Gluing Procedure for Module Loading

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ATLAS ITK Strip Detector
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1.1 Setup

- **Dispenser**: Techcon TS5000DMP-DCX Rotary Auger Valve
- **Controller:** Techcon TS5700
- Techcon controller fired via interface with Arduino
- LabVIEW sends commands to Arduino to set voltage high/low
- Width of trigger pulses set within LabVIEW VI (150 ms)
  - $\rightarrow$ **NOTE:** Firing failures observed for 125 ms trigger pulse
- Dispenser operates based upon preset controller settings
- Cycle terminates automatically based upon controller settings

1.1 Setup - Controller

- Password: 0000 (keep locked unless modifying parameters)
- Run in *Sequential Encoder* mode
  - → *Sequential*: dispense series of unique cycles frame-by-frame
  - → *Encoder*: dispense duration set by encoder motor steps (N)
- First dispense sequence corresponds to purge process
  - → **NOTE:** Controller should be reset before running to ensure the dispense sequence begins at the first frame

1.2 Mixing

For loading one module ...

1. Before combining, thoroughly mix the individual components of SE4445 in respective containment vessels
2. Measure 3.5g of each SE4445 component (7g total) and thoroughly mix together until no separation is visible
3. Degas the mixture in the vacuum chamber for several minutes until the visible air bubbles disappear
4. Carefully pour the mixture along the inner wall of a syringe (PN 7012074) with a reusable dummy tip to prevent leakage
5. Insert a stopper (PN 7012170) and lower it to the glue level

1.3 Program

1. Place Kapton spacers onto the stave with the stencil using the assembly frame and HV tab for alignment
2. Execute *GlueRepeatedLinePattern.vi* from within module loading program at the location of the module to be loaded
3. Install a new 6-pitch feed path and tip (PN 7018107)
4. Manually lower the dispenser on the stage arm
5. Using the glue program calibrate the height of dispenser ($\approx 1 - 1.5$ mm) above the gluing surface
6. Remove the dummy tip and load glue syringe on the feed path
7. Connect the pressure line to the top of the glue syringe
8. Follow the prompts to automatically purge and glue
9. Manually raise the dispenser on the stage arm and dispose of entire glue pathway (syringe + feed path + tip)

1.4 Positioning

- The glue dispensing procedure relies on an accurate stave calibration (provided by *BuildThermomechanicalStave.vi*) to correctly position glue patterns onto stave
- *GlueRepeatedLinePattern.vi* reads from the virtual stave map and will move the dispenser into position over the top-left corner of the selected module
  - → **NOTE**: This relies on an accurate measurement of the camera-to-dispenser separation which is hard-coded into the glue VI. If the stage arm is modified, this must be re-measured and set within the VI.
- The user needs to manually set the height of the dispenser for each run, no changes along the lateral axes are required
- The glue procedure will proceed in the $-y$ direction of the stage (towards the user), first purging over the close edge of the stave assembly frame

1.5 Glue Pattern

- Series of repeated lines of varying offsets and lengths
- Pattern config file read by *GlueRepeatedLinePattern.vi*
- Format is shown below for Pattern9-10
  - dx, dy: relative shifts between consecutive lines in x, y
  - l: length of line (incl. direction if *flipped*)
  - t: time of stage motion
- Automatically negates dx, l every other line $(+x, -x, +x, \ldots)$

dx [mm]	dy [mm]	l [mm]	t [s]
12.05	8.1	68	6.725
-7	12.5	77	6.625
-5	12	77	6.625
-5	12	77	6.625
-5	12	77	6.625
-5	12	77	6.625
-5	12	77	6.625
-1	10	29	2.695
-23	0	-17	1.555

1.5 Glue Pattern - In Detail

For Pattern9-10, the stage will move as follows ...

