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**electricity north west**
Bringing energy to your door

# Tap Changer

Acoustic/Vibration-Based
Condition Monitoring System

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www.enwl.co.uk

# Background



NIA funded project to test feasibility of detecting problems

Acoustic/ vibration acquisition system

Record information during each tap change switching event for a period of two years

Goal: to process recorded data with DSP and AI tools looking for trends referable to ageing of tapchanger

Will lead to improved asset management of tap changers

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# System overview

**Transformer control kiosk**
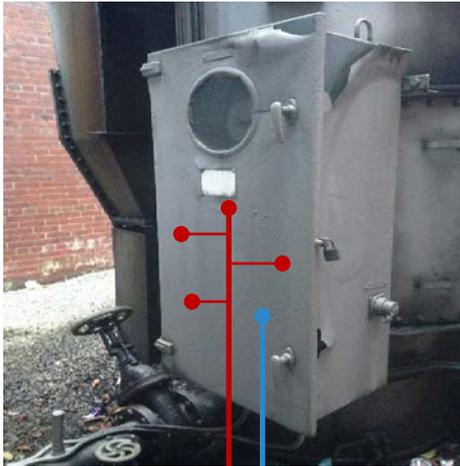
**Tap changer**
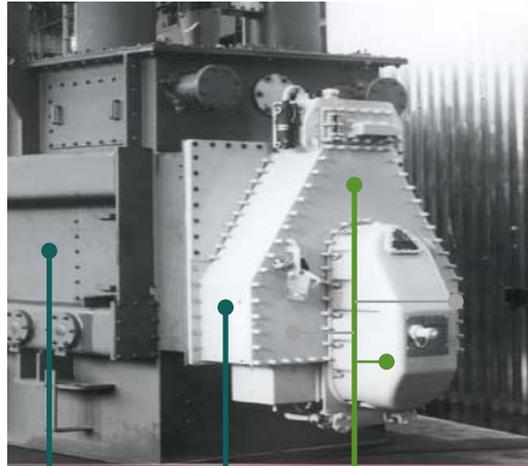
**Tap changer monitoring system**

**2G/3G link**

**SFTP server collects vibration and current waveform generated by each switchover**

**Ambient Temperature probe**
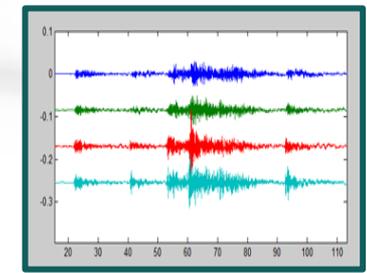
**2x temperature probes**
**(1x tap changer tank temp,**
**1x transformer tank temp.)**

**4x accelerometers or AE sensor**

**Tap position**

**4x CTs (1x transformer current,**
**3x tap changer motor current)**

**Mains power input**

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# Acquisition module



High and not scalable cost

Relatively low sampling frequency (50kHz)

Proprietary and high cost development tools (LabView)

Limited amount of data means **high failure risk of statistical analysis approach**

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# Acquisition model



All sensors →

**Tap changer acquisition module**

Usb

**Buzby2**

GSM antenna
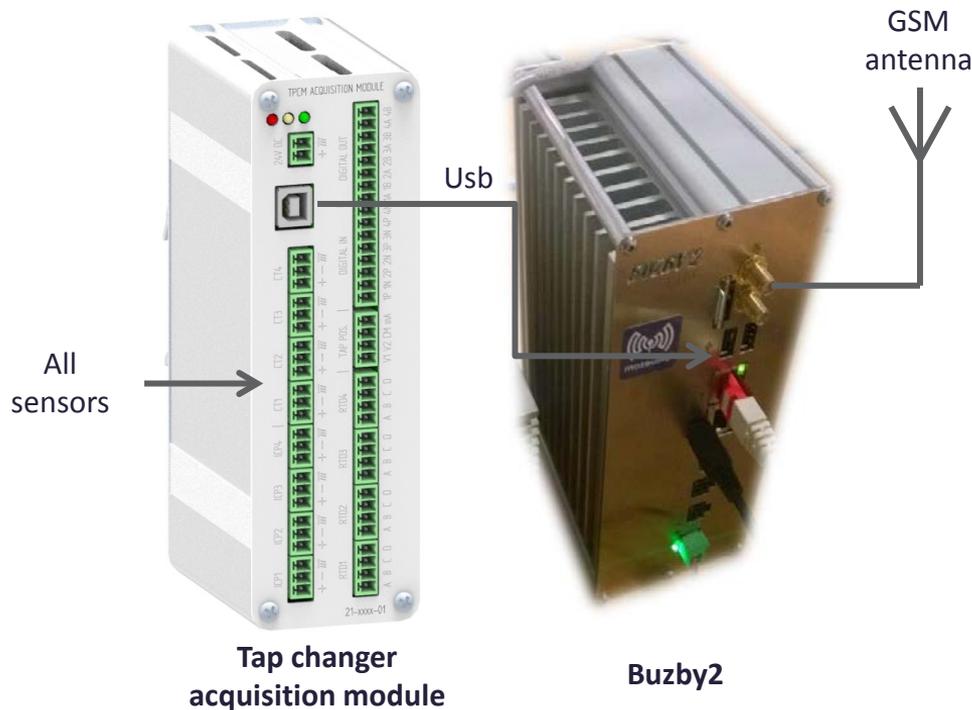
Complete custom USB acquisition module designed

