

# Filtered Variable Frequency Drives

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Why is a variable frequency pump drive better than an on-off pump controller?

As a wells fluid entry rate decreases over time the on-off controller will cycle more frequently which causes several problems:

- Decreased gas production. Gas production falls off every time the pump shuts down. This is because of the rising fluid level in the casing due to well entry rate and the u-tube effect from the tubing draining back through the pump. A variable frequency pump drive will slow the pump speed to match the well entry rate, therefore, maintaining a consistent fluid level giving the well constant gas production.
- Premature pump failure. Every time the pump restarts, the suction head and the discharge head of
  the pump are equal. As a result, the pump stages are pushed upward into the outlet of the pump
  causing premature pump failure. This condition is known as pump up-thrust. A variable
  frequency pump drive will run continuously, thus maintaining a constant fluid level and avoiding
  the pump up-thrust condition.
- Premature motor failure. The up-thrust condition during startup can cause the motor rotor to push against the motor end plate causing motor failure.

Variable frequency pump drives have one problem. They produce electrical harmonics which are harmful to other electrical equipment. In the past the only way to correct harmonics was to install a filter at each service location in the field. Brennan Engineering has developed an electrical harmonic filter that fits inside the drive enclosure thus eliminating any external filter requirements. This harmonic filtered drive system has been tested and approved for use by Powder River Energy. Another advantage to our drive system is the customized software for the CBM Industry.

### Advantages of using individually filtered drives

- Our filtered drive package is more cost effective than buying a separate filter, plus the added cost
  of installation.
- Our drive applied filter concept allows the operator to mix linear and nonlinear loads together, with no adverse affects to your total harmonic distortion.
- ABB has worked with us to develop software that is specific to the Coal Bed Methane Industry.
   Consequently, making the initial start-up and operation of the drive very user friendly.

# Disadvantages of using non filtered drives

- Using a non filtered drive requires filtering from a central location; adding or deleting wells will adversely affect the performance of the filter. Thus requiring replacement of the existing filter.
- Adding loads to a filtered service point will require an increase in the size of the filter. All linear
  loads will have to be separated from the filtered loads at the electrical service point.



January 11, 2002

David Brennan
Brennan Engineering & Instrumentation
5700 Antelope Valley St.
Gillette, WY 82718

ENERGY

CORPORATION

RE: Harmonic Test

Mr. Brennan,

At your request, Powder River Energy Corporation agreed to field test your Power Quality Solutions (PQS) - Prototype #1 - Harmonic Filter. As you know, non-linear currents caused by variable frequency drives (VFD's) result in harmonic currents that are detrimental to the utility system. Effective filtering is essential in controlling the propagation of this problem.

A site in Sheridan County was selected for the test. A Metrosonic PA-7 Power Quality Monitor was utilized for the data collection. It was programmed to capture one cycle every second, and the test runs were approximately two minutes in duration. Representative waveforms are attached from each of five (5) test runs.

# SITE INFORMATION

Fidelity E&P Rice & Sons 34c-264 SWSE T56N R84W Sec. 2 Sheridan County, WY

The motor is a 10hp submersible located approximately 2,500' from the utility source. The drive is a 20hp ABB unit. Power Factor was not a problem despite the mismatch in the drive and motor horsepowers.

# **TEST DATA**

<u>Test #1</u> – (Page #1) Ambient Condition –Existing voltage waveform at the Point of Common Coupling (PPC) with the motor *not* running. The V<sub>THD</sub> background is 2.58%.

 $\underline{\text{Test } #2}$  – (Page #2,3,4) Motor running w/o filter –The V<sub>THD</sub> is 2.50% and the I<sub>THD</sub> is 43.41%.



<u>Test #3</u> – (Page #5,6,7) Motor running (60Hz) with filter – The  $V_{THD}$  is 2.50% and the  $I_{THD}$  is 9.24%.

