



# IPMSG의 발전 효율 비교 및 강성 해석

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2016033836 홍석현



# MSG

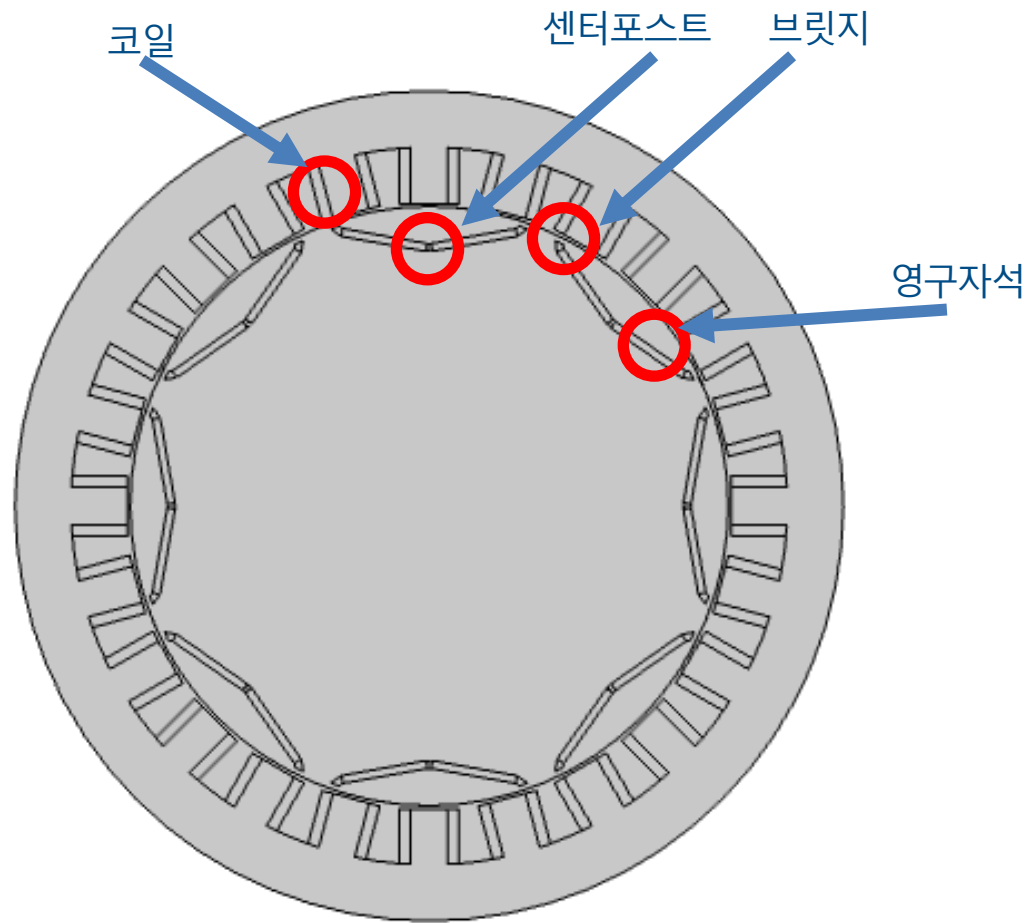
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김재현 – 고정자 코일 설계 및 강성 해석  
김남헌 – Rectifier 회로 및 SOC 효율  
홍석현 – 회전자 설계 및 전자기 해석

