adapter – for continuous readiness in cars

4 Description

4.1 Definition of XL Meter™

XL Meter™ is a battery operated universal acceleration/deceleration meter with an alphanumeric LCD display, built-in service brake performance or acceleration evaluation program, and RS-232 compatible PC interface.

4.2 Outlook

From technical viewpoint the design of XL Meter™ is composed of three parts. These are the housing containing the electronic control unit, the vacuum cup and the jointed arm for flexible suspension.

4.2.1 Box

XL Meter™ has an aluminium box specially designed to be suitable, easy to handle and easy to install for acceleration measurement purposes. The jointed arm on the top enables the calibration of the zero level when installed on the windscreen by the vacuum cup. Under the bottom cover the AA type battery holder can be found. (See detailed in chapter 4.4)

4.2.2 Connectors

There are two connectors on the back panel of XL Meter™. The nine-pole SUB-D type is the RS-232 compatible interface connector that enables communication to a PC. The PC link cable (supplied) should be connected here during data upload. The same connector is used for the input of the brake pedal switch and the output of the trigger signal.

Table 1 The pin assignment of the nine-pole D-SUB connector

Pin	Name	Description
1	-	-
2	RX	RS-232 receive
3	TX	RS-232 transmit
4	Brake Trigger Input 1	Brake Trigger Input 1
5	GND	System Ground
6	Trigger Out	Trigger Output
7	-	(Optional) Analogue Input
8	Brake Trigger Input 2	Brake Trigger Input 2 (Optional)
9	-	(Optional) VCC

The round one is the external power supply (DC in) connector. Use only approved external adapter for powering XL Meter™. The housing of XL Meter™ is negative grounded, the pinout of the external power supply connector can be seen on *Figure 1*.

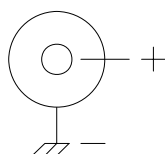


Figure 1 The pinout of the external power supply connector

Note: The maximum input voltage allowed is 18.0V.

4.2.3 Suspension

XL Meter™ can be installed in seconds, due to its suitable design of suspension. XL Meter™ is suspended by a high quality vacuum cup. Simply putting XL Meter™ to the desired point of the windscreen or any other fine surface and turning the knob of the vacuum cup is sufficient for a strong installation. Due to the high quality of the Veribor® vacuum cup, XL Meter™ has a particularly strong hold on the surface where it was installed.

4.2.4 Control buttons

XL Meter™ is extremely simple to operate. Three buttons can operate it. Each button has a different color and a dedicated function described below:

4.2.4.1 On/Off Button (Black Button)

The On/Off button has two functions: the first is to control the power supply, and the second is to control the backlight or the brightness of the display. If the XL Meter™ is off, you can

switch it on by pressing the On/Off button once for a couple of seconds. After switching on, pressing the On/Off Button for a short period of time (less than 2 sec.) will result in toggling the backlight or the brightness of the display (depending on the type of the display: LCD or PLED). This means that the backlight/brightness will turn on or increase by pressing the button once, and turn off or decrease by pressing it for the second time, turn on or increase also for the third time, and so on. It is important to note that the LCD backlight should only be used when it is necessary, as the power consumption is approximately tripled if the LCD backlight is on, resulting in shorter battery lifetime. XL Meter™ can be switched off by pressing the On/Off button for a longer period of time (more than 2 seconds). If this action is successful you see a shutdown message on the screen before releasing the button.

4.2.4.2 Display Button (Green Button)

The results of all measurements can be displayed on the screen by pressing the green button. From *Calibration Mode* you can enter *Display Mode* by pressing once either the green or the red button.

In *Display Mode* you can switch from one measurement to another by pressing the display button. You do not have to wait until all the results are displayed, but you can anytime interrupt one display cycle and enter the display cycle of the next measurement.

You can start a measurement (data acquisition) by pressing the red button. To stop data acquisition press the display (green) button. The evaluation automatically (if such evaluation was chosen) starts after the stoppage the measurement. Finishing the evaluation it enters *Display Mode* again and the currently performed measurement results will be displayed.

4.2.4.3 Measurement Button (Red Button)

Starting a measurement (data acquisition) can be invoked by the measurement button. You can also use the red button to enter *Display Mode* from *Calibration Mode* by pressing it once. Measurement can only be started from *Display Mode*. Anytime the currently displayed measurement will be overwritten by the new measurement. You do not have to wait until all the results are displayed, but you can anytime interrupt one display cycle and start data acquisition. Data acquisition can be stopped by the display (green) button.

Note: Before starting measuring, the XL Meter™ Pro Gamma will ask to overwrite the actual measurement. If yes, then the measurement starts, if No, it returns to *Display Mode*. In this way, you can avoid to overwrite a measurement accidentally.

4.2.5 Display

The display is a 2x16 character alphanumeric display; it features high contrast easy to read characters and numbers. There are two kinds of displays depending on the technology: Liquid Crystal Display (LCD) with switchable backlight and PLED with switchable brightness.

4.2.5.1 LCD

There is a possibility to illuminate the LCD during night measurements. The LCD backlight can be toggled (turned on/off) by simply pressing the On/Off button (See details in chapter 4.2.4.1).

Note: The LCD backlight consumes relatively high energy, meaning that the continuous usage of the LCD backlight can radically reduce the battery lifetime. So please make sure that the light is off when it is not necessary.

4.2.5.2 PLED

The PLED display uses yellow-green pixels to show characters. While the LCD display has switchable backlight, the PLED display has switchable brightness. Due to the production technology, the PLED display has outstanding brightness and contrast. Its brightness can be disturbing especially in darkness so its brightness can be increased and decreased by pushing the On/Off button for a short time (See details in chapter 4.2.4.1).

4.2.6 Buzzer

The XL Meter™ Pro Gamma has an integrated Buzzer. With the Buzzer's signal, it is easier to realise the different states of the instrument. The Buzzer can be turned on and off in the *Settings/Special settings/Buzzer* menu.

The default setting of the Buzzer is on, and the *Measuring mode* is signed by cheeping continuously. This cheeping can be turned off temporally (and turned on again) by pressing the *Red button* for approx. 1 second.

Note: In *Measuring mode*, toggling the Buzzer is temporally only and is not saved. For the next measurement, the Buzzer state set in *Settings* menu will be valid.

Table 2
Meanings of Cheeping

Event	Cheeping
Turn On / Off	1
System test OK	1
Press Display (green) button	1
Press Measuring (red) button a	1
Measuring	Continuous
End of measurement	1
Evaluation error	3
Change settings / write memory	1
Battery low	5
Change batteries	5

4.3 Functional description

4.3.1 Power-on

You can turn on XL Meter™ by pressing the black On/Off button for approx. 2 seconds (See detailed in chapter 4.2.4.1). Short button press will not turn the instrument on; this feature prevents the instrument from turning on unintentionally or accidentally. When the instrument is turned on, it cheeps one to sign (See chapter 4.2.6 for details), and then the instrument name (XL Meter Pro Gamma) is displayed in the first line of the display for identification purpose. At power-on, the LCD backlight is turned on while the system is checked internally for errors and the battery performance is evaluated. If there are no problems the System Check OK message can be read on the display. After this the backlight is turned off automatically and XL Meter™ enters *Calibration Mode*.

4.3.2 Calibration Mode

Entering *Calibration Mode* is automatic after System Check. In *Calibration Mode* the component of the gravity acceleration ($\approx 9.8 \text{ m/s}^2$) in line with the sensing axis of XL Meter™ can be read on the display with 0.1s refresh rate. *Calibration Mode* has three purposes: In calibration mode both the longitudinal (a_x) and lateral (a_y) acceleration components are displayed simultaneously. The objectives of calibration:

- After installation - before starting a measurement - XL Meter™ has to be set to the 0.0 m/s^2 calibration level. This procedure was implemented in order to have maximum resolution during measurement.
- Sensor test possibility. (See detailed in chapter 4.3.2.1)

4.3.2.1 Sensor Test

This function is a perfect possibility to test the measuring capabilities of XL Meter™, as the user is able to test the performance of the acceleration sensor. The sensor test can easily be performed using the earth's gravity as an etalon. Turning the sensitive axis of XL Meter™ to the ground, in ideal case the well-known 9.8 m/s^2 should be seen, and turning XL Meter™ upside down with 180 degrees -9.8 m/s^2 should be seen on the display.

To be able to decide whether the actual performance of the sensor enables to take correct (legally and technically acceptable) measurements or not, the calibration status of the instrument should be determined. (See chapter 8.3)

Note: After power-on the acceleration sensor may require some seconds to “warm-up” and show the correct value.

4.3.3 Display Mode

Entering *Display Mode* automatically starts the display cycle that shows the measurement results. XL Meter™ starts the display of the measurement results with the one that was active before power-off. The displayed measurement results under each measurement number are always the results of the last successfully evaluated measurement.

If there was an evaluation error, there is no display cycle of measurement results, but the evaluation error code is displayed under the corresponding measurement number. The meaning of the error codes are listed in chapter 7.4.

Note: Regardless of the fact of an evaluation error the measured data are stored, thus they can be uploaded to the PC for manual evaluation.

From *Calibration Mode* you can enter *Display Mode* by pressing either the green or the red button once. In *Display Mode* you can switch from one measurement to another by pressing the display (green) button. You do not have to wait until all the results are displayed, but you can anytime interrupt one display cycle and enter the display cycle of the next measurement. You can start a measurement (data acquisition) by pressing the red button. Data acquisition can be stopped by pressing the display (green) button. Stopping the measurement the device returns to display mode, where the actual measurement results are displayed. The results are scrolling on the display continuously, thus the results can be easily noted. The results are depending from the type of the measurement. The detailed explanation of the different evaluations and results can be found at chapter 4.3.5

4.3.4 Measurement – data acquisition

4.3.4.1 Acceleration measurement

XL Meter™ uses a complete acceleration measurement system on a single monolithic IC. It contains a polysilicon surface-micromachined sensor and signal conditioning circuitry which implements a force-balance control loop. XL Meter™ is capable of measuring both positive and negative acceleration to a maximum level of ± 2 g. The characteristic of the acceleration sensor assures the quality of the measurement results.

