Setting Electrical Neutral
DC Machines - AC Method

Presented to:

Presented by:
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Construction of DC Machines

- Armature Coil
- Pole Face Bars
- Main Field
- Brush Yoke
- Armature
- Shaft
- Banded Commutator
- Commutator Coil (Interpole)
- Brush Arm
Details of Brush Arms and Adjustment Yoke
Quiz: What is Electrical Neutral?

- Electrical Neutral is:
  1. Point of Optimum Commutation
     - Or -
  2. Point of Optimum Performance
     - Or -
  3. Point of Zero Induced Voltage

- Answer:
  - Point of Zero Induced Voltage
Quiz: What is Wrong with this Picture?
Quiz: What is Wrong with this Picture?

Is this Mark the Original Factory Neutral?
Quiz: What is Wrong with this Picture?

How about this Mark?
Various Methods of Setting Electrical Neutral

- PVN (Pencil Volt Neutral)
- DC “Kick” or “Flash” Method
- Bi-Directional Speed Matching
- Generators, Voltage Drop at Stall
- AC Null Method
- Brush Potential Method
- Tram Markings / Mechanical Method
- AC Curve Method
Neutral on DC Motors VS DC Generators

• DC Motors:
  – Typically set on Precise Electrical Neutral, as in many cases, they are in reversing applications
  – It is possible to aid commutation in single rotation direction motor applications by “slightly” moving yoke off neutral; however, recommended in extreme cases only

• DC Generators:
  – Typically, intentionally set ½ to ¾ commutator bar against rotation to boost commutating field strength and aid in commutation
PVN - Pencil Volt Neutral Method

- Proven, accurate, excellent results
- Requires special template
- Brushes must be well seated
- Requires technical data from GE
- Requires working in close proximity to energized and rotating equipment
- Requires shutdown, multiple lockouts to adjust yoke before retest
- Time consuming
DC “Kick” Method

- Very accurate and safe
- Requires 12 or 24 Vdc battery or battery charger
- Requires bi-directional analog DC milli-volt meter
- Results are susceptible to Test Technicians interpretation
- Very time consuming
- Typically requires two Technicians
Bi-Directional Speed Matching

- Very accurate
- Typical and convenient for in-shop testing and adjustment
- Obtain same speed CW as CCW by adjusting neutral, test by reversing the armature voltage while field current remains the same
- Not a very practical test in the field
Generator Voltage at Stall

- Very accurate
- Application only to multiple generators and motors in one or more loop configurations
- While producing rated armature amps, adjust yoke to provide equal voltage at generator output
- Very time consuming
- Requires multiple Technicians
- Requires working in close proximity to energized / rotating apparatus
The Big Question?

- Is setting electrical neutral on a DC Machine, using the static AC Curve Method, as accurate as the PVN or any of the other above mentioned methods?
- Lets explore the process and then you decide!
SAFETY - First and Always

PERFORM NO WORK BEFORE:

**ALL** Electrical, Mechanical and / or Other Stored Energy Sources have been Properly Disabled, Locked and Tagged

- LOCK
- TAG
- TRY
Theory of Test

- Shunt Winding ~ Transformer Primary
- Armature ~ Transformer Secondary
- Results in a Very High Transformer Turns Ratio
- Induced AC Voltage into the Armature Winding is very Low
- Effectively Single Phase Transformer, with Multi-tap – Single Turn Secondary
Typical 6 pole dc machine may have 200 +/- turns / pole, or approximately 1200 turns.
Single Phase Transformer Equivalency

.120 Volts / 60 Hz / 1 Phase

.100's of Turns Shunt Field Circuit

.1 Turn Coil with Multiple Taps

Typical 6 pole dc machine may have 200 +/- turns / pole, or approximately 1200 turns

Each commutator bar represents a tap on the transformer secondary
Single Phase Transformer Equivalency

- 120 Volts / 60 Hz / 1 Phase
- 100's of Turns Shunt Field Circuit
- 1 Turn Coil with Multiple Taps
- Each commutator bar represents a tap on the transformer secondary

Typical 6 pole dc machine may have 200 +/- turns / pole, or approximately 1200 turns
Single Phase Transformer Equivalency

.120 Volts / 60 Hz / 1 Phase

.100's of Turns Shunt Field Circuit

.1 Turn Coil with Multiple Taps

Iron core

Typical 6 pole dc machine may have 200 +/- turns / pole, or approximately 1200 turns

Each commutator bar represents a tap on the transformer secondary

Resulting secondary voltage:

\[ V_s = V_p \times \frac{N_s}{N_p} \]

or

\[ V_s \approx 120V \times \frac{1}{1200} \approx 100mV \]
Preparation / Step 1 Following L/O-T/O-TRY

VERIFY and CORRECT as Necessary to obtain Equalized Circumferential Spacing

TOLERANCE: +/- 1/32”
Circumferential Spacing Details

Circumferential spacing must be equal distant with in 1/32”

X = X w/in 1/32”
Preparation / Step 2

VERIFY and CORRECT As Necessary to obtain proper Brush Box Elevation

TOLERANCE: .070” to .080”
Review

- VERIFY and CORRECT as Necessary
  Equalized Circumferential Spacing
  – TOLERANCE: 1/32”

- VERIFY and CORRECT as Necessary
  Brush Box Elevation
  – TOLERANCE: .070” to .080”

- Note: Adjustments to One Parameter may Influence the Other
  – VERIFY AND RE-VERIFY
TEST SETUP – Step 1

- Lift All Brushes
  - Isolate Armature Circuit Frame Components from the Armature
  - Not always necessary
- Number the Commutator Bars
  - Per Following Illustrations
- Apply GFCI Protected, 120 Volts A/C
  - Fe / Fo Shunt Field Circuit
  - F1 to F2
  - (or) F1 to F4, as Connection Dictates
Quiz...........

