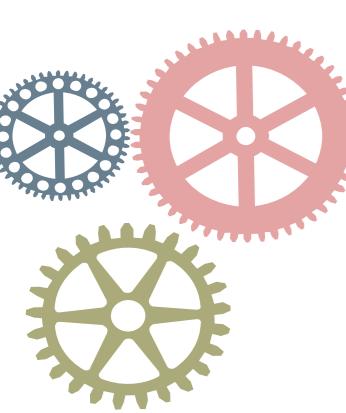
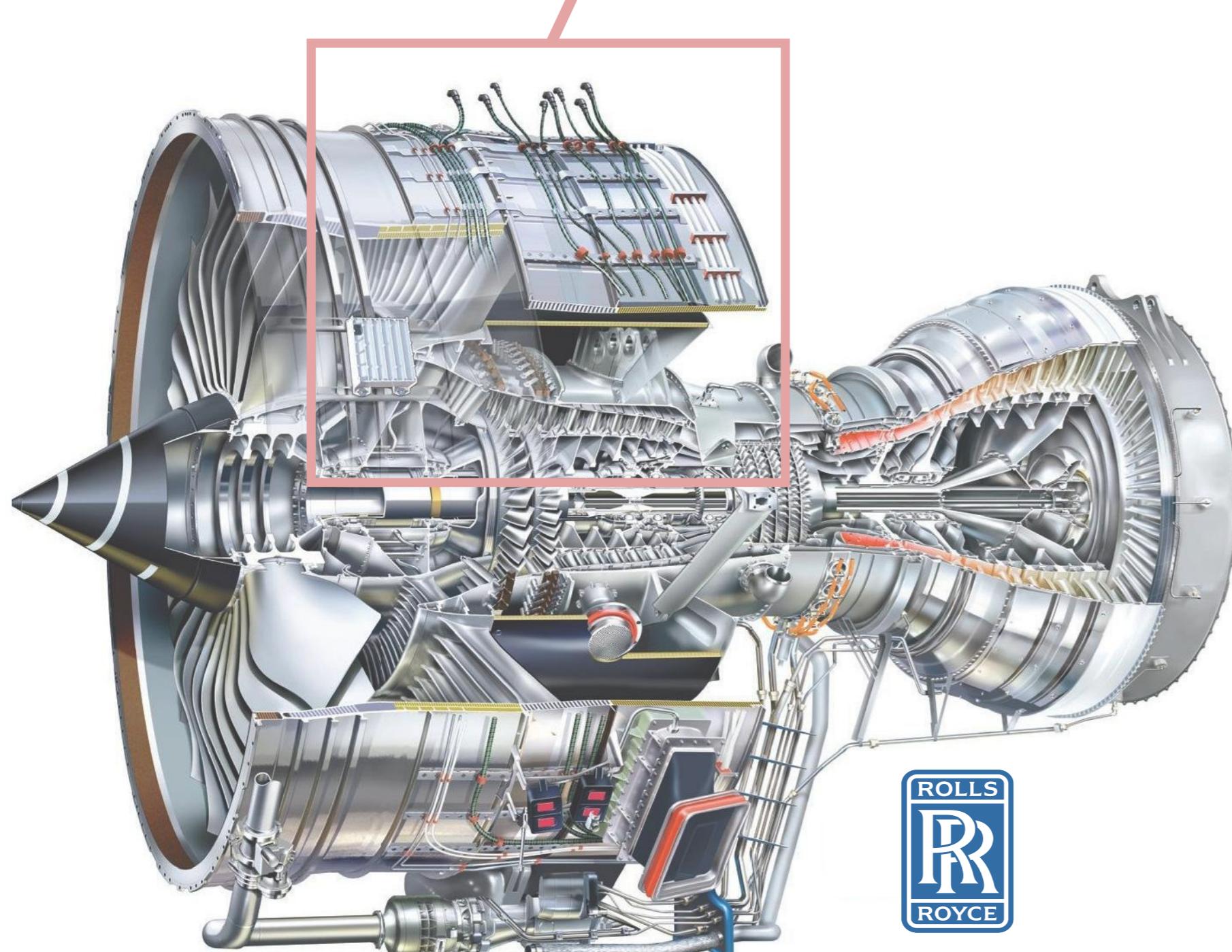