4.3.4.2 Acceleration sensor

XL Meter™ uses a differential capacitor acceleration sensor. The differential capacitor acceleration sensor consists of independent fixed plates and central plates attached to the main beam that moves in response to an applied acceleration.

The two capacitors are series connected, forming a capacitive divider with a common movable central plate. When at rest, the values of the two capacitors are the same, and therefore, the voltage output at their electrical centre is zero. When acceleration is applied, the common central plate moves closer to one of the fixed plates while moving further from the other. This creates a mismatch in the two capacitances, resulting in an output signal at the central plate. The output amplitude of the signal varies directly with the amount of acceleration experienced by the sensor. You can simply check the performance of the acceleration sensor in *Calibration Mode*. (See detailed in sections 4.3.2 and 8.3)

Note: Right after power-on the acceleration sensor may require some seconds to “warm-up” and show the correct value.

Note: The maximum shock survived by the acceleration sensor for 0.5ms is 500g in powered, and 1000g in unpowered status. Remember that drops onto hard surface can cause shocks of greater than 1000g, so care should be taken in handling XL Meter™ to avoid this damage.

4.3.4.3 Data acquisition

The XL Meter™ Pro Gamma is designed to measure the acceleration in two axis (longitudinal and lateral) *Measuring Mode* (data acquisition) can only be started from *Display Mode* by pressing the red button. Since you have started data acquisition the acceleration data are stored in the memory. No matter how long you drive in *Measuring Mode* before braking, in each case the last 40 (80)³ seconds of measured data are available in the memory. You cannot switch off the XL Meter™ during data acquisition. The display button is the only button that has effect on the measurement cycle, pressing it will stop data acquisition.

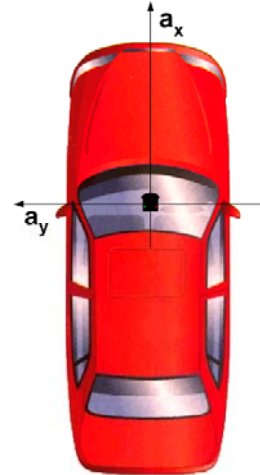
³ The measuring time depends on the *Measurement number* and the *Measuring frequency*

Note: Data acquisition and on-the-spot evaluation are independent, separate functions of the instrument. It means that due to the data acquisition theory, the data are always stored into the memory and can always be uploaded to a PC, regardless of the result of the built-in service brake performance evaluation program.

4.3.4.4 Measuring Directions

In XL Meter™ Pro Gamma, the X-Y measuring directions are interchangeable, and each of them can be negated. You can reach these features in *Settings* menu.

In some cases (e.g. broken windscreen), it can be useful to install the equipment in some other places than the recommended one (the middle of the windscreen). In these cases, interchanging the measuring directions and/or negating them can be very useful. After proper settings, the acceleration or deceleration measurement is possible even installing the equipment on one of the side windows.



Example: installing the equipment in the back windscreen, both directions must be negated.

4.3.4.5 Data storage

XL Meter™ has a storing capacity of eight⁴ different measurements and results at a time. The data storage capacity is 40s (80s) per measurement. There is continuous data acquisition during one measurement so anytime the last 40 (80) seconds of data measured are stored for future availability. The sampling rate of the acceleration is 200Hz, meaning that there is acceleration data available in every 5ms. The battery is not needed to retain the stored measurement data, because of the non-volatile type memory, so they will be accessible even after shut down. The guaranteed data retention is over 200 years.

Note: Should the built-in evaluation program send an error message during on-the-spot evaluation the currently measured data are available in the memory, thus can be uploaded and evaluated on a PC with the XL Vision™ program.

4.3.4.6 Measurement identifier

In XL Meter™ Pro Gamma, each measurement has a unique identifier. This is a number incremented by one at each measurement, so the actual measurement identifier also can tell how many measurements were carried out altogether.

⁴ Three, six or eight different measurements are available depending on the configuration

4.3.5 On-the-spot evaluation

XL Meter™ has several built-in evaluation programs to enable fast on-the-spot evaluation of service brake performance or acceleration. The type of evaluation can be chosen in *Settings* menu and it must be chosen prior to starting the measurement. For a measurement, only one on-the-spot evaluation can be chosen, but if you upload the measured data to a PC, the same measurement can be evaluated in different ways.

Available On-the-spot evaluations:

- **No Evaluation (optional):** Only data acquisition is performed. Useful for measurements with no built-in evaluation.
- **Service Brake Evaluation (default):** After finishing data acquisition, this evaluation is started automatically. The evaluation is used to qualify the vehicle service brakes. Useful for on-the-spot investigation of accidents, creation of forensic engineering reports on accidents, the task of service brakes testers.
- **Acceleration Evaluation (optional):** The evaluation running parallel with acquisition is used to analyse the vehicle acceleration and dynamic. Useful for journalists of motoring or car/motor mechanics, drag race and tuning fans.
- **Retarder Evaluation (optional):** For the moment, it can be performed only in PC, but in the future, it will be available as a built-in feature.
- **Tram Brake Evaluation (default):** For the moment, it can be performed only in PC, but in the future, it will be available as a built-in feature.

4.3.5.1 Service Brake Evaluation

XL Meter™ has a built-in evaluation program to enable fast on-the-spot evaluation of service brake performance. The built-in evaluation program is valid for the automatic evaluation of braking performed by the service brake. (This built-in evaluation program facilitates on-the-spot investigation of accidents, creation of forensic engineering reports on accidents, the task of service brakes testers, etc.)

As the built-in service brake performance evaluation program starts automatically right after finishing a measurement.

Important! After the vehicle has stopped and the vehicle reaches absolute standstill, the user has to wait approximately one second before pushing the display button and terminating data acquisition. XL Meter™ then automatically starts the evaluation procedure. First, it learns the standstill level that will be the base level for further calculations.

Note: Pushing the display button earlier will result in an evaluation error, see chapter 7.

The brake start time and brake end time of the deceleration process is determined based on the measured characteristics. The braking time (Tbr) is calculated by subtracting the brake start time from the brake end time. The initial vehicle speed value is calculated by the simple numerical integration of the acceleration data in the interval of the brake time. Brake distance (So) is calculated by the duplicate integration of the acceleration data in the interval of the brake time. The calculation method of 'MFDD' is described section 5.3. The successful evaluation gives the following results.

- So [m] distance in the time of braking (Tbr)
- Vo [km/h] initial vehicle speed at the time of braking
- Tbr [s] time from the start till the end of braking
- MFDD [m/s²] is a standard measurement number described in ECE Regulation No. 13. (European Braking Regulations ECE R.13 & EEC 71/320)

Example:

The results get from evaluation are as follows: So=18.17 m, Vo=57.42 km/h Tbr=2.17 sec MFDD=7.27 m/s².

The meanings of them are the following: The initial speed of the vehicle was 57.42 km/h when started braking. It took 2.17 seconds to stop, and the vehicle went 18.17 meter in this time. The MFDD (Averaged maximal deceleration) is 7.27 m/s².

4.3.5.2 Acceleration Evaluation

The XL Meter™ Pro Gamma offers a possibility to analyse the acceleration or dynamics of a vehicle. This feature can evaluate the accelerations capability of a vehicle in different intervals, which makes possible to compare different types of vehicles objectively and quickly. The range can be speed as well as distance. The limit can be chosen before each measurement if Acceleration evaluation was set as Evaluation type in Settings menu.

Note! The acceleration evaluation starts with the standstill level recognition. If a measurement is too long, the initial part of the measurement, which contains the standstill level, can be overwritten and the evaluation on PC can result false values. The on-the-spot evaluation is right because it is independent from the stored data.

The automatic start-recognition algorithm enables that the evaluation starts when the vehicle starts and not when the red button is pushed. During measuring, the actual speed and distance are displayed continuously. The acceleration integrated once is the speed, while integrated twice is the distance.

Table 3**Available intervals⁵**

Speed ranges	Distance ranges
0-20 km/h	0-50 m
0-40 km/h	0-100 m
0-60 km/h	0-201 m (eighth part of mile)
0-80 km/h	0-402 m (a quarter mile)
0-100 km/h	
0-120 km/h	
0-140 km/h	
0-180 km/h	

The measuring stops automatically if the desired range is reached. The measurement results are displayed immediately. If it is not possible to reach the desired range, pressing the green button can stop the measurement.

The measurement results are the followings:

- **v [km/h]:** the actual speed when the measuring is stopped
- **s [m]:** the distance made from the start of the measurement till the end of it
- **t [s]:** the time passed between the start and the end

Example:

The evaluation results are as follows: s=143.1 m v=95.69 km/h t=10.73 s. The meanings of them are the following. The vehicle speed was 95.69 km/h when the button was pushed at the end of the measurement. This speed was reached in 10.73 seconds while the vehicle moved 143.1 meter.

4.3.6 Settings Mode

This operation mode enables the user to change certain parameters or characteristics of the measuring instrument.

4.3.6.1 Entering Settings Mode

Settings Mode can be accessed by pushing and holding down the green button right after power-on through the message System Test OK. When the display shows “Settings” the XL Meter™ Pro Beta has entered Settings Mode.

⁵ More intervals are available for user's request

4.3.6.2 Setting Possibilities

The following items can be set in Settings Mode:

- Language
- Measuring Parameters
 - Measuring Frequency
 - Measurement Axis
 - Measurement Range in X direction
 - Measurement Range in Y direction
 - X direction
 - Y direction
- Type of Evaluation
- Special Settings
 - Auto Power Off
 - Buzzer
 - Trigger Output
- Reset Defaults

In addition the following identification information can be get in Settings Mode:

- Serial Number
- Firmware Version Number

4.3.6.2.1 Language

The User can set the display language of the instrument. Currently the following languages are available:

- English
- Deutsch (German)
- Magyar (Hungarian)

A language setting is the first item in Settings Mode and the changing takes effect immediately.

