P10511: Miniaturization of Xerography

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Zaw Htoo (ISE)
**Project Description**

- The scope of P10511 is to create a test fixture that will allow the use of various charging devices along with multiple diameters of photoreceptors.

- Test affect of charge uniformity with various device configurations and input parameters.

- Xerox test fixture is currently limited in versatility.
Project Description (cont.)

• Reasons for Reducing Drum Diameter
  ➢ Advances in Charging Technologies
  ➢ Reducing Wear Rate of Photoreceptor
  ➢ Higher Rotational Speeds for Higher PPM
  ➢ Reduced Footprint for Charging Devices
  ➢ Cost Effective
  ➢ Increased Reliability
Risk Assessment

- Difficult to apply/isolate ground to photoresistor
- Deflection occurs on motor mounts due to weight
- Faulty test fixture
- Inaccurate range of voltage uniformity
- Inaccurate motor speed differs from output speed
- Photoreceptor misses flange on endcaps
- Tight time constraint
- Human error in calculation
- Lack of Labview skillset
- Not enough budget
- Photoreceptor slips on endcaps
- Team member illness/absent
- Unsafe fixture
Risk Assessment

• Risks have been reviewed since Systems Design Review

• Modifications
  – Causes and effects added on initial risks
  – Lead time risk has reduced in severity
    • No parts have significant lead time
  – Added more risks after further design development
Risk Assessment

• Faulty Equipment (Importance: 4)
  – Obtained locker to protect parts
  – Will add subcomponent tests to Test Plan

• ESV/Erase/Charger Gap Alignment (Importance: 6)
  – Incorporate fully adjustable gap in design
  – Feeler gauges part of Test Plan

• Difficult to Operate (Importance: 4)
  – Step by step test plan for test fixture operation

• Subcomponents incompatibility (Importance: 4)
  – Review component interfaces
  – Assembly drawings to make sure they will be compatible
Risk Assessment

• Hard to change components (Importance: 6)
  – Step by step test plan for user to assemble/disassemble components
  – Finger screws for charger mount components

• Difficult to isolate ground (Importance: 6)
  – Endcap is made of plastic material
  – Graphite brush

• Deflection of motor mounts (Importance: 4)
  – Deflection analysis
  – Motor cradle implemented to support heavy PR motor

• Unit conversion error (Importance: 6)
  – Photoreceptor length and diameter in mm
  – Purchased parts and designed components in English units
  – Take multiple measurements in assembly
  – Assembly drawing and measurements given for feasibility
Assembly: Iso View
Jig Plate

• Plate size: 24” x 12”.

• Jig Plate datum point around center (shown in drawing).

• ½” thickness for good screw mounting depth.

• Screw lengths are 3/8”.
  – Brackets are 0.104” thickness
  – Results in 0.271” mount depth
Assembly: Top View
Charger Subassembly
Charger Mounting Design

• Benefits
  – Stability of charger
  – Variable for:
    • Tangency with photoreceptor
    • Photoreceptor diameters
    • Charger variation

• Tradeoffs
  – BCR charger requires touch condition
    • Charger sliding toward photoreceptor is limited
    • Depending on charger, depth is limited
      – 30mm PR; 1.41 inch gap
      – 40mm PR; 1.21 inch gap
      – 60mm PR; 0.81 inch gap
      – 84mm PR; 0.35 inch gap
Charger Bracket Analysis

• Mounting bracket has a range of motion of 3 inches
  – Difference in max/min photoreceptor radii:
    • $(42\text{mm} - 15\text{mm}) = 27\text{mm} \ (1.063\text{in})$
    – The other 2 inches of freedom is for charger variation and gap distance

• Mounting bracket is aligned with PR endcaps so charger will have no interference (reference assembly drawing).

• Spacing of the brackets
  – $360\text{mm} - (2\times2\text{mm}) = 356\text{mm} \ (14.0157\text{in})$
Photoreceptor Shaft and Endcaps
Photoreceptor Shaft

• Purchased shaft: 1/2” diameter, 36” long
  – Cut to 18” long
  – Add key for endcap drive
  – Add c-clip groove
Photoreceptor Shaft Mounting Bracket

• PR shaft centerline is 4.9213” (125mm) from ground plane.

