Interpretation guide of vibro-acoustic signatures

Version 0 **Rev. 0**

December 17, 2009

Cette version est une version préliminaire et temporaire pour **diffusion très limitée**.
Cette version fait référence au logiciel DIAC dont le développement est arrêté par Hydro-Québec.

Le logiciel OpenZen - Zensol (issu de nos logiciels existants CbaWin, GenWin, CbvWin, etc., copyright 1992 à 2009) remplacera DIAC totalement à court terme.

Il sera donc nécessaire de réviser et de corriger cette version, en supprimant notamment toutes les références à DIAC et en les remplaçant par les références équivalentes à OpenZen.

Merci de me contacter directement pour tout commentaire (bon ou mauvais), toute nouvelle idée, ainsi que toute suggestion d'amelioration de ce document ou du logiciel OpenZen et ces documents associés, dans le but ultime de l'obtention d'un logiciel et d'une documentation claire et pratique pour vous et tous nos utilisateurs. Tous vos retours d'information seront très appréciées.

Vous remerciant par avance pour votre collaboration,

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This version is a draft and temporary version for **limited distribution ONLY**.
This version refers to DIAC software whose development by Hydro-Québec is stopped.

The OpenZen – Zensol software (based on our existing softwares CbaWin, GenWin, CbvWin, etc., copyright 1992-2009) will completely replace DIAC in the short term.

This version needs to be reviewed and corrected by Tap-Changer specialists. Among other things, all references to DIAC software will be replaced by their equivalents in the OpenZen Software.

Text in red requires special attention and will be corrected.
If you want the original version of this text, please download the French document.

Please do not hesitate to contact me directly for any comment (good or bad), any new idea, or any suggestion regarding the improvement of this document or the improvement of the OpenZen software and any of its related documents, in order to ultimately obtain clear and useful documentations for you and all of our users. All of your feedbacks will be appreciated.

Thank you for your cooperation.

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Interpretation guide of vibro-acoustic signatures

The following document is designed to provide a basic guide for interpreting the data acquired using the vibro-acoustic system: TAP-4 and DIAC. The user remains a key element of the diagnostics, and concepts presented in this guide will help to make a more accurate diagnosis, either by visual interpretation of signatures, or by an understanding of how the discrepancies can manifest themselves in the tabular report.

Thus, although the report makes these calculations and displays the data and the results found by the algorithms, **it is important for users to get accustomed with the different features of the signatures and to identify at first glance if a problem is present in the tap changer (OLTP) in question.**

1. Diagnostic levels

There are two levels of diagnostics:

1. The tabular report: this first level of analysis is fully automated and provides a fast and basic diagnostic.
2. The visual interpretation: this second level of analysis involves the interaction of a user familiar with the signatures of the OLTP model analyzed. With this visual interpretation the full potential of the acoustic diagnostics can be achieved.

2. Analytical methods

Two different methods of analysis are used in the diagnostics of signatures:

1. A historical comparison (*trending*) of the signatures of a OLTP. This method is based on the systematic monitoring of a tap changer through his useful life.
2. A statistical comparison with the units of the same family. The criteria (good, doubtful, bad) of the tabular report are set in this manner when adequate sampling of a family of OLTP is measured.

3. Features of the signatures

Throughout this section the different types of signatures of the motor current, of the high frequency (HF) and the low frequency (LF) will be defined.

3.1. The motor current signature

The signature of the motor current is an envelope of the peak value (**and not RMS**) of the amplitudes of the oscillations measured. The extraction of this envelope is illustrated in the **Figure 1** below.

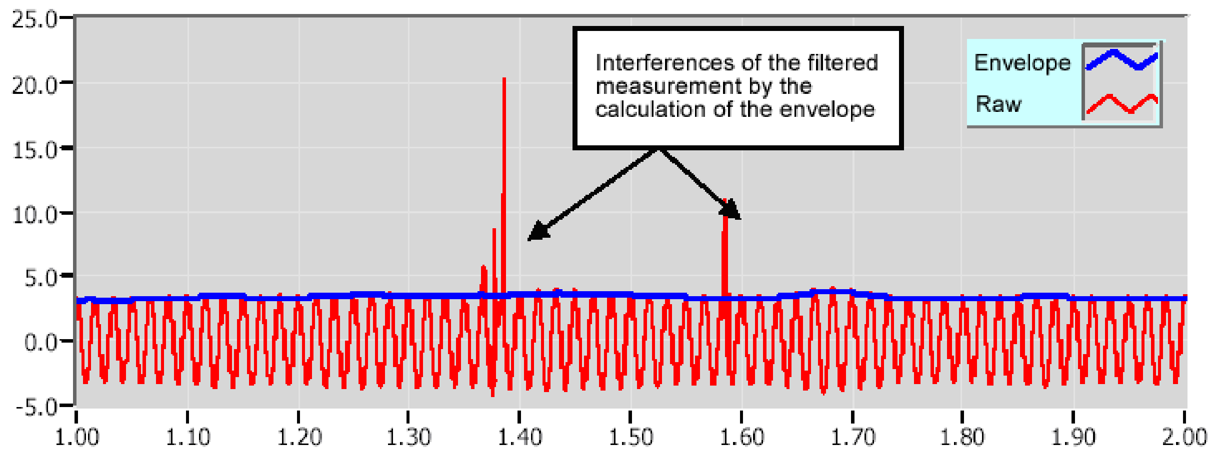

Figure 1: Extraction of the envelope of the motor current

There are two types of driving mechanisms of OLTPs:

1. Spring drive or energy accumulator:
2. Direct drive

And the features of the respective signatures must be analyzed in a different way.

3.2. Spring drive or energy accumulator

These are the most common and new models. The mechanism loads the springs and the transmission of the switch is activated by their release. This principle of operation ensures a speedy and full operation of the switch, even in case of interruption of the motor. On the other hand, in this type of mechanism, the switch is usually driven directly and slowly by the motor.

There are three different main areas on the motor current signature of this type of drive:

Zone 1: The inrush current (*inrush*)

The inrush current is the input current that follows the start. It presents a peak current usually short at the start of the operation. The inrush ratio is defined as the ratio of the peak value over the nominal value of the motor.

Zone 2: Loading of springs and operation of the selector, the inverter and switch

Depending on the model and motor type, current fluctuations can be seen while loading the springs. Usually, this area is stable and has only small increases of current. For the selector OLTP types (UZ), the selector is driven by the springs, and it presents no distinct signature on the current trace. On the other hand, the operation of the inverter requires much more effort from the motor and can lead to significant increases of the current.

Zone 3: Braking

In the pool of OLTPs at Hydro Quebec, there are three different principles of braking as shown in **Figure 2, Figure 3, and Figure 4**, that is, the mechanical braking, braking by DC injection, and braking by capacitor (*dynamic AC braking*). On rare occasions, there is no braking mechanism (e.g. Reagent RT32). For a well synchronized device, there should be no acoustic noise during braking.

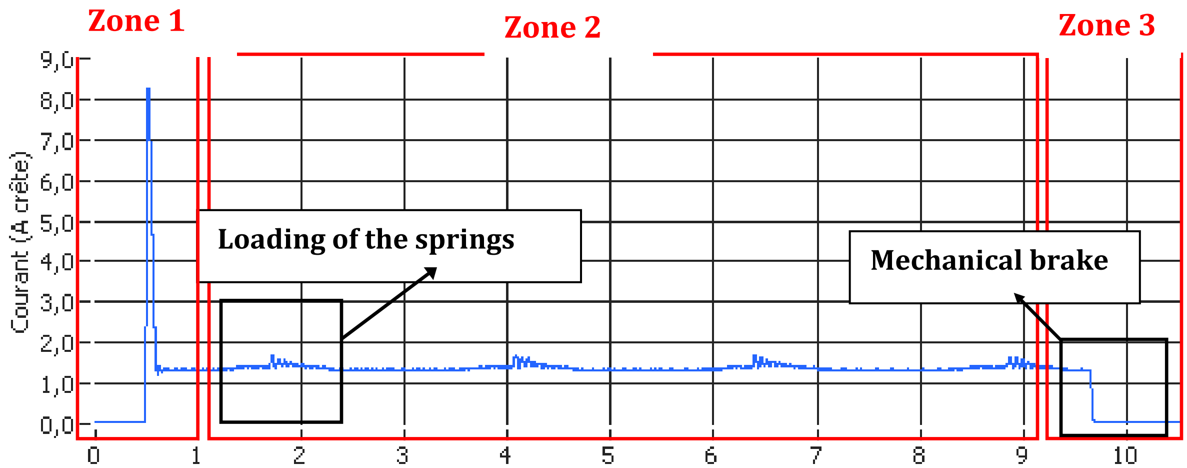

Figure 2: Example of the motor current with a mechanical brake (ABB UZCRN)

The normal feature of a mechanical braking is a clean break of the current.