Note: Additional languages can be implemented upon special request.

4.3.6.2.2 Measuring Parameters

Measuring Frequency (Sampling Time)

The Measuring Frequency (Sampling Time) determinates the time between two samplings. By changing the Measuring Frequency the User has the possibility to decide the trade-off between high sampling rates versus long measuring time.

The Measuring Frequency also has an influence on the accuracy of the measurement. The higher the Measuring Frequency is, the more accurate the measurements are. This is why Inventure suggests 200 Hz measuring frequency for Service Brake Performance evaluation tests.

Currently the following frequencies are available:

- 200 Hz (5 ms sampling time)
- 100 Hz (10 ms sampling time)
- 50 Hz (20 ms sampling time)
- 25 Hz (40 ms sampling time)

The following table shows the memory allocation, and the available time frame (measurement length) depending on the selected measuring frequency.

Table 4 **Memory allocations**

Frequency	Sampling Time	Base Memory			Memory Plus			Memory Max	
		M1	M2	M3	M4	M5	M6	M7	M8
[Hz]	[ms]	Measurement length [s]			Measurement length [s]			Meas. length [s]	
200	5	80	40	40	40	40	40	80	80
100	10	160	80	80	80	80	80	160	160
50	20	320	160	160	160	160	160	320	320
25	40	640	320	320	320	320	320	640	640

According to the different memory allocations the number of measuring locations can be 3 (Base Memory), 6 (Memory Plus) or 8 (Memory Max). The above table shows the storage capacity of each measuring location for the continuous storage of the measured longitudinal- and lateral acceleration signals.

Note: The accuracy of the measurement and the evaluation are effected by the measuring frequency.

Measurement Axis

In normal case, the longitudinal acceleration is in X direction while the lateral acceleration is in Y direction. There is a possibility to interchange directions, so the longitudinal acceleration will be in Y direction, and the lateral acceleration will be in X direction. It is important during the evaluation, because in this way, the lateral acceleration or deceleration can be evaluated as well.

Measuring Ranges

The Measuring Range determinates the minimum and the maximum acceleration level that is measured. By changing the Measuring Range the User has the possibility to decide the trade-off between high resolution versus wide range of acceleration. Measuring Range can be set independently for directions X and Y and they can be configured separately.

Currently the following ranges are available:

- Basic Range: It is between -14.0 m/s^2 and $+14.0 \text{ m/s}^2$.
- Narrow Range: It is between -5.0 m/s^2 and $+5.0 \text{ m/s}^2$.
- Wide Range: It is between -20.0 m/s^2 and $+20.0 \text{ m/s}^2$.

The following table shows the advantages and the suggested applications of each measuring range settings.

Table 5 **Measuring Range Settings**

Measuring Range						
Dir.	Type	Name	Min [m/s ²]	Max [m/s ²]	Advantages	Application
X direction	Symm	Basic	-14.0	+14.0	Normal Traffic Range, 0.1 m/s ² res.	Service Brake Eval, Veh. Dynamics
	Symm	Wide	-20.0	+20.0	Wide acceleration range	Small collision (< 5 km/h)
	Symm	Narrow	-5.0	+5.0	Higher Resolution 0 symm.	Retarder Brake Eval., Light car tests
Y direction	Symm	Basic	-14.0	+14.0	Normal Traffic Range, 0.1 m/s ² res.	Vehicle Dynamics Measurement
	Symm	Wide	-20.0	+20.0	Wide acceleration range	Small collision (< 5 km/h)
	Symm	Narrow	-5.0	+5.0	Higher Resolution 0 symm.	Slight Steer movement, SBR Eval.

Note: The measurement ranges has no effect on Evaluation.

Measurement Directions

In the *Settings* menu the directions of X and Y-axis can be set. The measuring direction can be Normal (default) or Reversed, meaning that the measured values are negated. The measuring direction can be set independently for axis X and axis Y. Further information about the measuring directions can be found in chapter 4.3.4.4.

4.3.6.2.3 Evaluation

The type of the evaluation can be as follows:

- Service Brake
- Acceleration
- No Evaluation

Service Brake

See chapter 4.3.5 for more information.

Acceleration

See chapter 4.3.5 for more information.

No Evaluation

In this case, only data acquisition is performed.

4.3.6.2.4 Special Settings

- Auto Power Off
- Buzzer
- Trigger Output

Auto Power Off

This function can prevent the instrument from turning on unintentionally. It prevents batteries from consuming when the black button is pushed accidentally. It provides two types of protection: delayed power on and automatic power off.

- Delayed power on

If this function is active, the instrument will be powered on by pressing On/Off button (black button) for approx. 2 seconds. Short button press will not turn the instrument on.

- Automatic power off

This function will switch off the instrument in Calibration mode after approx. 4 minutes. This means, that if the instrument remains in Calibration mode and it does not enter Display mode, the instrument will be powered off in approx. 4 minutes. The only exception is that case when data uploading starts in Calibration mode, because data communication on the serial port overrides Auto Power Off function.

Buzzer

The Buzzer can be enabled or disabled in this step.

Note: If the buzzer is enabled, it chirps when a button is pressed (acknowledgement) or the state of the instrument is changed (warning). During measurement, it cheeps continuously by default, but it can be turned off temporally (and turned on again) by pressing the *Red button*

for approx. 1 second. Toggling the Buzzer in Measuring Mode is temporal only and has no effect on other sound signs.

Trigger Output

The XL Meter™ Pro Gamma can be synchronized with other instruments with the help of the Trigger output. There are three kinds of Trigger Output: Start/Stop, Toggled, or No output.

- Start/Stop

When starting a measurement, the trigger output is changed from low level to high level (from 0 to 1). At the end of measuring, the trigger output is back to low level. With this feature, an other equipment can be started and stopped synchronously.

- Toggled

The trigger sign is an alternate signal according to the measurement frequency. Its periodical time is twice as much than the sampling time of the measurement. Using this feature, the XL Meter™ Pro Gamma and another equipment can sample synchronously.

- No output

The level of the trigger output is low (0).

4.3.6.2.5 Reset Defaults

When selecting “Reset Defaults” in the Settings Mode menu, all the setting parameters are restored to their factory default values.

The Default Settings (or Factory Settings) are the followings:

- Language: *English*
- Measuring Frequency: *200 Hz*
- Measurement Axis: *Normal (X = longitudinal, Y = lateral acceleration)*
- Measurement Range in X direction: *Base Range (between -14.0 m/s^2 and $+14.0 \text{ m/s}^2$)*
- Measurement Range in Y direction: *Base Range (between -14.0 m/s^2 and $+14.0 \text{ m/s}^2$)*
- X direction: *Normal*
- Y direction: *Normal*
- Evaluation: *Service Brake*
- Auto Power-off: *Yes*
- Buzzer: *Yes*

- Trigger Output: *No Trigger Output*

4.3.6.3 Identification data listed in *Settings Mode*

4.3.6.3.1 Serial Number

The serial number of the instrument is not only printed on the label inside the battery compartment, but also stored in the non-volatile memory. The serial number is listed in Setting Mode for easy reading.

4.3.6.3.2 Firmware Version Number

The software burnt into the instrument in the factory is called the Firmware. The functionality of the instrument depends on the version of the Firmware. The Firmware version number is listed in Setting Mode for easy reading.

4.3.6.4 Structure of *Settings Mode*

Setting Mode was organized in a way that it is easy to understand and easy to use. Left button (Green) always mean NEXT, so by pushing it one can go through the setting possibilities. Right button (Red) can either be OK or End. OK means a selection of a setting item or entering a level deeper in the menu. End means to exit Setting Mode.

As language setting is the first item of Settings Mode and the changing takes effect immediately, all the rest of the setting options will be displayed in the new language.

To make navigation in Settings Mode even easier, the following figures show the structure of the options.

