PCMx: faster pipeline surveying with simultaneous data gathering

Agenda

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- Corrosion Overview
- NACE and the PCM
- Principals
- Theory
- PCMx: an overview
- What's new?
- PCMx vs PCM+

A short introduction to Pipeline Current Mapping

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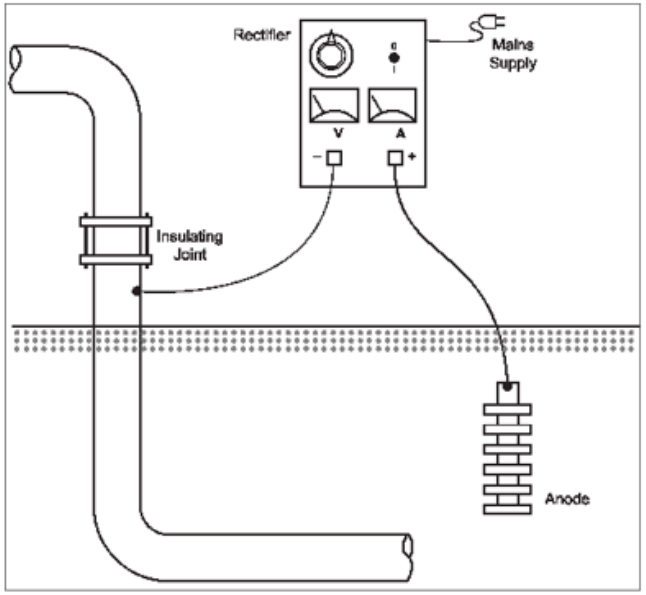
Oil and Gas pipelines usually have two protection mechanisms to prevent corrosion

1. The pipe will be coated for protection
2. A cathodic protection (CP) system is employed
    - Sacrificial anodes
    - DC current is supplied from a rectifier



A pipeline is normally anodic, it contains positively charged particles. By supplying an electric current the pipeline becomes passive or cathodic. As long as the current is arriving at the pipeline faster than oxygen is, then corrosion will be prevented or significantly slowed.

Pipeline current mapping -overview

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In the event of pipeline coating failures, there is the potential for corrosion to develop. At best, this can lead to higher costs as the CP system has to work harder to protect the pipe. At worst, there is the possibility of a pipe breach.

For this reason, it is required that oil and gas pipelines are surveyed regularly to ensure their integrity. (US Guidelines)

The Pipeline Current Mapper was developed by Radiodetection alongside industry partners to provide a convenient way to assess the condition of pipeline coatings, and locate and pinpoint coating faults.

According to PHMSA, over $166 million dollars was spent last year on corrosion related incidents on pipelines. NACE website

Where does PCM fit in?

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ANSI/NACE guidelines: SP0502- 2010

External Corrosion Direct Assessment

1. Pre-assessment
2. Indirect Inspection (2 complementary surveys)
3. Direct Examination
4. Post assessment

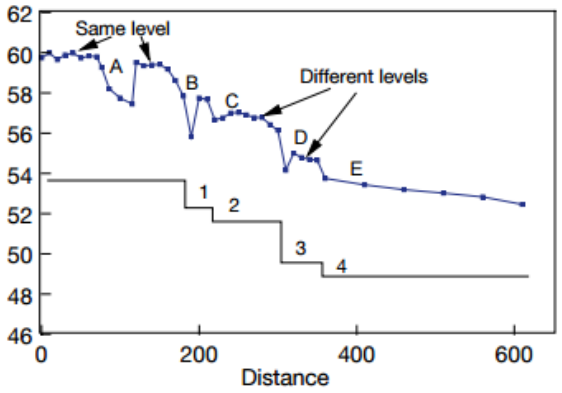
The PCM allows the user to conduct two types of "Indirect Inspection" surveys

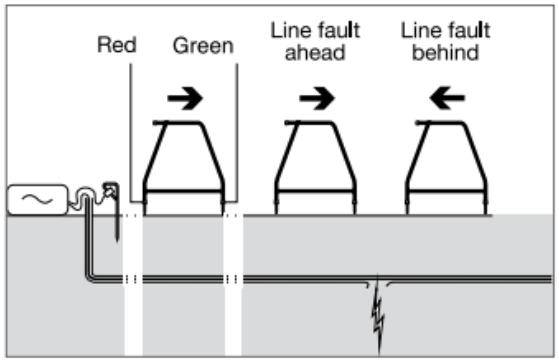
ACCA (Alternating Current, Current Assessment)

A 4Hz signal is applied to the pipeline and regular measurements are taken to identify areas of current loss.

ACVG (Alternating Current, Voltage Gradient)

Measures the leakage current in the vicinity of the pipeline to pinpoint coating defects





CP Theory

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Buried steel → pipelines corrode.

How to protect ?

- Coatings
- ... but are never perfect
- 1 Ampere for 1 year takes 1 kg of metal.

Reverse the electrochemical process → Apply a CP current !!

- Rectifier, or ...
- Sacrificial anodes (no AC required, no CPS).

Cathodic Protection - CP

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Keeping a pipe more negative then the dirt around it prevents most corrosion

Simple as a 12v battery charger

+ **(positive)** to the Anode bed

- **(negative)** to the Pipe(s)

So CP reverses the current flow, adding enough current to zero out the metal loss.

Typical Rectifier System

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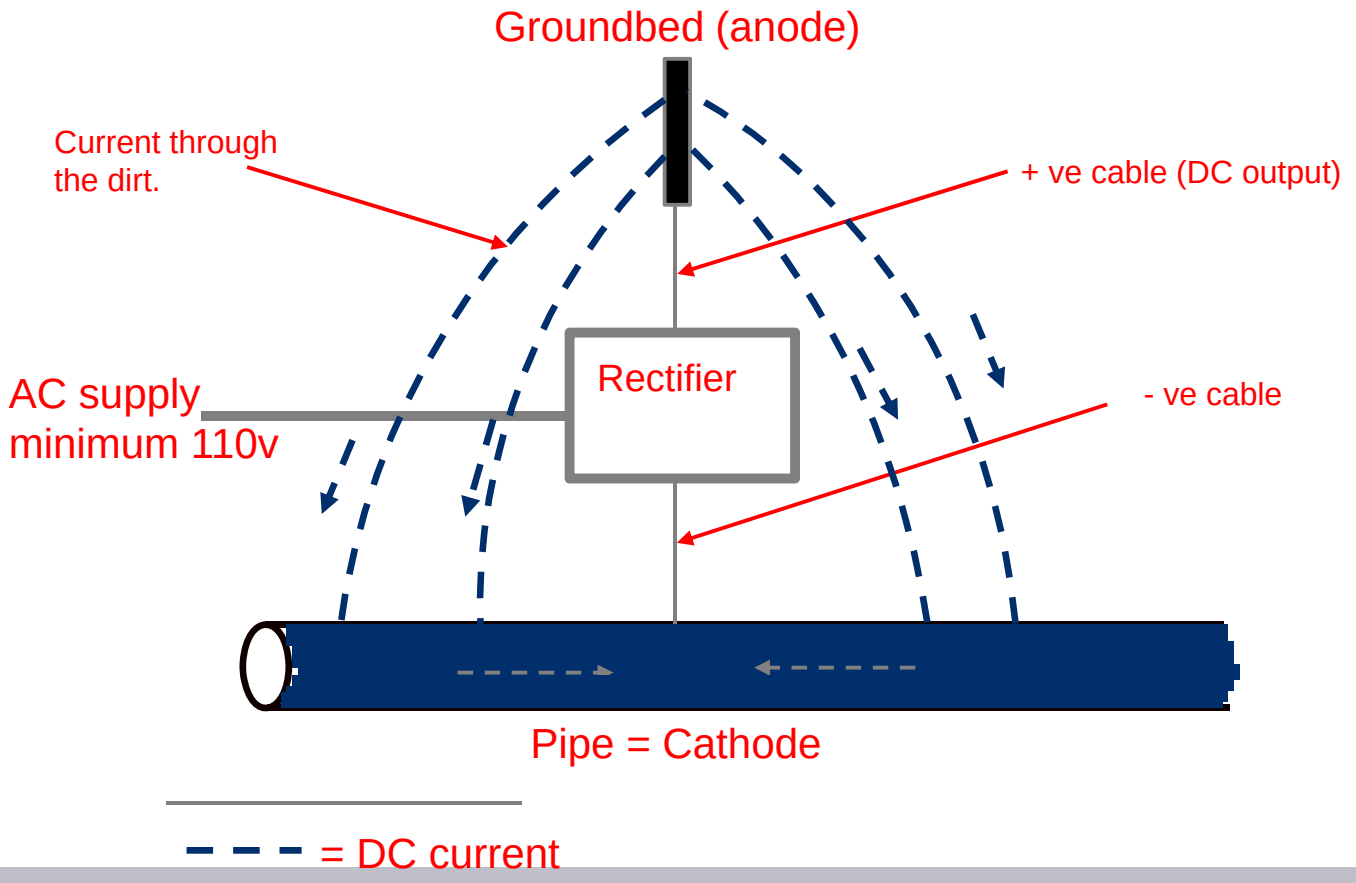

Typical Rectifier

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- Wasps
- 110 v plug
- On/Off Breaker
- - cable to pipe
- + GroundBed

Sacrificial Anodes

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A.K.A. 'Mags' (Magnesium) or 'Zincs'

Also supply current to reduce corrosion

By chemical action, not from 110v

NO CPS mode signal (perfect DC)

If they are at your Tx connection, they will suck LOTS of locate current to earth

- Thus much less on your target pipe
- May need to disconnect

Casings

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Misunderstood.

A casing is a larger pipe around the important pipe designed to take the brunt of mechanical loading from the road/RR.

The vent pipe is connected to the outer casing ONLY, it is usually NOT connected to the inner pipe.

Thus, connecting to vent does no good.

Casing Cut-away Picture

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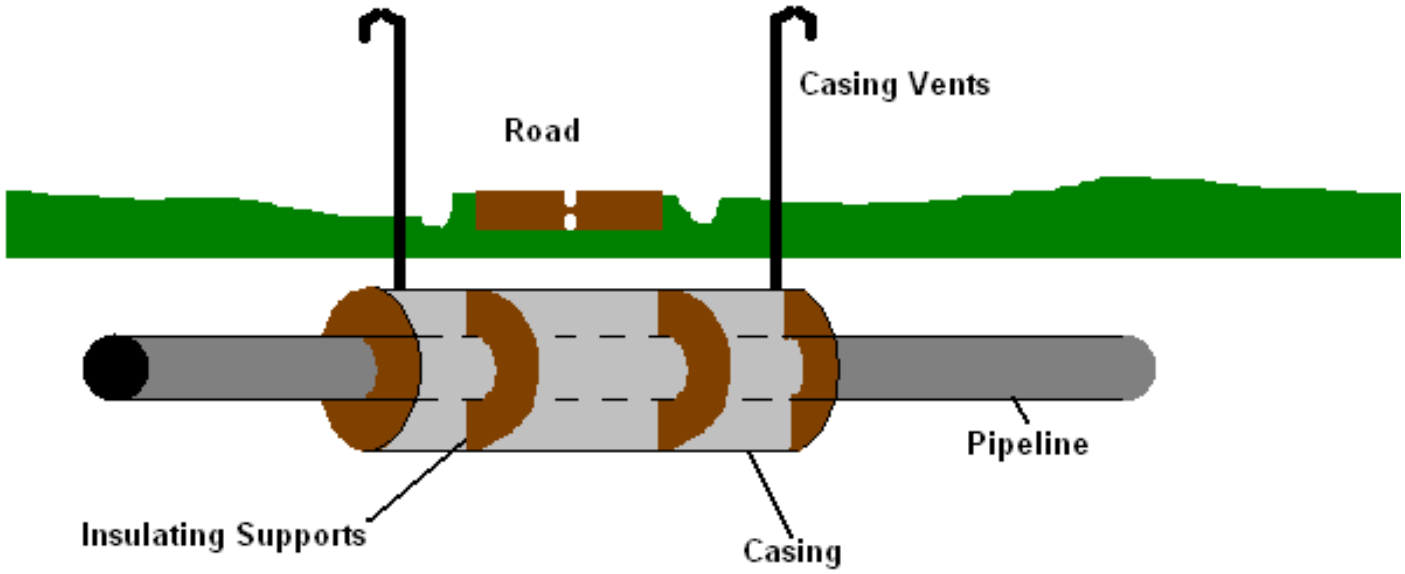
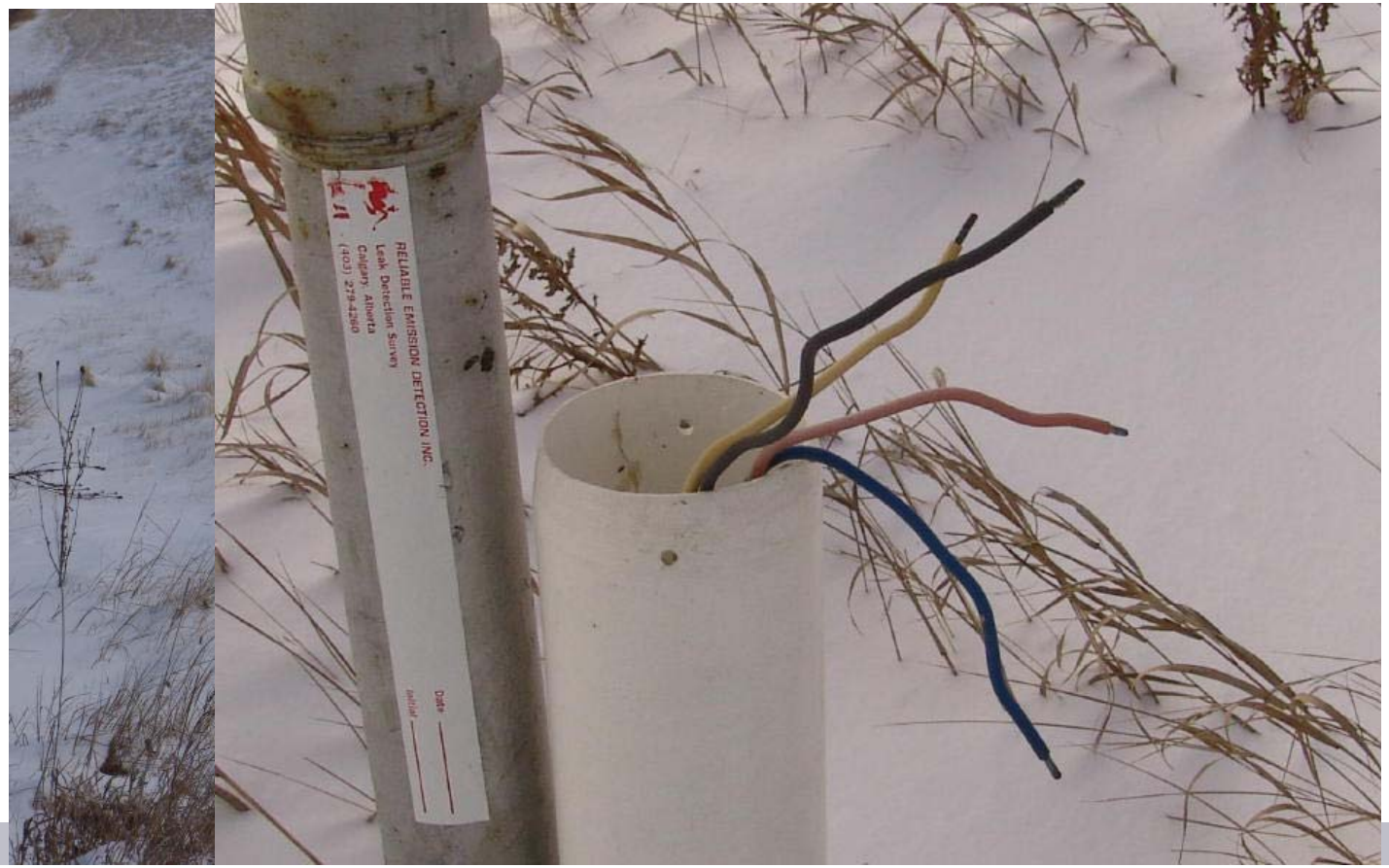
Target pipe inside casing, supported by insulating 'donuts'.