1. Shift by $dx = +12.05, dy = 8.1$ mm and move $+68$ mm in $6.725s$
2. Shift by $dx = +7, dy = 12.5$ mm and move -77 mm in $6.625s$
3. Shift by $dx = -5, dy = 12$ mm and move $+77$ mm in $6.625s$
4. Shift by $dx = +5, dy = 12$ mm and move -77 mm in $6.625s$
5. Shift by $dx = -5, dy = 12$ mm and move $+77$ mm in $6.625s$
6. Shift by $dx = +5, dy = 12$ mm and move -77 mm in $6.625s$
7. Shift by $dx = -5, dy = 12$ mm and move $+77$ mm in $6.625s$
8. Shift by $dx = +1, dy = 10$ mm and move -29 mm in $2.695s$
9. Shift by $dx = -23, dy = 0$ mm and move -17 mm in $2.695s$

2.1 Definitions

- **Controller**:
  - Pressure (P): pressure supplied to glue reservoir ($0 \rightarrow 100$ psi)
  - Voltage (V): voltage supplied to auger motor ($5 \rightarrow 24V$)
  - Encoder (N): number of encoder motor steps ($\propto R$)
  - Reverse Encoder (N_R): number of reverse encoder motor steps
- **Dispenser**:
  - Rotations (R): number of auger rotations
  - Motor RPM (RPM): rotations per minute of auger
  - Encoder Fraction (ϵ): fractional rotation of auger corresponding to one step of the encoder motor
  - Dispense Rate Parameters (α, β): linear fit parameters of dispense rate versus voltage under a constant pressure

2.1 Equations

- **Motor RPM**:

  $$RPM(V) = 15.1 \times V - 1.4$$

- **Encoder Fraction**:

  $$R(N) = \epsilon N \;\rightarrow\; \epsilon = R/N \text{ (constant)}$$

- **Dispense Time [s]**:

  $$t(R, RPM) = 60\frac{R}{RPM} \;\rightarrow\; t(N, V) = \frac{60\epsilon N}{15.1 \times V - 1.4}$$

- **Dispense Rate [g/s]**:

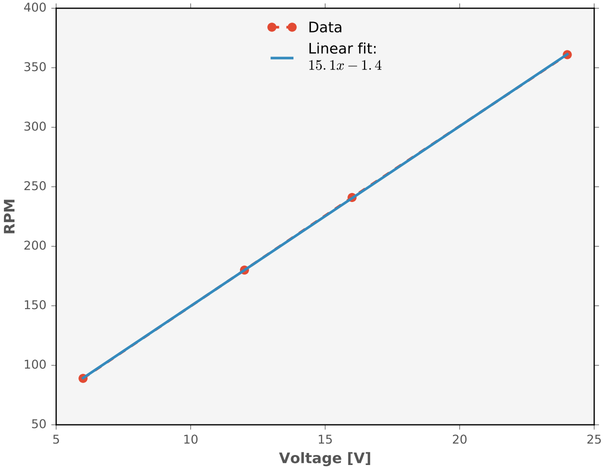
  $$r(V) = \alpha V + \beta$$

- **Dispense Amount [g]**:

  $$d(N, V) = r(V) \times t(N, V) = (\alpha V + \beta)\frac{60\epsilon N}{15.1 \times V - 1.4}$$

2.2 Motor RPM

- Provided by Techcon in specification sheet
- Linear dependence $RPM(V)$ on voltage within $5 \rightarrow 24V$



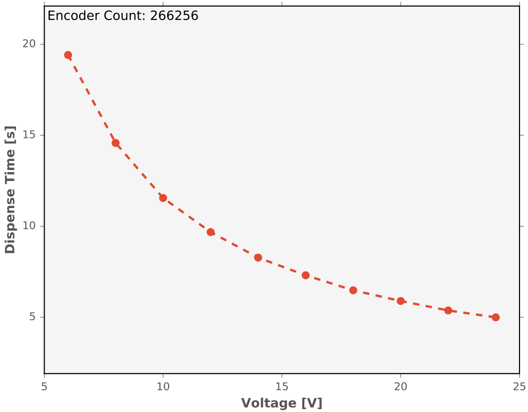
2.2 Encoder Fraction

- Encoder Mode, $N = 266256$
- Measurements conducted to determine encoder fraction (ϵ)
- Dispense time measured and averaged over 3 trials
- Motor RPM given by known equation
- Encoder fraction: $\epsilon = 1.1 \times 10^{-4}$