• How is it that we can apply 120 Vac to the shunt field circuit, which typically measures less than 2 Ω?
  – \( I = \frac{E}{R} \) or \( \frac{120\ \text{V}}{2\ \Omega} = 60\ \text{Amps} \) !!!

• Inductance is the answer.....
  – \( X_L = 2\pi f L \) or \( 377 \times 165\ \text{milli-Henrys} \)
  – \( X_L = 62\ \Omega \)

• Impedance: \( Z = \sqrt{2^2 + 62^2} = 62\ \Omega \)

• \( I = \frac{E}{Z} = 120\ \text{volts} / 62\ \text{ohms} < 2\ \text{amps} \)
Convenient Location to Apply 120 Vac
Test Setup – Step 2

- Determine the Total Number of Commutator Bars
- Determine the Total Number of Main Shunt Field Coils
- Divide the Total Bars by # Field Coils
- Resultant is the Throw
- Span = Throw + 1
Example - Data

- Total Number of Commutator Bars = 288
- Total Number of Poles = 6
- Throw = 288 / 6 = 48
- Span = Throw + 1 (or) 1 and 49
Original “As Found” Brush Centerline
Example of AC Curve Method – Step 1

**EXAMPLE:**

TOTAL NUMBER BARS = 288

TOTAL NUMBER POLES = 6

THROW = 288 / 6 = 48

SPAN = THROW + 1 = 49
Example of AC Curve Method – Step 2

EXAMPLE:

TOTAL NUMBER BARS = 288
TOTAL NUMBERpoles = 6
THROW = 288 / 6 = 48
SPAN = THROW + 1 = 49

EXAMPLE TEST RESULTS:
BAR 1 - 49 = .094 V
...
Example of AC Curve Method – Step 3

EXAMPLE:
- TOTAL NUMBER BARS = 288
- TOTAL NUMBER POLES = 6
- THROW = 288 / 6 = 48
- SPAN = THROW + 1 = 49

EXAMPLE TEST RESULTS:
- BAR 1 - 49 = 0.094 V
- BAR 2 - 50 = 0.050 V
- BAR 3 - 51 = 0.006 V
- BAR 4 - 52 = 0.038 V
- BAR 5 - 53 = 0.081 V

"AS FOUND" CENTER LINE OF TWO WAFER BRUSH

BRUSH HOLDER # 1
12:00 POSITION

BRUSH HOLDER # 2
2:00 (6 POLE) OR 3:00 (4 POLE) POSITION

DVM

NUMBER COMMUTATOR BARS CLOCKWISE AS VIEWED FROM COMMUTATOR END
Plot Step 1

Record:
1. Equipment I.D.
2. Machine I.D.
3. Date
4. Technician

Induced AC Voltage

Results:

BARS 1-49
BARS 2-50
BARS 3-51
BARS 4-52
BARS 5-53
Plot Step 2

Record:

The actual, measured induced voltage per the procedure.
Plot Step 3

Determine vertical scaling based upon highest induced voltage
Plot Step 4

Place the first of five recorded points on the graph
Plot Step 5

Place the second of five recorded points on the graph
Plot Step 6

Place the fourth and fifth of five recorded points on the graph.
Plot Step 7

Using a straight edge, draw a line directly through the center of each of the four points.
Finally, add the final point as a check. As a control measure, if plotted correctly, this point should fall perfectly on the line.
Precise Electrical Neutral is the point at which the drawn line intersects ZERO induced voltage.

Now it is necessary to transfer this graphical representation onto the actual commutator surface.
EXAMPLE:
TOTAL NUMBER BARS = 288
TOTAL NUMBER POLES = 6
THROW = 288 / 6 = 48
SPAN = THROW + 1 = 49

EXAMPLE
TEST RESULTS:
BAR 1 - 49 = .094 V
BAR 2 - 50 = .050 V
BAR 3 - 51 = .006 V
BAR 4 - 52 = .038 V
BAR 5 - 53 = .081 V
Original “As Found” Brush Centerline
“Final” Electrical Neutral Brush Centerline

“Final” “Exact” Electrical Neutral Position
What if....the throw is not a whole number?

- A few DC Machines have armature windings that result in a throw that is not a whole number, i.e. not evenly divisible.
- In this rare situation, it is necessary to plot two lines:
  - 1 plus throw less ½
  - 1 plus throw plus ½
- Electrical neutral will be ½ the distance between the two parallel plotted lines.
- As a Q/A, if plotted correctly, the two lines will be perfectly parallel to each other.
Conclusion...The AC Curve Method is:

- Extremely accurate, combined with Q/C checks along the way
- Safe, eliminates the inherent danger of working on rotating apparatus
- Safe, energized at 120 Vac
- Eliminates brush seating as potential error
- Fast, performed with minimal down time
- Does not require motor coupling be broken
Questions?

THANK YOU