Typical Casing

If you're lucky there will be a test post for the casing. Some wire(s) will go to the target pipe and wire(s) will go to the casing. Connect transmitter to each individually and observe.

Another Casing



NACE International

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Started in 1943 with 11 engineers as the National Association of Corrosion Engineers

Now 15,000 members in 93 countries and a name reflecting their world wide presence.

www.nace.org

Covers ALL aspects of corrosion

Members write standards, offer courses, lobby government, publish findings, more.

ECDA Practice

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The Pipeline Safety Improvement Act of 2002

US signed into law on December 17, 2002

Applies to nat. gas xmission (dist. coming)

Must ID "high consequence areas (HCA)"

- conduct risk analyses of these areas
- perform baseline integrity assessments of each pipeline segment
- inspect the entire pipeline system according to a prescribed schedule and using prescribed methods

Other provisions of the law include

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The Pipeline Safety Improvement Act of 2002

Participation in one-call notification

Increased penalties

“Whistle-blower" protection

Operator Qualification for employees

Government mapping of the p/l system

Other Housekeeping Stuff

Direct Assessment

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Direct Assessment came along

- It seems to have been accepted & implemented fast

There are 3 types of DA (for 3 types of threats)

- External Corrosion (ECDA)
- Internal Corrosion (ICDA)
- Stress Corrosion Cracking (SCCDA)

ECDA is the most mature of them.

RP0502 – 2002 is the defining NACE doc.

ECDA is a 4 Step Process

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Pre-assessment

- Most important step

Indirect Inspections

- Above-ground Tools

Direct Examinations

- Verification Digs AND Mitigation

Post-assessment

- Define Reassessment Period (US: 7 yr typ. max)
- Assess Overall Effectiveness

Which tools are applicable

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Close-Interval Survey (CIS)

AC Voltage Gradient

DC Voltage Gradient (A-Frame)

Pearson

Electromagnetic

AC Current Attenuation Surveys (PCM)

- Stray Current analysis (Stray Current Mapper)

Different regions may require different tools

CIS Survey

DCVG Survey

Principals

The PCM Performs Three Broad Functions

- Locating Pipes and Cables
- Current Attenuation Surveys
- ACVG Surveys

History

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PCM – 1995 - 2007

PCM+ 2007 - 2017

PCMx – 2017

Principals

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Principals

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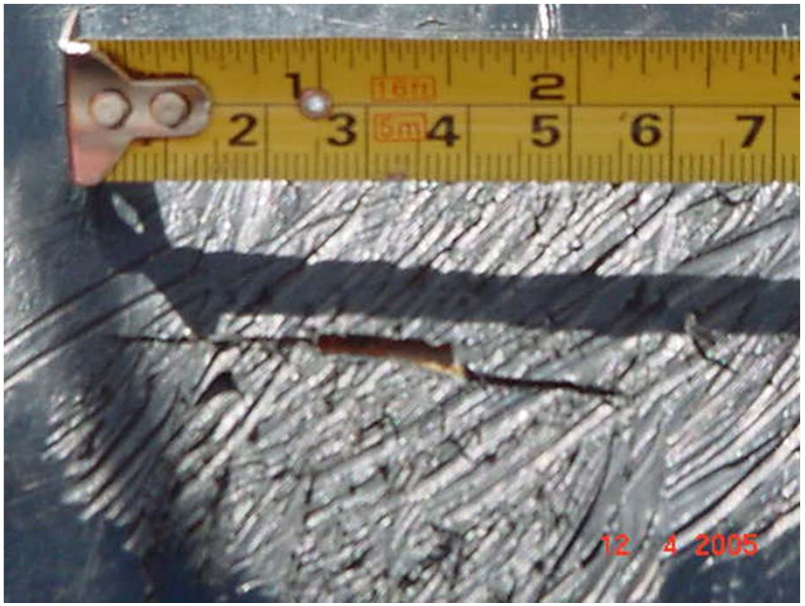

Principals

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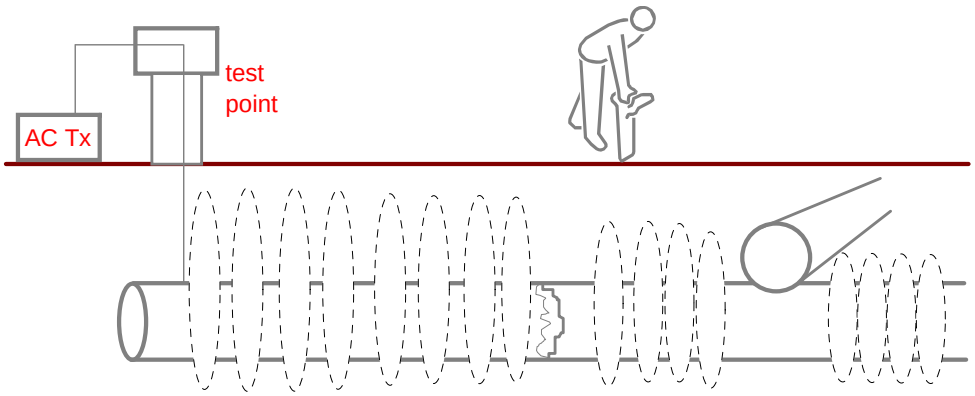

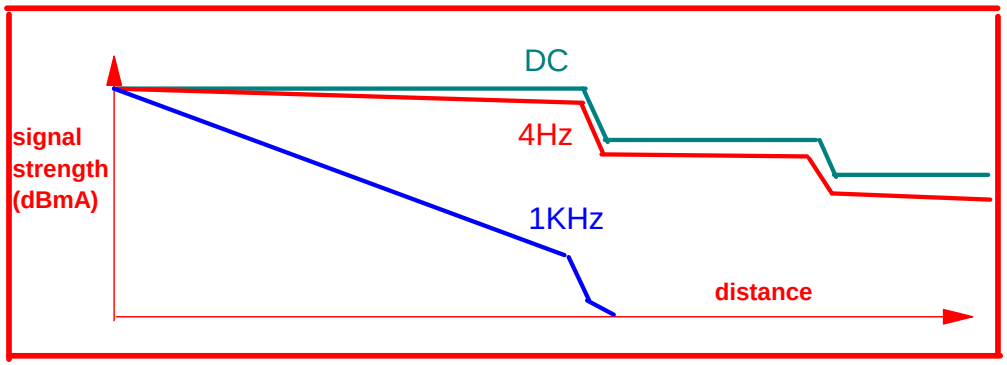

Actual Graph Data

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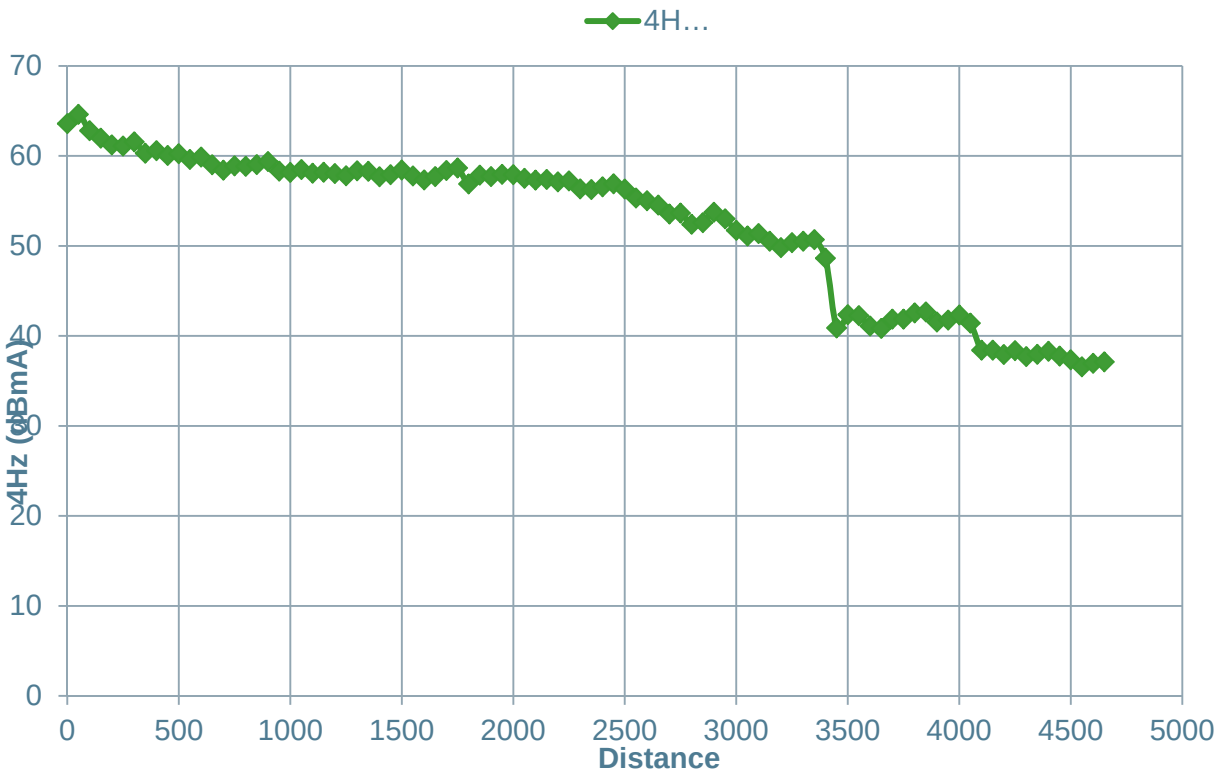

PCM Uses

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- Find contacts with other structures
- Evaluate pipe coating for defects
- Perform periodic pipeline surveys
- Find defective insulation joints

Pipe and Cable Locators Don't Find Pipes and Cables...