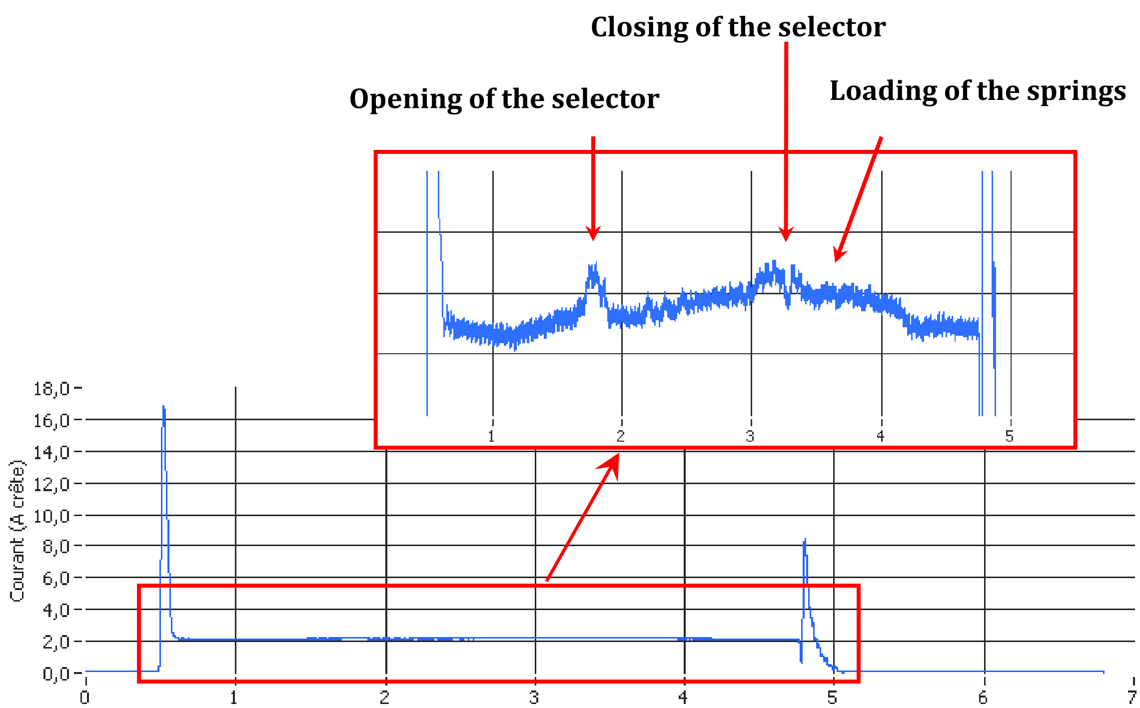

Figure 3: Example of the motor current with capacitor braking of the drive mechanism (Reinhausen MA7)

The capacitor braking is recognized by a fast increase of the current followed by a typical discharge curve of less than one quarter of a second.

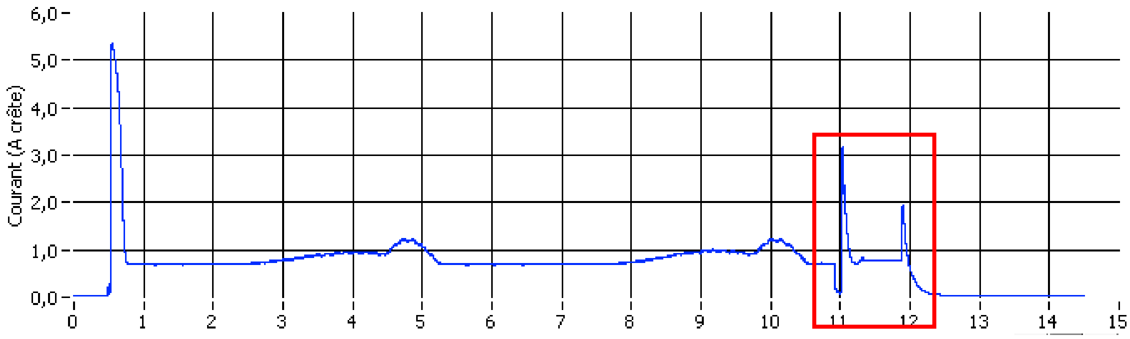

Figure 4 : Example of the motor current with DC injection braking (Federal Pioneer)

The braking by DC injection is recognized by a shape such as the one shown in **Figure 4**, The typical duration is about ½ up to 2 seconds.

Any increase in current is synonymous with an increased stress from the motor. If a change of current can't be associated with a normal activity of the drive mechanism, such as loading the springs or the operation of the selector, such fluctuations should be investigated. Possible causes are:

- A misadjusted mechanism or poorly lubricated;
- Damaged gears;
- Wear of the control rod;
- The presence of electromagnetic interference (e.g. internal or external arcs) captured by the current clamp;
- Bad timing or malfunction of a control relay.

3.3. Direct drive

The direct drive mechanism is often found on older U.S. models OLTP (GE, Westinghouse, Moloney, etc...). The switching is slower and is driven directly by the motor.

There are three main areas on the motor current signature of this type of transmission. For these mechanisms, Zones 1 and 3 are identical to those of OLTP driven by an energy accumulator. Only the Zone 2 includes special features:

Zone 2: Operation of the interrupter-selector, or of the selector with load and the inverter

In this zone, there are obvious current fluctuations due to all operations of the different components of the OLTP. There are two mechanisms, either interrupter-selector and selector with load. Typical signatures are shown in **Figure 6 and Figure 5**

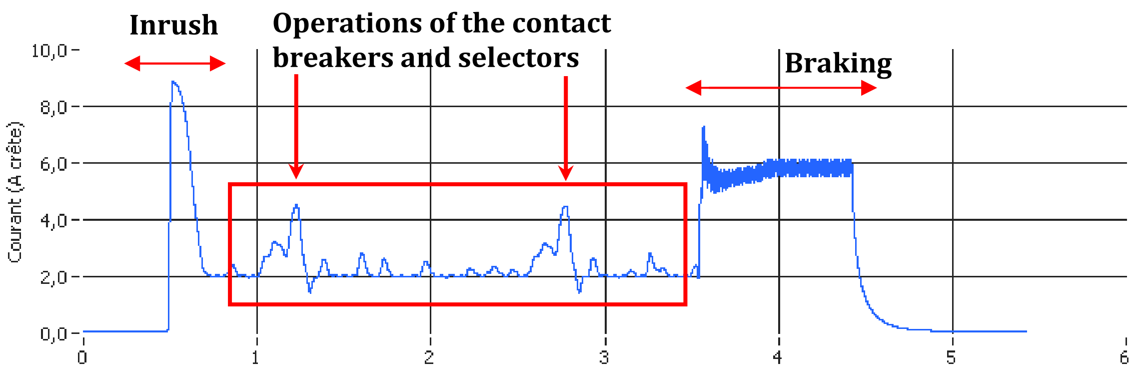

Figure 5 : Dual operation of a LR83 GE

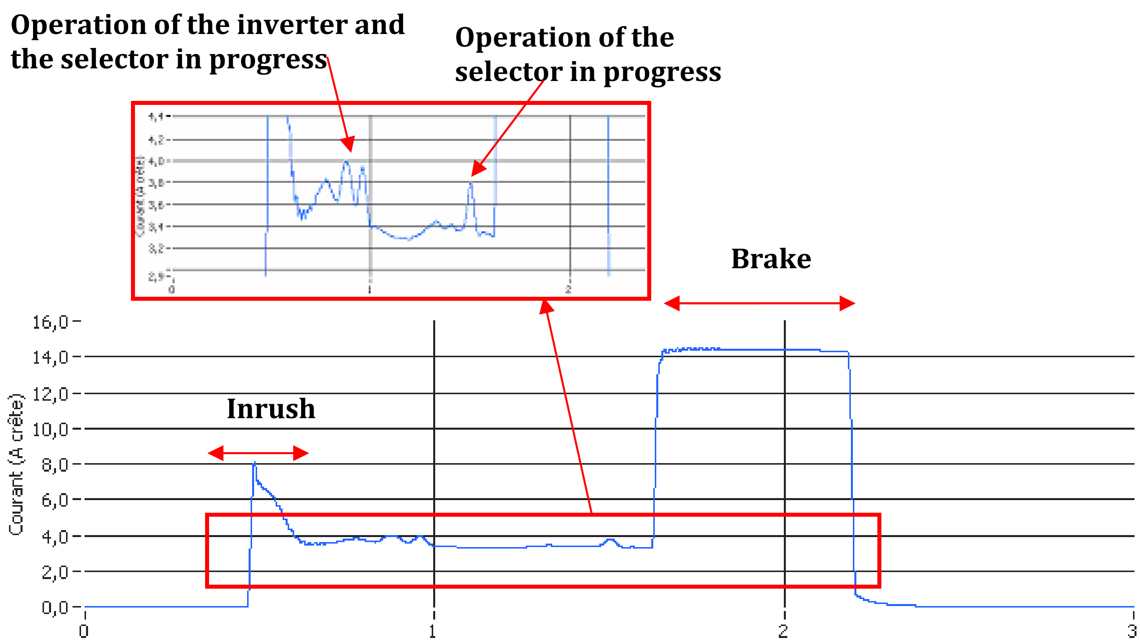

Figure 6 : Dual operation of a Westinghouse URS at 17 taps

4. Vibro-acoustic signatures

To create the vibro-acoustic signature, the algorithm first divides the frequency of the measurement (2-20 kHz) in two distinct bands which are: the Low Frequency (LF) and high frequency (HF) respectively covering 2-10 kHz and 10-20 kHz. These bands represent the envelopes of the raw data and are useful because make signatures more appropriate analysis. Thus, only the relevant parts are kept for the diagnostics and the random noise are filtered, as shown in **Figure 7**.