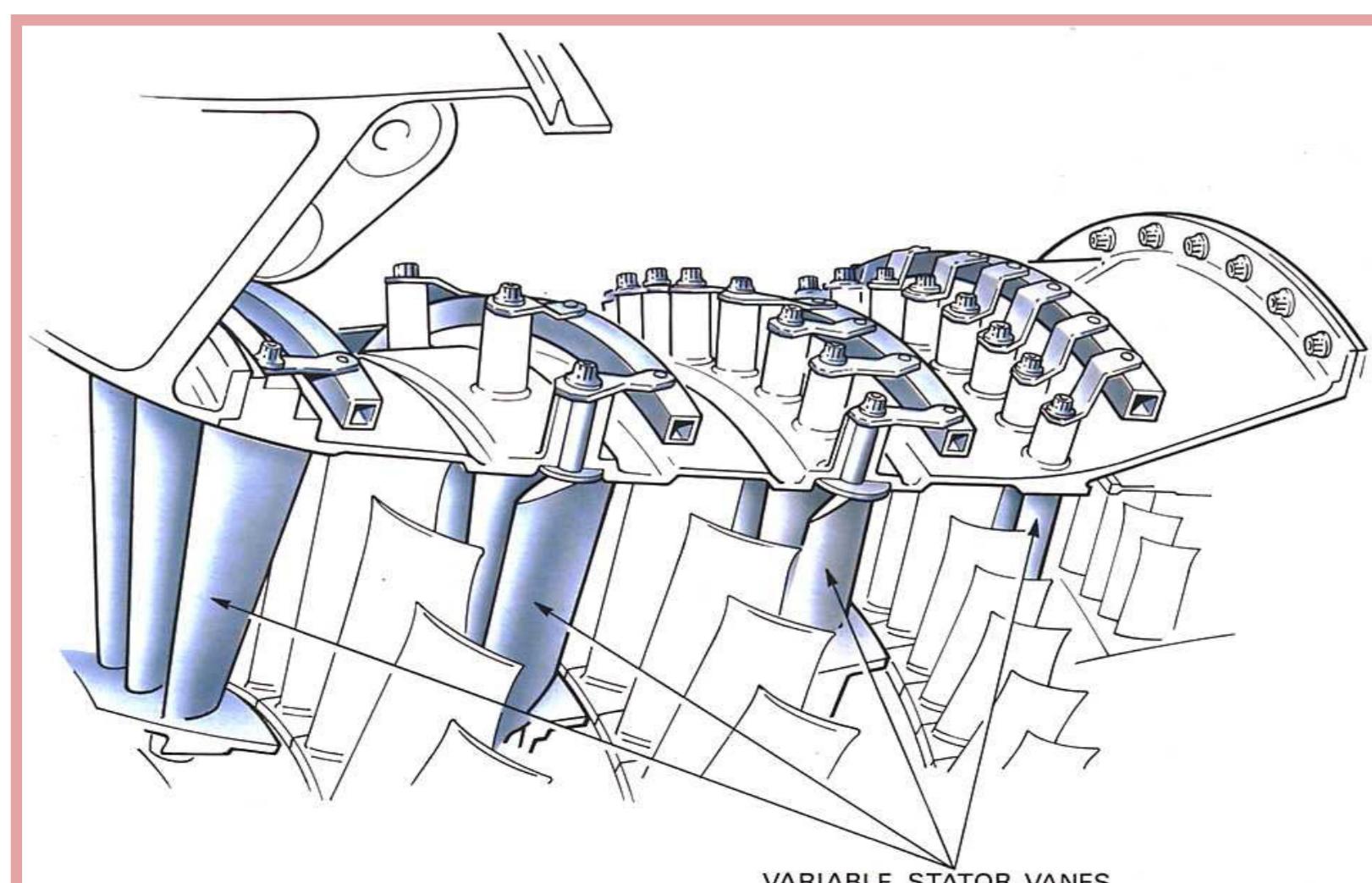