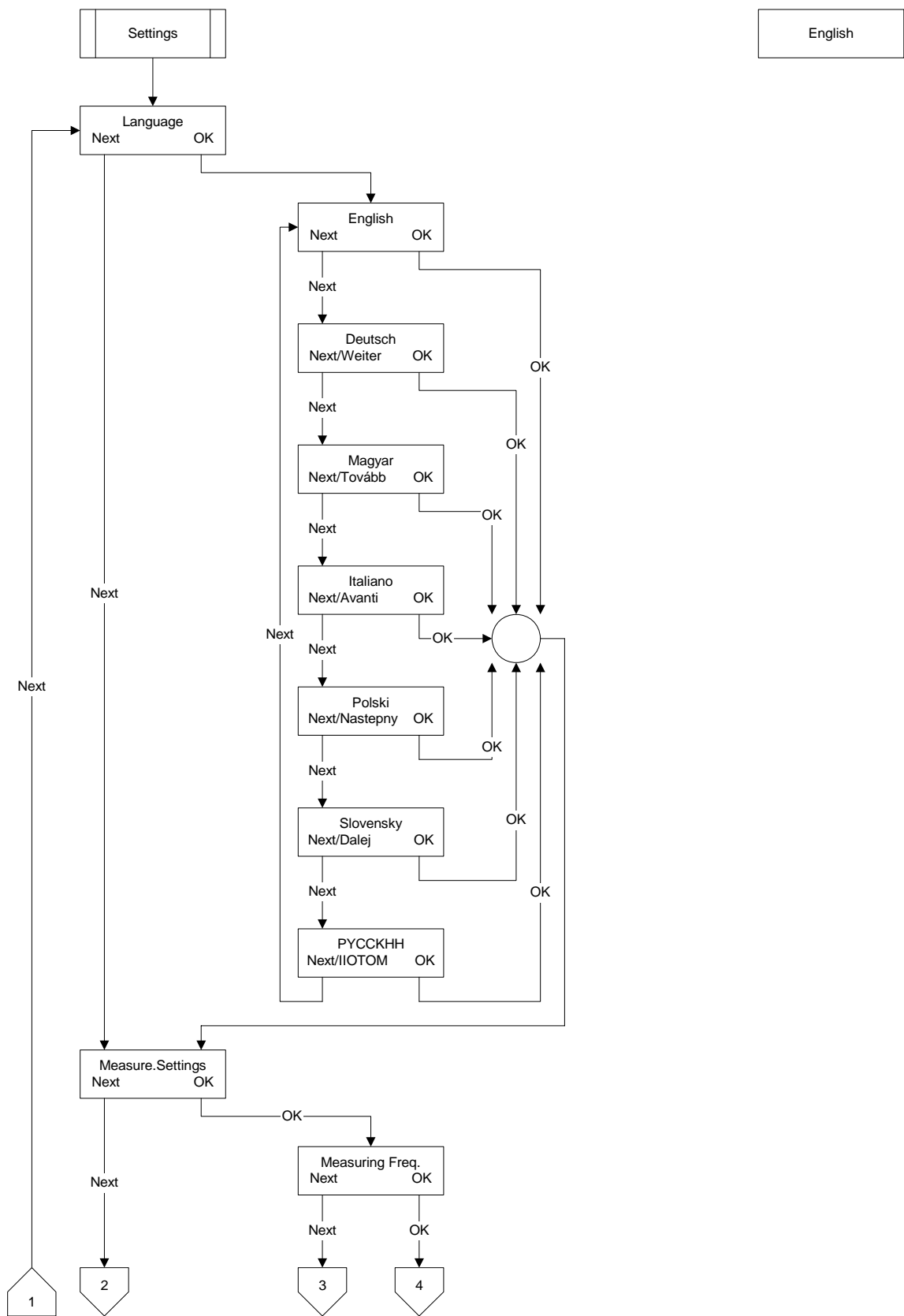


Figure 2

Structure of Settings Mode

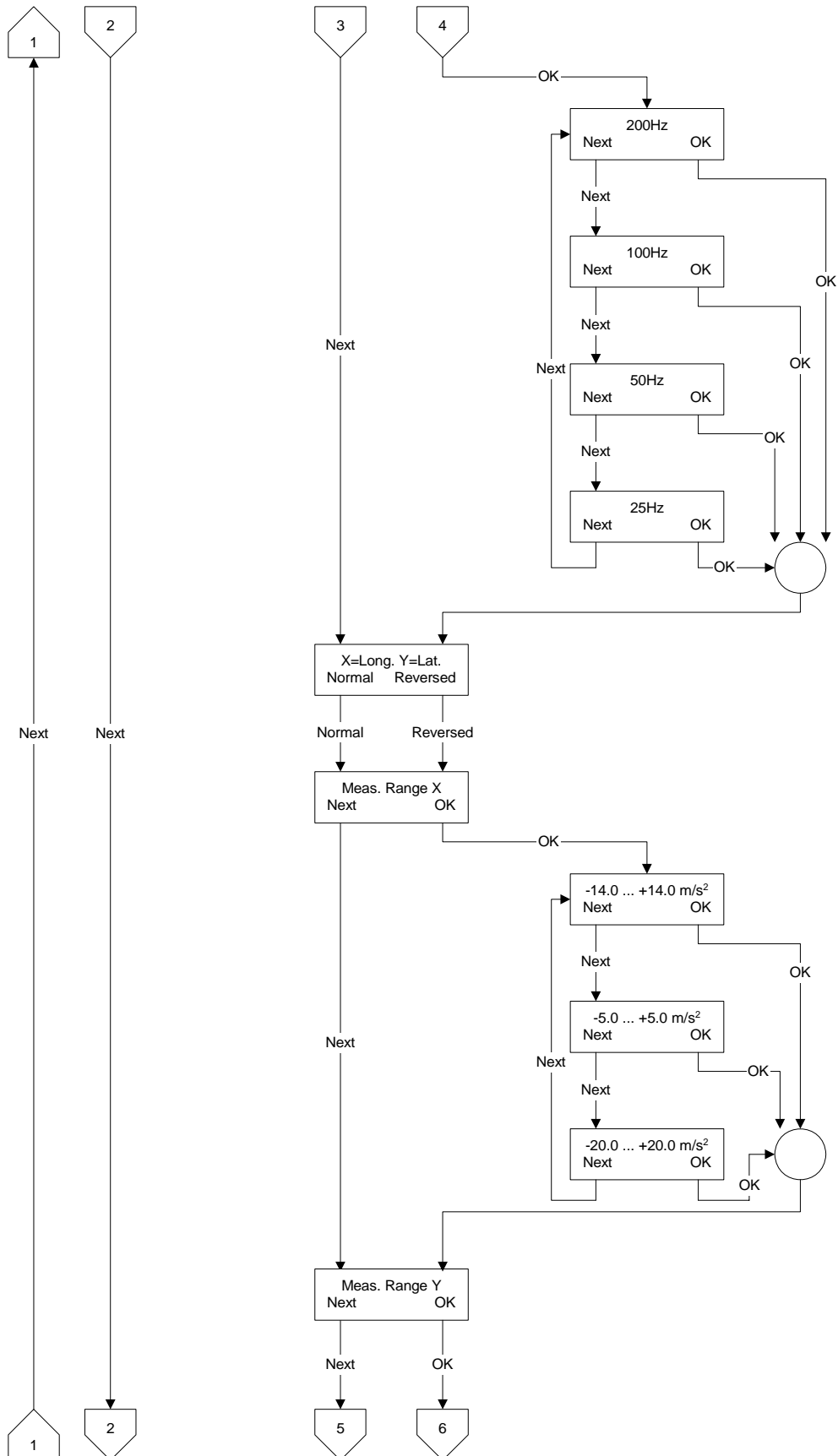


Figure 3

Structure of Settings Mode

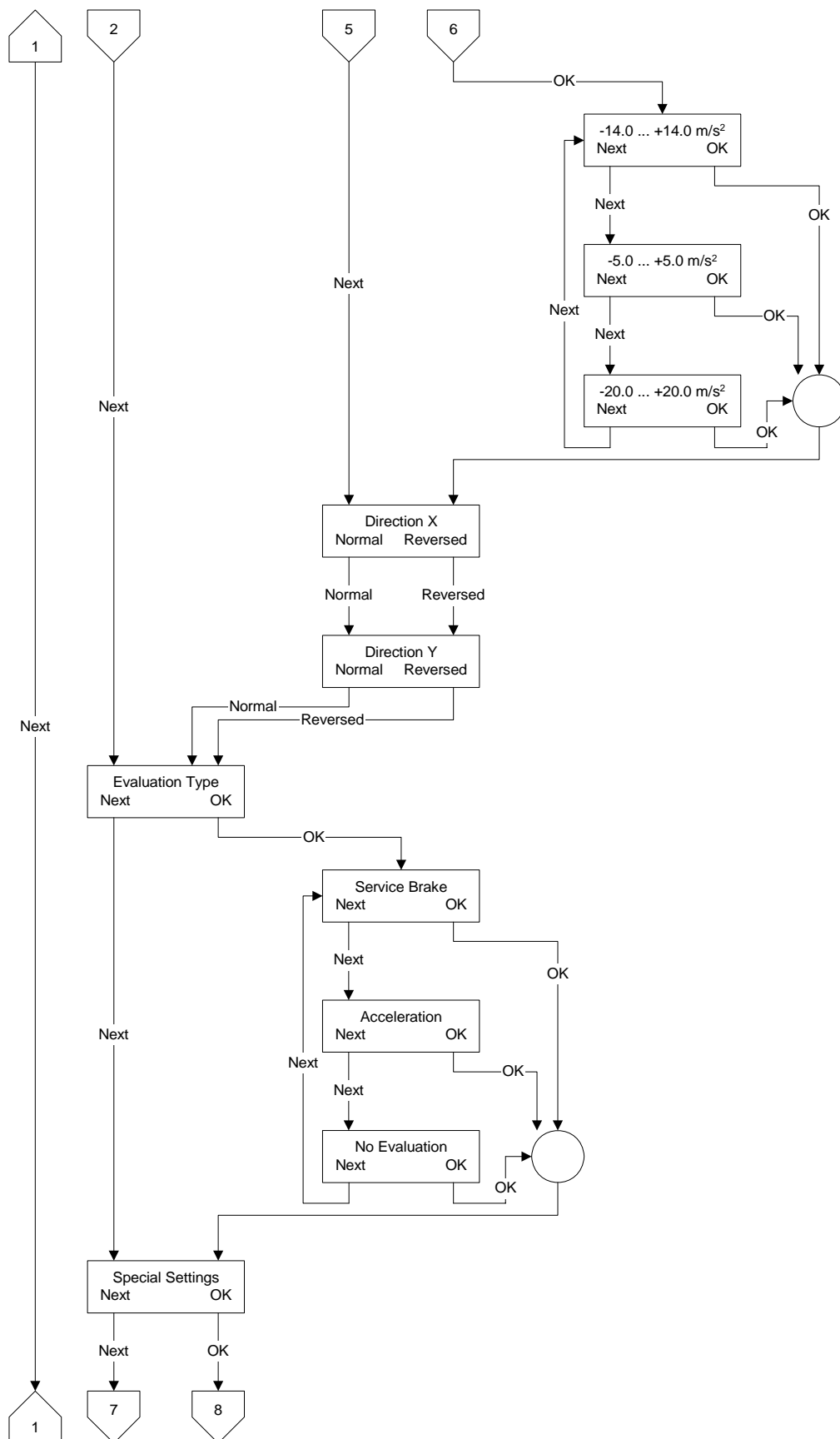


Figure 4

Structure of Settings Mode

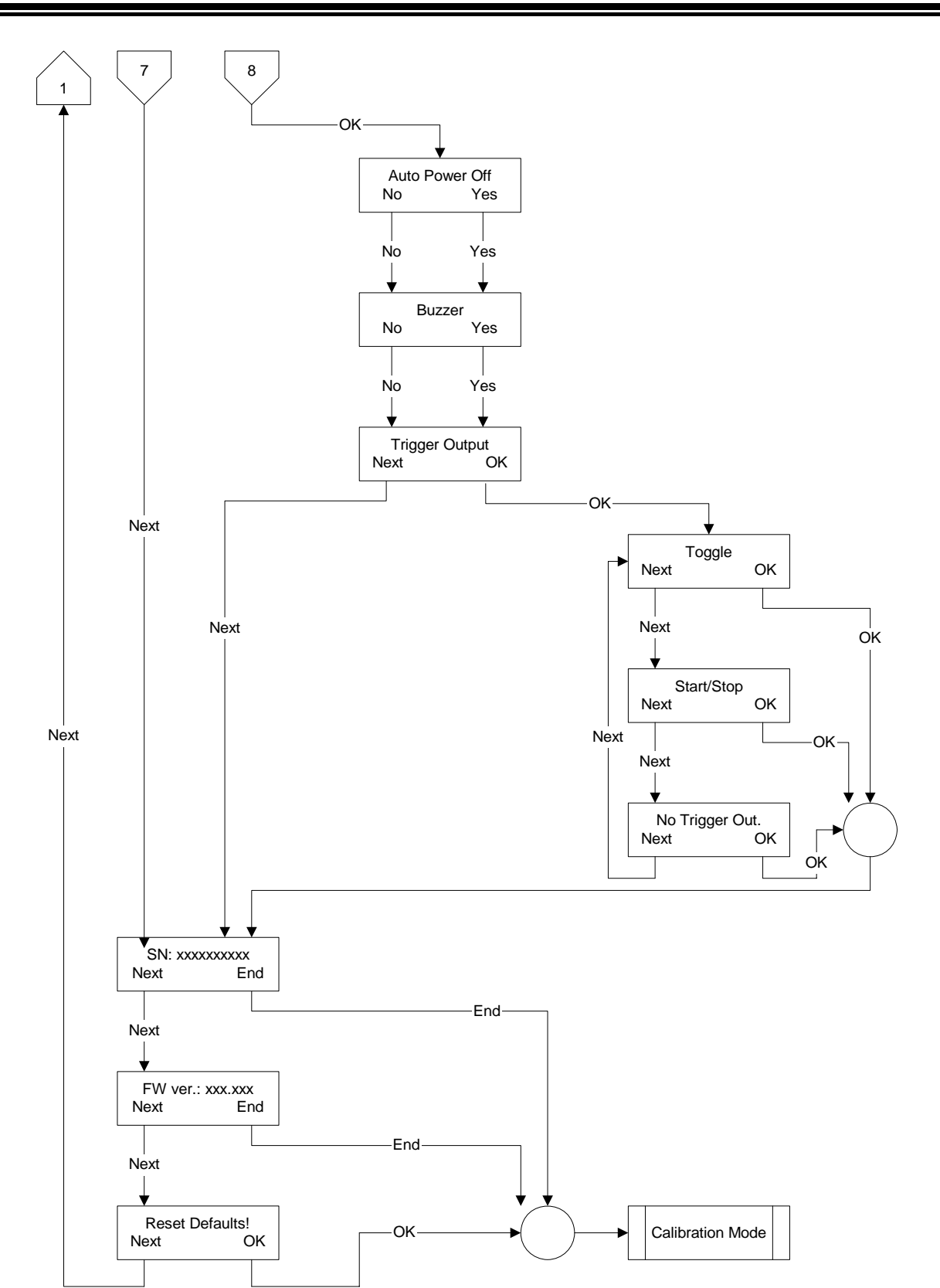


Figure 5 Structure of Settings Mode

4.3.7 View Current Settings Mode

This mode is an easy way to get information about the current settings of XL Meter Pro Gamma.

4.3.7.1 Entering View Current Settings Mode

Right after power-on when the on/off button (Black) is not released. While the button is pushed the display cycle goes round and round and the settings data are listed.

4.3.7.2 Display Cycle

The display cycle in View Current Settings Mode lists the following data:

- Language
- Measuring Frequency
- Measurement Axis
- Measurement Range in X direction
- Measurement Range in Y direction
- X direction
- Y direction
- Evaluation
- Buzzer
- Trigger Output
- Serial Number
- Firmware Version Number

4.3.8 Brake Trigger Input

4.3.8.1 Brake Pedal Switch Design

The Brake Pedal Switch (not supplied) was designed to be easy to install and easy to handle. When installed correctly it does not influence the braking, movement and applicable pedal force.

4.3.8.2 Brake Pedal Switch Installation

The Brake Pedal Switch (not supplied) can be installed by a cable binder. The cable binder should be put through the proper holes of the Brake Pedal Switch housing and should be tightened to the brake pedal itself.

4.3.8.3 Checking Brake Trigger Input Functionality

There is a possibility to check the functionality of the Brake Pedal Switch after installation. When everything works properly, a 'Tr' sign appears in the right bottom corner of the display in Calibration Mode when the brake pedal is pushed (pedal switch is active).

4.3.8.4 Using Brake Trigger Input

The Brake Trigger Input handles only one pedal touch per measurement. To avoid the storage of double or unsuccessful pedal activations, only the first pedal touch is detected during one measurement time.

In Measuring Mode the 'Tr' sign in the right bottom corner of the display shows the status of the brake pedal. The 'Tr' sign appears when a pedal activation was detected.

Note: When the measurement memory "turns around" the brake trigger storage is also erased. If the Brake Trigger sign is erased the 'Tr' sign also disappears from the display.

Important! The time resolution of the brake trigger point depends on the sampling time. The sampling time determines the smallest time interval that the brake trigger point can be.

4.3.8.5 Displaying Brake Trigger results

With the help of a Brake Pedal Switch, e.g. the brake delay time can be measured. The successful activation of the brake pedal can immediately be seen on the display of the XL Meter instrument. Evaluation of Brake Trigger timing requires running Service Brake Plus module (not supplied) under XL Vision.

4.4 Battery installation/replacement

