Tuning Up DC Motors and Generators for Commutation and Performance

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Sometimes your machine may not run just like it should.
That is an indication that it might be time for a “tune-up”
Distributor Cap

Spark Plug Wires
But even with all new parts, the machine may not run right!
Unless you make the “tune-up” adjustments!!
That includes setting the spark plug gap, the ignition point gap or dwell, and the ignition timing.
DC machines need tune-up adjustments to run properly, too!
DC machines tune-up adjustments to run properly, too!

These adjustments include setting neutral and adjusting the commutating field (interpole) strength.
Electrical Neutral Methods

- Black Band
- Kick Inductive Neutral
- AC Neutral
- Speed Reversibility
- DC Current In Armature
- Pencil Volt Neutral
- Tram Markings/Mechanical Method
Electrical Neutral Methods

• Also see “Setting Neutral by AC Curve Method for DC Machines” by Rick Scherer, Flanders, WMEA, November 2005 (WMEA Web Site, www.wmea.net)
Electrical Neutral

Setting Neutral on an electric motor or generator is similar to setting timing on an engine.

The brushes are basically electrically positioned on the commutator between the areas of main pole flux so commutation can take place at the right time and in an area where no electrical work (torque) is being produced.
Neutral

Usually it is best to look for “factory mark” and set brush yoke to this position after reassembling the motor.

The OEM has the benefit of knowing the electrical design and how previous motors were adjusted. They also have more test equipment than the typical motor repair shop, for running the motor under load at various speeds.
Shifted off the factory mark
If armature has been changed, or brush arms moved on yoke, correct setting may not be on “factory mark”.

[Image of a mechanical assembly with an emphasis on the text above it]
Methods For Adjusting

DC Machines
Adjustments

1. Brush Position

2. Commutating Field Strength
Factory Method

Field Method
Excavator MG Set
Black Band

A test where you intentionally misadjust the magnetic strength of interpole (comm field) by adding or subtracting current to find the limits of sparking.

Also use this data to adjust neutral setting and interpole shimming for good commutation over the range of speeds and loads.
Black Band

- **Procedure**
  - Connect buck-boost power supply (low Voltage high current) in parallel with the commutating fields
  - Operate the machine at various loads (0% to 150%), apply buck-boost current and observe sparking
  - Adjust brush rigging position or shim commutating poles as shown from recorded and plotted data
<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Black</td>
</tr>
<tr>
<td>1+</td>
<td>Pinpoint Sparking</td>
</tr>
<tr>
<td>1 1/4</td>
<td>Sparking on a few brushes</td>
</tr>
<tr>
<td>1 1/2</td>
<td>Sparking on half of the brushes</td>
</tr>
<tr>
<td>2</td>
<td>Sparking on most brushes</td>
</tr>
<tr>
<td>3</td>
<td>Destructive Sparking plus streamers</td>
</tr>
</tbody>
</table>
DC Machine and Load

Field

ARM

Comm Field

Load
Black Band Set Up

Buck Boost Gen

Comm Field

ARM

Field

Load
No Load Boost

Buck Boost Gen

$I_A = 0$

Field

ARM

Comm Field

Load
No Load Buck

Buck Boost Gen

Comm Field

$I_A = 0$

Field

ARM

Load
Buck Boost Curve

- No Load Band
- Center on Buck Side (Strong)
- Corrective action – shift brush rigging with rotation (motor) or against rotation (generator)
Buck Boost Curve

No Load Band
Center on Boost Side (Weak)

Corrective action – shift brush rigging against rotation (motor) or with rotation (generator)
Take data with machine loaded, beginning at 50% load.
Band Center on Boost Side

(Weak)

No sparking in black area, sparking outside black area

Corrective Action – Remove nonmagnetic shims, add magnetic shims
Corrective Action – Remove magnetic shims, add non magnetic shims

Sparking with no buck or boost

Band Center on Buck Side (Strong)
Buck Boost Curve

Near perfect black band – centered at all loads
Black Band

• Advantages
  – Adjusts both neutral and commutating pole shimming
  – Tests over complete load range or can adjust for specific load and speed
Black Band

• **Advantages**
  – Adjusts both neutral and commutating pole shimming
  – Tests over complete load range or can adjust for specific load and speed

• **Disadvantages**
  – Requires field supply and armature supply capable of 1.5 to 2 times rated armature Amperes
  – Need control of loading, voltages, speeds, etc.
  – Need buck-boost power supply (low voltage and high current)
Kick Inductive Neutral

• **Procedure**
  - Connect an analog DC voltmeter between shunts of brushes on adjacent arms (brushes need to be well seated)
  - Repeatedly apply and remove DC voltage from shunt fields
  - Shift brush yoke for minimum deflection (kick) if meter needle
Shift brushes for minimum needle deflection
Kick Inductive Neutral

• Advantages
  – Static Test
  – Little equipment required
Kick Inductive Neutral

- **Advantages**
  - Static Test
  - Little equipment required

- **Disadvantages**
  - Best compromise neutral for reversible machines. Best for motors that could run either rotation.
AC Neutral

- **Procedure**
  - Connect an AC voltmeter between the shunts of brushes of adjacent arms (brushes well seated)
  - Apply 120 Volt AC to the shunt fields, connected where the DC field supply would normally connect
  - Shift the brush yoke to get minimum AC voltage on the voltmeter
Analog or Digital AC Voltmeter