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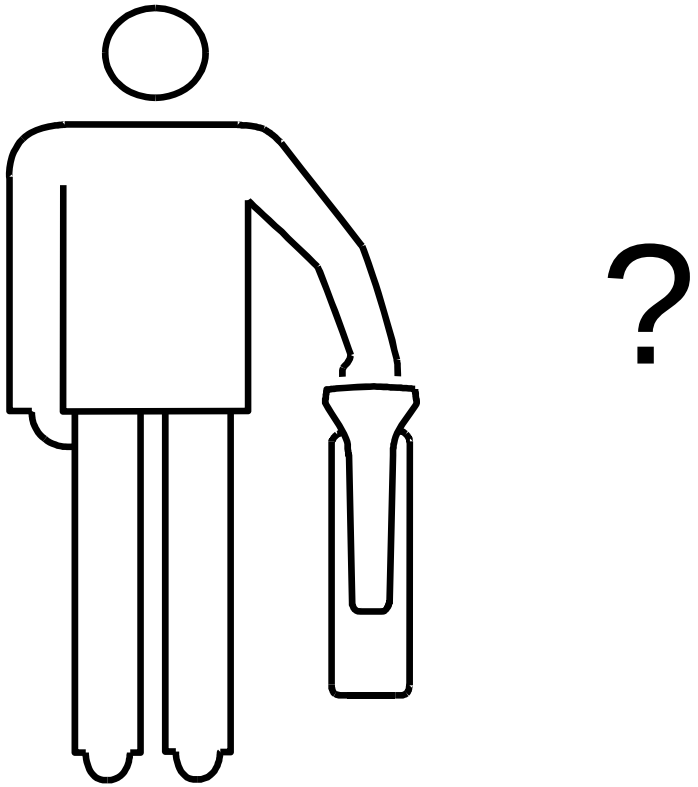

?

...They Find Electro-Magnetic Fields

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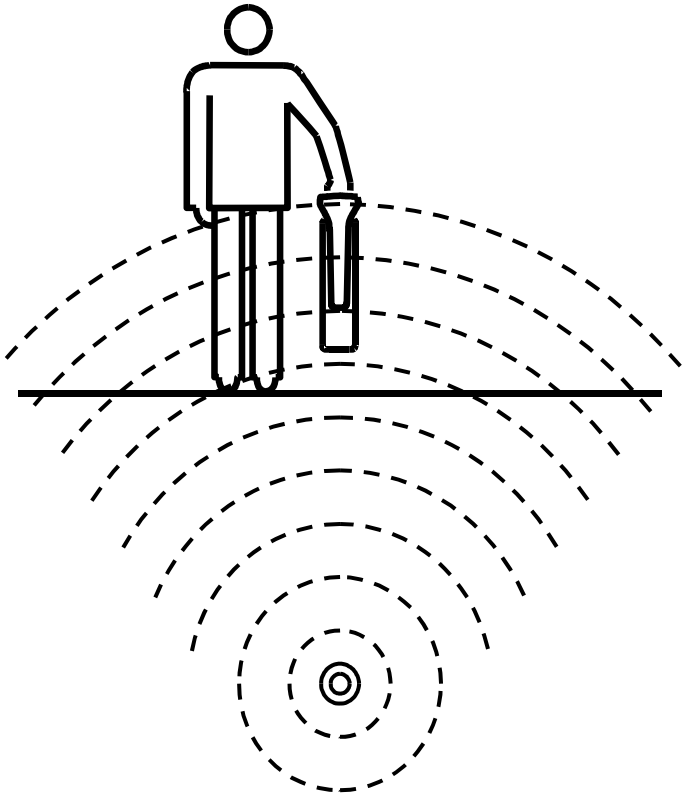

Because electro-magnetic fields do things that pipes and cables don't do.

Buried conductors don't move, but the fields they're tracing are subject to…

...Distortion

- Which is Affected By:
- Grounding
- Peak or Null Antennas
- Congestion
- Frequency Applied

Distortion - Grounding

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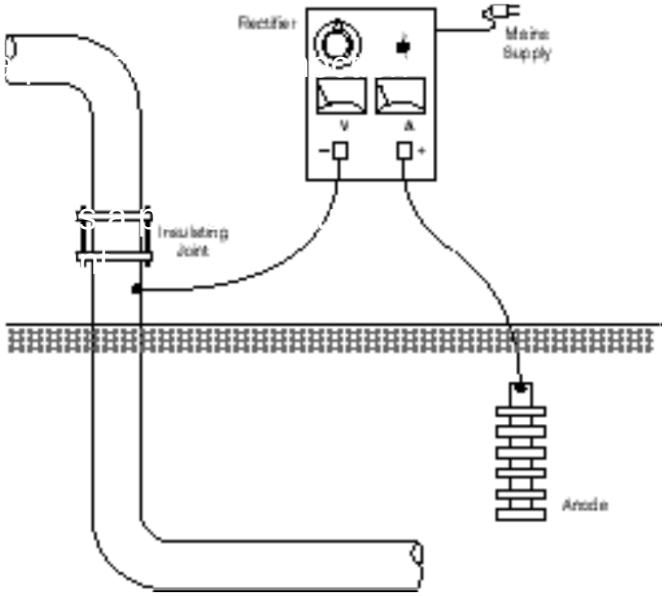
Typical rectifier installation



Distortion – Grounding: PCM+ Connection To Pip

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NOTE !!!

There are hazardous voltages present inside rectifiers.

Accidents happen, an Alberta CP tech with years of experience was killed (electrocuted) just two years ago.

Only qualified technicians (formal electrical and safety training) may open and work inside a rectifier.

This is shown for reference and so you may assist a qualified electrician connect your transmitter inside a rectifier.

Distortion - Peak or Null Antennas

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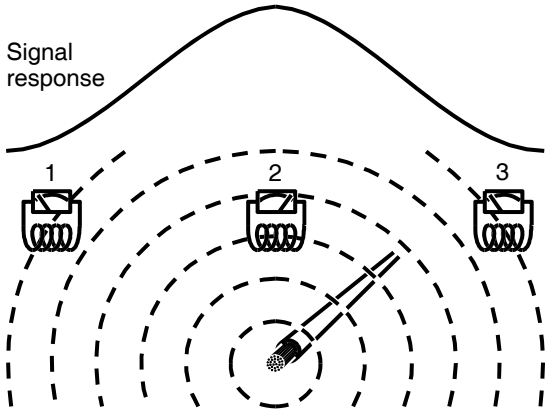
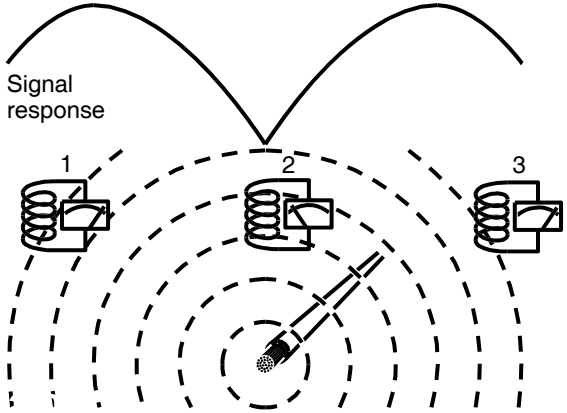
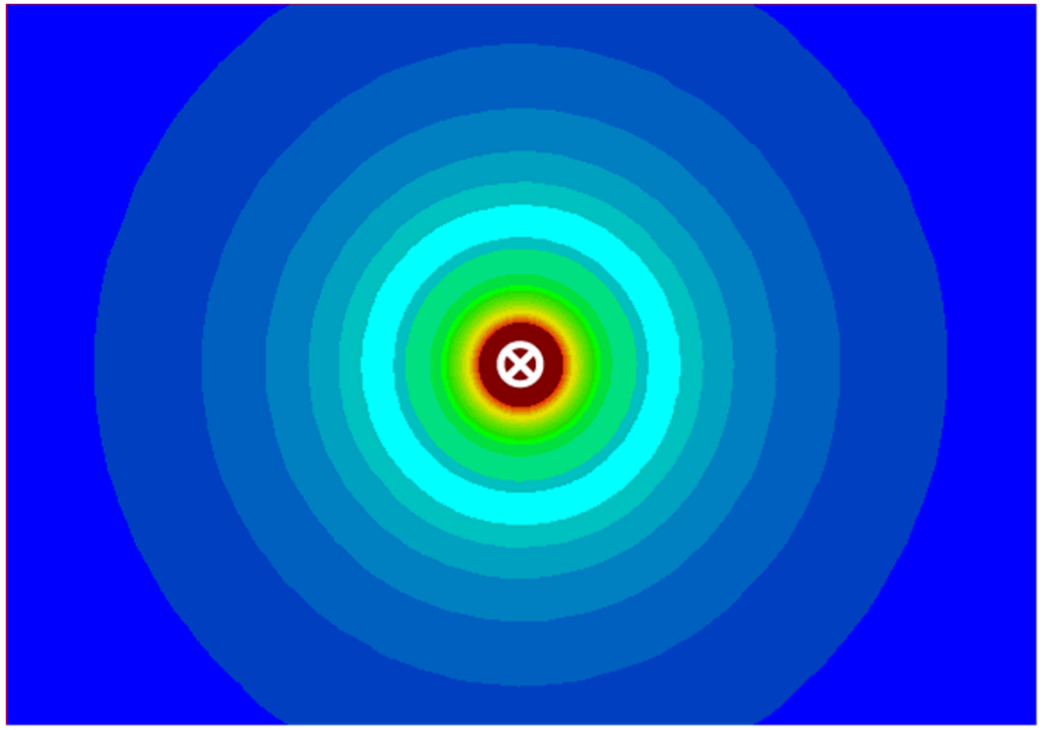


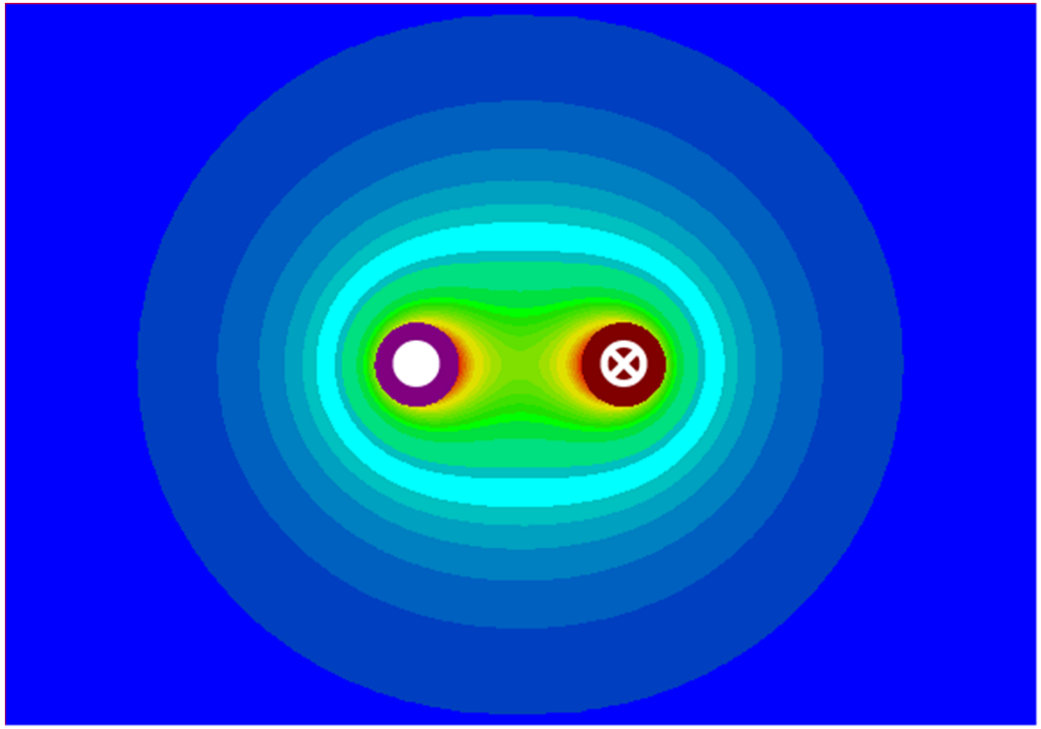
Peak



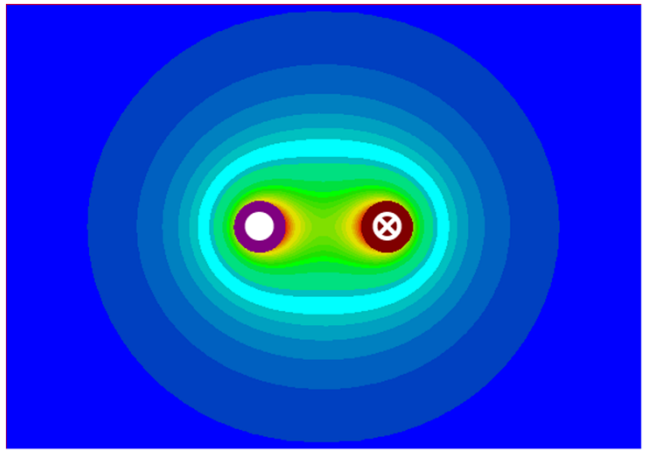
Null



In a clean electro-magnetic field, the peak and null antennas agree



In a distorted electro-magnetic field, the peak and null antennas do not agree, and the peak is always more accurate



- Congestion creates a distorted field, which effects locate accuracy, depth estimation and current measurement.
- Congestion can be created by a nearby line carrying the signal, a "T" in the line, a bend in the line or a change in the depth of the pipe.
- Take your current and depth readings where peak and null agree and move several paces away from a bend or a "T" when taking your reading.