The battery compartment for the 4 'AA' size batteries can be found under the bottom cover. XL Meter™ operates with 4 AA type batteries (supplied). There is a built in battery check function in the XL Meter™. It shows a Battery Low message at every start-up if the batteries are needed to be replaced in the near future. That means that when the Battery Low message appears at power on, by pressing the display (green) or the measurement (red) button the XL Meter™ is still capable to perform a couple of measurements, but it indicates that the batteries should be replaced as soon as possible. There are no further warning messages in case the batteries are not replaced, thus Inventure can not guarantee the specified performance if the batteries are too low.

The batteries can be replaced by following the next instructions:

1. Shut down XL Meter™
2. Turn the base unit over, unscrew the two screws (PH2) that holds the battery cover.
The batteries are stored under the removable bottom cover.

3. Remove the battery cover
4. Remove empty batteries
5. Insert new batteries according to the +/- symbols
6. Put back battery cover, and screw it on

Note: All batteries should be replaced at the same time. Use AA type 1.5V top performance batteries. Do not leave empty batteries in the instrument.

Important! Do not use 1.2V rechargeable batteries, as their nominal voltage ($1.2V \times 4 = 4.8V$) is lower than the required ($1.5V \times 4 = 6.0V$). Since charging always results in an “overcharging” voltage higher than the nominal the instrument will start to operate, but with an extremely short operating time as rechargeable batteries soon reach their nominal voltage.

Note: XL Meter™ also operates from a DC power adapter. (See section 4.2.2)

4.5 PC connection

XL Meter™ can be connected to a PC via a standard RS-232 link cable (supplied). The interface is based on RS-232 protocol. If a PC (particularly Laptop or Notebook) has no RS-232 serial port, the solution can be the *USB Cable Kit* (optional accessory). The *USB Cable Kit* connects the serial port of the XL Meter™ Pro Gamma to the USB port of the computer. The XL Vision™ software establishes the communication with the XL Meter™ and uploads the measurement data from it. Data upload is only allowed in *Calibration Mode* and in *Display Mode* at the end of the display cycle.

4.6 XL Vision™ data upload and evaluation program

XL Vision™ is a Microsoft Windows™ based data upload and evaluation program (supplied) that supports XL Meter™ having a wide and continuously broadening scale of features. All the measurement data can be uploaded to the PC and fully evaluated by XL Vision™. The objective of the continuously improving services of XL Vision™ is to support the experts by offering a fully featured PC evaluation of the acceleration and deceleration performance of the different vehicles like passenger cars, commercial vehicles, buses, agricultural machinery, stacker trucks etc. XL Vision™ not only extends XL Meter™ with the visualization of the measurement data, but also gives the opportunity to measure exactly time, distance, momentary velocity and acceleration values, and enables average acceleration calculation. The documentation and archiving of measurements is easy with the help of XL Vision™. The measurement results can be printed in a measurement report form containing all relevant data and information.

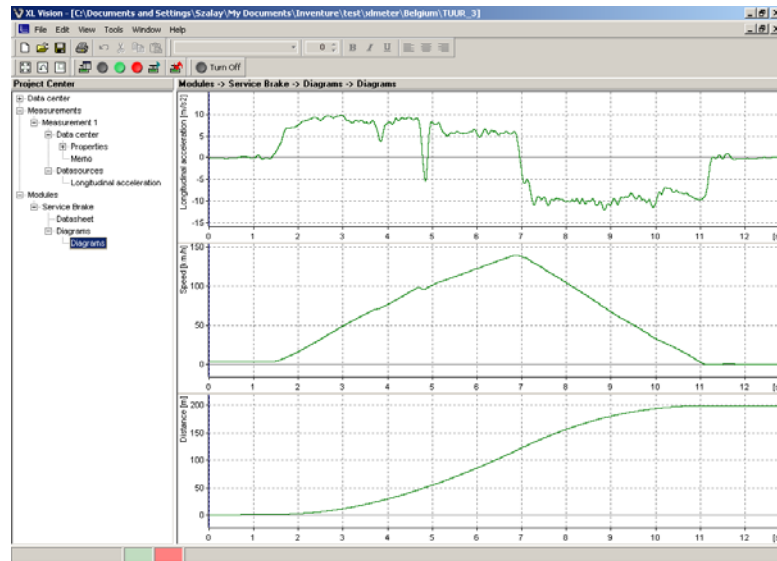


Figure 6

XL Vision 4.0 screenshot

4.6.1 Synchronization

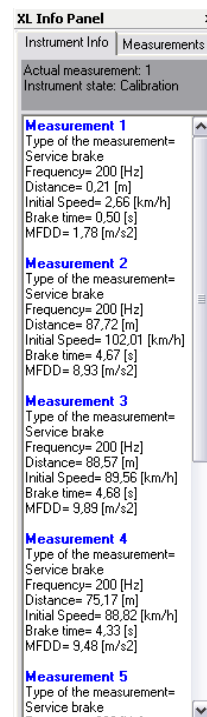
This function makes it possible that XL Vision™ 4.0 program can show on the screen immediately the actual data displayed by XL Meter™, and also the measurement results of every measurement.