# Rolls Royce Electrical Actuator



## Variable Stator Vanes



**Variable Stator Vanes (VSV)** are blades within the compressor that can be individually rotated around their axis, as opposed to the power axis of the engine. For startup they are rotated to "closed", reducing compression, and then are rotated back into the airflow as the external conditions require.



## Motor Control

### Exponentially Weighted Moving Average (EWMA)

EWMA is type of Infinite Impulse Response (IIR) filter that applies weighting factors which decrease exponentially. The weighting for each older observation decreases exponentially, but never reaching zero. EWMA is used in order to decrease the effect of the reading noises.

$$\text{EWMA at } t: S(t); \quad \text{Reading: } X(t)$$

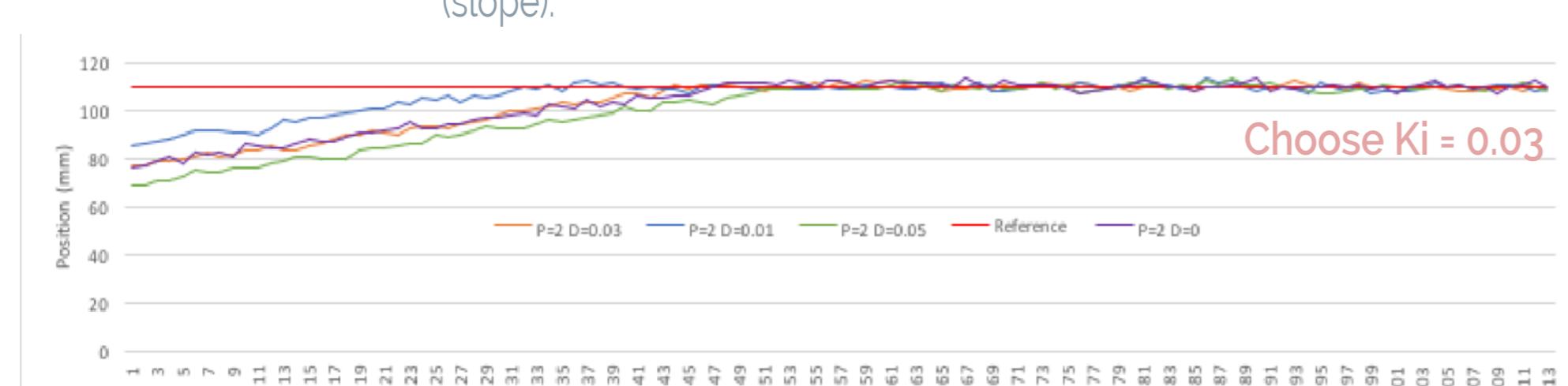
$$S(t) = 0.755 \cdot X(t) + 0.155 \cdot S(t-1) \quad \text{Alpha} = 0.755;$$

### PID Control Parameters Tuning

**Firstly: Kp Tuning** Proportional Gain should be large enough to meet speed requirement



**Secondly: Kd Tuning** Derivative Gain damping the fluctuation by taking the rate of changing (slope).



**Thirdly: Ki Tuning** Integral Gain gives the accumulated offset that should have been corrected previously. We have tuned Ki from 0.1 to 2, but it doesn't work well in our case.



## Electrical Fail-Safe Circuit

The failsafe circuit is designed for emergency power supply in case the main power supply fails. The failsafe circuits consists of capacitors to store charge and MOSFETs to switch ON/OFF parts of the circuit when necessary.