<u>Test #4</u> – (Page #8,9,10) Motor running (45Hz) with filter – The  $V_{THD}$  is 2.57% and the  $I_{THD}$  is 14.25%.

<u>Test #5</u> – (Page #11,12,13) Motor running (60Hz) with filter plus additional 10hp linear motor running – The  $V_{THD}$  is 2.48% and the  $I_{THD}$  is 5.70%

Powder River Energy Corporations "Harmonic Distortion Limitation" Policy requires that all customers meet IEEE Standard 519-1992. The  $I_{SC}/I_L$  ratio is between 100<1000 and the TDD must fall below 15% to be in compliance. The results of the field-testing show that the subject filter meets the Harmonics criteria and appears to be a viable solution to the harmonics issues.

Please advise if we can provide any additional information on this matter.

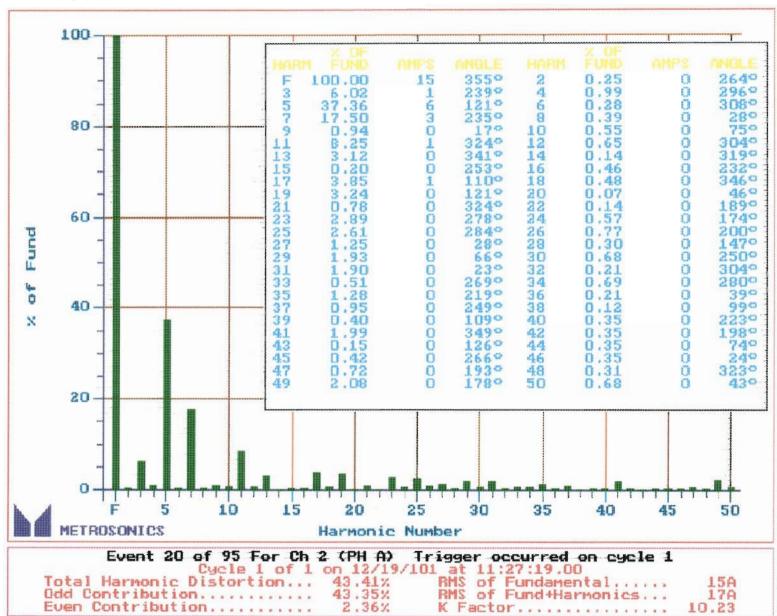
Respectfully,

Rick Browne

Sheridan Division Engineer

Cc: Steve Taylor, Sundance

Filename......PQS-2
Customer Name...
Account/Meter #.
Address One.....
Address Two.....
City,State,Zip...
Phone Number....
Comment 1......@ meter # R1010



```
Account/Meter #.
Address One....
Address Two....
City, State, Zip...
Phone Number....
Conment 1..... @ meter # R1010
Comment 2.....
   30.6 -
   24.5 -
   18.4-
   12.2.
     6.1 -
AMDIS
     0.0-
  -12.2-
  -18.4
  -24.5 -
  -30.6 -
        0.0
                   2.1
                             4.1
                                       6.2
                                                  8.3
                                                           10.3
                                                                                14.5
                                                                                          16.5
                                                                      12.4
     METROSONICS
                                          Time (Ms)
                                      2 (PH A) Trigger occurred on cycle 1 on 12/19/101 at 11:27:19.00 43.41% RMS of Fundamental..... 43.35% RMS of Fund+Harmonics...
           Event 20 of 95 For Ch 2 (PH A)
                       Cycle 1 of 1
   Total Harmonic Distortion...
                                                                                        15A
17A
  Odd Contribution......
  Even Contribution.....
                                         2.36%
                                                      K Factor.....
                                                                                      10.23
```

```
Account/Meter #.
Address One....
Address Two....
City, State, Zip...
Phone Number....
Comment 1......@ meter # R1010
Comment 2.....
      406
      325 -
      244 -
      162 -
        81 -
Volts
      -81
     -162 -
     -244 -
     -325 -
     -406 -
           0.0
                          2.1
                                        4.1
                                                      6.2
                                                                     8,3
                                                                                  10.3
                                                                                                12.4
                                                                                                              14.5
                                                                                                                             16.5
      METROSONICS
                                                          Time (ms)
   Event 20 of 95 For Ch 1 (PH A) Trigger occurred on cycle 1