This function enables, that the measurements results and state of the device can be displayed immediately in XL Vision XL Vision™ 4.0 program

The information is displayed on XL Info Panel. The XL Meter™ Pro Gamma can proceed the synchronization by clicking on a button. Synchronization contains the following information: the present state of the equipment, the actual measurement number, the parameters and the results of all measurements.

4.6.2 Remote Control

The XL Vision™ 4.0 program can provide remote control feature. Pushing of each button of the instrument can be simulated from the program so full functionality can be achieved using the PC. The measurement number can be chosen, the measurement can be started and stopped (the program can also display a warning message to avoid overwriting a message accidentally), then, with the help of synchronization, the measurement results can be displayed on the screen.



XL Meter™ Pro

Using the features of Synchronization and Remote Control, the XL Meter™ Pro Gamma can be controlled easily, while the measurement parameters and results can be seen on the PS's screen.

4.6.3 System requirements

XL Vision™ is a 32-bit Windows™ application; it runs under Win95/98/ME or 2000/NT environment. If you are going to install the software your computer needs to meet the following minimum requirements:

- An IBM PC (or 100% compatible) Pentium 2 processor or better
- A CD-ROM drive
- 7 megabytes (MB) or more free hard disk space (HDD)
- 2 MB or more RAM free RS-232 serial communication port or a free USB port plus the USB Cable Kit
- Microsoft® Windows™ 98/ME/XP/NT/2000 operating system

4.6.4 Software installation

Before starting installation please read carefully the *readme.txt* file located in the root directory of the disk. To start installation run the file named *setup.exe* and follow the instructions.

Note: The latest version of the XL Vision™ Standard software can be downloaded free of charge from the Internet web site of Inventure, Inc. (<http://www.inventure.hu>)

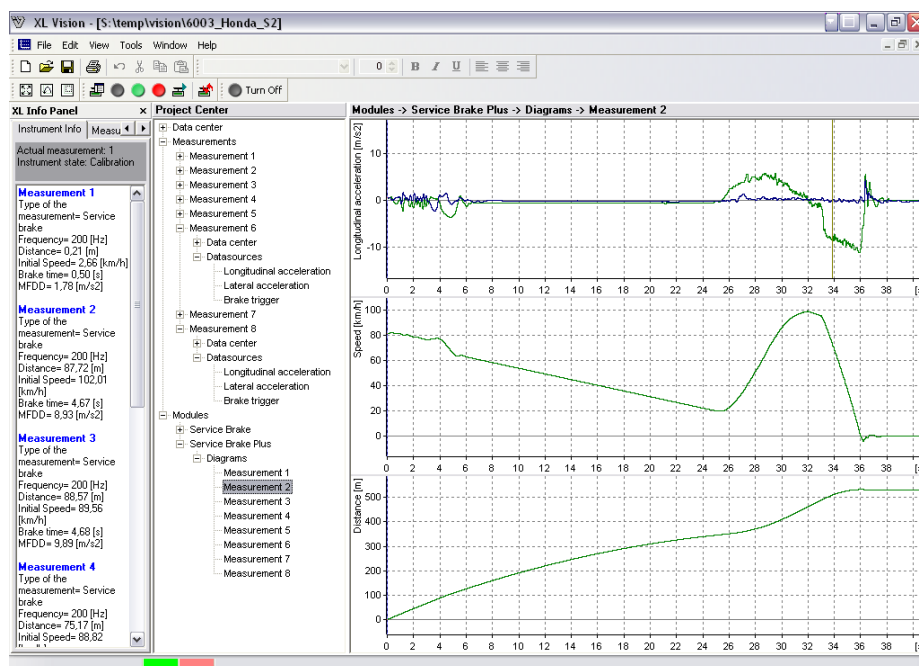


Figure 7

XL Vision™ PC software

4.7 Compatibility with other Applications

The outputs of XL Meter™ is compatible with the input of several widespread application used for accidental reconstruction and data process. The Export function of XL Vision™ enables the exportation of the data to ASCII format. The exported ASCII file can easily open by other application such as MS Excel.

4.7.1 Accidental Reconstruction Application

Virtual Crash⁶ and PC Crash⁷ are widespread accidental reconstruction applications. Using the export function in the file menu allows the users a high level PC evaluation of the XL Meter™ results, embedded to an accident simulation environment. See example below.

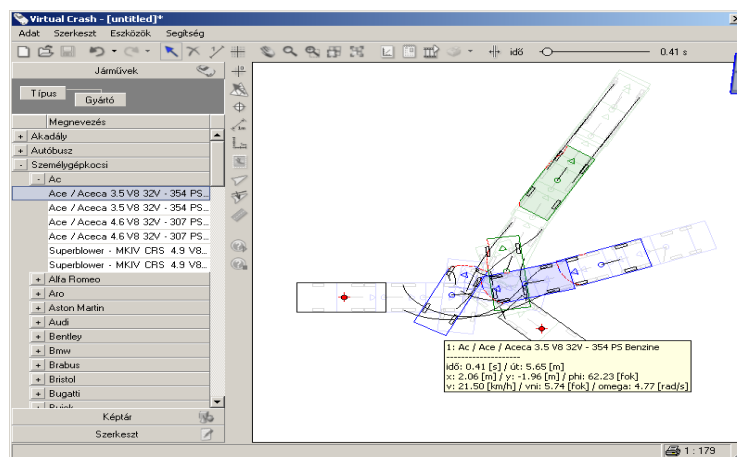


Figure 8

A Virtual Crash program

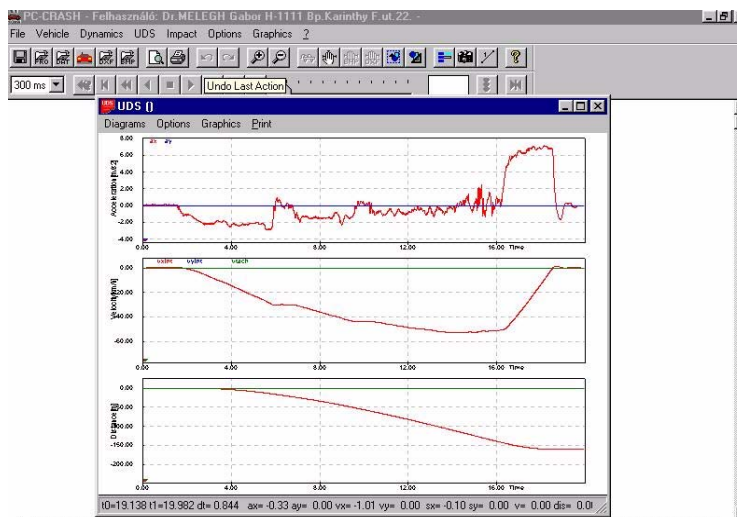


Figure 9

A PC Crash program

Note: The zero level should be adjusted when evaluating an XL Meter™ measurement with PC Crash, as there is no automatic standstill level recognition in PC Crash

⁶ A Virtual Crash is an Accidental Reconstruction Application.

⁷ A PC Crash is an Accidental Reconstruction Application.

5 System Characteristics

5.1 Absolute Maximum ratings

Table 6

Absolute maximum ratings

	Circumstances	Min.	Typ.	Max.
Temperature	Operating [°C]	0	25	50
	Recommended Operating [°C]	15	25	35
	Storage [°C]	-20	25	60
Voltage	Operating [V]	5.2	6.0	18.0

5.2 Technical data

Table 7

Technical data of XL Meter™

General features	
Number of measurements:	3–8 ⁸
Measurement storage capacity (200 Hz)	1x80 s + 2x40 s (5x40 s + 3x80 s) ⁹
Display:	16x2 character PLED or LCD with backlight
PC interface:	RS-232, USB ¹⁰
Dimensions (HxWxD):	50x97x110 mm
Acceleration Measurement	
Longitudinal direction - (a_x)	Longitudinal direction - (a_x)
Range:	-5.0...+5.0m/s ² to -20.0...+20.0m/s ²
Resolution:	0.0021m/s ²
Acquisition Frequency:	200 Hz to 25 Hz
Lateral directions - (a_y)	
Range:	-5.0...+5.0m/s ² to -20.0...+20.0m/s ²
Resolution:	0.002m/s ²
Acquisition Frequency:	200 Hz to 25 Hz
Power-supply	
External supply:	6-18V DC
Battery:	4 AA type

5.3 MFDD calculation

The primary objective of XL Meter™ development was to create a massive but extremely easy to handle instrument by which an expert can on-the-spot evaluate braking tests and the performance of braking systems.

⁸ Depending on the configuration

⁹ Depending on the configuration

¹⁰ Only with USB Support kit.

The legal regulations for braking tests are described in ECE Regulation No. 13. According to this, “The performance prescribed for braking systems is based on the stopping distance and/or the mean fully developed deceleration. The performance of a braking system shall be determined by measuring the stopping distance in relation to the initial speed of the vehicle and/or by measuring the mean fully developed deceleration during the test.”