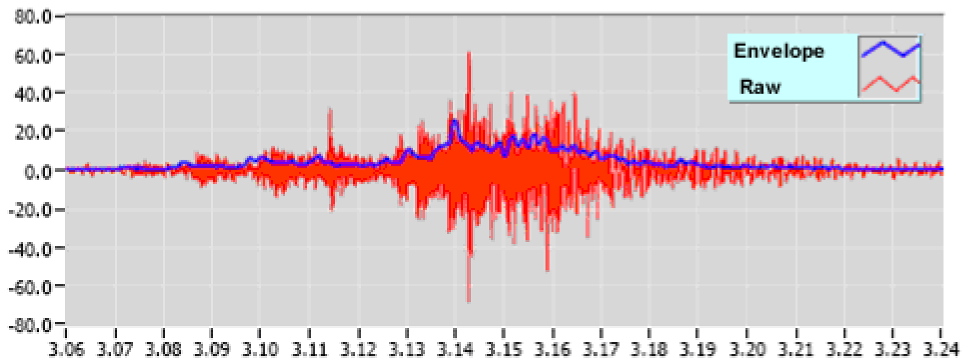

Figure 7 : Acoustic Envelope extracted from the raw signal

Experience has shown that each band reacts differently depending on the nature of the problem or the type of OLTP which improves the accuracy of the diagnosis. In particular, the HF band reveals the presence of arcing, and provides greater accuracy for the timing analysis and the transition time.

On the other hand, the LF band is useful for evaluating the general wear (especially in the drive mechanism). On some models, the difference between the two bands is used to evaluate the wear of the switch.

The acoustic signatures reveal all the internal working details of the OLTP, so in their interpretation one must take into account the different principles of operation. The two main categories reflect the transition of the impedance: resistances vs. reactances.

1. **Resistive types :**
    - Switch - Selector
    - Selector with load
    - Vacuum Switch

2. **Reactive types :**
    - Interrupter – Selector
    - Selector with load
    - Vacuum Switch

Inverter (Preselector)

For both types, there is often a pre-selector that allows doubling the number of positions for the same number of taps. This preselector may be an inverter (higher current at HQ) or an Approximate / Accurate, adjustment type. The operation of the preselector does not occur when there are two tap changes, e.g. changes on -8 and +10 on ABB models of 17 positions. The operating range coincides with that of the selector, we can notice an increase in the motor current and often the presence of pulses in the trace of the acoustic noise caused by a capacitive discharge during the test in service.

Multiple operations

Multiple operations may be needed depending on the model when the number of positions required is less than the capacity of selector. In these situations, rather than designing a specific selector, manufacturers bypass a number of consecutive taps and the control is programmed accordingly. At Hydro-Quebec, the standard is 17 positions, while most manufacturers' selectors are designed for 21 or more. Thus, one often finds the following situations:

1) Dual or multiple operations with intermediate positions around the neutral position (9A-9B etc...)
2) Dual operations on every position for a 33 tap OLTP converted to 17 taps.

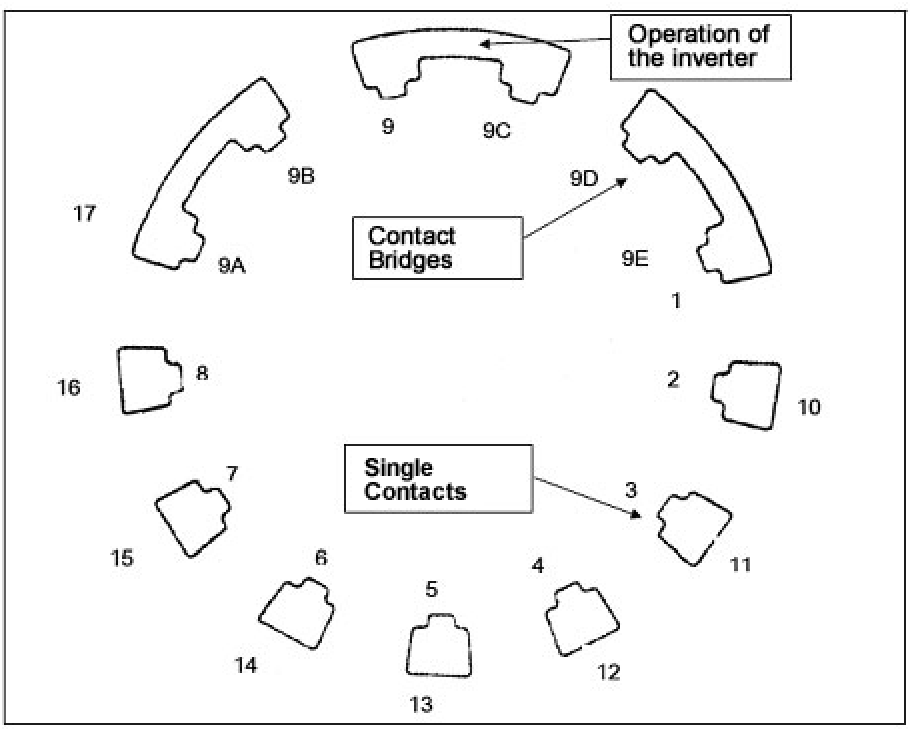

Figure 8 : Distribution of multiple taps on a ABB UZ OLTP model

Configuring for an operation at 17 positions

The following sections describe the features of each operating principle.

4.1. Resistive types

The transition mechanism of the resistive-type tap changers should minimize the insertion time of the resistances to around 50 ms. These are fast-acting complex mechanisms. A significant amount of information is concentrated in a small window of time of the acoustic signature. The diagnosis must keep a particular attention to this window.

Resistive models are the most common and their problems are easier to diagnose using the vibro-acoustic method.

4.1.1. Switch – Selector

a) Models

The models listed below are included in this category.

- ABB UC and UT (all)
- Reinhausen B, C, D, E, F, G, M, MS, T
- Ferranti-Packard 25RT32, 34RT32, 69RT32, 138RT32
- GE CLR100
- AEG ARSD

b) Definition and operation

In this type of tap changer, the selector includes two assemblies (odd and even) of moving and fixed contacts which carry the load alternately. The operation of these OLTPs takes place in two stages. 1) The moving contact of the selector which is not under load moves to selected tap (upward or downward). 2) The switch then transfers the load in a fast action of an accumulator to complete the transaction.

There is no operation of the selector when changing direction (upward operation after a downward of the tap, or vice versa) since the two selectors are already located on their proper taps.