Encoder =	266256	Reverse =	0				
Voltage (V)		**Times (s)**		**Time (s)**	**RPM**	**Rotations**	**Encoder Fraction**
6	19.310	19.490	19.430	19.410	89.20	28.856	1.08E-04
8	14.420	14.530	14.780	14.577	119.40	29.008	1.09E-04
10	11.490	11.560	11.600	11.550	149.60	28.798	1.08E-04
12	9.620	9.750	9.660	9.677	179.80	28.998	1.09E-04
14	8.250	8.350	8.220	8.273	210.00	28.957	1.09E-04
16	7.260	7.300	7.350	7.303	240.20	29.238	1.10E-04
18	6.450	6.530	6.450	6.477	270.40	29.188	1.10E-04
20	5.830	5.920	5.920	5.890	300.60	29.509	1.11E-04
22	5.320	5.360	5.430	5.370	330.80	29.607	1.11E-04
24	4.960	5.030	4.980	4.990	361.00	30.023	1.13E-04
						Average:	1.10E-04

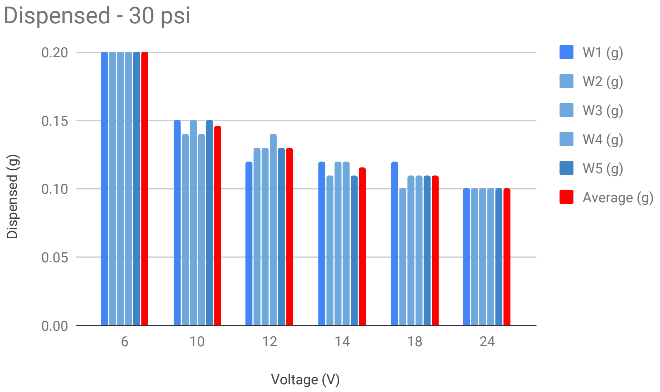
2.2 Dispense Time

- Encoder Mode, $N = 266256$
- Follows $1/V$ dependence
- $t(R, RPM) = 60\frac{R}{RPM} \rightarrow t(N, V) = \frac{60\epsilon N}{15.1\times V - 1.4}$



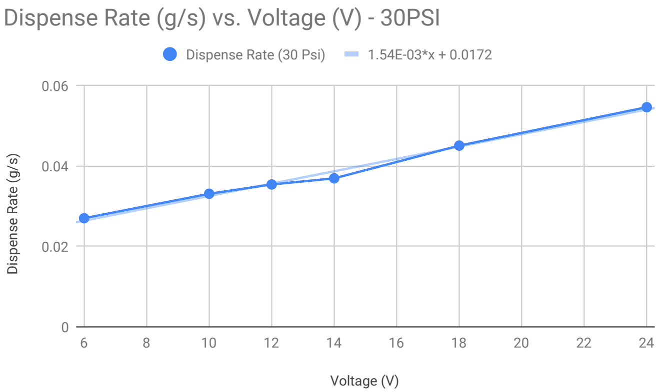
2.2 Dispense Amount - 30 psi

- Encoder Mode, $N = 100000$, 6-pitch screw
- Results of 30 psi measurements over 5 dispense trials
- Stable performance observed for pressure setting ≥ 30 psi



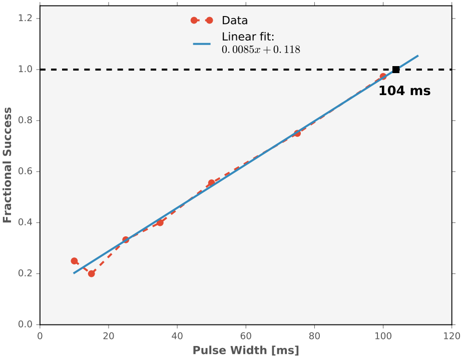
2.2 Dispense Rate - 30 psi

- Average over 5 dispense trials used for analysis
- Dispense time obtained from $t(N, V)$ using experimentally obtained value of encoder fraction (ϵ)
- Dispense rate parameters: $\alpha = 1.54 \times 10^{-3}, \beta = 0.0172$