Cycle 1 of 1 on 12/19/101 at 11:27:19.00

Total Harmonic Distortion... 2.50% RMS of Fundamental..... 288.3V
Odd Contribution..... 2.49% RMS of Fund+Harmonics... 288.4V
Even Contribution..... 0.21%
```

```
Account/Meter #.
Address One....
Address Two....
City,State,Zip...
Phone Number....
Comment 1.....@ meter # R1010
Comment 2.....
     404 -
     323 -
     242 -
     161 -
      81 -
Volts
     -81 -
    -161 -
    -242 -
    -323 -
    -404
         0.0
                     2.1
                                4.1
                                            6.2
                                                       8.3
                                                                  10.3
                                                                             12.4
                                                                                         14.5
                                                                                                    16.5
     METROSONICS
                                              Time (MS)
                         f 122 For Ch 1 (PH A) Trigger occurred on cycle 1
Cycle 1 of 1 on 12/19/101 at 11:04:19.01
istortion... 2.58% RMS of Fundamental..... 288.10
2.58% RMS of Fund+Harmonics... 289.20
           Event 20 of 122 For Ch 1 (PH A)
                                             2.58%
2.58%
0.12%
   Total Harmonic Distortion...
   Odd Contribution.....
   Even Contribution.....
```

Customer Name... Account/Meter #. Address One.... Address Two..... City, State, Zip... Phone Number.... Comment 1......@ meter # R1010 Comment 2..... 406 -325 -244. 162 -81 -Volts -81 --162 --244 -325 --406 -8.3 2.1 6.2 4.1 10.3 0.0 12.4 14.5 16.5 METROSONICS Time (MS) Event 20 of 136 For Ch 1 (PH A) Trigger occurred on cycle 1
Cycle 1 of 1 on 12/19/101 at 11:38:19.00
Total Harmonic Distortion... 2.50% RMS of Fundamental..... 289.20
Odd Contribution...... 2.49% RMS of Fund+Harmonics... 289.30
Even Contribution...... 0.19%

Filename.....PQS-3

Even Contribution.....

```
Address One....
Address Two....
City, State, Zip...
Phone Number....
Comment 1.....@ meter # R1010
Comment 2.....
   25.1 -
   20.0-
   15.0-
   10.0-
    5.0-
AMDS
    0.0
   -5.0
  -10.0-
  -15.0-
  -20.0-
  -25.1-
                  2.1
                                                          10.3
                                                                     12.4
                                                                               14.5
        0.0
                             4.1
                                       6.2
                                                 8.3
                                                                                         16.5
    METROSONICS
                                         Time (MS)
          Event 20 of 136 For Ch 2 (PH A)
                                                  Trigger occurred on cycle 1
  Cycle 1 of 1 on 12/19/101 at 11:38:19.00

Total Harmonic Distortion... 9.24% RMS of Fundamental.....
Odd Contribution..... 9.07% RMS of Fund+Harmonics...
                                                                                       16A
                                                                                       16A
                                                     K Factor....
  Even Contribution.....
                                         1.73%
                                                                                      2.79
```