c) Typical trace

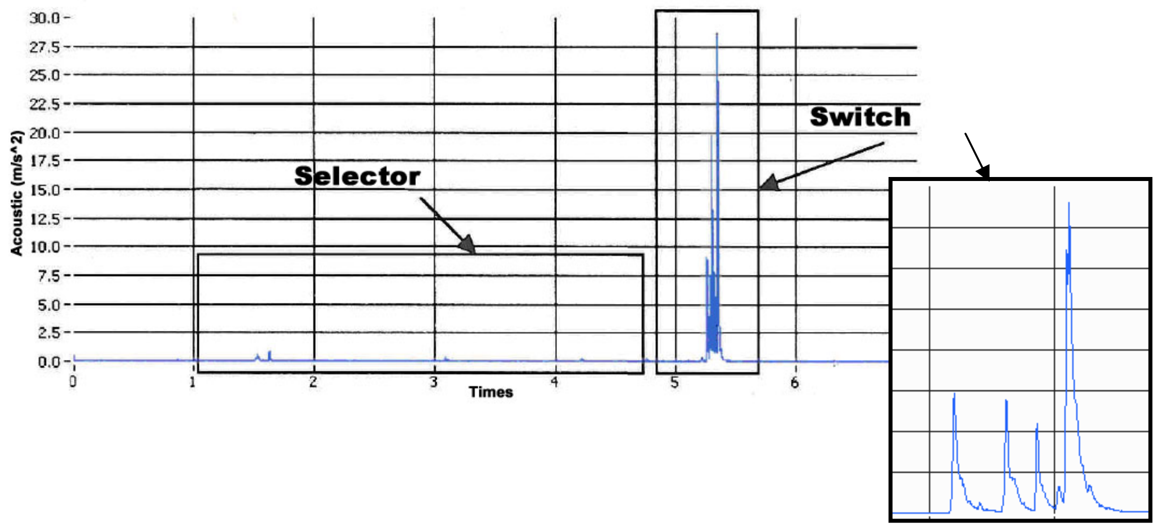

Figure 9: Single operation without an inverter of a ABB UC OLTP

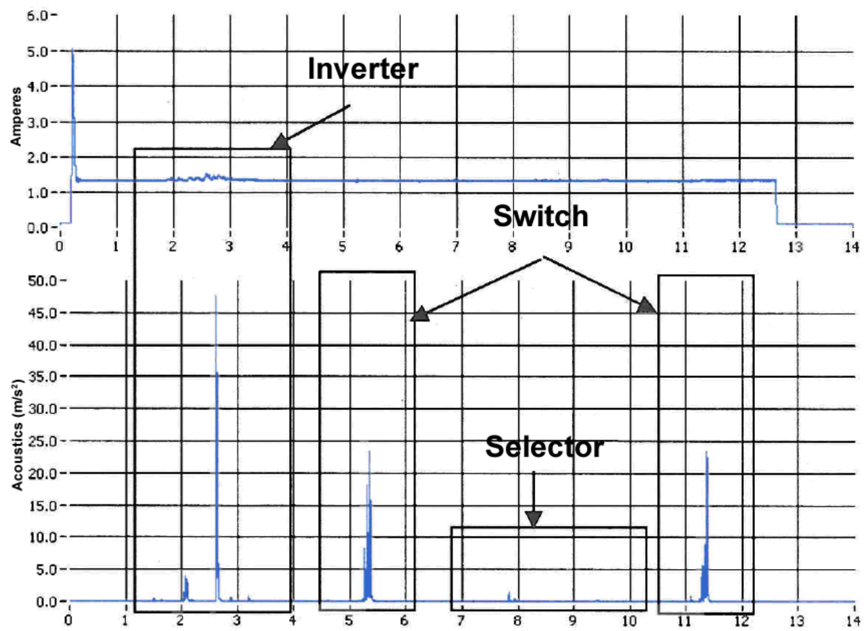

Figure 10 : Dual operation with an inverter of a ABB UC OLTP

4.1.2. Selector with load

a) Models

The models listed below are included in this category.

- ABB UZ (All)
- Reinhausen V

b) Definition and operation

The tap changers operating with selector with load are usually limited in voltage (138 kV) and number of positions (33). This type of OLTP uses a single mechanism which acts both as a selector and as a switch. The whole process occurs simultaneously and quickly through an energy accumulator and a set of rolling contacts. Therefore, the diagnosis is mainly focused on a section of trace.

c) Typical trace

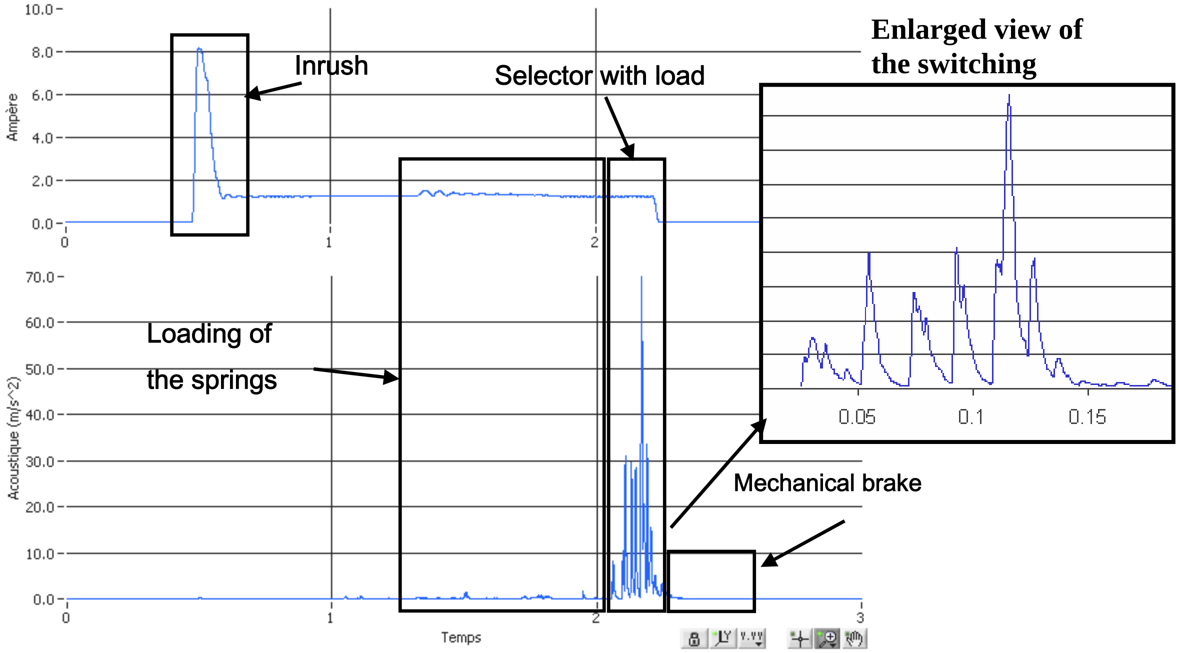

Figure 11 : Typical trace of a single operation of a ABB UZ

1.1.1. Vacuum switch

a) Models

The models listed below are included in this category.

- ABB VUCG (all)
- Reinhausen VR (all)
- Reinhausen VV

b) Definition and operation

The vacuum switch tap changer may be the operating principle of the OLTP switch-selector or the selector with load. Its operation has on the other hand, certain additional steps, particularly when a deflection mechanism (bypass switch) is used. Resistive models are driven by an accumulator.

c) Typical trace

This technology is relatively new and few units are in use, such as TransÉnergie. Below, a HRV model is shown.

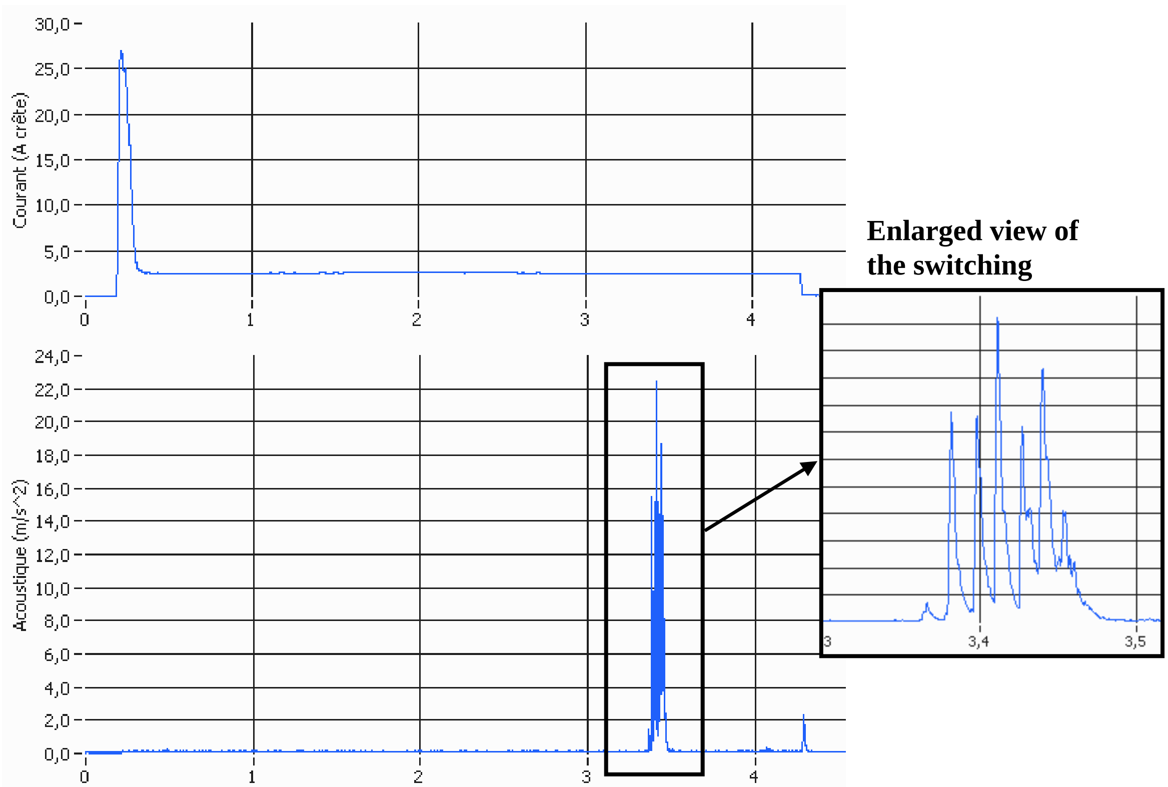

Figure 12 : Single operation of a HRV Reinhausen

1.1.2. Tanks with multiple tap changers

The resistive tap changers are not only installed individually in their tank. There are tanks with multiple tap changers (2 or 3 OLTPs per tank). The models most often used with this configuration are TransÉnergie with 3xD, 3XF, 2xM, 3xM, 2XT Reinhausen.

For these configurations, only one accelerometer is used and the acoustic signatures of the OLTP appear and merge on a single trace making the interpretation complex. An example is shown below.