# Contents

- Modeling Procedure
- Analysis
- Conclusion
- Q&A

# Modeling Procedure



# Modeling Procedure

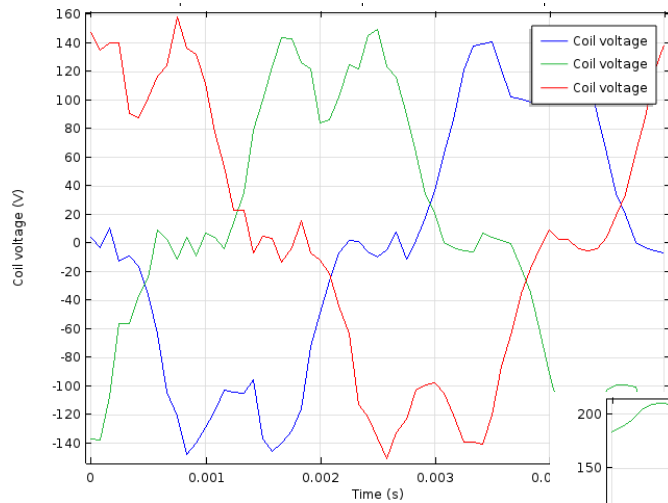
## Modeling Parameters

구분	설계변수값	구분	설계변수값
로터 반지름	80[mm]	자석 비투자율	1.05
공극 길이	0.8[mm]	턴수	231
자석 길이	46[mm]	극수	8
자석 두께	5[mm]	센터포스트 길이	1[mm]
브릿지 길이	1.5[mm]	로터 두께	184[mm]

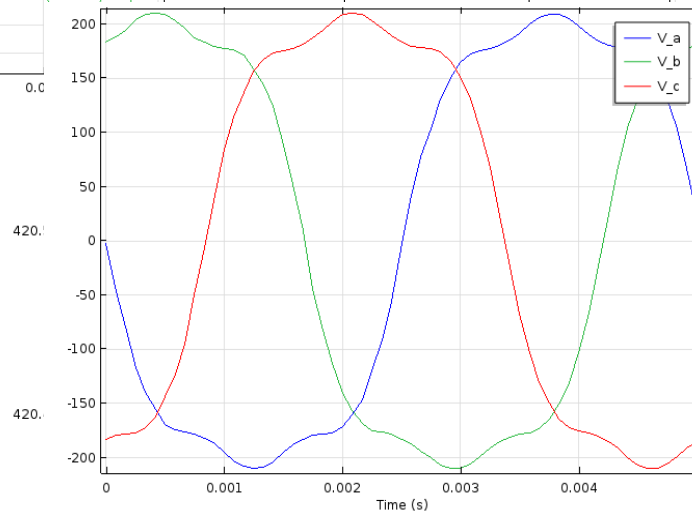
출처: 전기자동차 주행거리 확장용 매입형 영구자석 발전기 최적 설계 (서울대학교 대학원 전기·컴퓨터 공학부 임 동 국)