Flexible 8 channel 24bit 192kHz differential input

Auxiliary isolated analogue input

Auxiliary isolated digital I/O

4 input for RTD temperature sensor

USB interface compatible with any Linux PC using standard drivers

Acquisition module designed and tested in about 6 months

Cost effective and quantity scalable solution

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**Analysis of mechanical vibration produced by gear and switch**

Require sensor capable of vibration detection with phase coherence across spectrum up to 10kHz

*ICP Industrial accelerometer used (0.5 to 10-15kHz)*



Sensitivity Plot

Temperature: 72 °F (22 °C)    Relative Humidity: 58 %

15kHz

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# Vibration and acoustic sensors
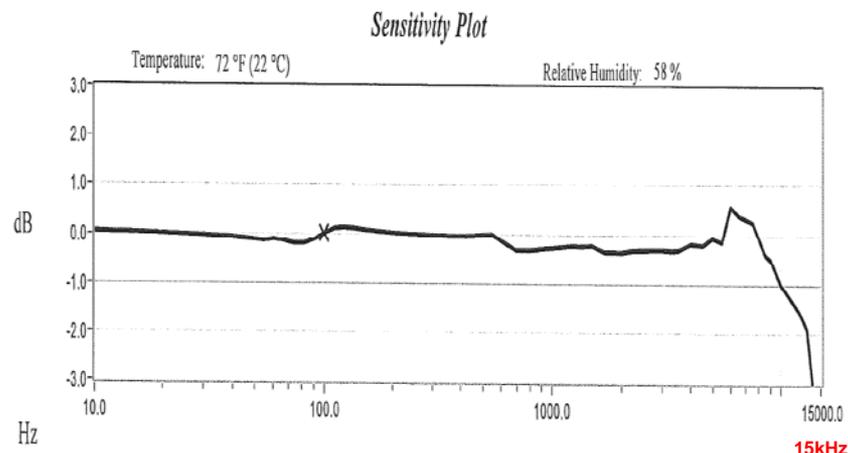
**Detection of noise produced by arcing and PD during switching**

Require sensor capable of detect high frequency acoustic energy (> 50kHz, where mechanical noise roll off)

*Acoustic emission resonating sensor used (15 to 150kHz)*



150kHz



Ceramic chip

Electromagnetic isolation

# Vibration and acoustic sensors
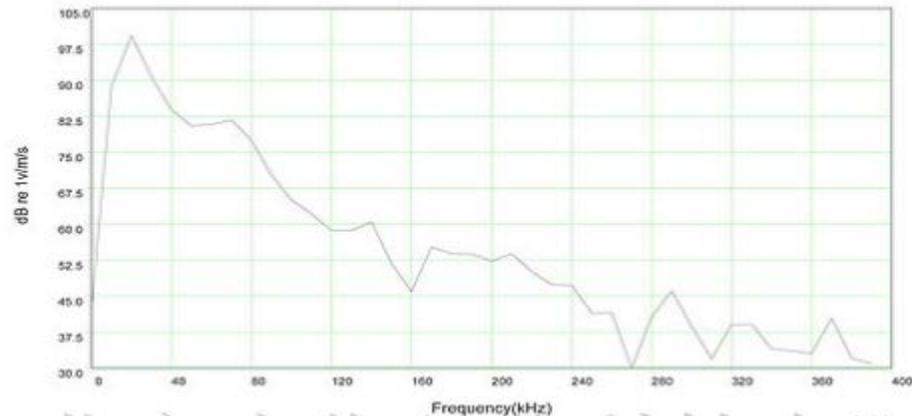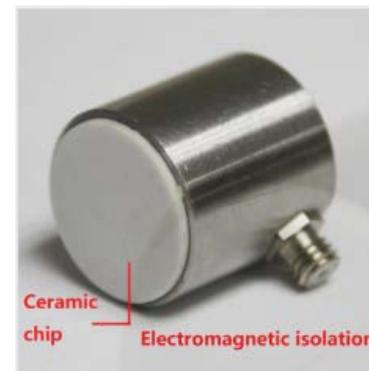
**Acquisition module can sample up to 192kHz so can be used with all kind of sensor (AE requires specific preamp)**

Hi quality industrial accelerometer is similar cost to AE sensor and seems capable to detect energy up to 100kHz.