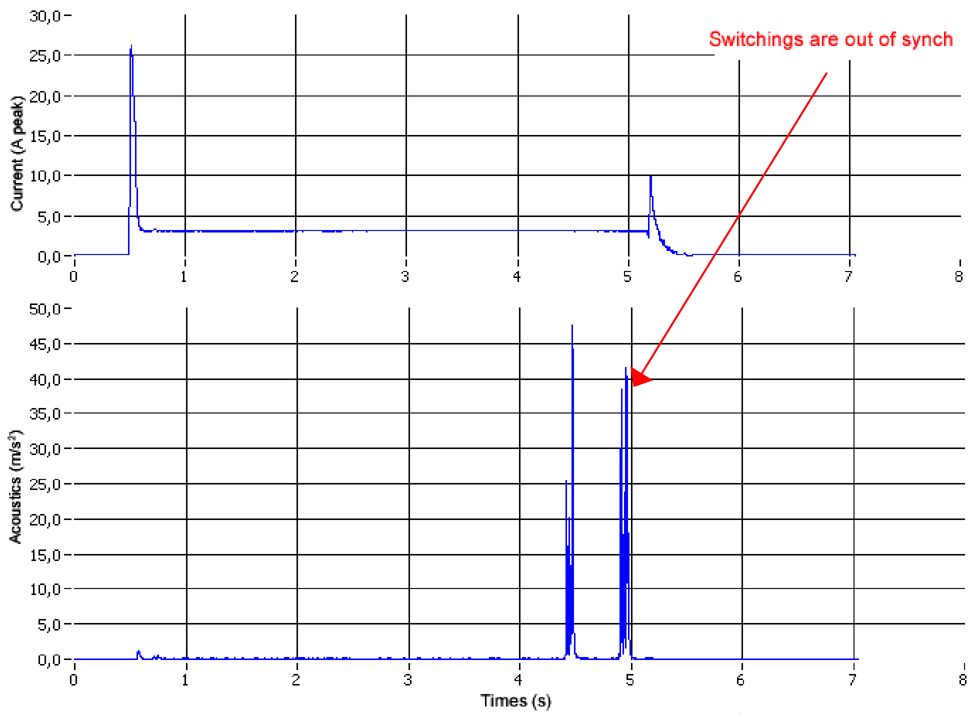

Figure 13 : HF signature of a 2xM Reinhausen with out of sync switchings.

1.2. Reactive types

The tap changers of reactive type are limited to lower voltage levels. However, they can support higher loads and have no limitation on the transition time. This feature allows their use by means of intermediate taps (transitional reactance circuit) as additional positions, doubling the number of positions for the operation. Because of this feature, many designs use a direct drive motor, which in fact has slower mechanisms therefore their maintenance is easier. For the acoustic signature, this behavior usually results in lower noise amplitudes and events less well defined. On the other hand, for models driven by accumulators (springs), the operation is faster and the signature may be confused with that of a OLTP of resistive-type.

Finally, the autotransformer (or reactance) needed for the transition is the source of vibrations that are perceptible to the intermediate positions. Certain high amplitudes may be signs of an autotransformer in poor condition.

1.2.1. Interrupter – Selector

a) Models

The models listed below are included in this category.

Direct drive for the motor:

- Ferranti Packard RT32 reactive
- GE LR (all except LRT)
- Westinghouse UTT, UTR and UNR
- McGraw Edison 550
- Reinhausen RMT

- Moloney MA and MB

Driven by accumulator

- Federal Pioneer TC15, TC23, TC34, TC46, TC525, TC546 (sometimes referred as RCBT)

b) Definition and operation

In this type of OLTP, the two selectors in parallel are coupled to as many interrupters that cut into alternating the current so that the tap changing is initiated. The sequence then comprises three steps: 1) Cut the current by opening the interrupter 2) Move the selector associated 3) Close the interrupter. Of the 17-tap models found on our network, this sequence is performed twice consecutively.

c) Typical trace

The figures below show two examples of tap changer with a interrupter-selector, driven either directly by the motor, or by springs.

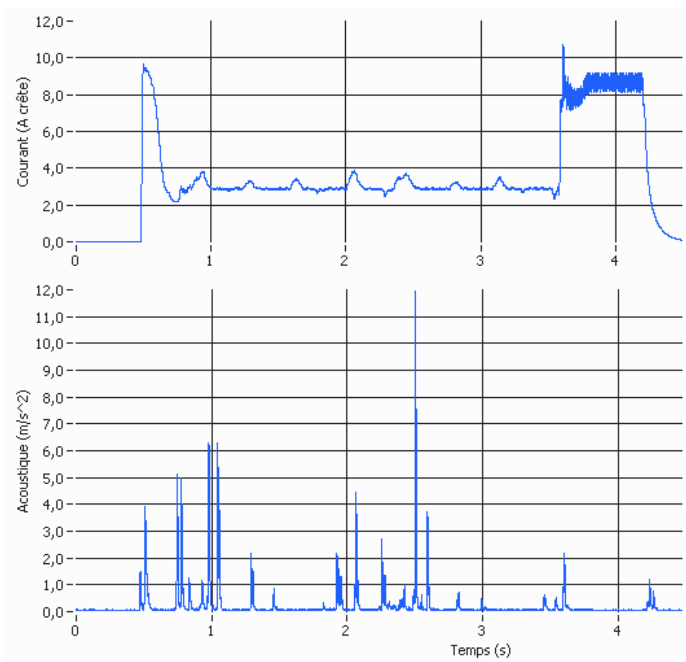

Figure 14 : HF signature of a LR65 GE

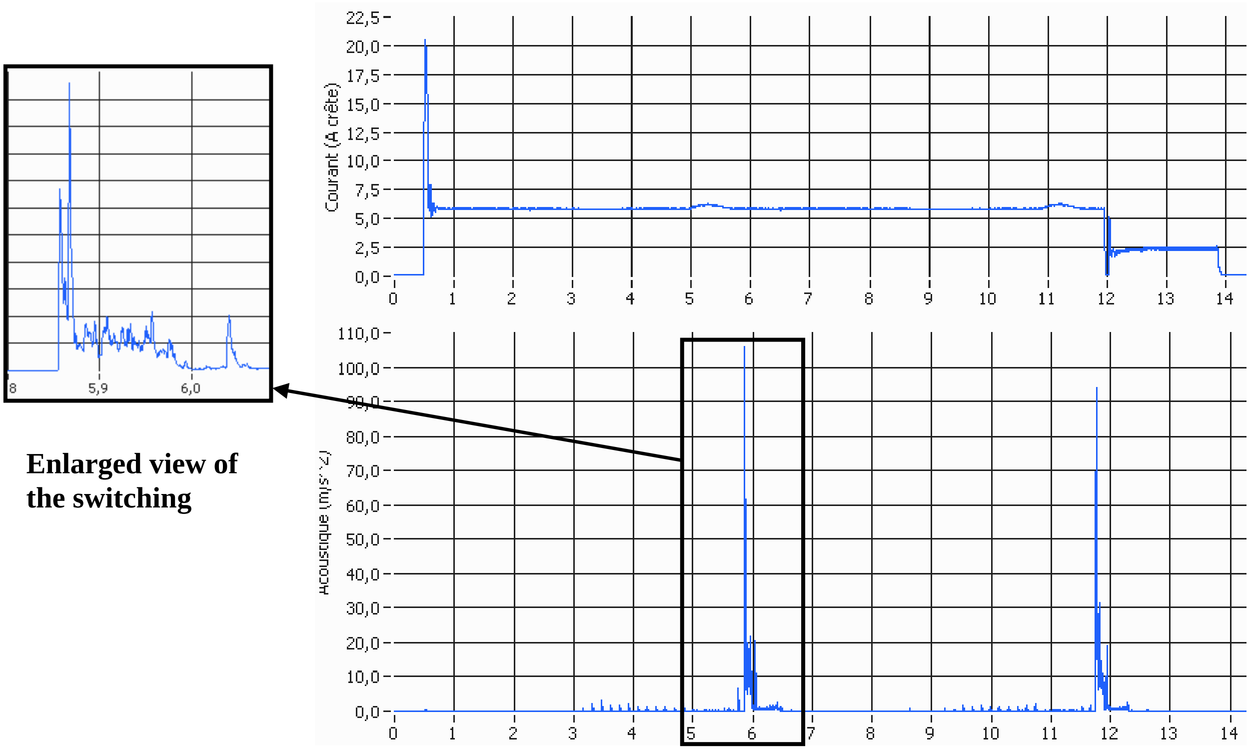

Figure 15 : HF signature of a dual operation of a TC546 Federal Pioneer

1.2.2. Selector with load

a) Models

The models listed below are included in this category.

- Westinghouse URS

b) Definition and operation

The tap changers operating with a selector with load are usually limited in voltage (138 kV) and number of positions (33). This type of OLTP uses only one selector that acts both as a selector and as a switch. It does not operate at high speed since it is driven directly by the motor.

c) Typical trace

The figure below shows the acoustic signature of a typical reactive OLTP with a selector with load. It is shown the single operation of a URS Westinghouse.