# Modeling Procedure

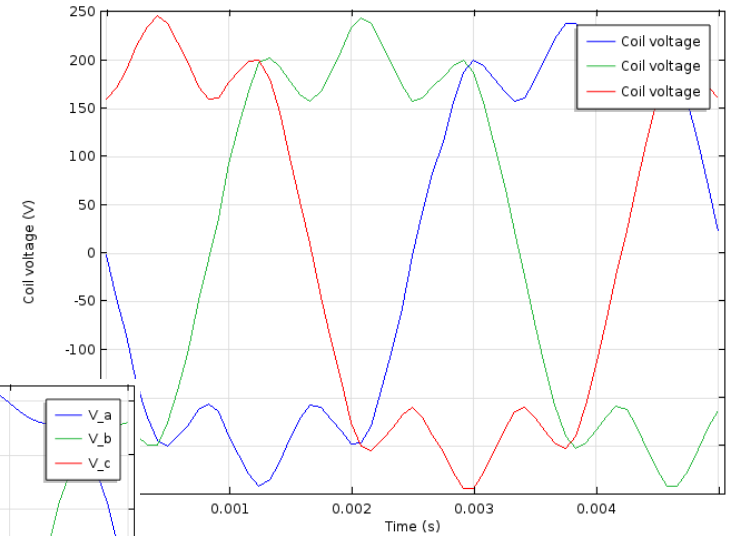
## Charging time Voltage Waveform



VER1



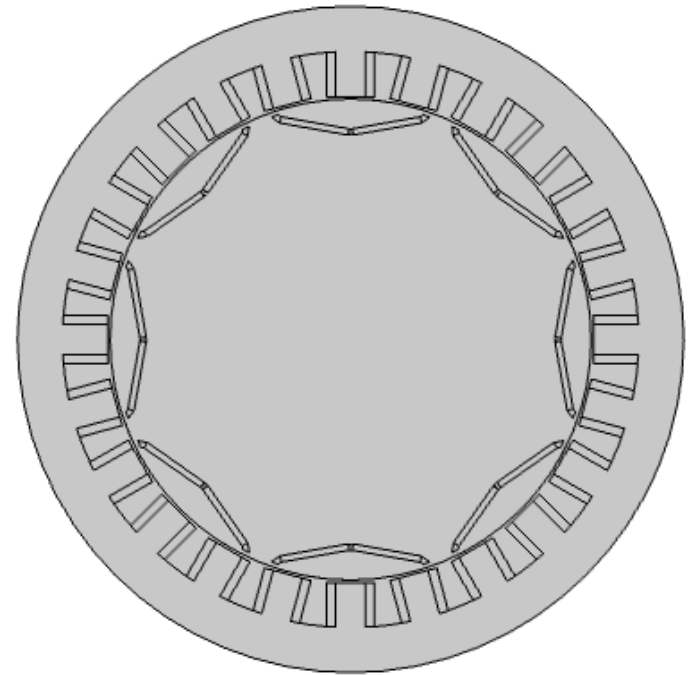
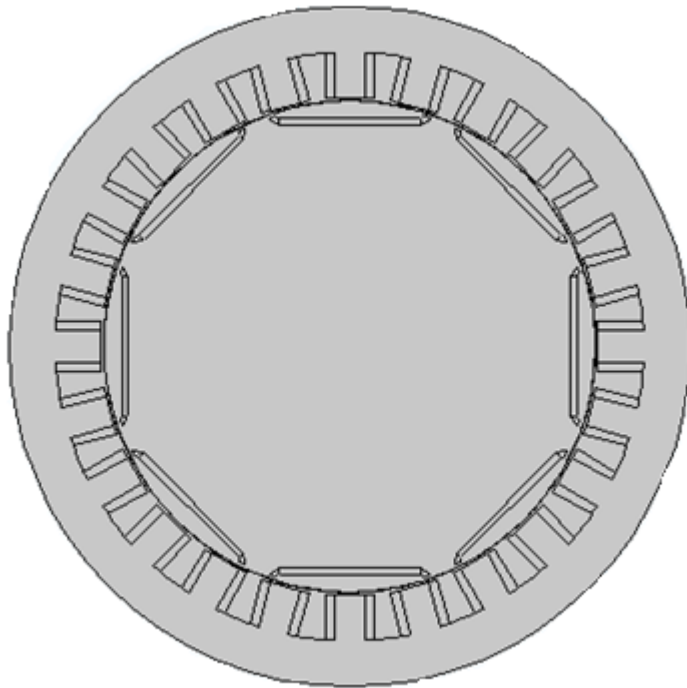
VER2



