

Dynamic Testing of DC Motors with MCEGold™

Note 0703

Description

The EMAX tester provides the user with a variety of tests for qualitative and quantitative analysis while the motor is running: Armature and Field Power tests, DC Current Analysis, DC In-Rush/Start-Up tests, and Drive Input Tests. For DC motors the primary interest is the condition of the ground wall and turn insulation systems of the armature and field and the health of the DC drive supplying power to the motor. The overlapping time domain of the current entering and exiting the field or armature allows leakage current to be qualitatively and quantitatively identified and trended. Modulating time domain signals at the DC pole-pass frequency (Fp) indicate lost turns in the armature circuit due to a shorted commutator, riser, or armature coils. This time domain can be transformed to the frequency domain and the DC Fp can be identified and trended for amplitude changes.

The *DC In-Rush/Start-Up* test provides the following:

- RMS enveloped current signal for a specified period of time.

The *Armature and Field Power* tests provide the following:

- Time Domain of Voltage
- Time Domain of Current
- Harmonics evaluation to the 50th harmonic

The Time Domains of voltage and current are captured simultaneously at a sampling rate of over 12 kHz. VFD anomalies, and armature and field winding anomalies can be seen through overlaying graphs and spectral analysis. Power tests are also performed upstream of the drive for a more detailed analysis of the DC drive.

The *Armature Current Analysis* test provides the following:

- Armature Current Time Domain
- High Resolution Armature Current Spectrum

The Armature Current Time Domain allows for a longer evaluation of the Armature signal for VFD and Armature winding anomalies. The High Resolution Armature Current Spectrum allows for tracking the amplitude variations of the DC Fp.

Procedure

Armature Testing

- Zero the current probes DC offset
- Connect EMAX current test lead 1 to A1 with the arrow pointing in the direction of current flow to the motor
- Connect EMAX current test lead 2 to A2 with the arrow pointing in the direction of current flow away from the motor.
- Connect EMAX voltage test lead 1 (black) to A1
- Connect EMAX voltage test lead 2 (blue) to A2
- Connect EMAX voltage test lead 4 (green) to ground
- Select the armature tab in the test selection window
- Run the desired EMAX tests and save data

Field Testing

CAUTION! Field lead terminals are often in close proximity of each other. Extreme caution should be given to connecting voltage leads to prevent shorting between the field leads.

- Zero the current probes DC offset
- Connect EMAX current test lead 1 to F1 with arrow pointing in the direction of current flow to the motor

- Connect EMAX current test lead 2 to F2 with the arrow pointing in the direction of current flow away from the motor
- Connect EMAX voltage test lead 1 (black) to F1
- Connect EMAX voltage test lead 2 (blue) to F2
- Connect EMAX voltage test lead 4 (green) to ground
- Select the field tab in the test selection window
- Run the desired EMAX tests and save data

Data Analysis

Figure 1 shows the initial in-rush transient current, after applying the initial voltage to the motor.

RMS current is calculated and plotted 60 times per second. The current rises until the armature starts to rotate, at which time CEMF acts to limit the current.

The drive continues to automatically increase the armature voltage and the motor accelerates to full speed. We see the current drop as the motor approaches full speed. Any deviations from a start-up as compared to a baseline or previous test would elevate the condition status.

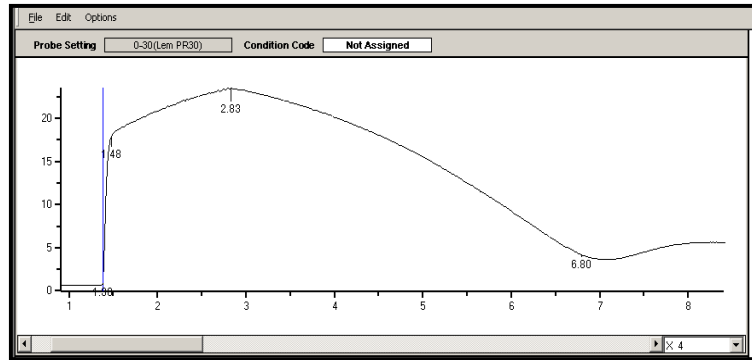


Figure 1: DC Motor In-Rush/Start-Up

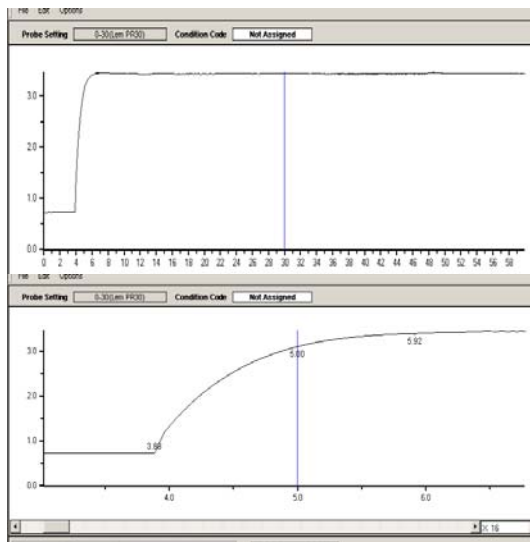


Figure 2: Amps vs. Seconds - Energizing the Field Circuit

The DC Power Test utilizes one current clamp on each of A1 and A2; plus voltage leads on A1 and A2. Per channel sampling rate is 12,288 samples/second; fast enough to capture detailed current and voltage waveforms. Each cycle takes $1/60 \text{ sec} = 0.017 \text{ seconds}$. Figure 3 shows a screen width of 0.02 seconds, slightly more than one cycle; in a three-phase full wave bridge we see six SCR conductions per cycle because the current is discontinuous.