Customer Name... Account/Meter #.

```
Address One....
Address Two....
City,State,Zip...
Phone Number....
Comment 1.....@ meter # R1010
Comment 2.....
    100
                                                       50
                                                                                     2710
                                                16
                                                              2
                                                                    0.49
                                                                                0
                               F
                                   100.00
                                                                    0.22
                                                                                     112°
15°
123°
                                     1.74
7.27
2.92
                                                      3260
                                                                                0
                               3
                                                 0
                                                              4
                                                       200
                               5
                                                                                Ö
                                                              6
                                                      3550
                                                 0
                                                              8
                                                                                0
     80.
                                                      1320
                                                                                     1860
                                     1.06
                                                                    0.26
                                                                                0
                               9
                                                 0
                                                             10
                                                       340
                                                                    0.28
                                                                                     1210
                                                                                0
                                     1.75
                                                 0
                                                             12
                                                                    0.16
                                                      2239
                                                                                0
                                                                                     1689
                                     2.39
                                                 0
                                                             14
                              13
                                     0.30
0.28
0.75
                                                      2920
                                                                                     256°
                                                                    0.63
                                                                                0
                                                 0
                                                             16
                              15
                                                      1990
                                                                                Ö
                                                                                     1750
                                                 0
                                                             18
                                                      1430
                                                                    0.19
                                                                                0
                                                                                     310°
                              19
                                                 0
                                                             20
                                                       320
                                                                                      380
                                                                    0.35
                              21
                                     0.68
                                                 0
                                                             22
                                                                                0
                                                                                     1880
     60 -
                                                      2890
                                                                    0.37
                                                                                Ō
                                                 0
                                                             24
                              23
                                     0.88
                                                                                      84°
83°
                                                                    0.06
                                                      2890
                                                                                Ö
                                                 0
                                                             26
Fund
                              25
                                     0.61
                              27
                                                      2580
                                                                                Ö
                                     0.17
                                                 O
                                                             28
                                                       950
                                                                                     206°
                                                                    0.26
                              29
                                                 0
                                                             30
                                                      3040
                                                                    0.05
                                                 0
                                                             32
                                                                                0
                              31
                                     0.10
                                                      2580
                              33
                                                 0
                                                             34
                                                                                0
                                                                                     2560
10
                                     0.12
                                                                                     2470
                                                      2550
                                                             36
                                                                                0
                              35
                                     0.39
                                                 0
                                                                    0.16
                                                                    0.26
     40 -
                                                      1930
                                                 0
                                                                                Ö
                              37
                                     0.12
                                                             38
                                                 0
                                                       990
                                                                                0
                                                                                      390
×
                              39
                                     0.38
                                                             40
                                                      1710
                                     0.26
1.34
0.56
                                                                                     158°
                              41
                                                 0
                                                             42
                                                                    0.59
                                                                                Ū
                                                                                       90
                                                 ō
                                                      1420
                                                             44
                              43
                                                                    0.09
                                                                                O
                                                             46
                                                      3250
                              45
                                                 O
                                                                    0.16
                                                                                Ö
                                                                                     2340
                                                      2390
                                                                                     2880
                              47
                                     0.68
                                                 O
                                                             48
                                                                    0.20
                                                                                Ū
                                                      3250
                                                                                      700
                              49
                                                             50
                                     1.62
                                                 U
                                                                    0.24
                                                                                0
     20 -
                 5
                        10
                               15
                                       20
                                               25
                                                      30
                                                              35
                                                                      40
                                                                             45
                                                                                     50
    METROSONICS
                                    Harmonic Number
         Event 20 of 136 For Ch 2 (PH A)
                                                Trigger occurred on cycle 1
                     Cycle 1 of 1 on 12/19/101 at 11:38:19.00
  Total Harmonic Distortion...
                                       9.24%
                                                  RMS of Fundamental.....
                                                                                   16A
  Odd Contribution......
                                                  RMS of Fund+Harmonics...
                                       9.07%
                                                                                   16A
  Even Contribution.....
                                                  K Factor.....
                                       1.73%
```