Distortion – Frequency

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Why Do We Use 4Hz ?

To enable coating defects to be located the PCMx uses very low frequency signal

- **4hz**
- **Almost DC**
- **Sticks to the pipeline**
- **Less bleed off or coupling to other utilities**
- **Increased distance (up to 19 Miles)**

Benefits of Low Frequency

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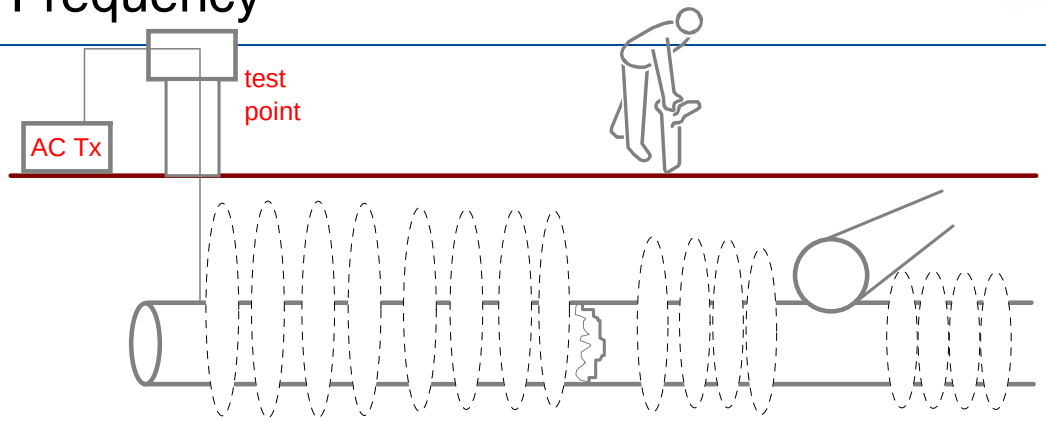

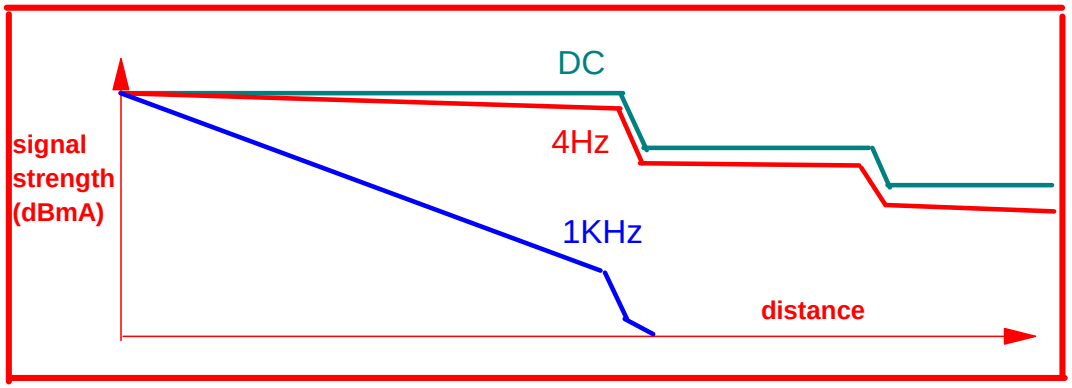

Transmitter Settings – Output Frequency

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ELF

- Extra low frequency
- 4Hz & 98Hz / 128Hz

ELCD

- Extra low frequency & current direction
- 4Hz, 8Hz & 98Hz / 128Hz

LFCD

- Low frequency & current direction
- 4hz, 8hz & 512hz / 640hz

Transmitter Settings – Signal Output

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Constant current output

- 100mA
- 300mA
- 600mA
- 1A
- 2A
- 3A

Ohms Law

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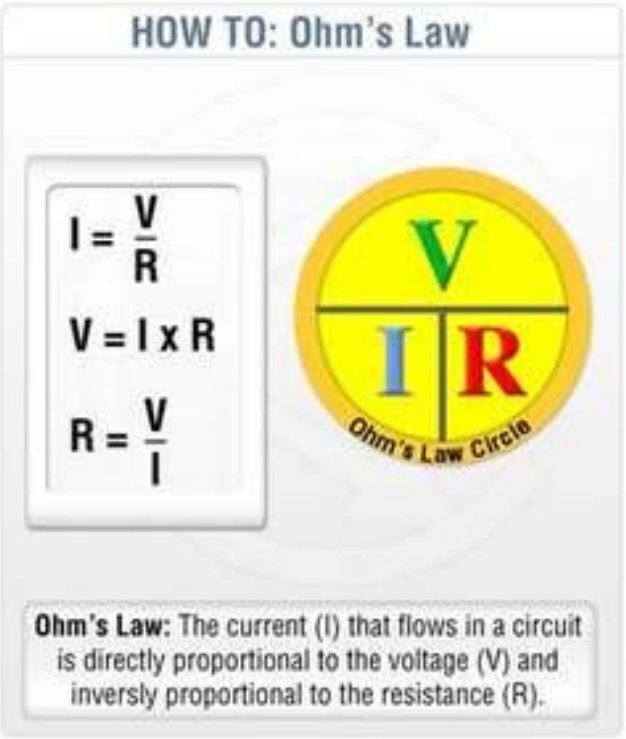

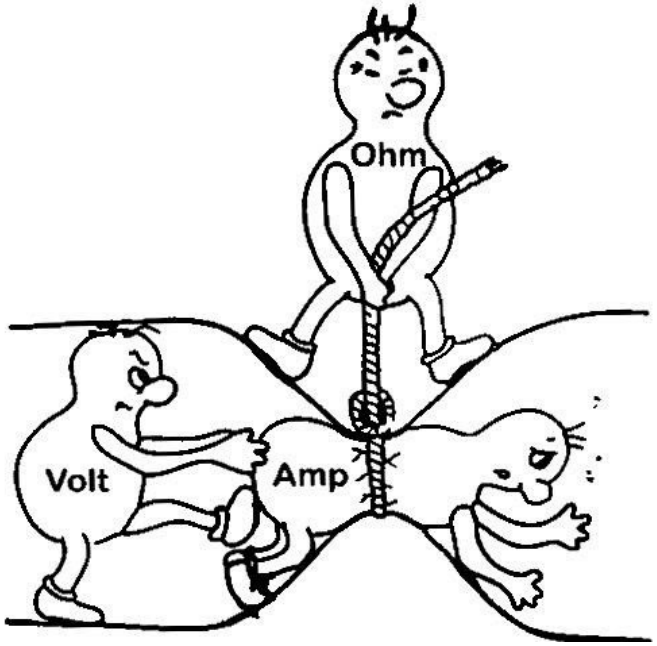

Taking Current Attenuation Measurements

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- Use an independent ground and try to mimic your CP circuit when possible
- Take your first measurement at least 150 feet from your connection point
- Make sure rectifiers are not influencing the signal (turn off *AND* disconnect if necessary)
- Isolate your circuit whenever possible (disconnect bonds for better surveys)

Taking Current Attenuation Measurements

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- Take readings at equal distances and record your distances
- Every 50 feet is a good standard (others can be used dependent on location)
- Use it as a macro tool and depth of cover tool (use A-frame for micro)
- Look for anomalies with more than a 5% change normally
- Make sure unit is upright and perpendicular to the pipe

Taking Current Attenuation Measurements

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- Stay on Peak and check peak and null readings and verify depth when readings are suspect
- Take multiple readings in one location if you are suspect of the accuracy
- Know what is in the area of your pipe and what it's connected to
- Use current direction to verify that signal is flowing back toward transmitter on pipe

Practical Example

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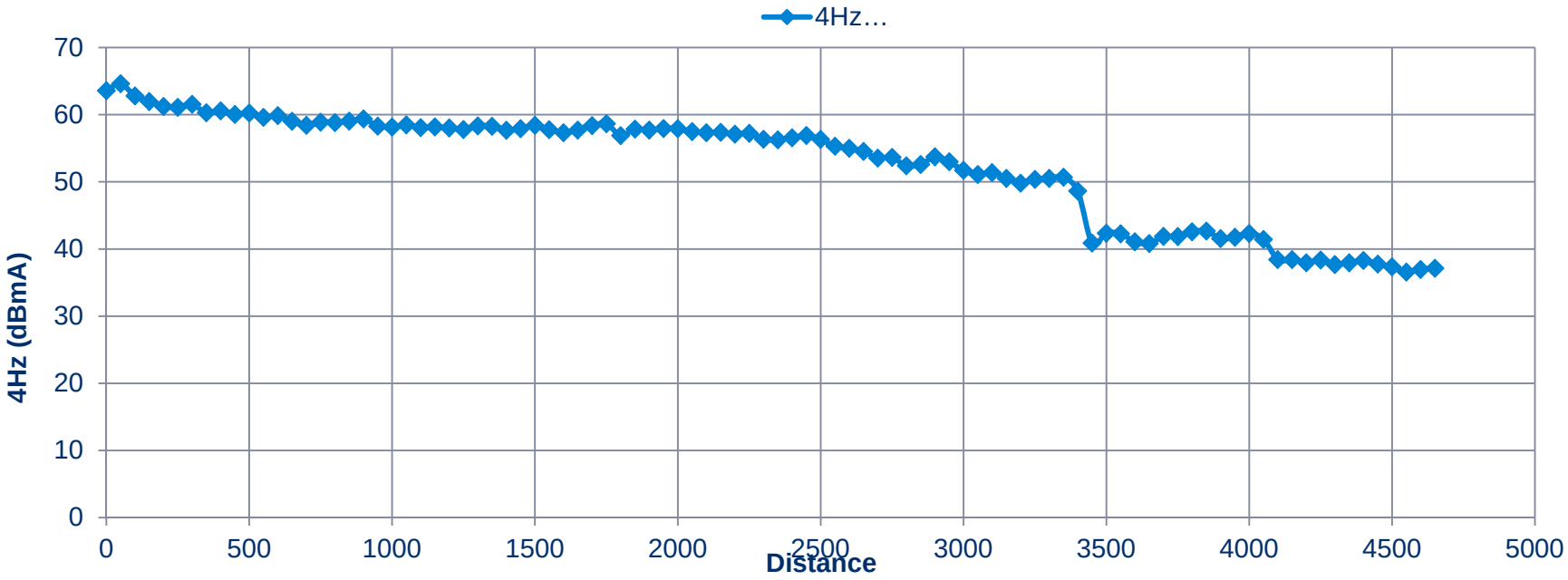

Current Attenuation Graph

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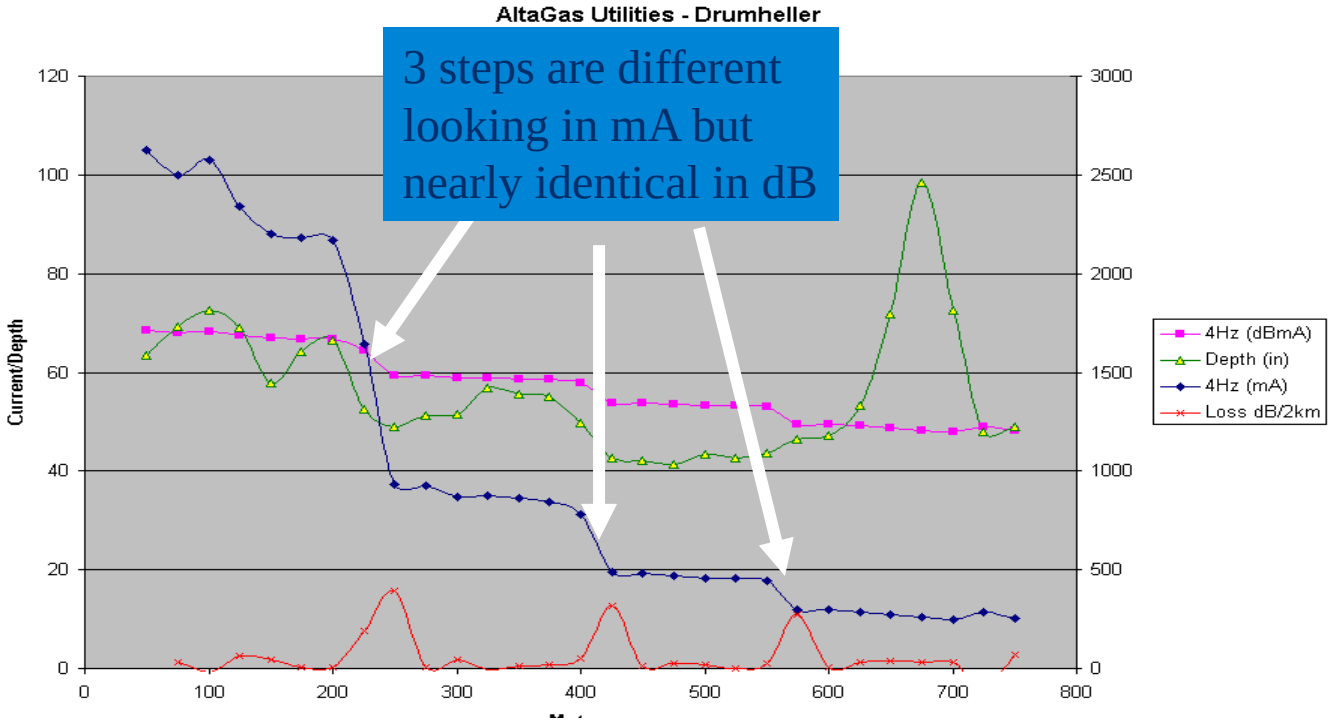

