Farm Wiring and Electrical Safety - Power Quality Recordings:
How to Decipher What the Recorder is Telling You

Pete Enstrom and Tom Seidl of We Energies

53rd Annual MREC Conference Thursday Feb 19th 2015
Embassy Suites Hotel - Bloomington MN
TABLE OF PQ EVENT TYPES and WHERE TO FIND THEM

MOST OF WHAT YOU NEED TO KNOW IS FOUND IN THE
MIN, MAX AND AVE STRIP CHART. ALL YOU NEED TO DO IS LOOK FOR IT.
WHY DO I NEED TO KNOW HOW FAST THE RECORDER SAMPLES?

Fast enough to detect the shortest event causing a PQ issue
Usually twice as fast or more, of the fastest event you want to see.
BAD CONNECTOR CH 1   Vmin - EASY TO SEE ISSUE

Problem only on CH 1 this is a secondary voltage issue local to this SECONDARY MAIN.
BAD CUTOUT – FUSE BLOWN – STILL OPERATING

Crew said cutout was glowing on arrival
High side issue both CH 1 + 2 see the same effect
The more Vmax, Vave, and Vmin you see the more severe the problem is!
CAPACITOR BANK SWITCHING 0630-2300 M-Su

Normal operating of a distribution system? YES or NO?
LOOSE NEUTRAL - 1 PH

Is it a Primary or Secondary issue?
Both CH 1 + 2 are effected. Isn’t that a Primary issue?
OPEN NEUTRAL – 3 PH

Same Vswell and Vsag as seen with OPEN NEUTRAL - 1 PH
Poor neutral bond at transocket. Metering CT neutral only effective neutral on the service when imbalance on service increased wire melted opening the CT circuit under load and destroying the CTs.
OPEN NEUTRAL – 3 PH AGAIN?

POLE MOUNT 3 TRANSFORMER OVERHEAD, ONE TRANSFORMER OPEN AT NEUTRAL BUSHING
CUSTOMER INDICATES NO DAMAGE TO EQUIPMENT INTERNALLY - WHEW!!
SELF FLICKER

The problem isn’t what you are doing to yourself.

It's what you are doing to others!!
MUTUAL FLICKER

THOSE NEARBY USUALLY TELL US IT’S YOU!! THEY KNOW WHEN THE AIR CONDITIONER CYCLES. They know you keep a welder in the closet!
The electric ore smelter doesn’t cool off fast enough to hide!
We know it’s you!!!
HARMONICS

DO YOU THINK IT HAPPENED AT 1:30PM?
HARMONICS – BUT WHICH ONES DO YOU LOOK FOR?

# of RECTIFIERS + 1 MORE HARMONIC = enough maybe?

IF IT WORKED BEFORE;
SOMETHING BROKE!
SOMEBODY ADDED LOAD! or SOMEBODY “FIXED” SOMETHING!
LOOK FOR VFDs; HOW MANY RECTIFIERS; 6 AND 12 ARE MOST COMMON
SOLAR FARM - #2Cu PRI w/ 167KVA 1 PH

CH 3 PRI-N AMPS @ PDMNT XFMR 19-24A WHEN THE SUN SHINES
SOLAR FARM 3950' AWAY@ 3 PH XFMR w/# 1AL PRI

CH 2 PRI DISTRIBUTION VOLTAGE Vswell
NOW A VERY NOTICABLE REGULATION ISSUE FROM 1 PH XFMR @ SOLAR FARM
CUSTOMER LEAST COST 1 PH INTERCONNECT MAY NOT BE LEAST COST TO UTILITY
WIND TURBINE EFFECT ON STRAY VOLTAGE TEST

9AM WIND TURBINE OFF FOR MAINTENANCE
LESS PRI-N + SCN VAC = LESS COW CONTACT VOLTAGE
WIND TURBINE STOP AND START AT 5AM-9AM

ZOOM PROVIDES A BETTER VIEW TO SEE RELATIONSHIP BETWEEN THE PRI-N, SCN, AND COW CONTACT VOLTAGES REGARDLESS OF THE SOURCE
ITEC (CBEMA) CURVE