Customer Name... Account/Meter #.

```
Account/Meter #.
Address One.....
Address Two....
City, State, Zip...
Phone Number....
Comment 1.....@ meter # R1010
Comment 2.....
     405
     324 -
     243 -
     162 -
       81 -
Volts
     -81 -
    -162 -
    -243 -
    -324 --
                                             6.2
                                                         8.3
                                                                    10.3
          0.0
                      2,1
                                 4.1
                                                                                12.4
                                                                                            14.5
                                                                                                        16.5
     METROSONICS
                                                Time (ms)
           Event 20 of 119 For Ch 1 (PH A)
                                                           Trigger occurred on cycle 1
   Cycle 1 of 1 on 12/19/101 at 11:57:19.00

Total Harmonic Distortion... 2.57% RMS of Fundamental..... 289.0V
Odd Contribution...... 2.55% RMS of Fund+Harmonics... 289.1V
Even Contribution...... 0.30%
```

```
Account/Meter #.
Address One....
Address Two....
City, State, Zip...
Phone Number....
Comment 1.....@ meter # R1010
Comment 2.....
   14.6
   11.7
     8.8
     5.8 -
     2.9.
AMDS
    -0.0
    -2.9
    -5.8-
   -8.8-
  -11.7-
                  2.1
                                                  8.3
                             4.1
                                       6.2
        0.0
                                                           10.3
                                                                      12.4
                                                                                14.5
                                                                                          16.5
    METROSONICS
                                          Time (Ms)
          Event 20 of 119 For Ch 2 (PH A)
                                                   Trigger occurred on cycle 1
  Cycle 1 of 1 on 12/19/101 at 11:57:19.00
Total Harmonic Distortion... 14.25% RMS of Fundamental.....
Odd Contribution...... 13.54% RMS of Fund+Harmonics...
                                                                                          94
                                         4.45%
  Even Contribution.....
                                                     K Factor.....
                                                                                       5.76
```

Account/Meter #. Address One.... Address Two.... City, State, Zip... Phone Number.... Comment 1......@ meter # R1010 Comment 2..... 100 F 100.00 9 260 2 0.46 O. 1550 75° 116° 0.98 12.15 2.28 2440 O 4 0.82 0 357 550 ŏ 6 2.63 Ö 160 Ö 3190 8 80 2250 9 1480 1.35 0 0.84 0 10 270 2910 2.29 0.46 11 0 12 0 2980 0.25 Ö 560 14 13 2.11 O 0.81 0.33 0.97 1.08 238° 0 660 15 0.17 0 16 388c 1.20 0.76 0.20 1800 0 17 0 18 2720 830 Ö 20 0 19 2960 2440 21 0 22 0 630 630 60 -23 0.61 O 24 0.32 0 1.71 0.49 0.78 0.94 460 1000 26 0.49 0000 25 0 Fund 234° 133° 260 0.57 27 0 28 2950 29 O 30 50° 3470 0.60 31 0 32 33 2610 34 0.69 ō Ö 3270 40 175° 185° D.48 D.78 1060 0.51 35 0 36 0 40 -960 0.48 0 38 0 37 0.80 0 370 40 0 2940 N 39 0.50 27° 354° 0.34 0 0.33 42 0 2640 41 1450 44 0,42 Õ 43 46 ō 1450 90 45 0.65 1.11 O 790 1050 47 2.67 0 48 0.66 ñ 200 260° 49 50 1.37 0 1.40 20-25 5 10 15 20 30 35 40 45 50 METROSONICS Harmonic Number Event 20 of 119 For Ch 2 (PH A) Trigger occurred on cycle 1 Cycle 1 of 1 on 12/19/101 at 11:57:19.00 14.25% RMS of Fundamental..... 9A Total Harmonic Distortion...

13.54%

4.45%

Filename......POS-4

Odd Contribution.....

Even Contribution.....

Customer Name...

94

5.76

RMS of Fund+Harmonics...