Figure 2 is an online view of energizing current to the shunt field circuit. The lower plot is an expanded view of field amps vs. seconds, during the energizing of the field. Any deviations from a start-up as compared to a baseline or previous test would elevate the condition status.

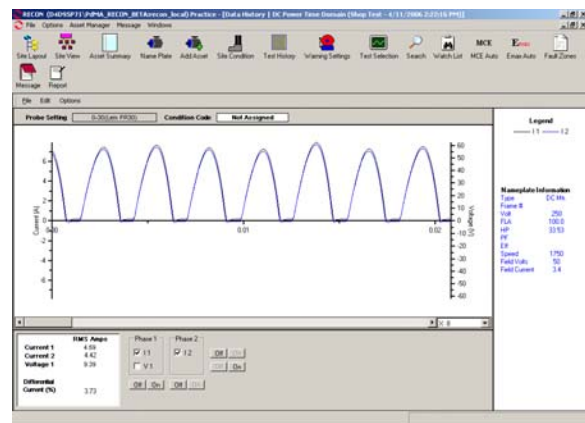


Figure 3: Full Wave Rectified DC Current

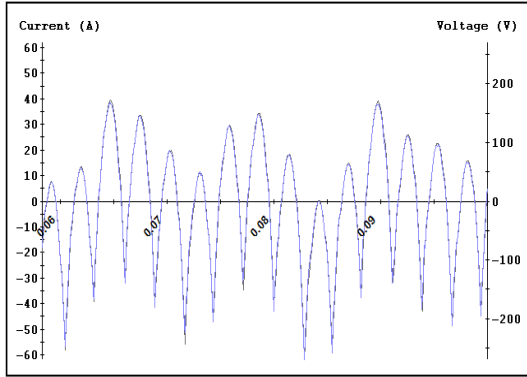


Figure 4: Full Wave Rectified DC Current

Large or developing modulations of the armature current shown in Figure 4 can indicate armature winding faults. A loss of one or more of the ripples through a cycle is indicative of a faulty firing circuit.

Detecting when the brushes are off the magnetic neutral axis can be difficult, especially if the motor is inaccessible during operation. Using voltage analysis in the time domain makes the job of properly setting the brushes for the desired load much easier. The voltage waveforms in Figure 5 appear to be clean (i.e., without noise). When the brushes are off the magnetic neutral axis, the voltage waveforms in the time domain have a lot of hash as shown in Figure 6.

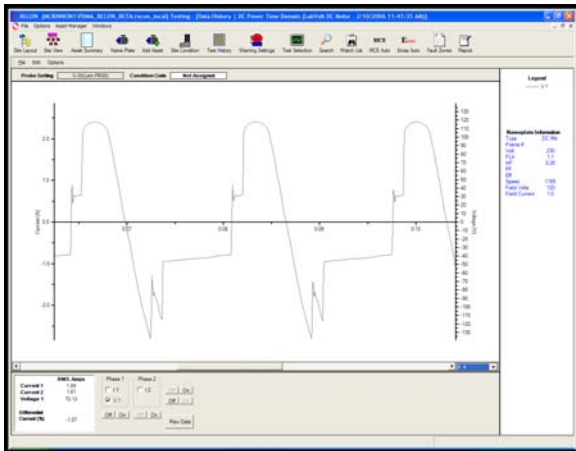


Figure 5: Brushes Precisely on Magnetic Neutral

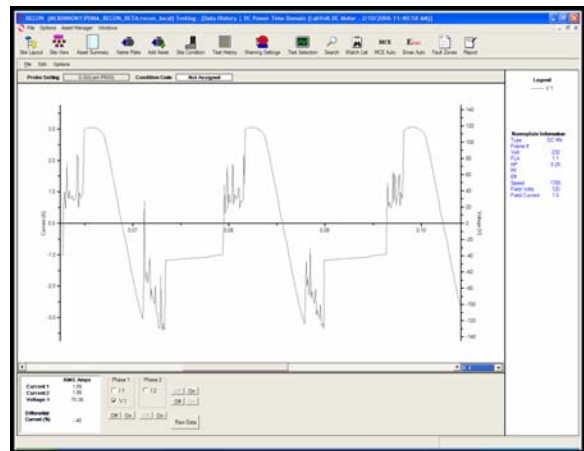


Figure 6: Brushes Off Magnetic Neutral Axis

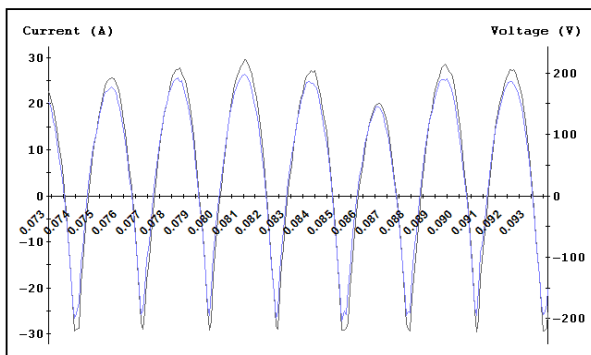


Figure 7: Differential Armature Current

Figure 7 shows a differential current between armature current A1 and A2. Differential current values in excess of 5% may warrant a shutdown insulation test to identify any possible ground leakage. Some capacitive current loss is expected and trending the differential current values will be a better indication of degrading ground insulation quality than a single test. Off-line MCE verification of resistance to ground is critical to confirm insulation condition.