VER3

# Modeling Procedure

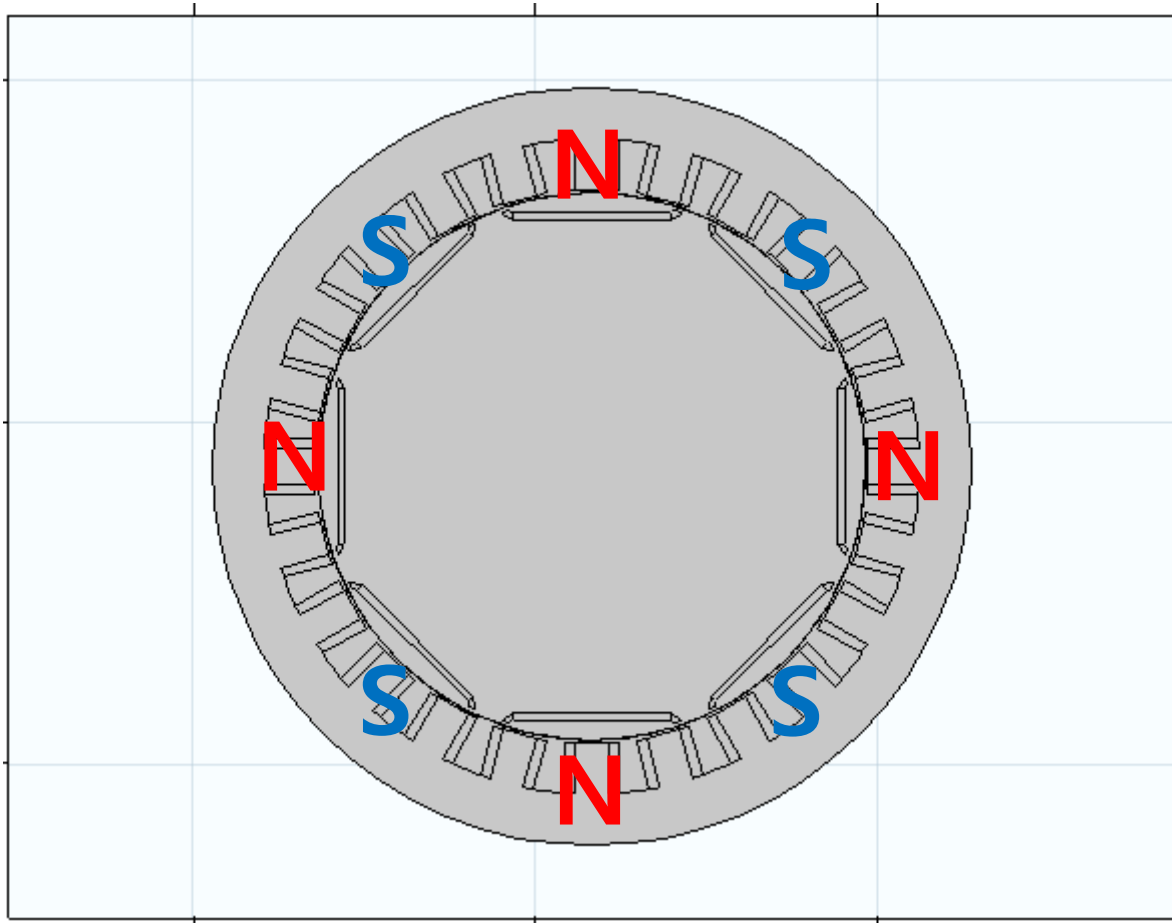
## I-Shape vs. V-Shape Geometry





# Modeling Procedure

## Magnet Modeling



# Modeling Procedure

## Coil Modeling

Settings  
Material

Label: Copper

Geometric Entity Selection

Geometric entity level: Domain

Selection: Manual

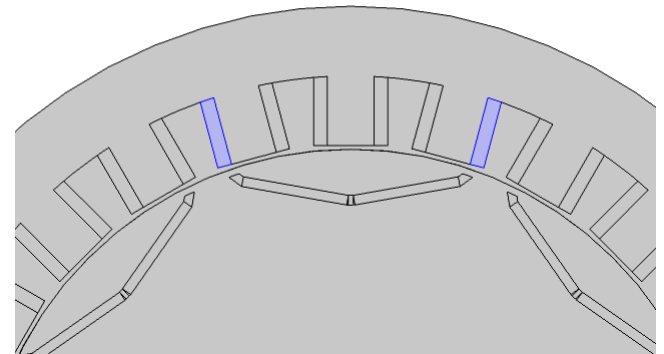
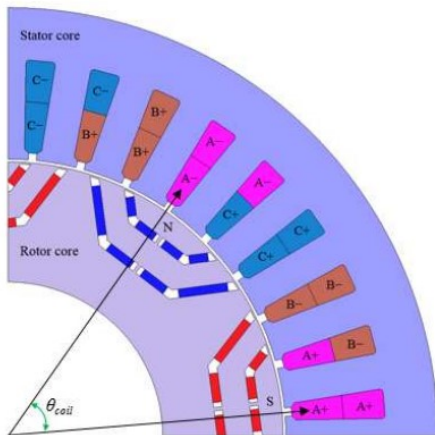
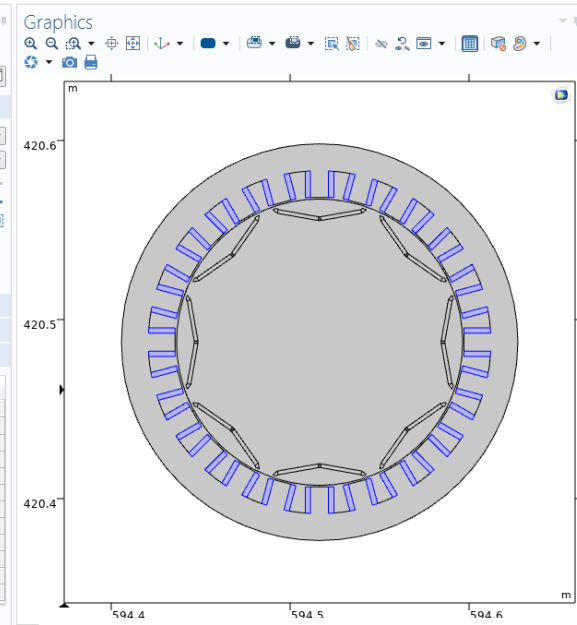
1  
4  
5  
6  
7  
8