Shift brushes for minimum AC Voltage

120 Volt AC

Shunt Field
AC Neutral

• **Advantages**
  - Static test
  - Little equipment required
AC Neutral

• **Advantages**
  - Static test
  - Little equipment required

• **Disadvantages**
  - Best compromise neutral for reversible machines. Not as good for single rotation machines. Really only gets you in the ball park for large machines with pole face windings.
Speed Reversibility

- **Procedure**
  - Apply known DC field **current**
  - Apply known DC armature **voltage**
  - Measure rotational speed (RPM)
  - Keep field **current** the same, but reverse the armature **voltage** polarity and measure RPM
  - Shift brush yoke as required to equalize speed in both directions within 1%
Set $I_f$, Set $V_A$, Measure RPM. Reverse Polarity of $V_A$. Measure RPM. Shift until RPMs agree within 1%.
Speed Reversibility

• Advantages
  – Good technique for reversible machines
  – Armature supply does not need to supply very much current
Speed Reversibility

- **Advantages**
  - Good technique for reversible machines
  - Armature supply does not need to supply very much current

- **Disadvantages**
  - Requires both field and armature DC supply
  - Machine must be uncoupled or able to rotate unloaded or with controlled load
  - Best compromise neutral for reversible machines. Best for motors that could run either rotation.
DC Current In Armature Circuit

- **Procedure**
  - Apply DC current through armature and commutation fields only
  - If on neutral, machine will not rotate. If off neutral, machine will rotate in one direction or the other depending on which way it is off neutral
  - Shift brush yoke as required so motor does not rotate

- **Warning** - Do not use this method on series motors as they will over-speed!!
Armature Will Not Turn on Neutral

DC Voltmeter

I_A

Comm Field

DC Power Supply

A1

A2

V_A
DC Current In Armature Circuit (Shunt Machines Only)

- **Advantages**
  - Only armature supply is required
DC Current In Armature Circuit (Shunt Machines Only)

- **Advantages**
  - Only armature supply is required

- **Disadvantages**
  - Limited to smaller anti-friction bearing machines
  - Limited to shunt machines (series or compound machines will over-speed)
  - Best compromise neutral for reversible machines. Best for motors that could run either rotation.
Pencil Volt Neutral

• **Procedure**
  – Place special template on the commutator
  – Run machine at 100 Volts, no load
  – Measure voltage through holes in the template with a special probe
  – Plot readings on graph paper and adjust yoke accordingly
PVN Template
PVN Test Points
PVN → Anchoring Point
PVN Voltmeter
Pencil Volt Neutral

- Voltmeter
- Pencil Probe
- Brush Stud
- Brush Box
- Template
- Rotation
Warning!!

Working around rotating electrical machinery can cause serious or fatal injury due to electrical shock hazards or contact with rotating parts. Contact the manufacturer’s service engineers for performing adjustments on electrical motors and generators. These people have the necessary training and information available to properly adjusting DC machines.
**Pencil Volt Neutral**

836 KW Generator  
Taken at 100 volts - No Load

<table>
<thead>
<tr>
<th>Lead Voltage</th>
<th>Hole No.</th>
<th>Trail Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.9</td>
<td>4</td>
<td>16.4</td>
</tr>
<tr>
<td>21.5</td>
<td>5</td>
<td>17.9</td>
</tr>
<tr>
<td>23.3</td>
<td>6</td>
<td>19.6</td>
</tr>
<tr>
<td>25.0</td>
<td>7</td>
<td>21.3</td>
</tr>
<tr>
<td>26.8</td>
<td>8</td>
<td>23.0</td>
</tr>
</tbody>
</table>

**Note:** Lead Volts Higher Than Trail Volts For Single Rotation Machine. For a Reversible Machine, Lead Volts Equals Trail Volts.
Neutral Adjustments

**Generator**
- To **lower** trail volts
  shift brush rigging
  against rotation

- To **raise** trail volts
  shift brush rigging
  with rotation

**Motor**
- To **raise** trail volts
  shift brush rigging
  against rotation

- To **lower** trail volts
  shift brush rigging
  with rotation
Pencil Volt Neutral

• **Advantages**
  - Repeatable, accurate way to set neutral
  - Can adjust single rotation machines
Pencil Volt Neutral

• **Advantages**
  – Repeatable, accurate way to set neutral
  – Can adjust single rotation machines

• **Disadvantages**
  – Requires working closely with energized rotating machinery
  – Motors must be mechanically uncoupled or able to operate with little load
Other Methods Of Setting Neutral

There are other methods of setting neutral. It is important that neutral be set by some method as commutation or motor or generator performance may suffer.
Using Static Neutral Setting
Methods for Single Rotation Machines

From experience, excavator generators can be shifted about ½ bar against rotation from symmetrical neutral to approximate black band or pencil Volt neutral.
Adjusting Commutating Field (Interpole) Strength

Adjusting comm field strength in the field is difficult to impossible.

The machine voltage, speed and load must be controlled, which is usually impossible, and some of the methods available, such as brush potential measurements, have safety issues.
Adjusting Commutating Field (Interpole) Strength

Some manufacturers (GE) use non-magnetic interpole bolts. These can be the same size as main pole bolts. Do Not mix these up. Look at bolt head markings. Magnetic bolts will have 3 (grade 5) or 6 (grade 8) radial marks.

The order of the shims is also important, make sure to put them back like you found them! Best to put tape around the whole “shim pack” and mark similar to:

4 o’clock pole this side toward frame ID
Properly adjusting DC machines not only affects commutation, but also machine performance and loop balance.
Properly maintained, the electrical equipment used in mining machinery can perform well for many, many years.
And it will not end up like this pair!!