Sensitivity Plot

Temperature: 66 °F (19 °C)    Relative Humidity: 64 %

20kHz
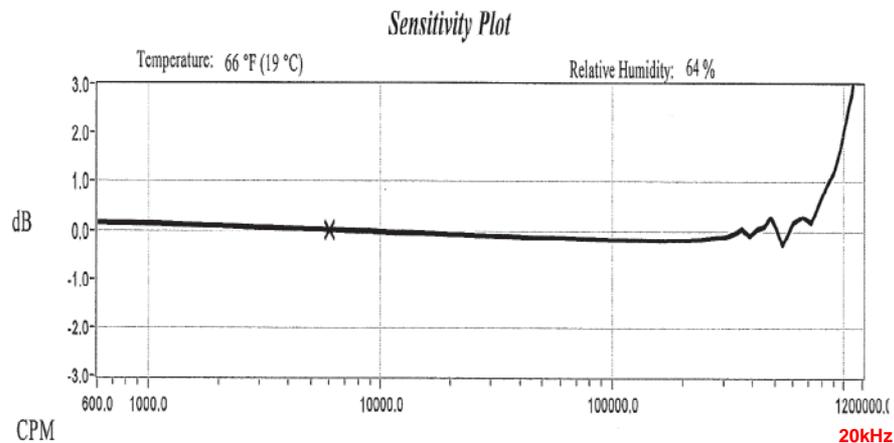
# Electro-mechanical system



Acquisition Module

Buzby2 EPC

GSM Antenna

Power Supply
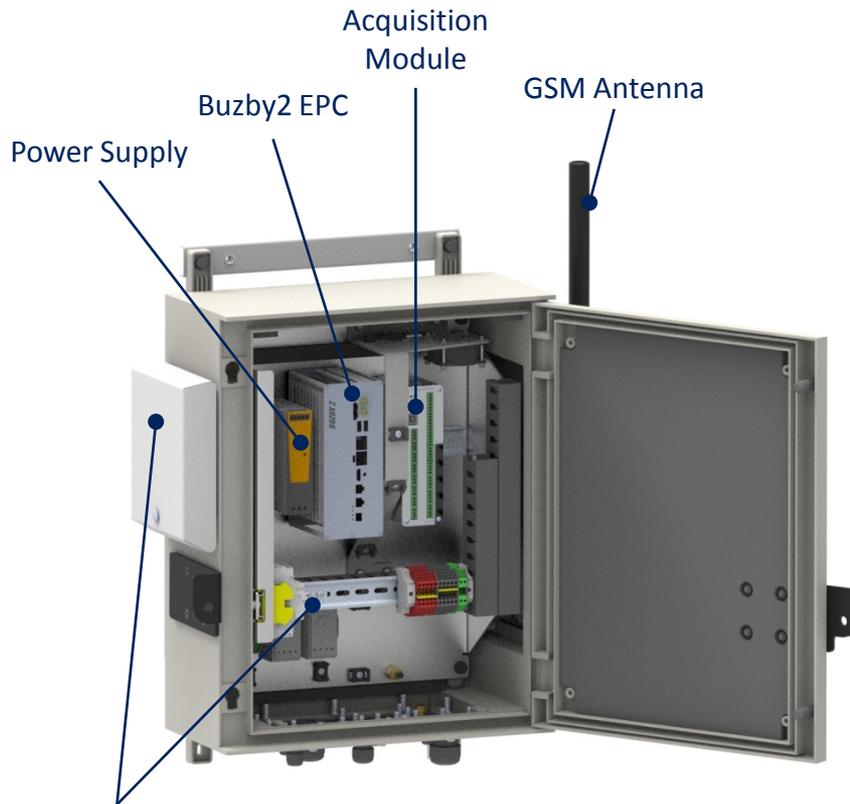
Cooling and Heating system

Customized enclosures suitable for indoor/outdoor

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# Project status

| | | | |
|---|---|---|---|
| Electromechanical fully designed (Lisburn) | Acquisition module fully designed and tested (Parma) | Linux software designed and tested (Glasgow) | Three alpha prototype installed and commissioned |
| Basic statistic implemented on server (Parma) | Site inspections carried out to plan installation | 40 systems installation scheduled | Statistical analysis of incoming data and algorithm development to determinate "system condition" |