ACVG Is Used to Pinpoint Defect Location

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Once survey is complete, use the A-Frame accessory to pinpoint defects

Connect the A-Frame to the locator

- **Set locator to ACVG**
- **Must use either ELCD or LFCD**

Transmitter Connections

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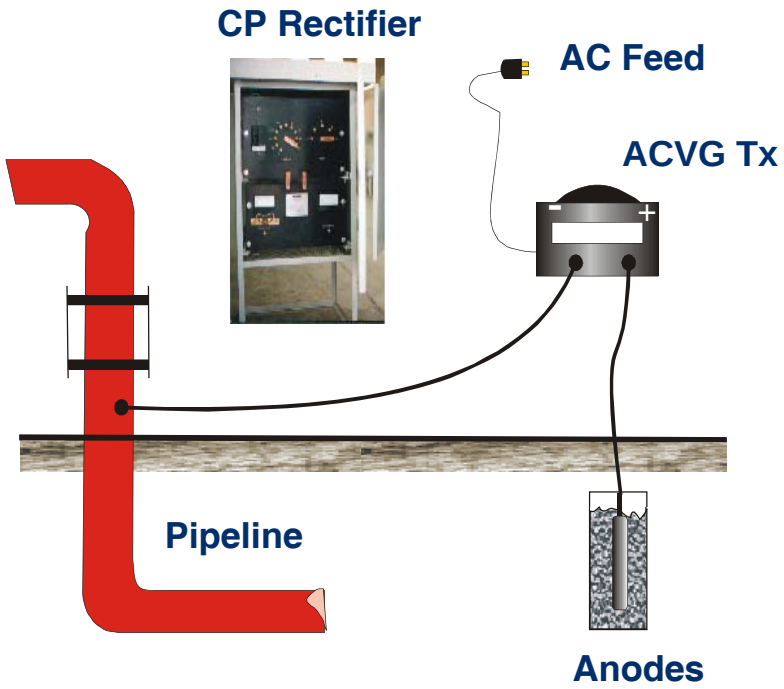
- Rectifier
- Test Station



ACVG - Pool of Potential

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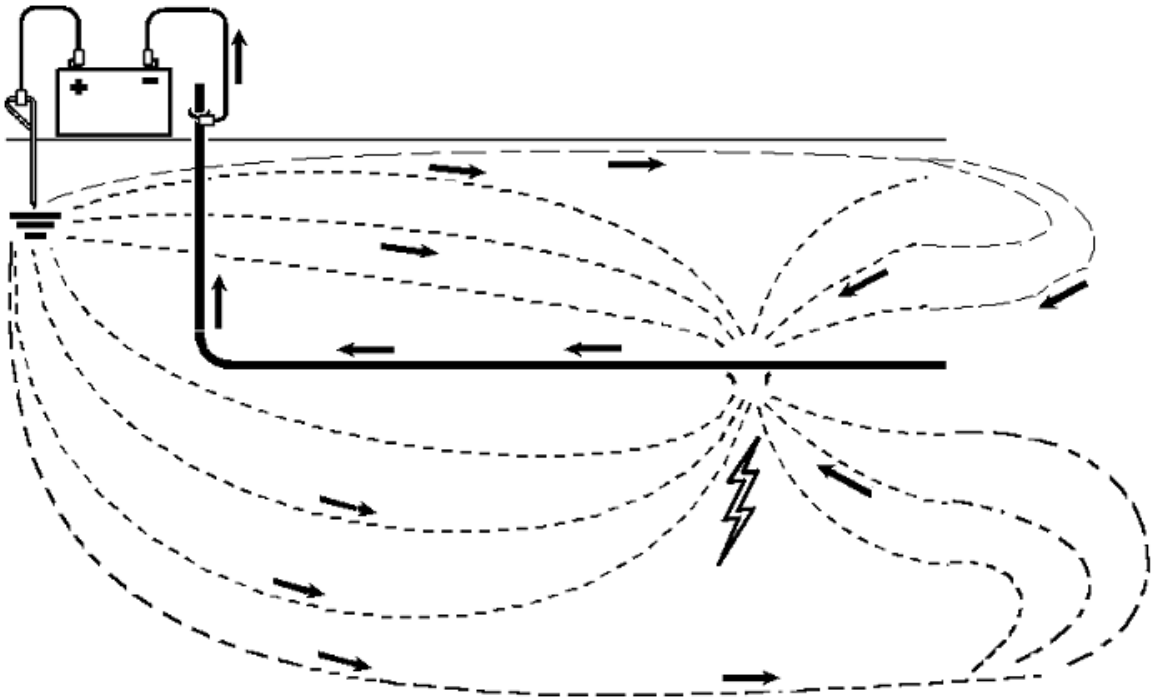

ACVG – Current Flow

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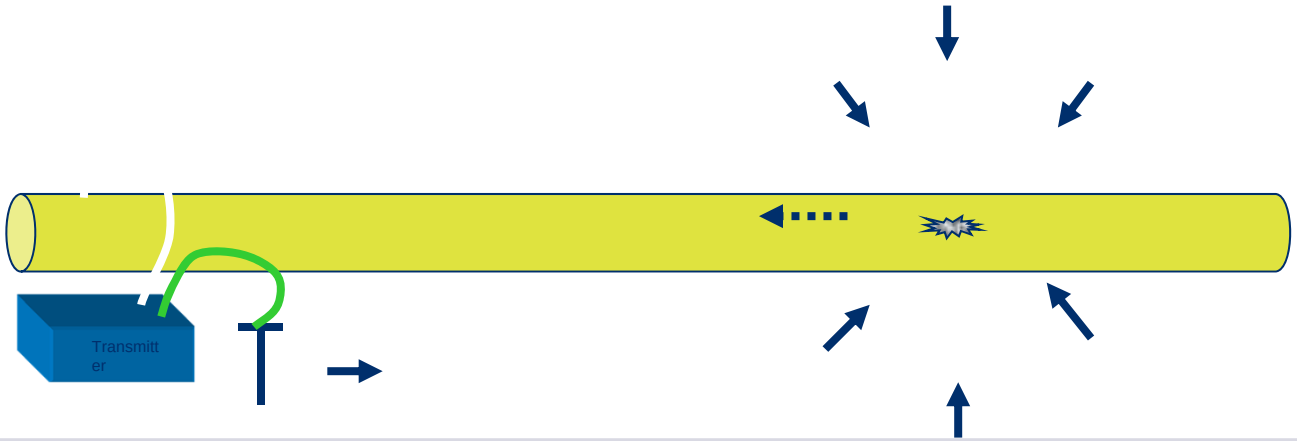
- Current from the transmitter creates a voltage gradient around coating defects
- Current density greatest at interface between the defect and the surrounding environment
- Current density function of soil resistivity & Tx output



ACVG – Using the A Frame

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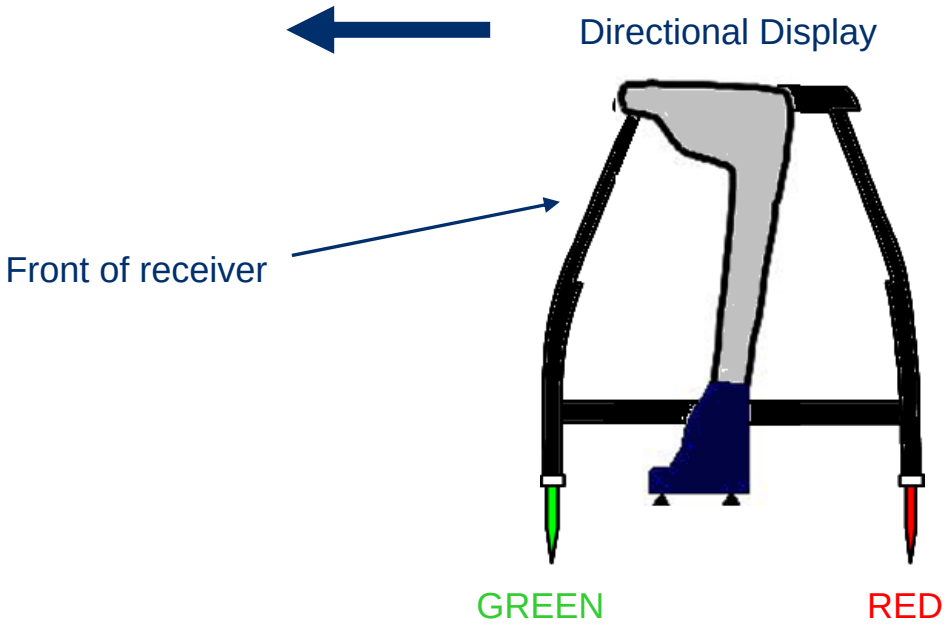

Keep the green pin facing forward

Finding Coating Defects

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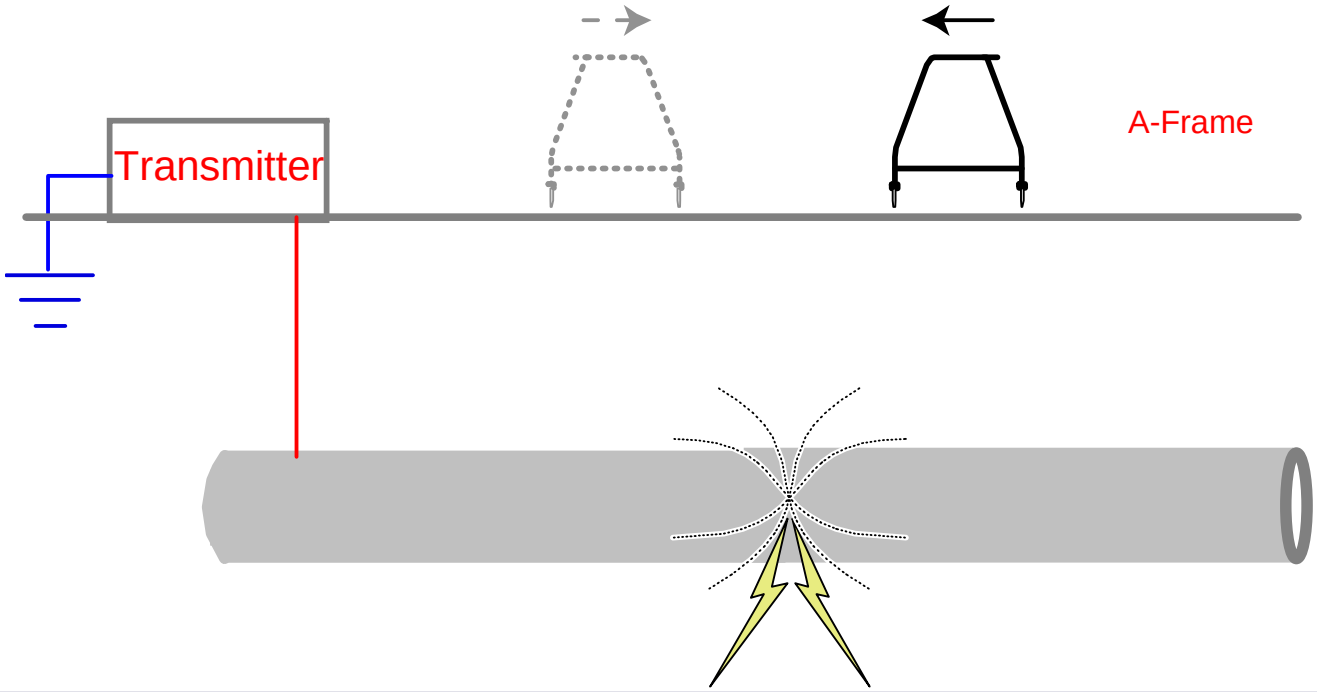

ACVG – Receiver Readings

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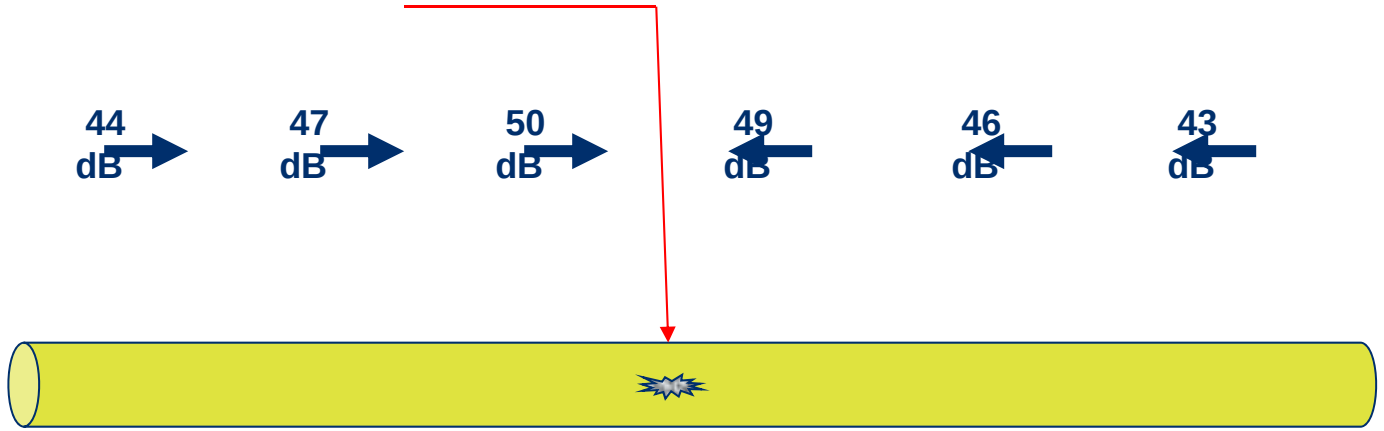
- **An increase in voltage gradient will cause an increase in current density near a given coating defect on the pipeline under test**
- **Signal current and voltage effects viewed on instrument's display**
- **Signal current direction is displayed as an arrow**
- **Voltage is identified as decibels (dB)**