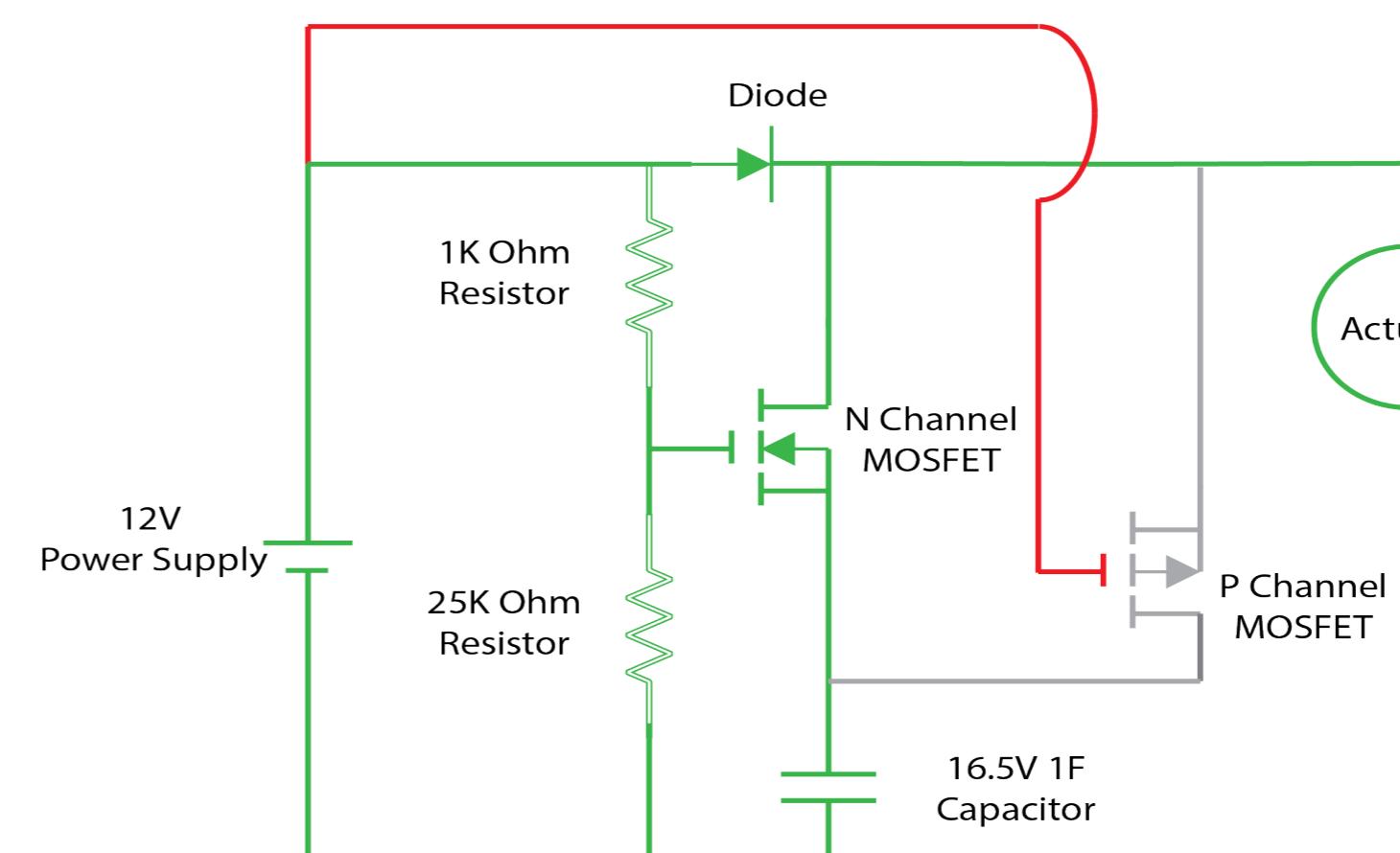


Fig. 1

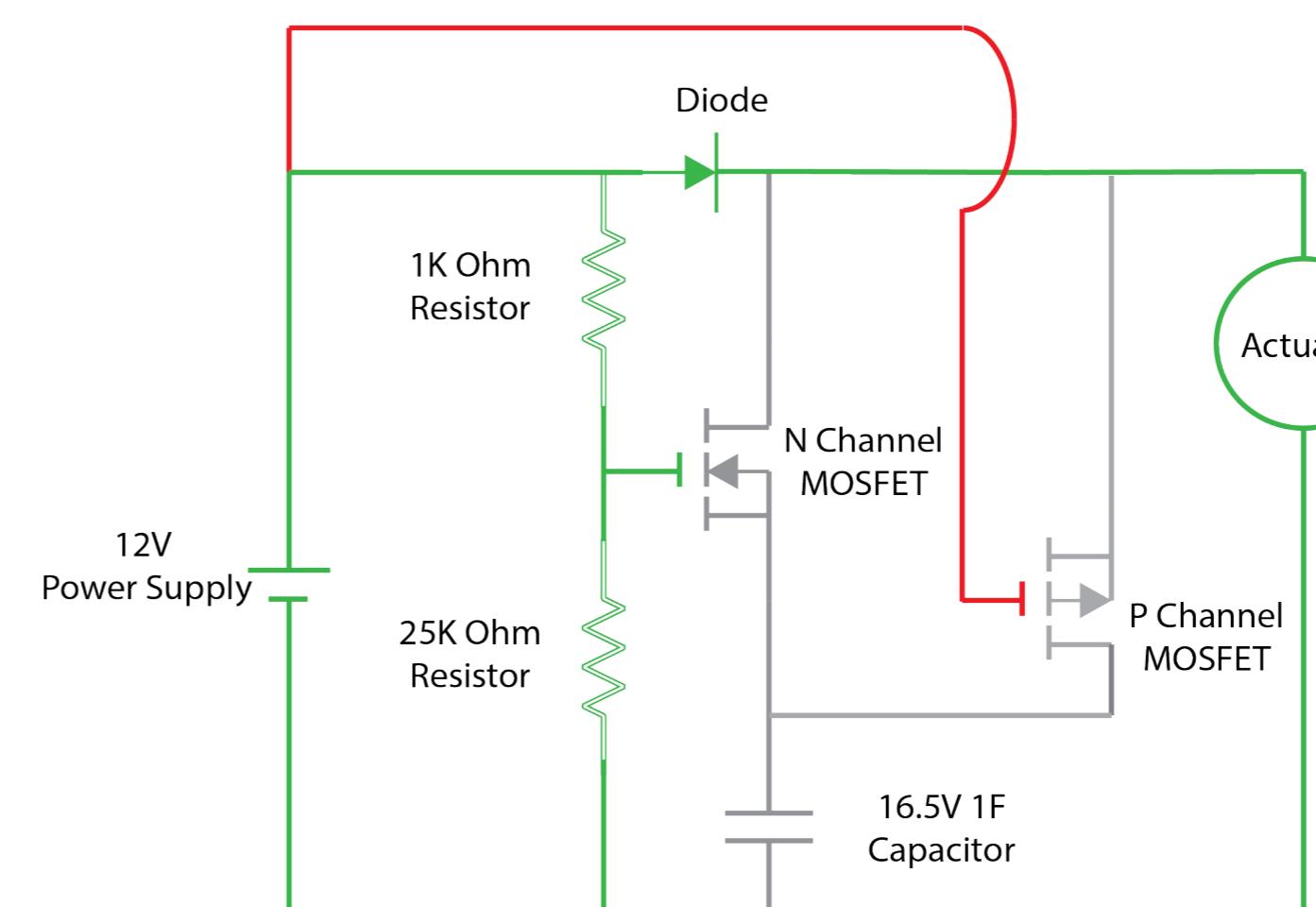


Fig. 1: When the power supply is ON the N-Channel MOSFET operates as a closed switch until the capacitor charges up to the desired voltage.

Fig. 2: When the capacitor is fully charged, the N-Channel MOSFET operates as an open switch turning OFF capacitor charging.