Override

Material Properties

Material Contents

Property	Variable	Value	Unit	Property group
<input checked="" type="checkbox"/> Relative permeability	mur_l...	1	1	Basic
<input checked="" type="checkbox"/> Relative permittivity	epsilo...	1	1	Basic
Electrical conductivity	sigma...	5.998e7...	S/m	Basic
Heat capacity at constant pre...	Cp	385 J/(k...	J/(kg·K)	Basic
Surface emissivity	epsilo...	0.5	1	Basic
Density	rho	8940[k...	kg/m <sup>3</sup>	Basic
Thermal conductivity	k_iso ...	400[W/...	W/(m...	Basic
Young's modulus	E	126e9[...	Pa	Young's modulus and P...
Poisson's ratio	nu	0.34	1	Young's modulus and P...
Reference resistivity	rho0	1.667e-...	Ω·m	Linearized resistivity
Resistivity temperature coeffi...	alpha	3.862e-...	1/K	Linearized resistivity
Reference temperature	Tref	293.15[K]	K	Linearized resistivity



# Modeling Procedure

straight\_ver2.mph - COMSOL Multiphysics

File Home Definitions Geometry Materials Physics Mesh Study Results

Application Builder Model Data Access Record a New Method Test Application Application Component 1 (comp1) Model Add Component Parameters Variables Functions Definitions Build All Import LiveLink Add Material Rotating Machinery, Magnetic (rmm) Add Physics Build Mesh Mesh 1 Compute Study 1 Add Study 1D Plot Group 2 Add Plot Group Results Windows Reset Desktop Layout

Model Builder

- ▾ Ampère's Law 13
- ▾ Ampère's Law 14
- ▾ Ampère's Law 15
- ▾ Ampère's Law 16
- ▾ air
- ▾ Prescribed Rotational Velocity 1
- ▾ coil A1
- ▾ coil A2
- ▾ coil A3
- ▾ coil A4
- ▾ coil B1
- ▾ coil B2
- ▾ coil B3
- ▾ coil B4
- ▾ coil C1
- ▾ coil C2
- ▾ coil C3
- ▾ coil C4
- ▾ coil Ap1
- ▾ coil Ap2
- ▾ coil Ap3
- ▾ coil Ap4
- ▾ coil Bp1
- ▾ coil Bp2
- ▾ coil Bp3
- ▾ coil Bp4
- ▾ coil Cp1
- ▾ coil Cp2
- ▾ coil Cp3
  - ▾ Reversed Current Direction 2
- ▾ coil Cp4
  - ▾ Reversed Current Direction 2