ACVG – Receiver Readings

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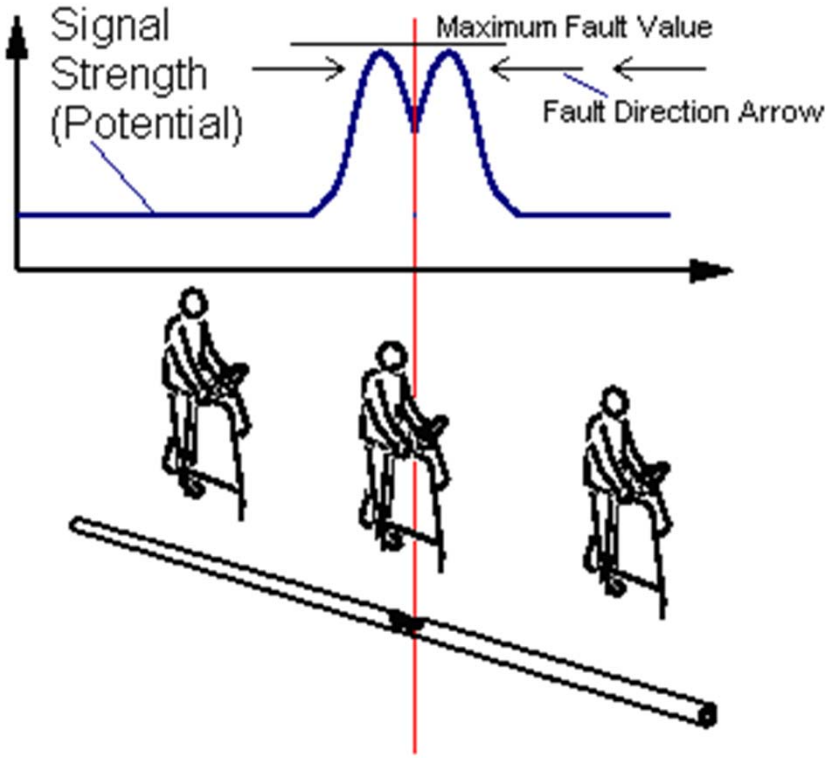

ACVG – Receiver Readings

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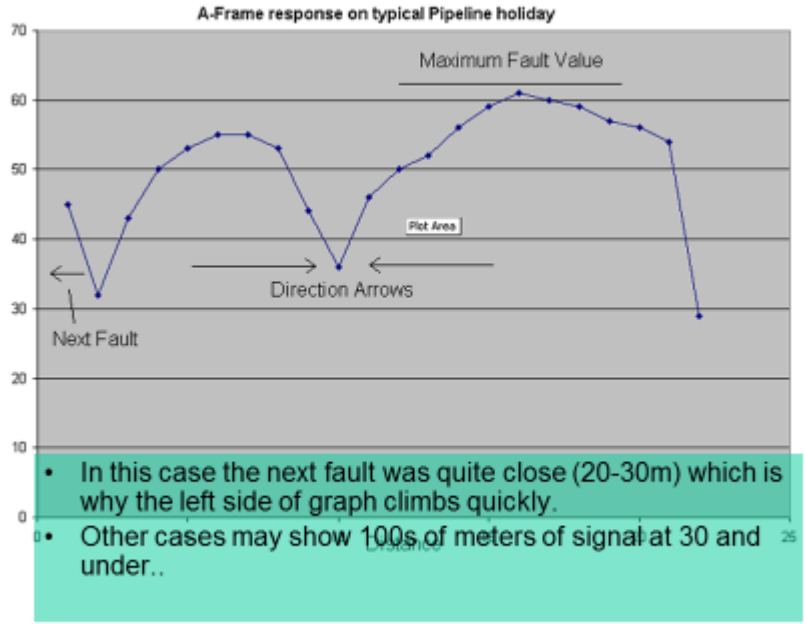

- In this case the next fault was quite close (20-30m) which is why the left side of graph climbs quickly.
- Other cases may show 100s of meters of signal at 30 and under..

ACVG – Receiver Readings

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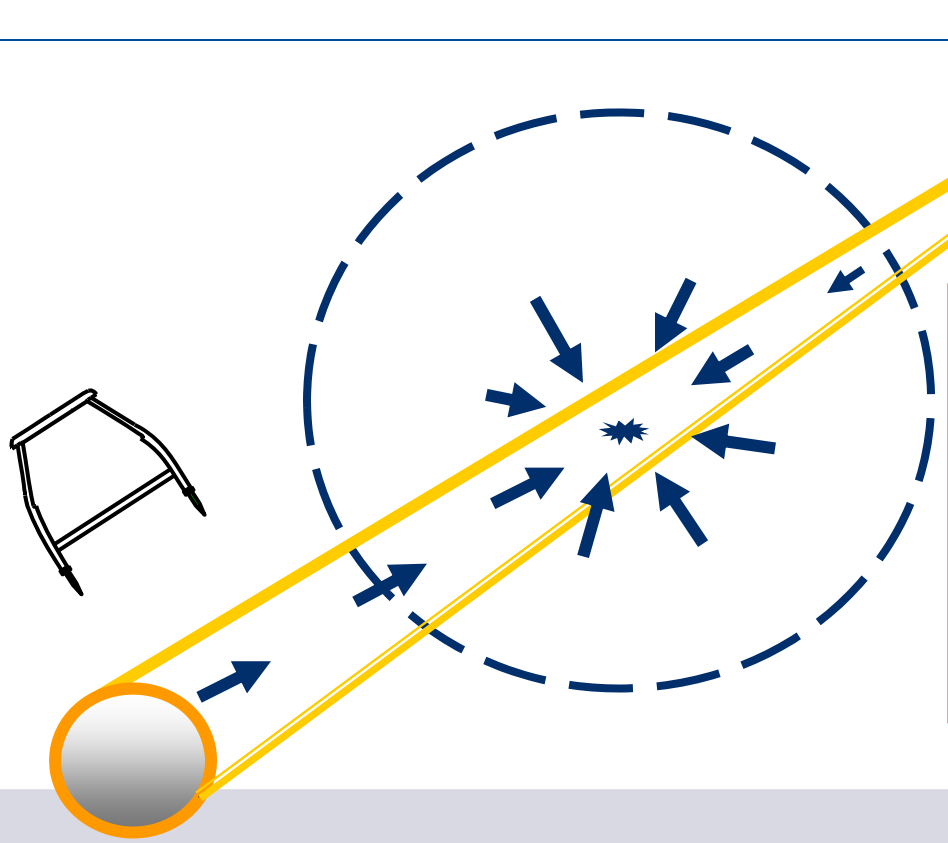

- **Take 4 readings in a cross pattern - two in line with the pipe and two perpendicular to the pipe**
- **All four arrows should point to the defect**
- **Record highest dB reading**

An explanation of dBs and why we use them

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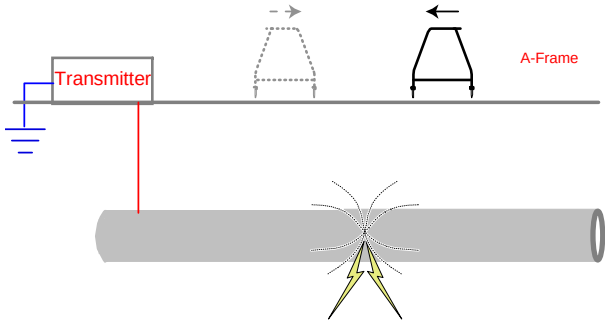
- ACVG results are expressed in dBuV
- We use the dB scale as it reduces large variances to relatable numbers
- Although the dB reading, when normalized, represents a good guide of the scale of current loss due to a coating defect, there are some factors which can affect the reading, such as:
  - Soil resistivity
  - Size of the defect
  - Making good ground contact with the A-Frame spikes
- Therefore: magnitude of the current lost from the pipe (measured by the dB reading) depends on both the size of the defect and the conductivity of the soil surrounding the pipe.



Categorizing the Results*

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Suggested category ranges – may vary by company

0 – 30dB	Clear for now
30dB – 60dB	Minor
60dB – 80dB	Intermediate
80dB+	Major

*Categories apply to normalized results @1A of 4Hz current.

The formula for calculating the normalized results:

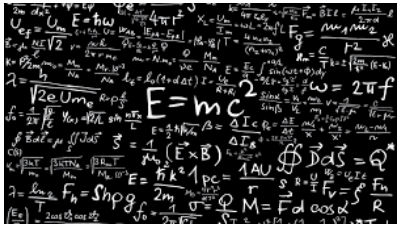
Normalizing adjustment = 20*log(i/iref)

The Formula

RADIODETECTION
The professionals' choice

This output of the formula gives you the number of dB to add or subtract from the reading, depending on whether the PCM (4Hz) current is above or below one Amp at (or just before) the defect.

Normalizing adjustment = 20*log(i/iref)



Example:

- Observed dB reading is max 65dB right before the defect.
- Measured PCM 4Hz survey current just before the defect is 500mA
- The iref is 1000 mA (one Amp).

In the case of 500 mA the formula is: 20 X log (500/1000) which equals -6.02

Therefore the actual dB reading when normalized is 65 + 6 = 71dB

Note: If the output of the formula is negative you add the number to the ACVG reading, if it positive you subtract it.
(see table on next page)

The Normalized Result

RADIODETECTION
The professionals' choice

This formula gives you the number of dB to add or subtract from the reading, depending on whether the PCM (4Hz) current is above or below 1 Amp at (or just before) defect.

Normalizing adjustment = 20*log(i/iref)

4Hz Current reading (i)	Result of formula	To get normalized reading
3,000mA	9.54	Subtract 10dB from ACVG reading
2,000mA	6.02	Subtract 6dB from ACVG reading
1,000mA	0.00	ACVG reading is already normalized
500mA	-6.02	Add 6dB to ACVG reading
250mA	-12.04	Add 12dB to ACVG reading
100mA	-20	Add 20dB to ACVG reading
31.6mA	-30	Add 30dB to ACVG reading
10mA	-40	Add 40dB to ACVG reading
1mA	-60	Add 60dB to ACVG reading

ACVG Summary

- Use an independent ground and try to mimic your CP circuit when possible
- Take readings parallel and along the pipe. When you see an arrow reversal go perpendicular to the pipe and make sure all four arrows point to the defect
- You do not have to be right on top of the pipe when surveying
- On concrete and asphalt use wet sponges or rags on the probes or wet the ground around the probes.
- Take readings at equal distances usually about every ten feet
- Use the largest dB reading seen around the anomaly for you records
- Record all faults seen with dB readings and footages or GPS coordinates.
- Take a PCM current reading at the site of the defect and adjust your dB reading to normalize for one Amp of current

Summary

RADIODETECTION
The professionals' choice

- PCMx is the new pipeline current mapping system to replace the PCM+
- **Receiver**
  - Lighter weight design based on RD8100 platform
  - Removable foot: RD8100PDLG with foot removed
  - Faster Measurements, simultaneous surveys
- **New transmitter Tx-25PCM**
  - 1 Amp battery powered transmitter for extra portability

PCMx: an overview

RADIODETECTION
The professionals' choice

Radiodetection's new pipeline current mapping range features a lighter weight design and battery operated transmitter for greater portability and flexibility in the field. In-built GPS on the receiver, and companion mobile application ensure field operators have the best information at their fingertips

PCMx: a complete system for pipeline surveying

RADIODETECTION
The professionals' choice

Not a single product but a range including :

PCMx Receiver:

- New lightweight design based on RD8100
- Detachable magnetometer makes receiver dual function. PCM functionality with foot on, premium RD8100 with foot off
- Faster survey measurements and take 2 types of measurements simultaneously

Tx-25

- Smaller, lighter weight, 1 Amp transmitter aimed at distribution networks
- Battery powered for easy portability
- 8kHz locating frequency

Tx-150

- Long range 3 Amp transmitter for transmission lines

Mobile App

- Improved survey experience using mobile app alongside receiver
- Live charting of results allows on-site analysis
- Walk forward and walk back features makes surveying easier

PC Application

- Improved charting capability

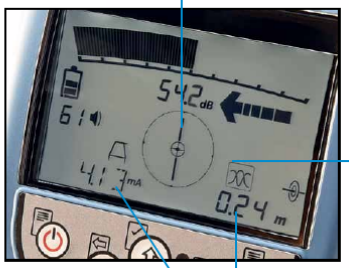
PCMx receiver features

RADIODETECTION
The professionals' choice

Built in GPS
Automatic capture of GPS co-ordinates on survey logs

One second 4Hz measurement
Faster collection of survey data

Compass
For ease and speed on pipeline alignment



Peak+ antenna mode
Combine Peak mode with Null or Guidance arrows to make surveys quicker

Simultaneous display of current and depth gives more confidence you are following the correct pipeline

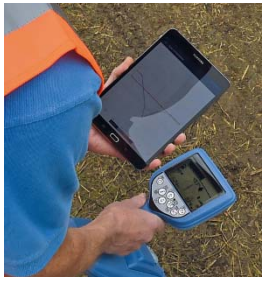
Simultaneous ACVG and ACCA data capture Plus depth of cover and GPS information.
Faster surveying: collect data in one pass of pipeline

Li-Ion rechargeable battery pack as standard
Prolongs working time in the field

eCert
Confidence in the field with self-test options

Removable magnetometer
Fully featured locator with all frequencies of RD8100PDLG when foot is removed

Mobile App
Graphing in the field, walk back and walk forward features



TX-25PCM: New battery powered transmitter

RADIODETECTION
The professionals' choice

New smaller, lighter weight transmitter is battery powered for greater portability and flexibility in the field.