• PR shaft bearing is 1/4” thick, shaft mount plate designed to be flush on both sides.

• Bearing load capacity of 1000lb. carries photoreceptor cantilever weight easily.
Photoreceptor Shaft Analysis

Determine masses

- mass, PR = 377.89g
- mass, shaft = 416.76g
- mass, endcap = 43.28g

\[ \delta_{\text{max}} = \frac{1}{3El} \sum (Fl^3) \]

\[ \delta_{\text{max}} = 0.01978 \text{ mm} \]

½” photoreceptor shaft is feasible design
Photoreceptor Spring Analysis

\[ F = k \times x \]

Compressed length = 1.22 in  
Uncompressed length = 2.00 in  
k = 19.58 lb/in  
\[ F = 19.58 \text{ lb/in} \times 0.78 \text{ in} = 15.27 \text{ lb} \]

\[ F_{\text{friction}} = F \times \mu \]

\[ F = 15.27 \text{ lb} \]
\[ \mu = 0.4 \]
\[ F_{\text{friction}} = 15.27 \times 0.4 = 6.11 \text{ lb} \]
Motor Dimensions for Analysis

ESV Unit Drive: S57-51

- Shaft Dia: 0.2500 (6.35) mm
- Shaft Dia: 0.2495 (6.43) mm

Photoreceptor Drive: S83-93

- Shaft Dia: 0.3750 (9.52) mm
- Shaft Dia: 0.3745 (9.51) mm

Model | A
------|----
S57-51, SX57-51, SXF57-51 | 2.0 (50.23)

Model | A
------|----
S83-93, SX83-93, SXF83-93 | 3.7 (93.98)
Photoreceptor Shaft Coupling

• Machinable bore shaft coupling
  – Bore A = ½” (PR shaft diameter)
  – Bore B = 0.235”, will be machined to 0.375” (motor shaft diameter)
Erase Subassembly
ESV is secured onto an internally grooved collar to fit a threaded cylinder.

NOTE: METALLIC CONTACTS ARE GREASED TO REDUCE FRICTION DURING OPERATION.
Motor Mount and Cradle Analysis

- ESV motor centerline height is 1.3”
  - Matches current ESV lead screw height

- PR motor centerline height is 4.921” (125mm)
  - Concentric with shaft height

- PR motor cradle feasibility:
  - Spacing from motor mount to cradle is 3.1”
    - ESV motor length + rear shaft length:
      - 2” + 0.83” = 2.83”
      - No interference with ESV motor
      - PR motor body length = 3.7”
      - Cradle is spaced to support PR motor
Material Selection

• ¼” Aluminum Plate: 12” x 12” (Qty. 2)
  – Motor Mount: 8” x 7”
  – PR Shaft Mount: 4.25”x 5.92”
  – Erase Mount (x2): 1.59” x 4.98”

• ½” Aluminum Plate: 12” x 12” (Qty. 1)
  – Charger Bracket (x2): 5.545” x 4”
  – PR Motor Cradle: 3.55” x 2”
Material Selection

• Aluminum Bar: 36” x 1.5” x 0.5” (Qty. 1)
  – Charger Mount: 14.0157” x 1.25” x 0.42”
  – Charger Support Beam: 15.0157” x 0.5” x 0.5”
High-Voltage Supplies

• Outputs:
  – Coronode: 5-8kV (constant current)
  – Grid: -300 to -800V (constant voltage)
  – Substrate: 0 to -800V (swept to specified value)
Motor Controller

• Two 68-Pin Connectors
  – Digital I/O for driving Voltage Supplies
  – Motion I/O to Motor Drive
  – Provides DAQ functionality

• PCI connection

• Requires Driver Software: NI Motion
Motor Drive

• Connects to 68-pin Motion I/O connector on the Controller via an internally-mapped cable
• Default setting of 10 microsteps/step (2000 steps/rev for a 1.8° resolution motor)
• Motor connections are wired in parallel for higher speed, lower torque
Stepper Motors

• S83-93 for Photoreceptor Drive
  – Continuous spinning requires Limits disabled
• S57-51 for ESV Drive
  – Limits will confine ESV to cover the range of a P/R length
• 200 steps/rev (1.8° resolution)
System Flow
System Flow In Detail