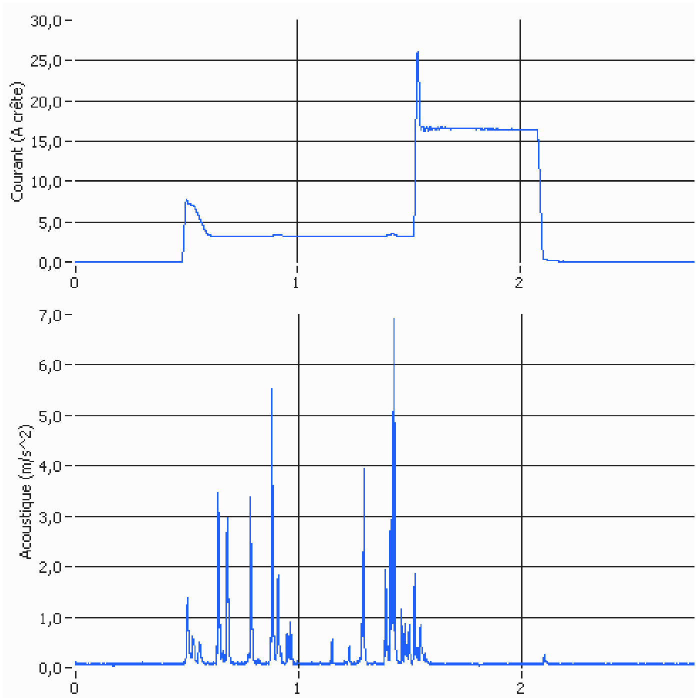

Figure 16 : Single operation of a Westinghouse URS

1.2.3. Vacuum Switch

a) Models

The models listed below are included in this category.

- Reinhausen RMV
- Federal Pioneer TCA15
- GE LRT200 and LRT500

b) Definition and operation

The tap-changer of a vacuum switch has the operating principle of the switch-selector OLTP or that of the selector in load. On the other hand, its operation comprises additional steps which vary depending on the model.

c) Typical trace

The **Figure 17** below shows the acoustic signature of a single operation of a RMV II Reinhausen.

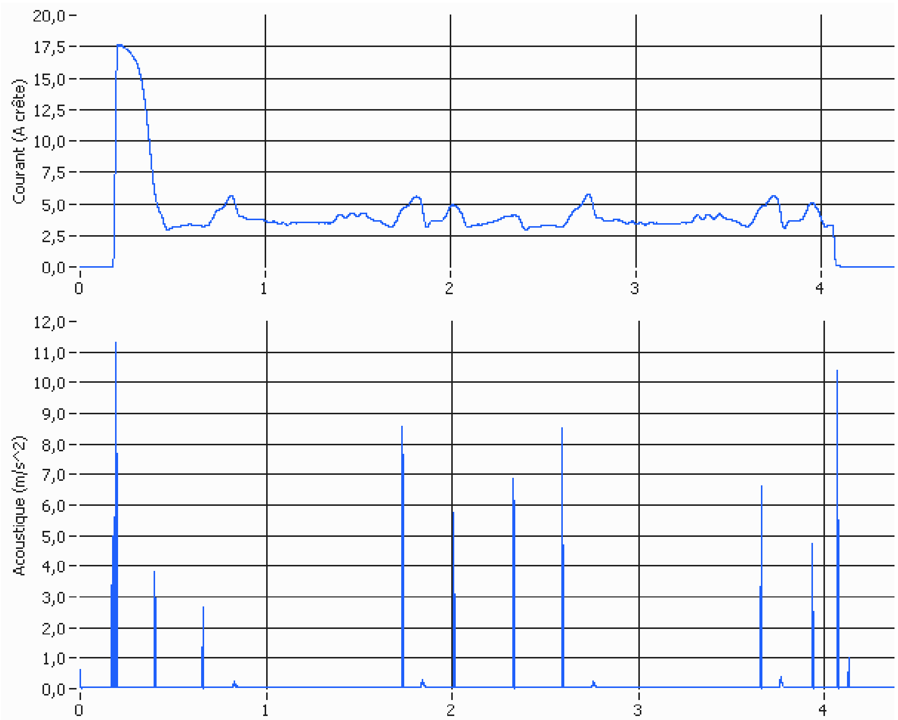

Figure 17 : Acoustic trace of a Reinhausen RMV II

2. The Analysis Interface : the report

1.2.1 Color coding

The program separates the signatures obtained in the sections analyzed. Key values are calculated for each of these sections and are displayed in the tabular report. Colors are then assigned to these values based on selected criteria. These criteria are based on a statistical basis and by comparison with a population data. They define the values considered statistically normal, and those that differ significantly from the observed statistics for the respective family of OLTPs.

The colors indicate whether the value is considered normal (green), doubtful (yellow) or abnormal (red). Thresholds are then established according to the type of intervention is recommended (**Table 1** below).

*NB: It is possible that some parts of the report can't be read by the color code (see **Figure 18**). Such values are used only as indication to the user. They do not define a specific action to be taken.*

Table 1: Definition of actions to be taken depending on the colors of the report

Green •	The value obtained is considered normal. The tap changer is in good condition. There is no action to take.
Yellow •	The value obtained is doubtful; it is outside the range established statistically. Repeat the data acquisition. If

	the second set of data are similar, <u>the OLTP must be monitored</u>.
Red •	The value obtained is abnormal; it is considerable outside of the normal range established statistically. <u>Repeat the data acquisition</u>. If the second set of data are similar, <u>**notify the Technical Support**</u> <u>and</u> <u>**investigate the cause of the discrepancy**</u>.

The report may differ from one type to another OLTP; relevant parameters and important analysis are not always the same.

1.2.2 The sections

The different sections that appear in the OLTP report present only in its tank are defined in **Figure 18 and Figure 19**. Whatever type of OLTP, the report displays sections on a regular basis, such as sections of the motor, of the brake, of the switching, and the selector (**Figure 18**).

Identification: 1U-0080
No Exploit.: T6
Heure: 14h07
Poste: MONTMORENCY 69 KV
Date: 2007-07-05
Type de CPC: ABB UCBRN
Type d'essai: HORS_SERVICE
Charge MW: 0
Compteur d'opération: 59527
Temp. Huile: 23

	MOTEUR			FREIN	SÉLECTEU			COMMUT/						
Prise	Durée (s)	Moyenne (A)	Inrush (Ratio)	Bruit BF (m/s2)	Bruit BF (m/s2)	Bruit HF (m/s2)	Delta I (A)	SyncFrein (s)	Forme (-)	Delta I (A)	Duree (ms)	EcartFréq (-)	Bruit HF (m/s2)	Moy BF (m/s2)
MOTEUR:	Triphasé													
+3	5,57	1,32	3,50	0,21	2,54	0,28	0,08	1,21	0,79	0,04	114,30	-0,43	11,23	4,46
+5	5,55	1,32	3,39	0,40	1,82	0,26	0,05	1,21	0,81	0,04	108,30	-0,44	11,56	4,77
+7	5,58	1,31	3,55	0,21	1,77	0,19	0,11	1,22	0,81	0,03	114,00	-0,42	12,34	4,32
+11	5,54	1,32	3,46	0,32	1,30	0,25	0,05	1,20	0,78	0,03	108,00	-0,44	11,69	3,98
+13	5,55	1,32	3,43	0,31	1,77	0,31	0,05	1,21	0,78	0,04	112,20	-0,43	12,51	4,78
+15	5,58	1,32	3,59	0,20	1,24	0,21	0,10	1,21	0,79	0,03	112,50	-0,44	12,09	4,28
+17	5,57	1,32	3,53	0,20	1,29	0,21	0,08	1,21	0,81	0,03	111,00	-0,47	9,53	4,54
-15	5,54	1,32	3,50	0,21	0,64	0,10	0,05	1,62	0,82	0,04	110,70	-0,43	13,27	4,30
-13	5,55	1,32	3,33	0,24	0,46	0,16	0,05	1,63	0,85	0,03	107,10	-0,46	11,48	3,89
-11	5,56	1,32	3,51	0,23	0,50	0,10	0,08	1,63	0,82	0,03	111,60	-0,44	15,21	4,14
-7	5,55	1,32	3,49	0,21	0,80	0,14	0,06	1,63	0,82	0,03	109,50	-0,41	14,30	3,86
-5	5,56	1,32	3,38	0,21	0,73	0,18	0,06	1,64	0,84	0,04	109,50	-0,43	13,04	4,23
-3	5,55	1,32	3,41	0,24	0,39	0,09	0,05	1,63	0,81	0,03	112,50	-0,44	14,24	3,99
-1	5,53	1,32	3,37	0,23	0,57	0,10	0,04	1,62	0,82	0,03	111,30	-0,40	17,13	4,04
+4	5,56	1,32	3,58	0,28	1,48	0,33	0,05	0,87	0,73	0,04	116,70	-0,44	14,31	4,45
+6	5,55	1,32	3,49	0,41	1,74	0,36	0,06	0,87	0,73	0,03	117,60	-0,42	16,48	4,42
+8	5,56	1,32	3,56	0,27	1,81	0,54	0,06	0,87	0,69	0,03	120,60	-0,44	13,92	4,15
+12	5,54	1,32	3,51	0,52	1,99	0,40	0,05	0,87	0,73	0,04	120,00	-0,42	17,12	4,10
+14	5,56	1,32	3,34	0,33	1,12	0,40	0,06	0,87	0,75	0,04	115,50	-0,43	12,82	3,95
+16	5,56	1,32	3,38	0,45	1,62	0,73	0,06	0,87	0,73	0,03	120,00	-0,47	13,69	3,79
-14	5,54	1,32	3,52	0,22	1,10	0,42	0,06	1,32	0,76	0,04	130,20	-0,47	18,02	6,15
-12	5,55	1,32	3,51	0,21	1,04	0,43	0,06	1,31	0,72	0,03	132,30	-0,47	16,23	6,30
-10	5,54	1,32	3,50	0,21	1,04	0,41	0,05	1,32	0,77	0,03	132,30	-0,45	16,95	5,97
-6	5,56	1,32	3,62	0,22	1,19	0,48	0,07	1,32	0,80	0,03	132,00	-0,49	15,94	6,40
-4	5,55	1,32	3,40	0,20	0,96	0,54	0,06	1,32	0,81	0,03	132,60	-0,50	14,30	6,58
-2	5,54	1,32	3,50	0,21	1,23	0,48	0,06	1,32	0,78	0,04	128,70	-0,50	14,35	6,31