6 current output selections
Match current output to your needs up to 1 Amp
Lower current outputs prolong battery life

Charging Times
Approx 4 hours to 80% full and 8 hours to full charge (trickle charge after 80%)

Li-Ion rechargeable battery
No need for mains connectivity in the field

Battery Life: 3.5 hours
Transmitter at full power can last 3.5 hours

8kHz
New high frequency locate signal for long distance, high impedance utility locating
NOTE: this is not a survey frequency!

PCM Receiver: responding to feedback

Ergonomics

- ✗ Too heavy
- ✗ Too physically long for some operators

Connectivity

- ✗ Bluetooth is difficult to manage unique data format has hampered usability & adoption
- ✗ RS232

Functionality

- ✗ Limited locate capability – effectively single-function
- ✗ Too slow to take measurements

Ergonomics

- ✓ 2.5lb lighter
- ✓ 1.5 inches shorter

Connectivity

- ✓ USB and Bluetooth options for faster data downloads

Functionality

- ✓ Fully functional RD8100 PDLG capability with foot removed
- ✓ Reduced time to take survey measurement

Age of product makes selling-against competition difficult

PCM Receiver comparison

RADIODETECTION
The professionals' choice

	PCMx	PCM+
Weight	4.9lb (2.24kg)	7.4 lb (3.38kg)
GPS	Internal	External device required
Magnetometer	Detachable	Fixed
Locator functionality	RD8100 PDLG	Limited
PEAK +	Yes	No
Self Test	Yes	No
Compass	Yes	No
4Hz measurement time	1 second	3 seconds
ACVG and ACCA	Simultaneous	Separate surveys

Questions

RADIODETECTION
The professionals' choice

PCMx

Phil Hembery

Technical Support Manager

PCMx System

RADIODETECTION
The professionals' choice

PCMx

RADIODETECTION
The professionals' choice

PCMx or RD8100…

- Foot on – PCMx
- Foot off – RD8100PDLG
- Can remove or fit foot while switched on

  - reverts to last used setting for PCMx or RD8100

PCMx

RADIODETECTION
The professionals' choice

Typical Locate Screen

- Modes available:

  Power, CPS, ELF, ELCD, LFCD & 8K

- Continuous depth and current displayed

  - current reading is the locate signal current

- Use antenna key to switch between antenna modes

  - Peak, Peak+, Null, Single or Guidance

  - Peak only in power mode

- Peak+ switch between Guide and Null arrows

  - hold down antenna key to switch

PCMx

RADIODETECTION
The professionals' choice

ACVG

- A-frame lead connected – automatically goes in to ACVG mode
- Direction arrow to fault
- dB uV reading

  - this is the voltage measured across the A-Frame spikes

- use 'f' key to switch to locate mode
- Save reading use 'graph' key

PCMx Locate Screen

RADIODETECTION
The professionals' choice

Simultaneous Mode

- With A-frame plugged in press 'f' key
  - toggle between ELCD, LFCD and 8K
  - mode recognised with A-Frame icon and locate screen
- Simultaneously take 4Hz and ACVG readings
  - 4Hz is the magnetometer reading
- Typical locate information as normal locate mode
- Before taking a 4Hz reading:
  - arrow is to direction to fault
  - dB value is FF voltage reading in dBuV

PCMx

Taking a Measurement

- When over and inline with pipe press graph key once
- 4Hz reading will be displayed – bottom right
  - reading is 'live' so may fluctuate
  - option to save or reject using up / down arrows
- In this screen arrow is current direction (CD)
- Selecting save will automatically store reading within unit
  - up to 10000 logs
  - if BT is on the unit will attempt to send via BT
  - in menu set BT- PC to OFF for internal save only

PCMx

Holding a Reading

- Useful when taking measurements in traffic etc.
- When over and inline with pipe press graph key once
- 4Hz reading will be displayed – bottom right
- Press antenna key to 'hold' 4Hz reading and locate screen

  - reading can be saved or rejected while being held

  - or press antenna key to make active again

PCMx

RADIODETECTION
The professionals' choice

TruDepth

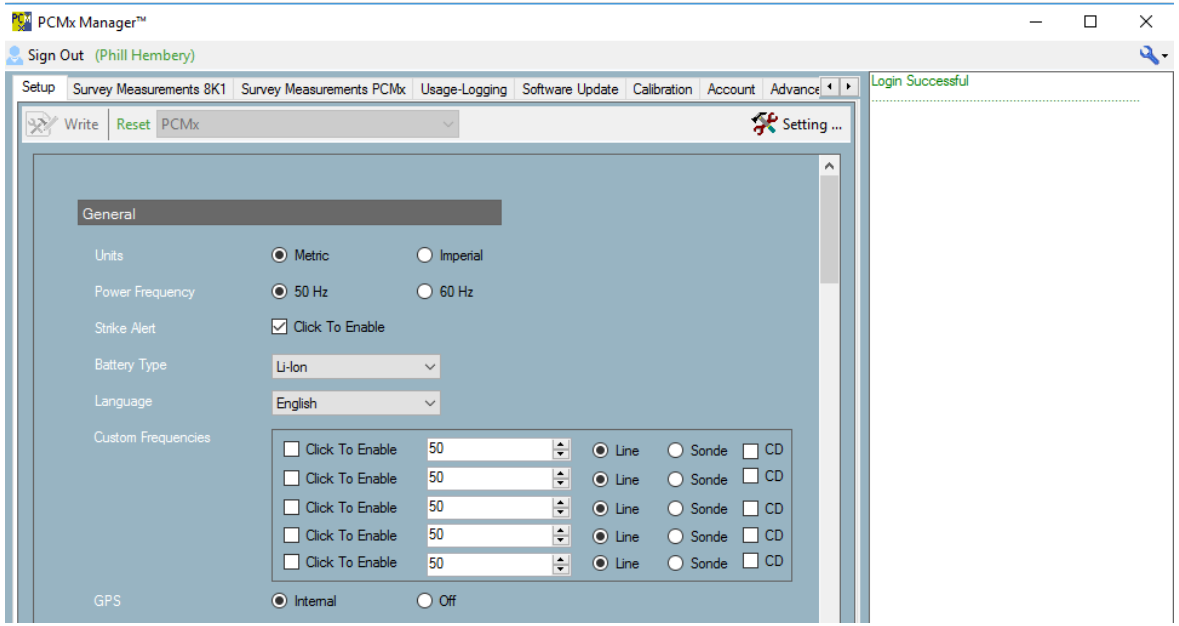
- Same rules as RD8100 when displaying depth / current
  - compass angle / signal strength / left right arrows
- TruDepth important on PCMx
  - 4Hz reading calculated using depth reading
  - if depth reading incorrect, 4Hz reading incorrect
- Advisable to use Peak+ Null mode
  - check for Peak and Null locate for distortion
  - hold antenna key to toggle

PCMx

RADIODETECTION
The professionals' choice

PCM Manager

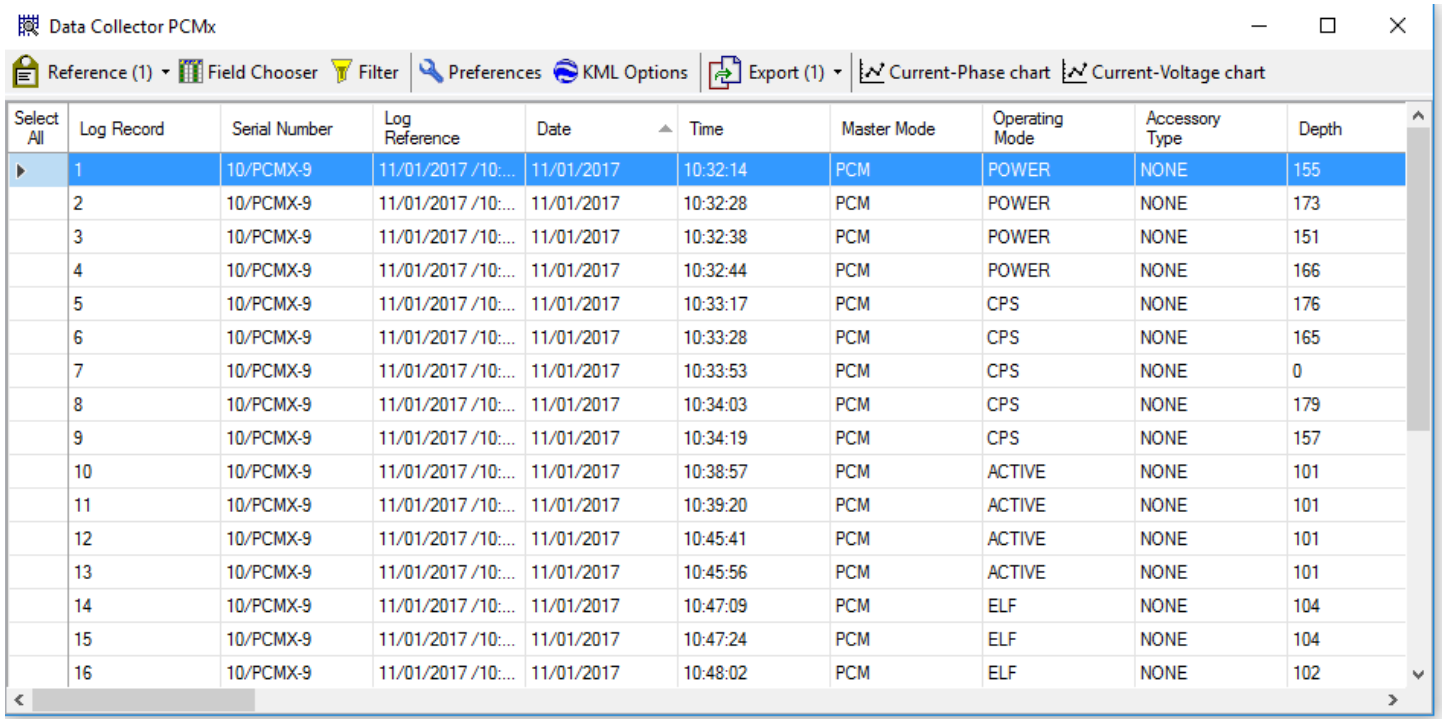
- Very similar to RD Manager
  - connection via USB
  - Survey Measurements upload
  - Calibration (eCert)
  - Software update



PCMx

PCM Manager – Uploading Survey Measurements

- Charting
- Export
  - CSV
  - XLS
  - KML



Select All	Log Record	Serial Number	Log Reference	Date	Time	Master Mode	Operating Mode	Accessory Type	Depth
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	2	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:32:28	PCM	POWER	NONE	173
	3	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:32:38	PCM	POWER	NONE	151
	4	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:32:44	PCM	POWER	NONE	166
	5	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:33:17	PCM	CPS	NONE	176
	6	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:33:28	PCM	CPS	NONE	165
	7	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:33:53	PCM	CPS	NONE	0
	8	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:34:03	PCM	CPS	NONE	179
	9	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:34:19	PCM	CPS	NONE	157
	10	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:38:57	PCM	ACTIVE	NONE	101
	11	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:39:20	PCM	ACTIVE	NONE	101
	12	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:45:41	PCM	ACTIVE	NONE	101
	13	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:45:56	PCM	ACTIVE	NONE	101
	14	10/PCMX-9	11/01/2017 /10:...	11/01/2017	10:47:09	PCM	ELF	NONE	104
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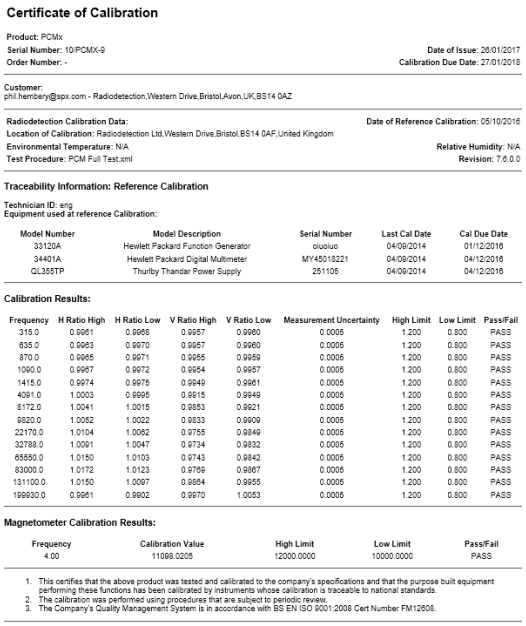
PCMx – eCert Calibration