If you know how long an event is you can plot it to determine compliance
Just knowing the Vsag or Vswell gives you a good start
# 1 Phase Voltage Drop Test

<table>
<thead>
<tr>
<th>Site Location</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire Size (AWG)</td>
<td>14C</td>
<td>12C</td>
<td>6A</td>
<td>10C</td>
<td>6A</td>
<td>4A</td>
<td>2A</td>
<td>100A</td>
<td>350AL</td>
<td>AWG</td>
<td></td>
</tr>
<tr>
<td>Feed Length (Ft/100)</td>
<td>1.20</td>
<td>2.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%MRH / MTHI (see notes below)</td>
<td>0.26</td>
<td>0.16</td>
<td>0.11</td>
<td>0.07</td>
<td>0.04</td>
<td>0.03</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>TOTAL OHMS</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured Current [AMPS]</td>
<td>70.00</td>
<td>70.00</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculated Voltage Drop</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.32</td>
<td>1.58</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>VOLTS</td>
</tr>
</tbody>
</table>

Under the correct AWG Column C-L above, Enter values described below:

1. Length of each conductor span divided by 100 (120” / 120 = 1.0)
2. Enter the current on this circuit on Row 13

This is Resulting Vdrop per conductor @ the distance and in. Voltage Drop 2.51

<table>
<thead>
<tr>
<th>Transformer Size kVA</th>
<th>Phase Load</th>
<th>All Load</th>
<th>Transformer Vdrop @ 2.51</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>30.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>7.5</td>
<td>32.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>10</td>
<td>42.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>15</td>
<td>62.5</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>25</td>
<td>105.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>37.5</td>
<td>157.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>50</td>
<td>210.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>75</td>
<td>312.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>100</td>
<td>416.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

TOTAL Vdrop Xfmr to Load 3.51

Site Location Codes:

<table>
<thead>
<tr>
<th>Transformer and Main</th>
<th>A</th>
<th>14</th>
<th>0.42</th>
<th>0.26</th>
<th>2</th>
<th>0.027</th>
<th>0.016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main to Drop</td>
<td>B</td>
<td>12</td>
<td>0.26</td>
<td>0.16</td>
<td>1</td>
<td>0.021</td>
<td>0.013</td>
</tr>
<tr>
<td>Drop to main house panel Disconnect</td>
<td>C</td>
<td>10</td>
<td>0.17</td>
<td>0.10</td>
<td>1/0</td>
<td>0.017</td>
<td>0.01</td>
</tr>
<tr>
<td>Disconnect to other panel (Feeder)</td>
<td>D</td>
<td>9</td>
<td>0.11</td>
<td>0.064</td>
<td>2/0</td>
<td>0.013</td>
<td>0.002</td>
</tr>
<tr>
<td>Panel to Branch Circuit</td>
<td>E</td>
<td>6</td>
<td>0.067</td>
<td>0.041</td>
<td>3/0</td>
<td>0.011</td>
<td>0.006</td>
</tr>
<tr>
<td>Other</td>
<td>F</td>
<td>4</td>
<td>0.042</td>
<td>0.026</td>
<td>4/0</td>
<td>0.008</td>
<td>0.005</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RESISTANCE CHART (ohms per 100 feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gauge</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

**Comments:** TOTAL Vdrop Xfmr to LOAD 3.51 VAC Assume 50kVA Xfmr

INITIALS:

---

Vdrop Spreadsheet Helps Find Where It’s All Going
REVIEW - MORE THAN YOU WANT TO KNOW

Most common problem - **FLICKER**
Caused by: Too Much, Too Many, Too Small
Solution: Bigger, Better, Shorter, or Less

Second place – **MOMENTARIES** Short duration lights out
Caused by: Tree Contact, Animals, Failing Distribution Equipment
Solution: Forestry, Animal Guards, Line Patrols, Thermal Cameras

Third place – **LOW VOLTAGE** Out of Tolerance
Caused By: Customer Load, Distribution System Equipment Failure,
See Causes for Flicker as well
Solution: Same as Flicker

Fourth place – **HIGH VOLTAGE** Out of Tolerance
Caused by: Usually Distribution System or Neutral Issue
Solution: Find and Repair Quickly Most Damaging of all of the above