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# Alpha Prototype Installations

3 Alpha prototype installed and commissioned on July 2017

Winifred Road Primary Altrincham Grid Baguley Primary

Complete waveform from Accelerometer and CTs @ 192kHz

Temperatures

Tap position for each switching event

All data sent to remote server

Introduction of specific lossless compression reduced data size by 50%

Installed system generate on average 3/4 events per day each around 15/25MB

Each system should generate about 2/3 GB per month

Down sampling of CT's waveform should be implemented to reduce data of about 30%

Preliminary "hand-crafted" data analysis has identified issues on 2 of 3 monitored tap changers

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# Alpha prototype installation: Winifred Rd

Site: **Winifred Road Primary**

Tap changer type: **Ferranti DC3**

During the selector movement phase of last step of switching sequence 5->4->3 or 3->4->5 arcing noise presence can be clearly heard.



| Event_ID | BS_TapPos[#] | AS_TapPos[#] |
|---|---|---|
| 20170717T052222 | 3 | 4 |
| 20170717T055305 | 4 | 5 |
| 20170717T055808 | 5 | 4 |
| 20170717T080014 | 4 | 5 |
| 20170717T081220 | 5 | 4 |
| 20170717T091245 | 4 | 3 |
| 20170717T091806 | 3 | 4 |
| 20170717T162033 | 4 | 3 |
| 20170717T163919 | 3 | 4 |
| 20170717T172635 | 4 | 5 |
| 20170717T173504 | 5 | 4 |
| 20170717T191248 | 4 | 3 |
| 20170717T192946 | 3 | 4 |
| 20170717T193015 | 4 | 5 |
| 20170717T194042 | 5 | 4 |
| 20170717T204802 | 4 | 5 |
| 20170717T213717 | 5 | 4 |
| 20170717T234952 | 4 | 3 |



*Any other switchover*



*4->3 or 4-5 switchover*

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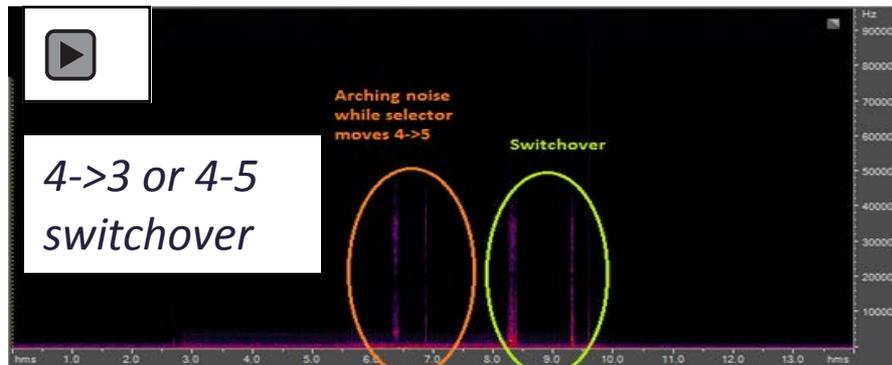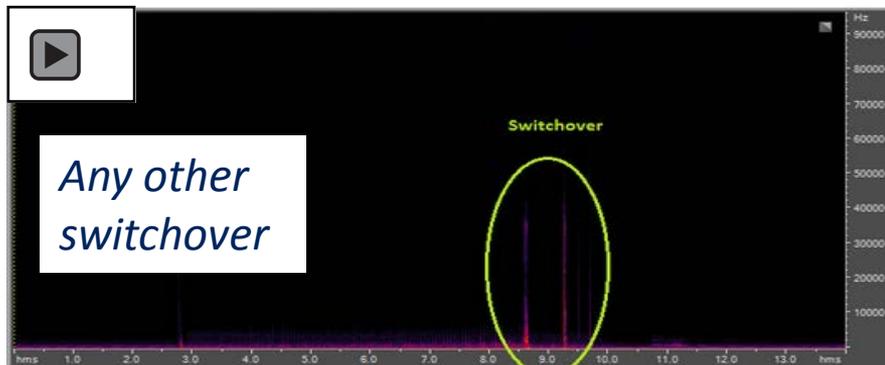
The arcing noise indicates that tap 4 contact of one of the three selectors is excessively worn
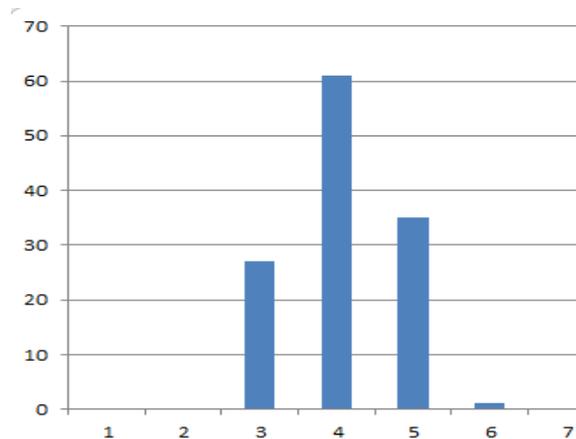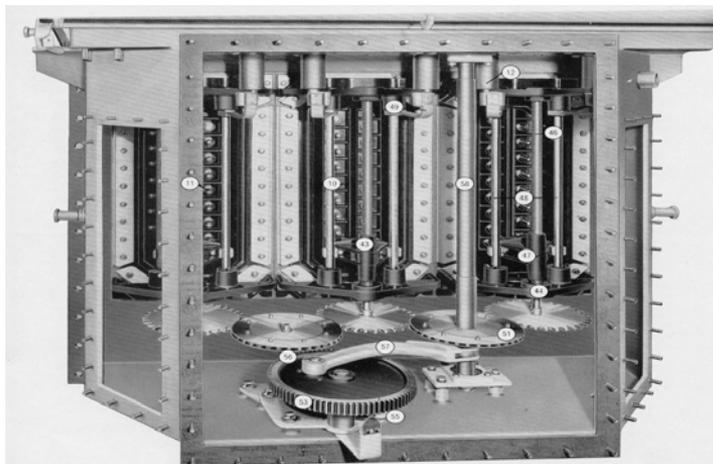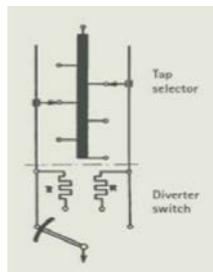