The mean fully developed deceleration (MFDD) is calculated as the deceleration averaged with respect to the distance over the interval V_b to V_e , according to the following formula:

$$MFDD = \frac{v_b^2 - v_e^2}{25.92(s_e - s_b)} \quad [m / s^2]$$

where:

- V_o = initial vehicle speed in km/h,
- V_b = vehicle speed at 0.8 V_o in km/h,
- V_e = vehicle speed at 0.1 V_o in km/h,
- S_b = distance travelled between V_o and V_b in meters,
- S_e = distance travelled between V_o and V_e in meters.

According to the regulation the accuracy of the mean fully developed deceleration shall be within ± 3 per cent. XL Meter™ fully complies with this regulation. (See Appendix 1)

For the approval of any type of vehicle, the braking performance shall be measured during road tests conducted in the conditions specified by the ECE Regulation No. 13.

6 How to measure with XL Meter™?

6.1 Detailed description of the measurement process

Install XL Meter™ onto the windscreen. Try to find a place in the middle to be able to install XL Meter™ into the driving direction. Remember the sensitive axis of XL Meter™, which should always be oriented to the direction of the acceleration to be measured. The X-Y swapping and X-Y negate function of XL Meter™ enables the installation in any mode independent from the axis. If the installation into to the windscreen is not possible (broken windscreen), the XL Meter™ can be installed into the back windscreen. In these cases, you have to pay attention at the proper settings of axis and directions.

If XL Meter™ is battery operated now, then turn it on, otherwise install the 12V power supply cable first. The external power supply cable (not supplied) should be connected to the standard DC connector at the back panel of XL Meter™.

Note: The maximum allowed input voltage is 18.0V.

After having successful system check, the instrument enters *Calibration Mode* automatically. In *Calibration Mode* the component of the gravity acceleration in line with the sensing axis of

XL Meter™ can be read on the display. Drive the vehicle to an approximately horizontal surface. With the help of the jointed arm on the top of the instrument calibrate XL Meter™ to approximately 0.0 m/s² level.

Note: It is not essential to calibrate exactly to 0.0 m/s² because there is a built-in automatic standstill level recognition in XL Meter™. (Standstill level stands for the acceleration level at which the vehicle is stopped and does not move at all.)

After successful calibration, to enter *Display Mode* press the display or measurement button. Select the measurement location that you want to be overwritten, by the display button. You do not have to wait until the end of the display cycle, you can anytime interrupt and change to another measurement or start data acquisition. To start data acquisition, press the measurement (red) button. Press it again to overwrite selected measurement. The measurement processes are different according to the selected evaluation so we provide detailed information in the following chapters.

6.2 Evaluating Service Brake Performance

To start data acquisition, press the measurement (red) button. Drive to the place of measurement. No matter how early you started data acquisition, the recording is continuous and anytime the last 40 or 80 seconds of measurement data is available in the memory. It is much more convenient to start data acquisition early, even if you do not know exactly when and where the brake test will be performed.

Brake definitively, continuously until the vehicle is stopped!

After the car has stopped, first wait that it reaches the position of absolute rest. Then you have to wait for one second more - because of the automatic standstill level recognition - and only after that should press the display button stop the data acquisition. So to terminate data acquisition and to start the evaluation process, press the display button. Then data acquisition is aborted, and the evaluation procedure is started automatically. After finishing evaluation XL Meter™ enters *Display Mode* and displays the result of the evaluation.

Since XL Meter™ has a capacity of storing eight¹¹ independent measurements and their results in its memory, the above described steps can be performed eight times, without data loss, thus the measurement series can be finished even without uploading them.

6.2.1 Quick guide, a reminder-summary of how to make measurement

1. Install XL Meter™ onto the windscreen.
2. Turn it on.
3. Standing on a horizontal surface calibrate XL Meter™ to approximately 0.0 m/s² level.

¹¹ Three, six or eight different measurements are available depending on the configuration

4. Press the display or measurement button to enter *Display Mode*.
5. Select one measurement that will be overwritten.
6. Start data acquisition by pressing the measurement (red) button.
7. Drive to the place of measurement.
8. Brake definitively, continuously until the vehicle is stopped
9. After the car has stopped wait for one second in absolute rest then press the display button.
10. Wait for the result of the evaluation procedure.
11. To make another measurement, choose the next measurement that will be overwritten.
12. Continue with step 6

6.3 Acceleration evaluation

Attention! The vehicle must be on the start position before starting the measurement.

Accepting the overwriting you will get to the acceleration settings menu. Here you have to choose the thresholds to be reached during the measurement. (Reaching the chosen speed or distance limit will finish the measurement). You can choose between the different ranges by pushing the green button.

If the vehicle is not on the start position, it is the last time it can be driven to. If we have chosen the desired range using the green button, it can be acknowledged by pressing the red button. After accepting the range the measurement starts automatically.

At the beginning of the measurement an automatic standstill level conversation is done. In this state you “Initialise” is displayed. When the standstill level has found and the acceleration can be started, the device displays “Start”.

The automatic start recognition enables, that the evaluation starts exactly at the start of the vehicle. The device recognizes the start and it displays the actual speed and distance values.

By reaching the chosen threshold the measurement stops automatically. It can be stopped manually by pressing the green button. In this case the results will be the actual values. After stopping the measurement the device returns to display mode, where the results are displayed automatically.

6.3.1 Quick guide, a reminder-summary of how to make measurement

1. Install XL Meter™ onto the windscreen.
2. Turn it on.
3. Standing on a horizontal surface calibrate XL Meter™ to approximately 0.0 m/s² level.
4. Press the display or measurement button to enter *Display Mode*.
5. Drive the vehicle to the start position.

6. Select one measurement that will be overwritten.
7. Start the measurement by pressing the measurement (red) button
8. Press the measurement button one more to acknowledge the overwriting.
9. Choose the desired range.
10. Wait the initialisation. Start when the „Start” label is displayed
11. Accelerate until reaching the limits.
12. Wait for the result of the evaluation procedure.
13. Continue with step 5.

7 Display Messages

The display messages are organized into three different groups like normal operation, warning and error messages. The language of the display messages is selectable. The desired display language has to be defined when placing an order for XL Meter™.

7.1 Operation Messages

These messages are displayed during normal operation. These include the System Check OK, *Calibration Mode*, *Display Mode* etc. messages. These messages inform the user precisely about the actual operation mode of the instrument.

7.2 Warning messages

The device contains a power level monitor algorithm which is aim to monitor the overvoltage and the battery level at power on and before starting the measurement. The abnormality is indicated with beeping and warning message.

There are two types of warning messages. The first one is for the low battery level. The device displays “Low Battery”. If the voltage of the battery reached the lower threshold and the batteries should be replaced as soon as possible. Should you get a Battery Low message, by pressing the green or red button XL Meter™ will still be able work. So you do not have to replace batteries immediately, but as soon as possible. If the voltage of the battery reaches the lowest threshold, the XL Meter™ is not operable, so it shut down automatically.

The second warning message is the Overvoltage message. This means that the user exceeded the predefined maximum input voltage (18.0V). As overvoltage can cause severe damages to the circuit, this event is stored in the failure memory of XL Meter™, and the **warranty is no longer valid**. Should this happen XL Meter™ displays the Overvoltage message and shuts down automatically.

7.3 Error messages

There are two types of error messages implemented. The first type is the system error message the second type is the service brake performance evaluation message. Normally

you should not get any system errors during the lifetime of the instrument. Service brake performance errors can happen sometimes, especially if an inexperienced user operates the instrument.

Should any error occur please look up the error code in the following table, read carefully the description about the source of the problem and follow the suggested actions to prevent errors the next time. If the error still remains, please note the error code and try to specify the situation when it occurs then contact Inventure Automotive to be able to find a fast and satisfying solution to the problem.

In case of a service brake performance evaluation error message, the error code appears right below the corresponding measurement number and XL Meter™ can be further operated normally. The evaluation errors are stored so when the measurement results are listed next time the error number is displayed instead of the wrong evaluation results. In case of a system error, the only way to continue is to shut down XL Meter™ and turn it on again with the black button.

7.4 Error Codes

Table 8		Explanations of Error Codes
Ec:	Description	What to do
10-47	System errors	Contact Inventure Automotive to describe the situation and the resulting error code.
48	Non valid password in PC-XL Meter™ communication	Use XL Vision™ software to upload measurement data from XL Meter™
49-85 and 140-180	Internal errors	Contact Inventure Automotive to describe the situation and the resulting error code.

7.5 Plausibility Error Codes

Table 9		Explanations of Error Codes
90	In case of acceleration evaluation, the device couldn't recognize the start.	Try to start the vehicle with higher acceleration. If you cannot increase the acceleration, please contact with Inventure Automotive.
91	Standstill level not found. The device cannot calculate the standstill level correction. The reason for this error is the too early stoppage,	After the vehicle stop, wait 1 seconds before pressing the green button,
100	Measurement length too short	The length of a measurement must be at least 1 second.
122	Brake distance (So) too large. The calculated value is too large probably false result.	The value of the braking distance (So) exceeded the maximal 1000 m . Upload the measurement and check the diagram and its results with the XL Vision™ evaluation

	(XL Meter™ evaluation error)	program. In case a need for higher brake distance on-the-spot evaluation, contact Inventure Automotive.
124	Initial speed (Vo) too large The calculated value is too large probably false result. (XL Meter™ evaluation error)	The value of the initial speed (Vo) exceeded the maximal 1000 km/h . Upload the measurement and check the diagram and its results with the XL Vision™ evaluation program. In case a need for higher initial speed on-the-spot evaluation, contact Inventure Automotive.
126	MFDD (MFDD) too large The calculated value is too large probably false result.	The value of the MFDD (MFDD) exceeded the maximal 100 m/s² . Upload the measurement and check the diagram and its results with the XL Vision™ evaluation program. In case a need for higher MFDD on-the-spot evaluation, contact Inventure Automotive.
130	Brake end time could not be recognized	Upload measurement data to the PC with XL Vision™ and check why the brake end time could not be found. (See also section 4.3.5)
132	Brake start time could not be recognized	Upload measurement data to the PC with XL Vision™ and check why the brake start time could not be found. (See also section 4.3.5)

8 Certification/Calibration

The XL Meter™ Pro type universal acceleration and deceleration meter was tested and verified by two independent organizations. In both cases the instrument fulfilled the requirements with excellent results. The appendix contains the copies of the certificates.