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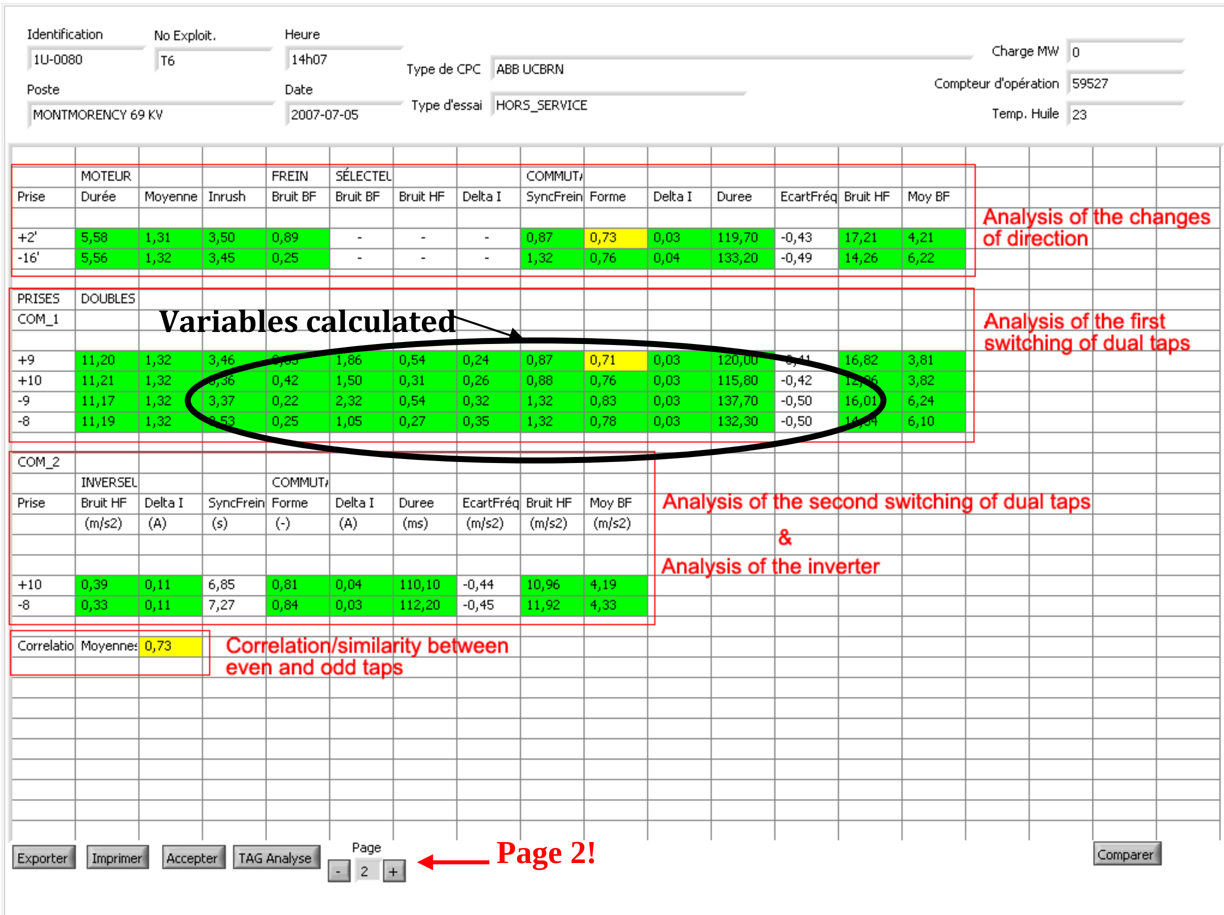
Figure 18: Analysis report of an OLTP type ABB UCBRN

The inverter is analyzed only if it is operating during the data acquisition. It is the same for dual taps and changes of direction. This analysis is seen on the next page of the report, that is on page 2 (**Figure 19**).

As shown in **Figure 18 and Figure 19**, each section of the report is easily identified and recognized. Below the header of each section, the variables analyzed are listed. The calculated values are shown below the second header (see **Figure 19**).



	MOTEUR			FREIN	SÉLECTEL			COMMUT/						
Prise	Durée	Moyenne	Inrush	Bruit BF	Bruit BF	Bruit HF	Delta I	SyncFrein	Forme	Delta I	Duree	EcartFréq	Bruit HF	Moy BF
+2'	5,58	1,31	3,50	0,89	-	-	-	0,87	0,73	0,03	119,70	-0,43	17,21	4,21
-16'	5,56	1,32	3,45	0,25	-	-	-	1,32	0,76	0,04	133,20	-0,49	14,26	6,22
PRISES	DOUBLES													
COM_1														
+9	11,20	1,32	3,46	[illegible]	1,86	0,54	0,24	0,87	0,71	0,03	120,00	[illegible]	16,82	3,81
+10	11,21	1,32	[illegible]	0,42	1,50	0,31	0,26	0,88	0,76	0,03	115,80	-0,42	[illegible]	3,82
-9	11,17	1,32	3,37	0,22	2,32	0,54	0,32	1,32	0,83	0,03	137,70	-0,50	16,01	6,24
-8	11,19	1,32	[illegible]	0,25	1,05	0,27	0,35	1,32	0,78	0,03	132,30	-0,50	[illegible]	6,10

COM_2									
	INVERSEL			COMMUT/					
Prise	Bruit HF (m/s2)	Delta I (A)	SyncFrein (s)	Forme (-)	Delta I (A)	Duree (ms)	EcartFréq (m/s2)	Bruit HF (m/s2)	Moy BF (m/s2)
+10	0,39	0,11	6,85	0,81	0,04	110,10	-0,44	10,96	4,19
-8	0,33	0,11	7,27	0,84	0,03	112,20	-0,45	11,92	4,33

Correlatio	Moyennes	0,73

Figure 19: Analysis Report of a OLTP type ABB UCBRN

Table 2 shows the complete list of variables used in the report. For each OLTP model, only a selection of relevant variables is presented in the report.

The format and content of the report also adjusts automatically depending on the operations measured.

Table 2 : Definition of variables in different sections of the report

Section	Variable	Definition
Motor	Durée (Duration)	Duration of the operation, from the start of the inrush to the end of the brake.
	Moyenne (Average)	Average value of the peak current in the section between the end of the inrush and the start of the brake.
	Inrush	Relationship between the peak inrush current (inrush) and the average value defined above.
Brake	Bruit BF (LF noise)	Amplitude corresponding typically to the 99th percentage of the signature of the low frequency during the period of activity associated with the brake.
Selector	Bruit BF (LF noise)	Amplitude corresponding typically to the 99th percentage of the signature of the low frequency during the period of activity associated with the selector.
	Bruit HF (HF noise)	Amplitude corresponding typically to the 99th percentage of the signature of the high frequency during the period of activity associated with the selector
	Delta I	Increase of the motor current due to mechanical stress during the selection operation (= maximum value - minimum value)
Switching	SyncFrein (SyncBrake)	Difference in time between the start of the brake and the start of the commutation. This variable defines thus the switching synchronization with the brake.
	Forme (Shape)	Variable that indicates the consistency level of the signature with a bank of referential signatures. These references are a representation of a selection of OLTPs in good condition. A shape coefficient of 1.00 indicates a perfect resemblance. The lower the value is, the less the signature is similar to a OLTP in good condition.
	Delta I	Increase of the current motor due to mechanical stress during the switching operation (= maximum value - minimum value).
	Durée (Duration)	Indirect measurement and the approximated duration of the switching (ms).
	ÉcarFréq (DiscFreq)	Variable that indicates the average difference between the amplitudes of the signature of low frequency and that of high frequency during switching. The value obtained is normalized by the LF signature.
	Bruit HF (HF noise)	Amplitude corresponding typically to the 99th percentage of the signature of the high frequency during the period of activity associated with the switch.
	Moy BF (Average noise)	Amplitude corresponding typically to the 50th percentage of the signature of the low frequency during switching.