Observing tap usage statistics shows that tap 4 is the most used tap position.
**Currently the tap changer is on fixed tap awaiting inspection.**

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# Alpha prototype installation: Altrincham

## Site: **Altrincham Grid**

Tap changer type: **Fuller HS319** ● Recorded anomalous events ● 2/3 time per week always involving tap 8 ● Currently under investigation

| Event_ID | BS_Timestamp | Event_Time[s] | BS_TapPos[#] | AS_TapPos[#] |
|---|---|---|---|---|
| 20170726T140949 | 26/07/2017 14:09 | 5 | 7 | 8 |
| 20170726T231255 | 26/07/2017 23:12 | 3 | 8 | 8 |
| 20170726T231433 | 26/07/2017 23:14 | 5 | 8 | 9 |
| 20170727T061730 | 27/07/2017 06:17 | 5 | 9 | 8 |
| | | | | |
| 20170728T234721 | 28/07/2017 23:47 | 5 | 8 | 9 |
| 20170729T063347 | 29/07/2017 06:33 | 5 | 9 | 8 |
| 20170729T101106 | 29/07/2017 10:11 | 3 | 8 | 8 |
| 20170730T014838 | 30/07/2017 01:48 | 5 | 8 | 9 |
| 20170730T043726 | 30/07/2017 04:37 | 5 | 9 | 10 |
| | | | | |
| 20170802T153206 | 02/08/2017 15:32 | 6 | 8 | 7 |
| 20170802T210651 | 02/08/2017 21:06 | 6 | 7 | 8 |
| 20170802T232039 | 02/08/2017 23:20 | 3 | 8 | 8 |
| 20170802T232254 | 02/08/2017 23:22 | 5 | 8 | 9 |
| 20170803T055703 | 03/08/2017 05:56 | 6 | 9 | 8 |
| | | | | |
| 20170812T065819 | 12/08/2017 06:58 | 5 | 10 | 9 |
| 20170812T081414 | 12/08/2017 08:14 | 5 | 9 | 8 |
| 20170813T004753 | 13/08/2017 00:47 | 3 | 8 | 8 |
| 20170813T005010 | 13/08/2017 00:50 | 3 | 8 | 8 |
| 20170813T005236 | 13/08/2017 00:52 | 5 | 8 | 9 |
| 20170813T065700 | 13/08/2017 06:56 | 5 | 9 | 10 |
| 20170813T081430 | 13/08/2017 08:14 | 5 | 10 | 9 |

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