EE & ISE System Flow
by Tony Zhang & Zaw Htoo

Inputs
- Length of Device
- P/R Diameter
- P/R Motor Speed
- V plate
- Uniformity / I-V Slope
- Output / Report

Outputs
- P/R potential
- I plate
- Voltage Uniformity Range
- Slope of Voltage across P/R
- V intercept
- Slope of I/V plot

System Flow Components:
- Voltage Supply (to Plate)
- Voltage Supply (to Shield)
- Current Supply (to Coronode)
- Motor Currents
- S-Drive
- Step Pulses
- Charger (BCR/Scorotron)
- P/R Motor (S57-51)
- ESV Motor (S83-93)
- AI Sub. or Finished P/R
- Fixture
- Computer
- 2-Axis Motor Controller (PCI)
- LabView
- Microsoft Excel
- DAQ
EE Wiring Schematic
Need for an Easy Interface

• Running the System
  – User will have a set of inputs
    • PR Diameter
    • Test Type
  – Easily usable interface
    • Outputs section by test type
    • Inputs $\rightarrow$ Outputs; Left $\rightarrow$ Right

• Stopping the system
  – Stop: The ESV will stop immediately and return Home.
User Interface
Diagram of ESV Resolution

1. Input of how many readings per length

2. Input of how many readings per rotation
System Flow Diagram

Type of Test

- Uniformity
  - Take Input
  - Run the System
  - Set motors’ speed
  - Set ESV Reading Rate
  - Acquire Data
  - Compute Results
  - Display & Export Results

- I-V Slope
  - Take Additional Input
  - Run the System
  - Apply Grid Voltage & Coronode Current
  - Apply V-Plate Voltage Incrementally
  - Acquire Data
  - Compute Results
  - Display & Export Results
# LabView Calculation Formula

## PR Motor Revolution

<table>
<thead>
<tr>
<th>Input</th>
<th>Original Unit</th>
<th>Conversion</th>
<th>Conversion</th>
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<tbody>
<tr>
<td>Speed of PR</td>
<td>meter/sec</td>
<td></td>
<td>Motor Revolution ((\text{Speed} / \text{Circumference}))</td>
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<tr>
<td>Diameter of PR</td>
<td>mm</td>
<td>Circumference ((\pi \times D))</td>
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P/R length = 360mm  
ESV Lead Screw thread width = 1.27 mm

## ESV Motor Revolution

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<tr>
<th>Inputs</th>
<th>Original Unit</th>
<th>Conversion</th>
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<tbody>
<tr>
<td>PR Revolution</td>
<td>rotation / sec</td>
<td>Time per rotation ((1/\text{PR Revolution}))</td>
<td>Time between readings ((\text{Time per PR rotation} / \text{ESV Resolution}))</td>
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<tr>
<td>ESV Resolution</td>
<td>reading/PR rotation</td>
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<td>The time ESV has to Travel Across PR ((\text{Reading per length} \times \text{Time between readings}))</td>
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<td>ESV Reading per length</td>
<td>reading / mm</td>
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<td>ESV Speed in (\text{mm/s} \ (360\text{mm} / \text{The time ESV has to Travel Across P/R}))</td>
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<td></td>
<td>ESV Rotation/Sec ((\text{ESV Speed/thread width}))</td>
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LabVIEW Block (Uniformity)
# Uniformity Result Summary (Excel)

Test Date:  
Test Time:  

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<tr>
<th>INPUT</th>
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<th>Readings</th>
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<td>Speed of P/R</td>
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<th>Final Result</th>
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<td>Range of Uniformity</td>
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<td>Slope of Voltage Vs Length</td>
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LabVIEW Block (I-V Slope)
# I-V Slope Result Summary (Excel)

**Test Date:**

**Test Time:**

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<tr>
<th>INPUT</th>
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<th>Voltage</th>
<th>Current</th>
<th>Final Result</th>
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# Bill of Materials

## ME Test Fixture Components

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<td>each</td>
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<td>Graphite Brush</td>
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Subtotal $365.11