8.1 Test by the Technical University of Budapest

The Department of Road Vehicles in the Technical University of Budapest carried out a series of tests to prove the applicability of XL Meter™ for evaluating brake performance of different vehicles from the technical experts' point of view. They verified that the measurement result calculation algorithm and the result accuracy are according to the corresponding ECE regulations. The result of the investigation can be found in Appendix 1.

8.2 Test by an OMH accredited laboratory

OMH stands for the Hungarian National Office of Measures (Országos Mérésügyi Hivatal). OMH itself does not deal with verification or calibration of devices measuring acceleration or deceleration. For this task an OMH accredited laboratory in Hungary is the "Békésy György" Acoustic Research Laboratory at the Department of Telecommunications and Telematics in the Technical University of Budapest. The extract from the minutes prepared by the Acoustic Research Laboratory is shown in Appendix 2. The minutes state that the features of XL Meter™ enable calibration using the field of gravity as etalon (9,81 m/s²) and a device keeping XL Meter™ in a vertical position.

8.3 Calibration

The principal characteristic of measuring devices is accuracy, which needs to be controlled from time to time. The owner and user of XL Meter™ himself can control the calibration of his instrument occasionally or on a regular basis according to the requirements of his own quality system, and can put the results in the 'Calibration Minutes'.

8.3.1 Sensor characteristics

A linear sensor like the one used in XL Meter™ has two characteristics value, the offset and the sensitivity. Offset means the output value when the input is zero, in other words where the characteristic curve crosses axis Y when axis X is zero. Sensitivity means the slope of the characteristic curve. It gives the output value change for a specific change in the input.

It is obvious from the above definitions that it is only the sensor sensitivity that has effect to the precision of the measurement results; the offset is only a "beauty factor". This means that if the offset of the instrument is greater than $\pm 1 \text{ m/s}^2$, but the sensitivity error is less than $\pm 1\%$ the instrument is still capable of perform valid measurements. If the sensitivity error is out of the predefined $\pm 1\%$ range than a recalibration is required before the instrument can perform valid measurements.

8.3.2 Calibration theory

The force of gravity is the most stable, accurate and convenient acceleration reference available. The calibration of XL Meter™ takes place with the use of the acceleration of gravity as an etalon and an approved calibration rack. During the calibration process, the acceleration value displayed by XL Meter™ has to be compared to the value of acceleration due to gravity ('g').

The basis of the calibration method is to make measurements at $+1 \text{ g}$ and -1 g . Both the offset and the sensitivity of XL Meter™ can be determined by these two measurements. This method has the advantage of being less sensitive to the alignment of the accelerometer because the on axis signal is proportional to the cosine of the angle. For example, a 5° error in the orientation at $+1 \text{ g}$ or -1 g results in only a 0.4% error in the measurement.

For the calibration, the sensitive axis of the sensor in XL Meter™ has to be aligned to match the orientation of the gravity vector (measurement of $+1\text{g}$) or to match the orientation opposite to the gravity vector (measurement of -1g). The calibration status of the instrument can be determined from the measured values. In order to ensure the accuracy and the reproducibility of the calibration process, Inventure Inc. has developed a special calibration rack that serves the accurate fixing of the orientation of XL Meter™.

8.3.3 Calibration procedure

The measurement needed for calibration is composed of two parts. First, the sensing axis of XL Meter™ has to be aligned to match the orientation of the gravity vector of the Earth (measurement of +1g) by putting the instrument in the calibration device in a way that the display faces upwards. The value displayed by the instrument in this position has to be noted down (“A”). Second, turning XL Meter™ by 180 degrees, the sensor axis of XL Meter™ has to be aligned to match the direction opposite to the gravity vector of the Earth (measurement of -1g) by putting the instrument in the calibration device in a way that the display faces downwards. The value displayed by the instrument in this position has to be noted down, as well (“B”). The offset and the sensitivity can be calculated with the two measured values using the following formulas:

Let “A” be the acceleration value noted down from the display in +1g direction

Let “B” be the acceleration value noted down from the display in -1g direction

Let “g” be the value of gravity – which depends to a small extent on the degree of latitude of the place where the measurement is taken – approximately 9.81 m/s²

Then the offset and the sensitivity (S):

$$\text{Offset} = (A+B) / 2$$

$$S = (A-B) / 2g$$

XL Meter™ makes measurements in the acceleration range of -12.7m/s²...+12.7m/s² and displays the sensed value of acceleration in 0.1m/s² resolution. The sensitivity of XL Meter™ has an accuracy of ±1%, which means that the value of “S” has to fall within the following boundaries:

$$0.99 \leq S \leq 1.01$$

Should XL Meter™ perform within the limit values specified above, the calibration of the instrument is satisfactory.

Note: The compliance with the limit values set out for the sensitivity (S) above is equivalent to the compliance of the measured “A” and “B” values to the limits below:

$$+9.7\text{m/s}^2 \leq A \leq +9.9\text{m/s}^2$$

$$-9.9\text{m/s}^2 \leq B \leq -9.7\text{m/s}^2$$

9 How to contact Inventure?

Inventure provides customer support via its World Wide Web (WWW) site. The Inventure Automotive web site is available by using your favourite Internet browser to attach to:

www.inventure.hu

Our web site provides a variety of services. Users may download the latest XL Vision™ software tool, read up-to-date information about the company, the products, application possibilities and the services. Frequently asked questions and the corresponding answers are also available on the Inventure site.

If you have problems, questions, suggestions, or you just want to express your opinion about us or our products, please feel free to write an email to us, and we surely will find a way to the solution.

support@inventure.hu

Come and visit our web site, tell us your experience concerning our product, fill out the registration form to be able to inform you directly about the latest results of research and development and the continuously improving customer services.

Your comments are also welcome under the following address:

Inventure Automotive Electronics R&D, Inc.

**H-1111 Budapest
Karinthy Frigyes út 26.
HUNGARY**

Phone: (+36) 1 381-0970

Fax: (+36) 1 361-0971

10 Appendix



BUDAPESTI MŰSZAKI EGYETEM
IGAZSÁGÜGYI MŰSZAKI SZAKÉRTŐI BIZOTTSÁG
1111 Budapest, Műegyetem rkp. 3.

IGAZOLÁS

a készülék mérési eredményeinek hitelességéről az ENSZ-EGB 13. számú előírása alapján

CERTIFICATE

concerning the authenticity of the measurement results of the equipment according to the ECE Regulation No. 13.

A készülék kereskedelmi megnevezése vagy jele: <i>Trade name or mark of the instrument:</i>	XL METER Pro Alpha 1.0
A készülék rendeltetése: <i>Function of the instrument:</i>	Gyorsulás- és lassulásmérő műszer Acceleration and Deceleration Meter
A gyártó neve és címe: <i>Manufacturer's name and address:</i>	INVENTURE Autóelektronikai Kutató és Fejlesztő Kft. H-1117 Budapest, Erőmű u. 6.
A vizsgálatok elvégzésével megbízott műszaki szerv: <i>Technical service conducting type approval tests:</i>	BUDAPESTI MŰSZAKI EGYETEM Igazságügyi Közlekedési Szakmérnöki Szak

A készülék az időt 10^{-4} s pontossággal méri és két tizedes jegy pontossággal jelzi ki. A készülék gyorsulásérzékelője a $\pm 12.7 \text{ m/s}^2$ gyorsulási tartományban ± 1 százalékos pontossággal érzékeli a jármű sebességváltozását. A számolt sebesség és út értékek pontossága meghaladja az egy tizedes jegyre kerekített kijelzés pontosságát. A készülék az ENSZ-EGB 13. számú előírásában foglalt kívánalmaknak teljes mértékben megfelel.

The time is measured with an accuracy of 10^{-4} s and displayed with an accuracy of two decimal places in the instrument. The acceleration sensor of the instrument is capable of sensing the velocity changes of the vehicle in the acceleration range of $\pm 12.7 \text{ m/s}^2$ with an accuracy of ± 1 per cent. The accuracy of the calculated velocity and distance values exceed the accuracy of the displayed values rounded to one decimal place. The instrument absolutely fulfills the requirements of the ECE Regulation No. 13.

A vizsgálatok eredményei alapján megállapítom, hogy a készülék

alkalmas

gépjárművek fékrendszereinek minősítésére.

Based on the results of the investigation I hereby state that the instrument is

approved

for evaluating brake systems of vehicles.



(Dr. Matuscsák Tamás)
IMSZB elnöke



Budapest, 1998. szeptember 1.



Dr. Melegh Gábor


BME Akusztikai Kutató Laboratórium
1112 Budapest, Budaörsi út 45

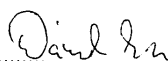
Bizonyítvány száma: 110
oldalszám : 1 / 3

Kalibrálási bizonyítvány és típusvizsgálat

1. A mérőeszköz
megnevezése: lassulásmérő
típusa: XL Meter
gyártási száma: ——— (típusvizsgálat)
2. A gyártó(k) neve: Inventure Autoelektronikai Kutató és Fejlesztő Kft.
3. A kalibrálást megrendelő neve és címe:
Inventure Autoelektronikai Kutató és Fejlesztő Kft.
H-1117 Budapest, Erőmű u. 6
4. A mérés ideje: 1999 június 22.
5. A mérést végezte: Dániel István
6. Az eredményeket lásd a mellékletekben.
7. A kalibrálást az OMH-MAB 049 sz. határozat alapján végezzük.

Budapest, 1999 június 22.


Dr. Illényi András
a laboratórium vezetője


Dániel István
fizikus



<http://www.inventure.hu>