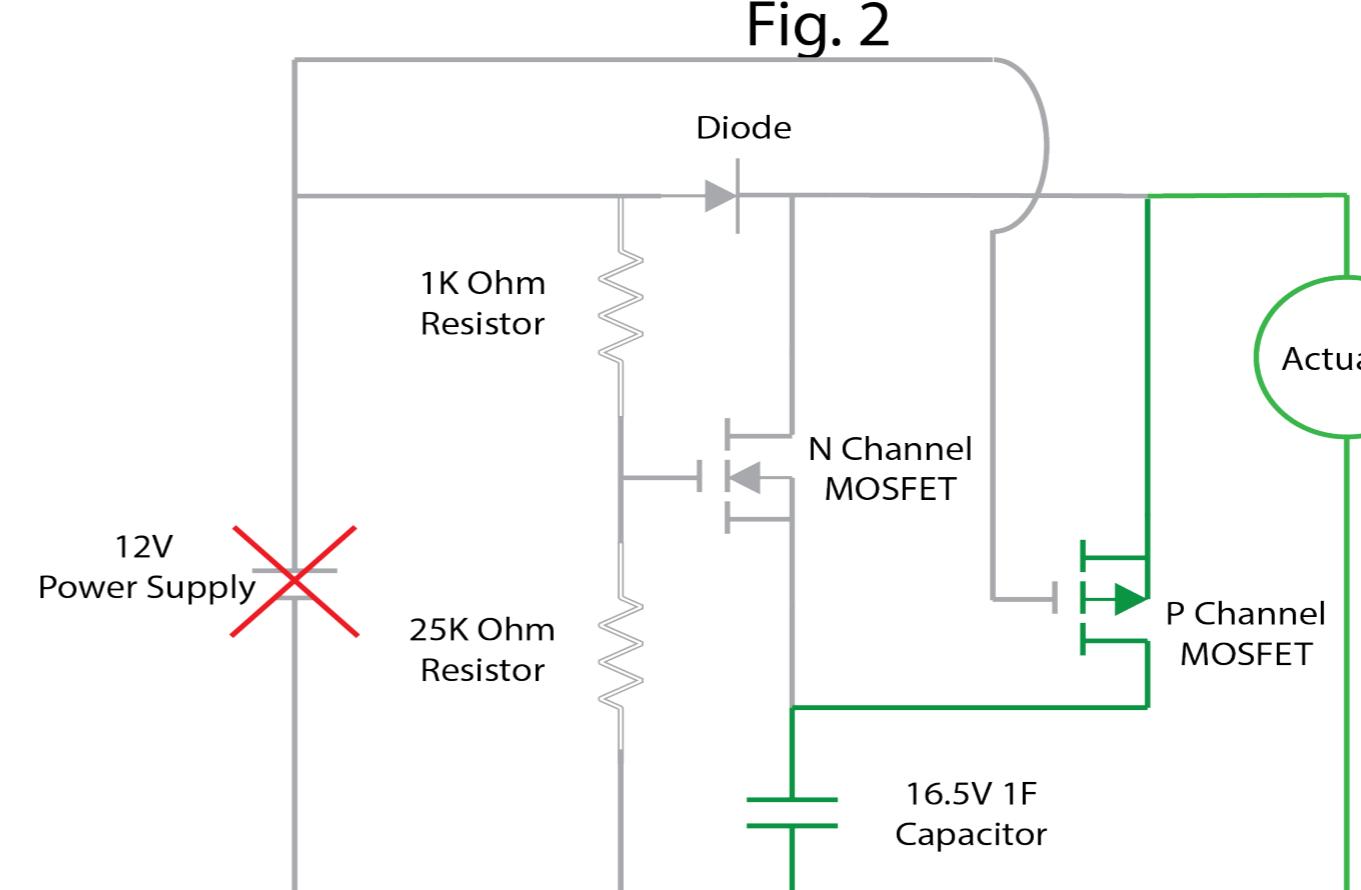


Fig. 3

Fig. 3: When the power supply fails, the P-Channel MOSFET operates as a closed switch and the capacitor discharges through the actuator.



## Test Experiment Result

### Logit Regression for Accuracy

**Model 1: All Independent Variables**

Estimate	Coefficients	Std. Error	z value	Pr(> z )
(Intercept)	2.3389683	0.852331	2.744	0.00607
Test Time	0.0048207	0.0073405	0.657	0.51136
Position	0.0009545	0.0125352	0.076	0.9393
ER	-0.7686799	0.8262362	-0.93	0.3522
Displacement	-0.0129206	0.0096878	-1.334	0.1823

All the Independent Variables: Test Time, Position, ER, Displacement are not significant.

AIC = 111.82 ; Intercept is significant at 0.01 level.

**Model 2: Intercept Only**

Coefficient = 1.69, Significant at 0.001 level

AIC = 107.54 (Less the better)

### Prediction

True	0	1	
Pred.	0	2	1
0	2	1	102
1	17	102	

Accuracy Model 1  
Threshold: 0.7  
Accuracy Level: 85.2%

True	0	1	
Pred.	0	-	-
1	19	103	
1	103		

Accuracy Model 2  
Threshold: 0.7  
Accuracy Level: 84.4%

### Logit Regression for Repeatability

**Model 1: All Independent Variables**

Estimate	Coefficients	Std. Error	z value	Pr(> z )
(Intercept)	1.11287	0.79428	1.401	0.161
Position	0.01135	0.01516	0.748	0.454
ER	-0.94796	1.07991	-0.878	0.38
RT	-0.04309	0.08217	-0.524	0.6

No significant Estimator.

AIC (Akaike information criterion) = 117.1

**Model 2: Intercept Only:**

Coefficient = 1.15, Significant at 0.001

AIC = 112.22 (Less the better)

True	0	1	
Pred.	0	-	-
1	23	74	
1	24	76	

Repeatability Model 1  
Threshold: 0.65  
Accuracy Level: 75%

Repeatability Model 2  
Threshold: 0.6  
Accuracy Level: 76%