	Synchro	For the OLTP with multiple switches, this value indicates the maximum offset (s) between the commutations.
	Corrélation Moyenne *ou* Facteur de symétrie (Average Correlation or Symmetry factor)	Value indicating the symmetry between odd and even switching. A value of 1.00 results in a perfect symmetry.
	Indice d'usure moyen (Index of average wear)	Wear indicator calculated by the average amplitude ratio of HF vs. LF on all test switchings (ABB-UZ).

3. Interpretation of discrepancies

The chart shown in **Figure 20** defines the actions to take once the data acquisition is finished. Each step is numbered and explained in more detail in **Table 3**.

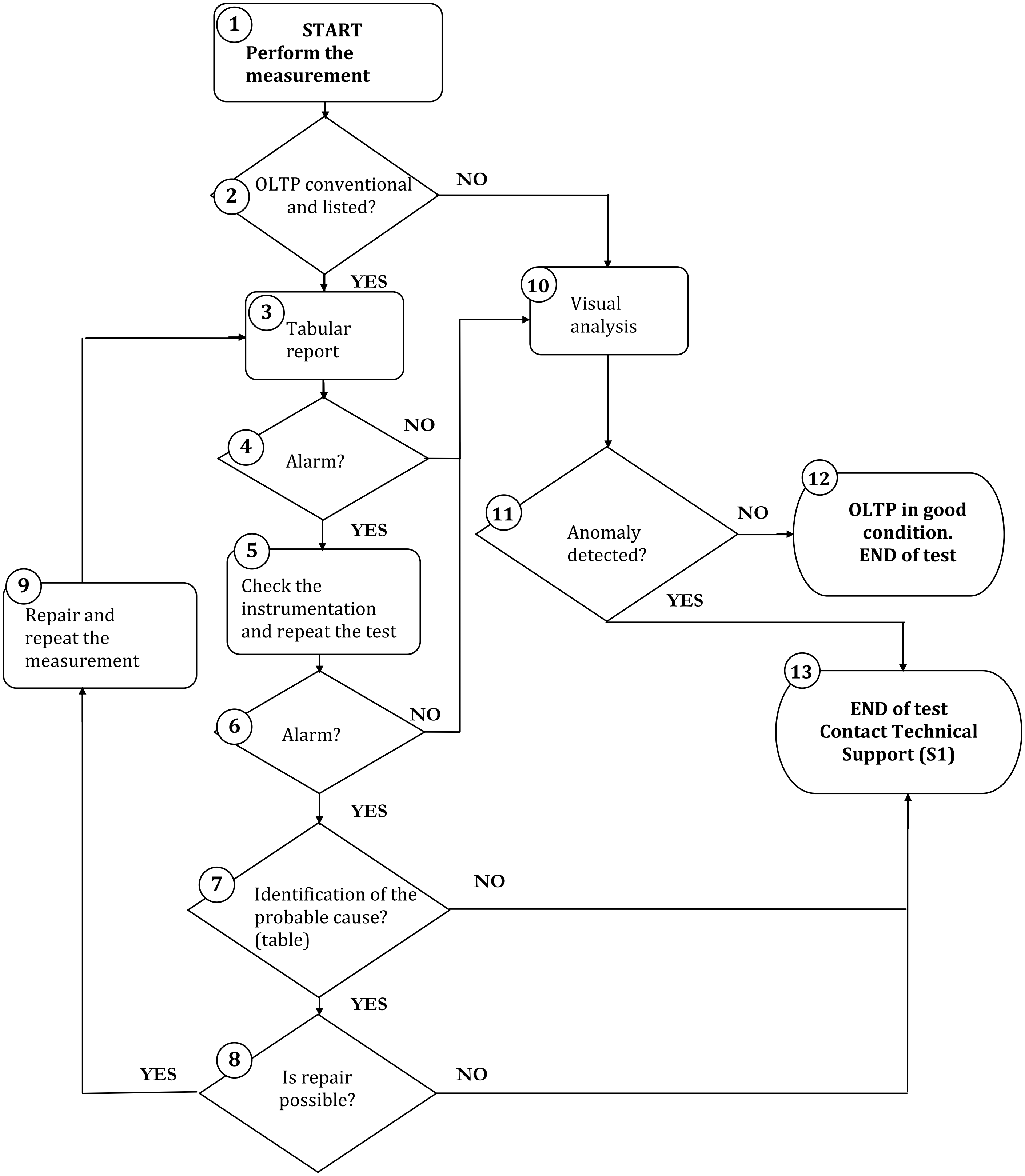


Figure 21 : Chart defining the chronology of actions taken during the data analysis

Table 3 : Explanation of the steps in the analysis of acoustic signatures as shown in **Figure 21**

Step	Details
1	Capture the data. Refer to the procedure devoted to this purpose or the *TET-EPA-P-xxxx - Procedure of data acquisition for acoustic tests on the OLTP*.
2	If the model of OLTP analyzed of a test plan is listed, generate the tabular report. Otherwise, go straight to the visual examination of the signatures.
3	The tabular report is generated automatically by clicking at the "Report" icon
4 & 6	Check for red or yellow boxes in the tabular report.
5	Check the instrumentation: 1. Make sure that the current clamp is installed properly and that it closes completely. Make sure it is installed on the proper wire of motor supply. 2. Make sure that the accelerometer is fully screwed. 3. Check all connections to the TAP4. Repeat the test and recalculate the report.
7	If the alarms are confirmed, identify the probable cause of the problem. Refer to the **Table 4** for an explanation of possible discrepancies of values. Refer also to the **Diagnostics Cards** of each OLTP model, this step requires a visual analysis of acoustic signatures. The available cards may be found on the Intranet site of OLTPs.
8	If the cause of the problem is identified and the solution is known, proceed to the repair. Otherwise, refer to the technical support.
9	Repair and repeat the steps to see if the problem has been solved.
10	If the report shows only green boxes, the summary verification has detected no obvious anomaly. However, a visual analysis by a technician or an electrician remains essential. Examine the traces visually and verify any evidence of anomalies by comparing with: • The cards of typical signatures • The diagnostic cards • Previous tests on the same unit (i.e. before the inspection in progress) or tests on a unit of the same family.
11	Has the visual analysis detected signs of anomalies?
12	If no anomaly is detected visually or by means of software algorithms, then the OLTP is considered to be in good condition.
13	If you can't identify the problem causing a divergence of values on the report, or if the repair can't be accomplished on site, or if a failure is detected visually notify the technical support.

Table 4 shows the interpretation of discrepancies in values and their probable causes. There are most likely other possible explanations for the discrepancies in values, these additional causes will be added to the table as and when they become identified.

Table 4 : Definition of variables in different sections of the report

Section	Variable	Possible causes of discrepancies
Motor	Durée (Duration)	**Duration too long :** Defective brakes Lack of lubrication Bad timing upward - downward
		Duration too short : Misadjusted cams Problem with the maintenance relay Bad timing upward – downward
	Moyenne (Average)	**Value too high :** Lack of lubrication Abnormal or excessive stress in the drive system Motor type wrongly detected (single or three phase)
		Value too low: Current clamp not closed Motor type wrongly detected (single or three phase)
	Inrush	**Value too high :** Motor type wrongly detected (single or three phase) Abnormal or excessive stress to start
		Value too low : Motor type wrongly detected (single or three phase) Slack in the drive mechanism
Brake	Bruit BF (LF noise)	**Value too high :** Mechanism not locked Brake problem
Selector	Bruit BF (LF noise)	**Value too high :** Poor adjustment, abnormal impact Arcing Misalignment of contacts Noise in the wheel drive
		Value too low : Wear
	Bruit HF (HF noise)	**Value too high :** Poor adjustment, abnormal impact Arcing Misalignment of contacts
		Value too low : Wear
	Delta I	**Value too high :** Abnormal or excessive stress Misalignment of contacts Electromagnetic interferences (glitches)
Switching	SyncFrein (SyncBrake)	**Value too high :** Bad adjustment of synchronization

		Value too low : Bad adjustment of synchronization
	Forme (Shape)	**Value too low :** Wear Poor measurement
	Delta I	**Value too high :** Poor measurement (ABB UC)
	Durée (Duration)	**Value too high :** Noise in the wheel drive Wear
		Value too low : Wear
	ÉcarFréq (DiscFreq)	**Value too high :** Wear of the contacts depending on the model
		Value too low : Wear of the contacts depending on the model
	Bruit HF (HF noise)	**Value too high :** Poor adjustment, abnormal impact Arcing Misalignment of contacts
		Value too low : Wear Poor measurement
	Moy BF (Average LF)	**Value too high :** Wear
		Value too low : Poor measurement Wear