## Electrical and LabVIEW components

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<tr>
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<th>Part #</th>
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<th>Unit</th>
<th>Total Price</th>
<th>Part</th>
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Subtotal $19,687.00

Purchased Subtotal $365.11

Donated Subtotal $19,687.00

Total $20,052.11
Test Equipment Required

• Multimeter
  – Available from EE labs
  – Test Vplate at steady state

• Vernier Calipers
  – Available from machine shop
  – Measure machined part tolerances

• Gauge Blocks/Feeler Gauges
  – Increments of 0.1mm or 0.5mm
  – Gap charger from photoreceptor surface
  – Check ESV alignment

• Tachometer
  – Measure surface speed of photoreceptor
Customer Needs

- Allow any charge device config
- Easily changeable components
- Allow different dielectric thicknesses
- Voltage reading across entire drum length
- Parallel ECV axis with photoreceptor
- Easy to use data acquisition menu
- Data for both aluminum substrate and prod. PR
- Repeatability
- Uniform pre-charge erase
- Accurate drum speed control
- Proper safety measures
- Accept multiple photoreceptor diameters
- Below target budget
- Generate minimal ozone
Engineering Specifications

- Charger Gap: (1-2mm)
- Surface Charge: (-300 to -800V)
- Budget: ($2k)
- Drum Size: (30-84mm)
- Surface Speed: (≤1m/s)
- Charger Type: (BCR or Scorotron)
- Dielectric Thickness: (~25µm)
- Uniform Erase Charge: (-100V)
- ESV distance: (1-2mm)
- Coronode Current: (0-2mA)
Test Plan

- **ES1 - Charger Gap:** Gapping block on each end of charger should have a just fit condition between the charger and photoreceptor.

- **ES2 - Surface Charge:** User’s input for the grid voltage matches with the bias on a photoreceptor within ±2V.
  - Equip a test drum into the fixture
  - Input a voltage (between 0 to -800V) for the grid bias
  - Measure the voltage drop between the surface of the test drum and ground using a voltmeter and compare measured value with input bias for grid voltage.

- **ES3 – Surface speed:** User’s input for surface speed of the photoreceptor should match with the actual surface speed within 5mm/sec.
  - Input a surface speed through the LabVIEW interface
  - While photoreceptor is spinning, apply a tachometer to the surface of the photoreceptor and record the speed
  - Compare the tachometer reading with the speed input
Test Plan

- **ES4 - Budget**: Review of Bill of Materials total. Purchased and gifted costs may exceed $2,000, but purchased costs alone must remain below $2,000.

- **ES5 – Drum Size**: Use vernier calipers to measure actual outer diameter of photoreceptor.

- **ES6 – Charger Type**: Multiple chargers of each configuration should fit on the fixture.

- **ES7 – Uniform Charge Erase**: Erase lamp should deliver a -100V bias to the photoreceptor surface
  - Equip a test drum into fixture
  - Allow the photoreceptor to spin at 1m/s and shine the erase lamp onto the test drum
  - Measure the surface bias with ESV and compare to -100V
Test Plan

- **ES8 – ESV Distance**: Apply a $V_{\text{plate}}$ to the photoreceptor through the graphite brush and scan the surface charge with ESV. Desired voltage should be $\pm 5$V. Feeler gauges can be used to verify gaps if any voltage variations exist. Desired distance is 1-2mm +/- 0.5mm.

- **ES9 – Dielectric Thickness**: Thickness will be given from manufacturer.

- **ES10 – Coronode Current**: The user’s input for the coronode current matches with the actual current output of the supply.
  - Input a current value (0 to 2mA) for the coronode current supply
  - Channel the analog current output of the current supply to DAQ and measure the actual current value
  - Compare the input value with actual output of the supply

- **Testing ESV**
  - Apply a voltage to a test drum surface
  - Scan the drum surface with the ESV
  - Compare the input voltage with ESV reading and observe the level of noise in the signal.
Test Plan

• Will use a light inhibiting enclosure during actual testing.
  – Will be sized for no interference with subcomponents
Action Items

• Determine required length of ESV
  – Slide and lead screw will be shortened
  – Designed motor mount will mate with ESV slide

• Add gap between photoreceptor endcap and shaft mount
  – C-clip and retainer/spacer
Questions?