RADIODETECTION
The professionals' choice



Certificate of Calibration

Product: PCMx
Serial Number: 10/PCMX-9 — **Date of Issue:** 26/01/2017
Order Number: - — **Calibration Due Date:** 27/01/2018

Customer:
phil.hembery@spx.com - Radiodetection,Western Drive,Bristol,Avon,UK,BS14 0AZ

Radiodetection Calibration Data: — **Date of Reference Calibration:** 05/10/2016
Location of Calibration: Radiodetection Ltd,Western Drive,Bristol,BS14 0AF,United Kingdom
Environmental Temperature: N/A — **Relative Humidity:** N/A
Test Procedure: PCM Full Test.xml — **Revision:** 7.6.0.0

Traceability Information: Reference Calibration

Technician ID: eng
Equipment used at reference Calibration:

Model Number	Model Description	Serial Number	Last Cal Date	Cal Due Date
33120A	Hewlett Packard Function Generator	oiuoiuo	04/09/2014	01/12/2016
34401A	Hewlett Packard Digital Multimeter	MY45018221	04/09/2014	04/12/2016
QL355TP	Thurlby Thandar Power Supply	251105	04/09/2014	04/12/2016

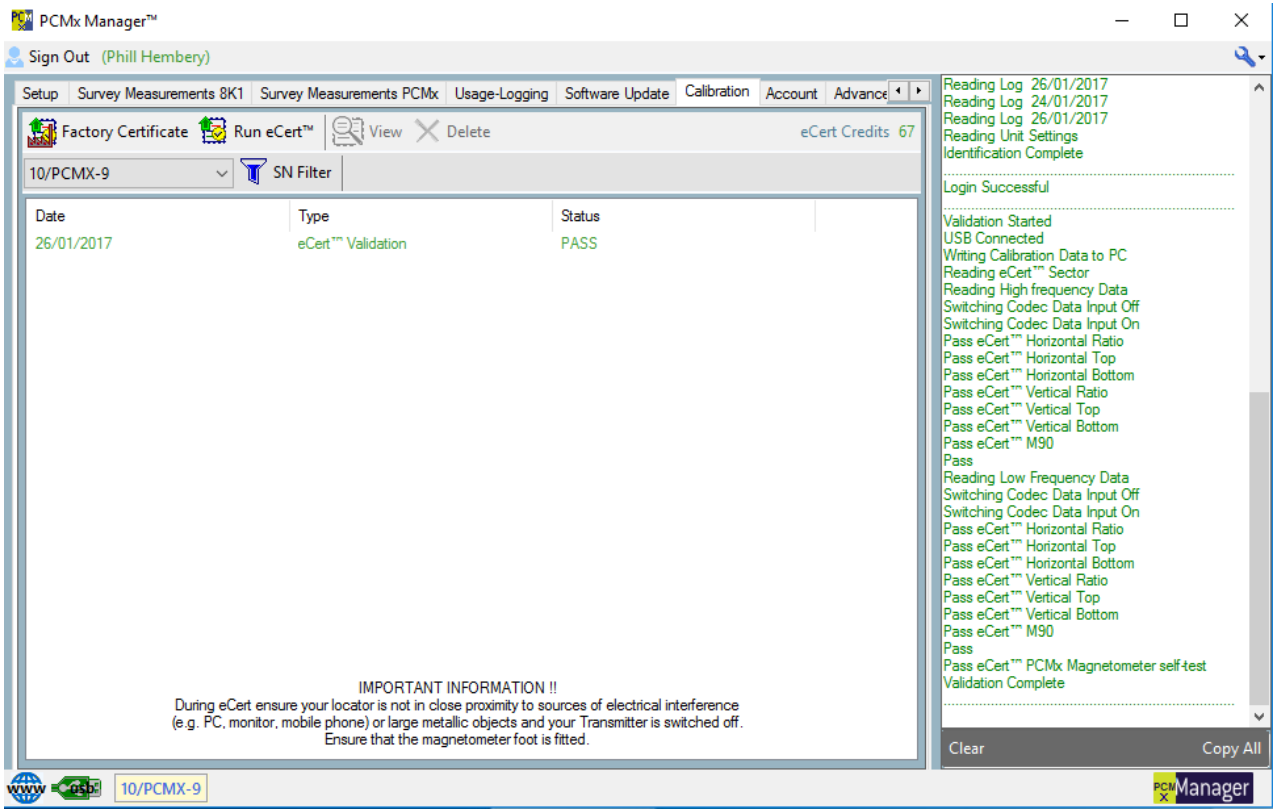
Calibration Results:

Frequency	H Ratio High	H Ratio Low	V Ratio High	V Ratio Low	Measurement Uncertainty	High Limit	Low Limit	Pass/Fail
315.0	0.9961	0.9968	0.9957	0.9960	0.0005	1.200	0.800	PASS
635.0	0.9963	0.9970	0.9957	0.9960	0.0005	1.200	0.800	PASS
870.0	0.9965	0.9971	0.9955	0.9959	0.0005	1.200	0.800	PASS
1090.0	0.9967	0.9972	0.9954	0.9957	0.0005	1.200	0.800	PASS
1415.0	0.9974	0.9975	0.9949	0.9961	0.0005	1.200	0.800	PASS
4091.0	1.0003	0.9995	0.9915	0.9949	0.0005	1.200	0.800	PASS
8172.0	1.0041	1.0015	0.9853	0.9921	0.0005	1.200	0.800	PASS
9820.0	1.0052	1.0022	0.9833	0.9909	0.0005	1.200	0.800	PASS
22170.0	1.0104	1.0062	0.9755	0.9849	0.0005	1.200	0.800	PASS
32788.0	1.0091	1.0047	0.9734	0.9832	0.0005	1.200	0.800	PASS
65550.0	1.0150	1.0103	0.9743	0.9842	0.0005	1.200	0.800	PASS
83000.0	1.0172	1.0123	0.9759	0.9867	0.0005	1.200	0.800	PASS
131100.0	1.0150	1.0097	0.9864	0.9955	0.0005	1.200	0.800	PASS
199930.0	0.9961	0.9902	0.9970	1.0053	0.0005	1.200	0.800	PASS

Magnetometer Calibration Results:

Frequency	Calibration Value	High Limit	Low Limit	Pass/Fail
4.00	11098.0205	12000.0000	10000.0000	PASS

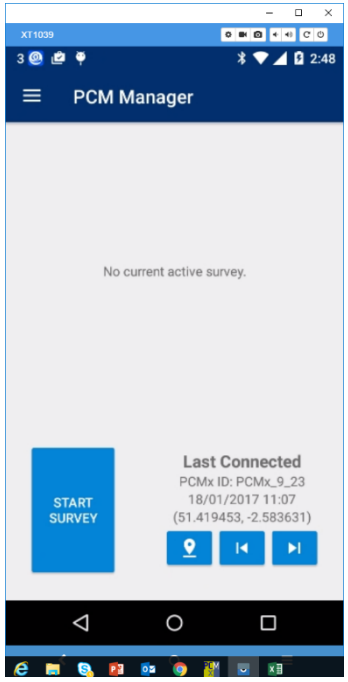
1. This certifies that the above product was tested and calibrated to the company's specifications and that the purpose built equipment performing these functions has been calibrated by instruments whose calibration is traceable to national standards.
2. The calibration was performed using procedures that are subject to periodic review.
3. The Company's Quality Management System is in accordance with BS EN ISO 9001:2008 Cert Number FM12608.

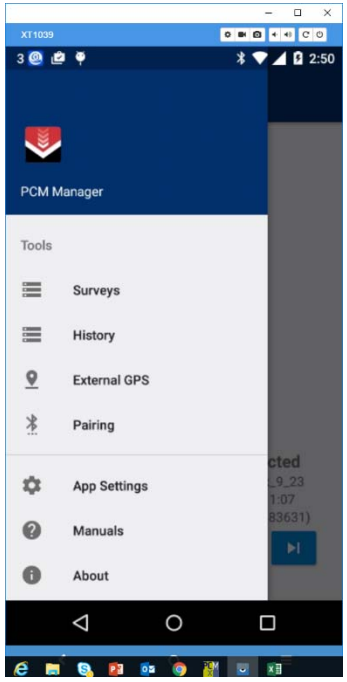


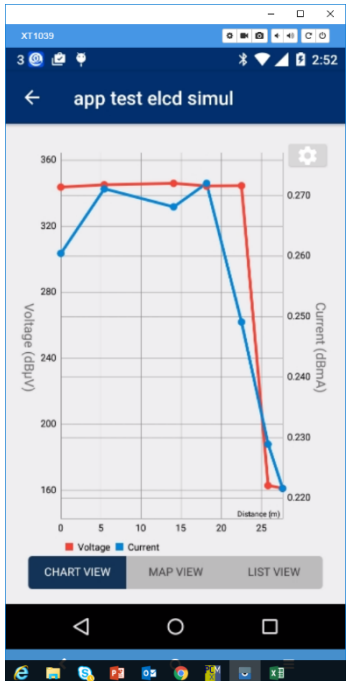
PCMx – Mobile App

RADIODETECTION
The professionals' choice

- Available from Google Play Store
  - also available from RD website
- Provides real time graphing
  - pair PCMx with mobile device
  - data sent from PCMx via BT
  - choice of graphs to display
  - review previous surveys
- Use internal PCMx GPS or external GPS



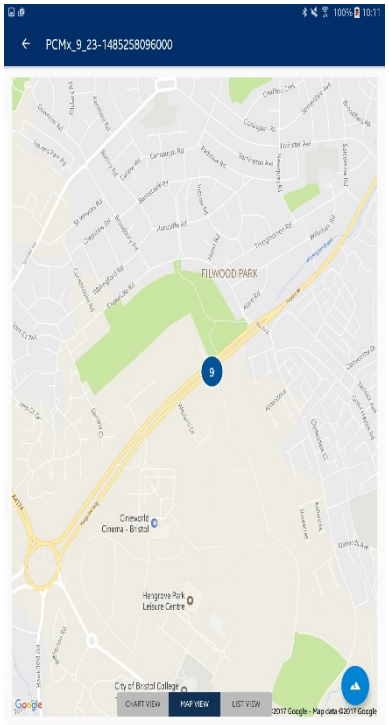


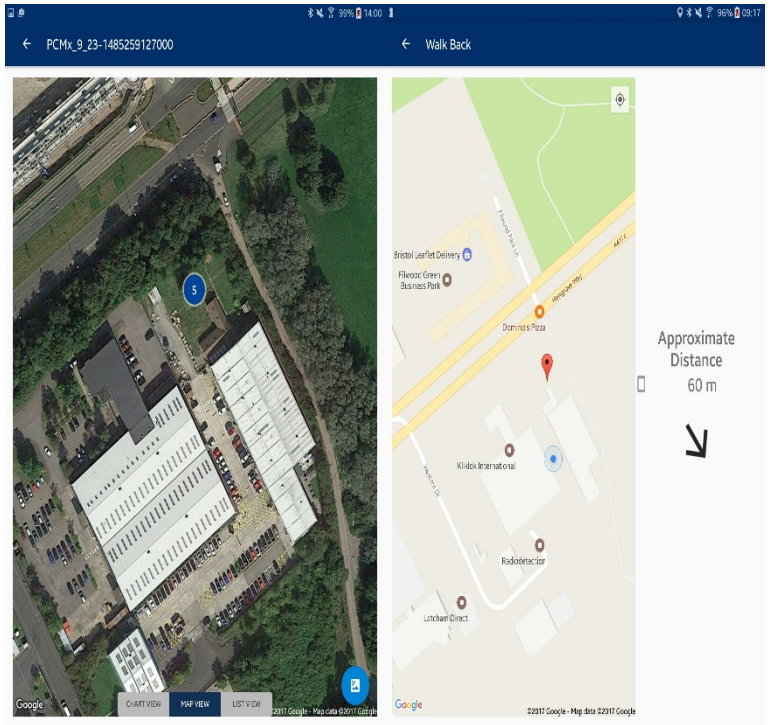


PCMx – Mobile App

RADIODETECTION
The professionals' choice

- Use map view for location
  - can be used for each point
  - 'Walk Back' feature
  - 'Walk Forward' feature





TX-25

RADIODETECTION
The professionals' choice

- 25 Watt Output

  - up to 1A and 100V

- Mains supply (100V to 240V)

- Two Internal Li-Ion batteries

  - approximately 4 hours continuous use at 1A

  - recharge when TX powered by mains or when in use