K Factor.....

```
Customer Name...
Account/Meter #.
Address One....
Address Two....
City, State, Zip...
Phone Number....
Comment 1.....@ meter # R1010
Comment 2.....with additional 10 hp linear load
     404 -
     323 -
     242 -
     162 -
      81 -
Volts
       -0
     -81 -
    -162 -
    -242 ----
    -323 -
    -404 -
         0.0
                     2.1
                                4.1
                                            6.2
                                                       8.3
                                                                  10.3
                                                                              12.4
                                                                                         14.5
                                                                                                     16.5
     METROSONICS
                                               Time (MS)
                         of 86 For Ch 1 (PH A) Trigger occurred on cycle 1
Cycle 1 of 1 on 12/19/101 at 12:05:19.00
Distortion... 2.48% RMS of Fundamental..... 289.10
2.48% RMS of Fund+Harmonics... 289.20
            Event 20 of 86 For Ch 1 (PH A)
   Total Harmonic Distortion...
```

2.48% 0.21%

Odd Contribution..... Even Contribution.....

Filename.....PQS-5

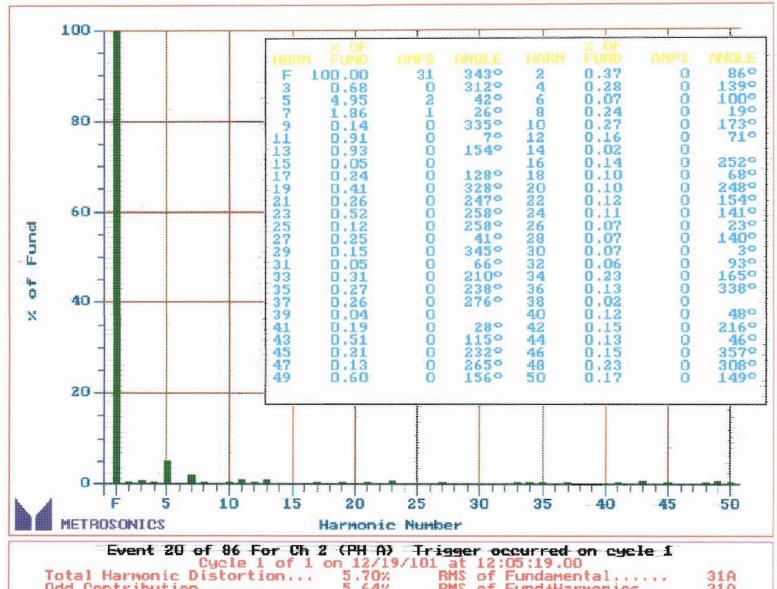
```
Account/Meter #.
Address One....
Address Two....
City, State, Zip...
Phone Number....
Comment 1.....@ meter # R1010
Comment 2.....with additional 10 hp linear load
   44.5
   35.6 -
   26.7 -
   17.8 -
    8.9-
AMDS
    0.0-
   -8.9
  -17.8 -
  -26.7-
  -35.6 -
  -44.5-
        0.0
                 2.1
                           4.1
                                    6.2
                                              8.3
                                                       10.3
                                                                          14.5
                                                                12.4
                                                                                   16.5
    METROSONICS
                                       Time (ms)
                     Cycle 1 of 1 on 12/19/101 at 12:05:19.00 istortion... 5.70% RMS of Fundamental..... 5.64% RMS of Fund+Harmonics...
         Event 20 of 86 For Ch 2 (PH A)
  Total Harmonic Distortion...
                                                                                  31A
  Odd Contribution.....
                                                                                  31A
                                      0.83%
  Even Contribution.....
                                                 K Factor.....
                                                                                 1.36
```

```
Filename......PQS-5
```

Customer Name... Account/Meter #. Address One.... Address Two.... City, State, Zip., Phone Number....

Comment 1...... @ meter # R1010

Comment 2......with additional 10 hp linear load



Event 20 of 86 For Ch	2 (PH A) T	rigger occurred on cycle 1	
Cycle 1 of 1	on 12/19/10	11 at 12:05:19.00	
Total Harmonic Distortion		RMS of Fundamental	31A
Odd Contribution		RMS of Fund+Harmonics	31A
Even Contribution	0.83%	K Factor	1.36