2.2 Sampling Rate

- Firing the controller through the serial port requires supplying a high pulse ($\approx 5V$) across pins 1 and 2
- Controller will not consistently fire for fast pulses (short width)
- Fractional success of firing is linear w.r.t. pulse width
- Linear fit of data used to estimate sampling rate $\gtrapprox$ 100 ms



3.1 Dispensing

- Dispense parameters (P, V, N) are only programmable within the controller and must be set before dispense cycle
- In *Sequential* mode, each frame can have unique parameters
- Desired glue amount can be estimated using dispense equations if pressure (P) is set accordingly
  - $\rightarrow$ Dispense parameters here assume fixed pressure ($P = 30$ psi)
- Slower dispense rates yield more consistent results and reduce undesired line offsets caused by timing delays between the controller firing and the start of stage motion
  - $\rightarrow$ Faster dispense rates require faster stage motion which exacerbates the problem of undesired line offsets
  - $\rightarrow$ As such, the dispense rate is set as low as possible ($V = 5V$)
- Timing of stage motion in pattern config file must be tuned based upon dispense time (see timing section)

3.1 Dispensing - Reverse Cycle

- Reverse cycle of dispenser set by number of reverse encoder motor steps (N_R) programmable in each controller frame
- Must be set sufficiently large to prevent glue leakage from dispenser tip in-between lines
  - → **NOTE:** If too large, will increase undesired offset between lines
- Good performance found for $N_R = 7500, V = 5V$
  - → Used for all frames in Pattern9-10
- Line offsets in pattern config file (dx) fine-tuned to hide undesired line offsets caused by reverse cycle and timing delays
- Requires a pause in stage motion at the end of each line
  - → Fixed to 750 ms in *GlueRepeatedLinePattern.vi* to accommodate time of reverse cycle ($t(N_R, V)$)

3.2 Timing

- The stage motion timing sets the time it will take for the stage to move across a given line (set in pattern config file)
  - It must be greater than the estimated dispense time (based on set dispense parameters) to ensure gluing terminates just as stage reaches the end of line
  - It must also include the sampling rate of the controller as the firing time is uncertain within the window of sampling
  - An additional buffer is include to fine-tune the process which requires extensive testing to determine
- $T_{\text{Stage}} = T_{\text{Dispense}} + t_{\text{Sampling}} + t_{\text{tuning}}$
  - $\rightarrow$ T_{Dispense}: given by $t(N, V)$
  - $\rightarrow$ t_{sampling}: approximated as 125 ms
  - $\rightarrow$ t_{tuning}: fine-tuning buffer typically 550 $\rightarrow$ 750 ms

4.1 Pattern Modifications

- If only the pattern is to be modified (without adjusting dispense volume), modify the pattern config file
- Offsets (dx, dy) and lengths (l) of lines may be freely changed
- Motion times (t) should *probably* not be changed
- Supply the new pattern config file as a default input to the VI
- Test to ensure dispensing/timing performance is as expected

4.2 Dispense Modifications

- For each line in the pattern ...
  1. Do not change pressure or voltage from the default values ($P = 30$ psi, $V = 5V$) unless absolutely necessary
  2. Calculate the number of encoder steps (N) based upon the desired dispense amount using $d(N, V = 5)$
  3. Calculate the corresponding dispense time (T_{Dispense}) using the calculated value of N and $t(N, V = 5)$
  4. Estimate the stage motion time (T_{Stage}) based upon the dispense time (see timing section)
- Input the new dispense parameters in the controller (P, V, N)
- Modify the pattern config file with the new values of T_{Stage} and any changes to the pattern geometry
- Supply the new pattern config file as a default input to the VI
- Test to ensure dispensing/timing performance is as expected