Settings

Multi-Turn Coil

Label: coil A1

Domain Selection

Selection: Manual

ON	22
	32

Active

Override and Contribution

Equation

Model Inputs

Material Type

Material type: Solid

Coordinate System Selection

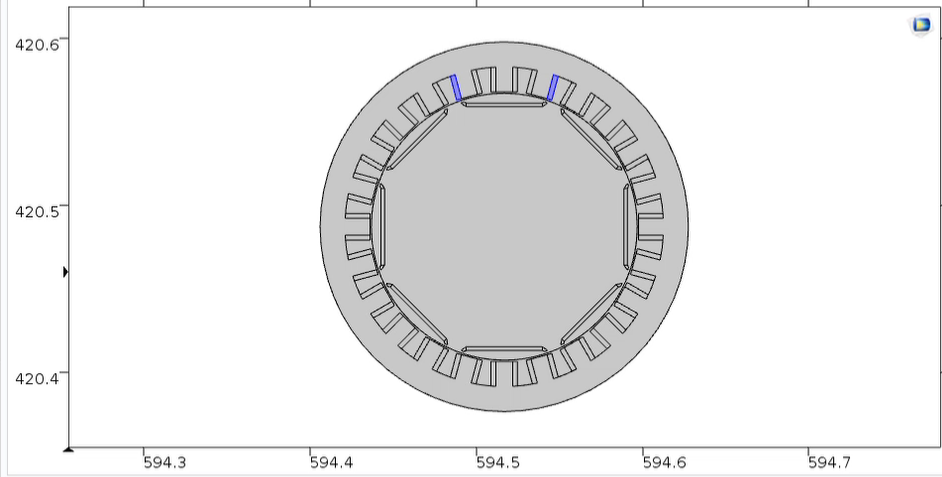
Coordinate system: Cylindrical System 3 (sys3)

Multi-Turn Coil

Coil name: 1

Coil group

Graphics Add Material Convergence Plot 1



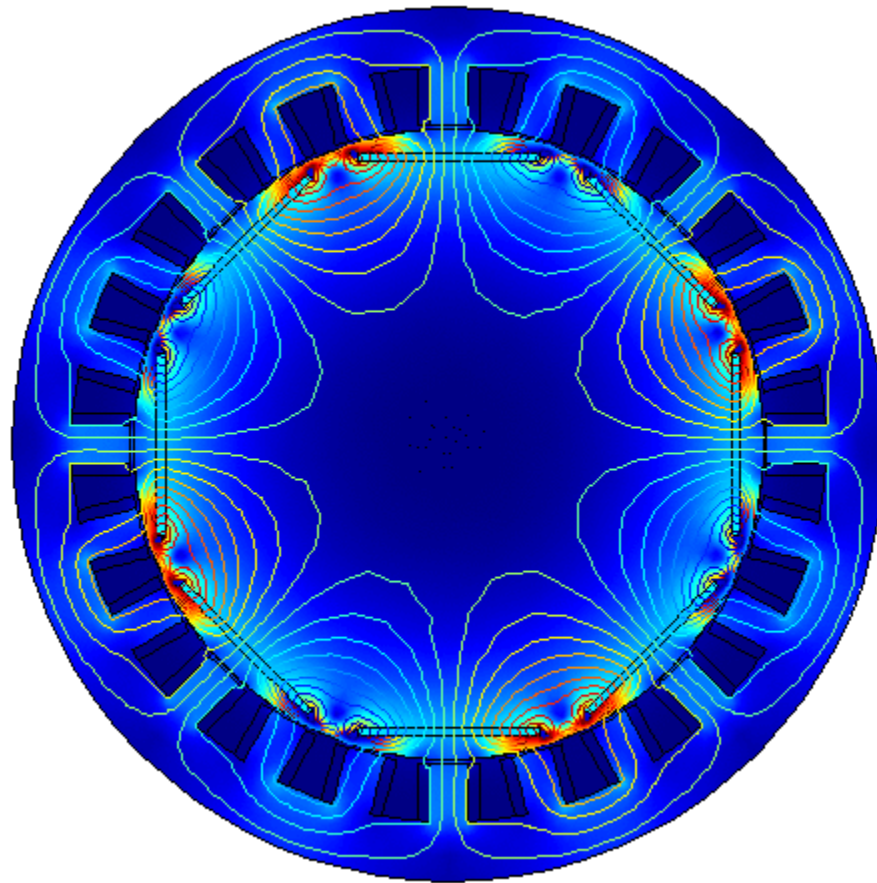
Messages Progress Log Table 4

1.35 GB | 1.62 GB

# Analysis

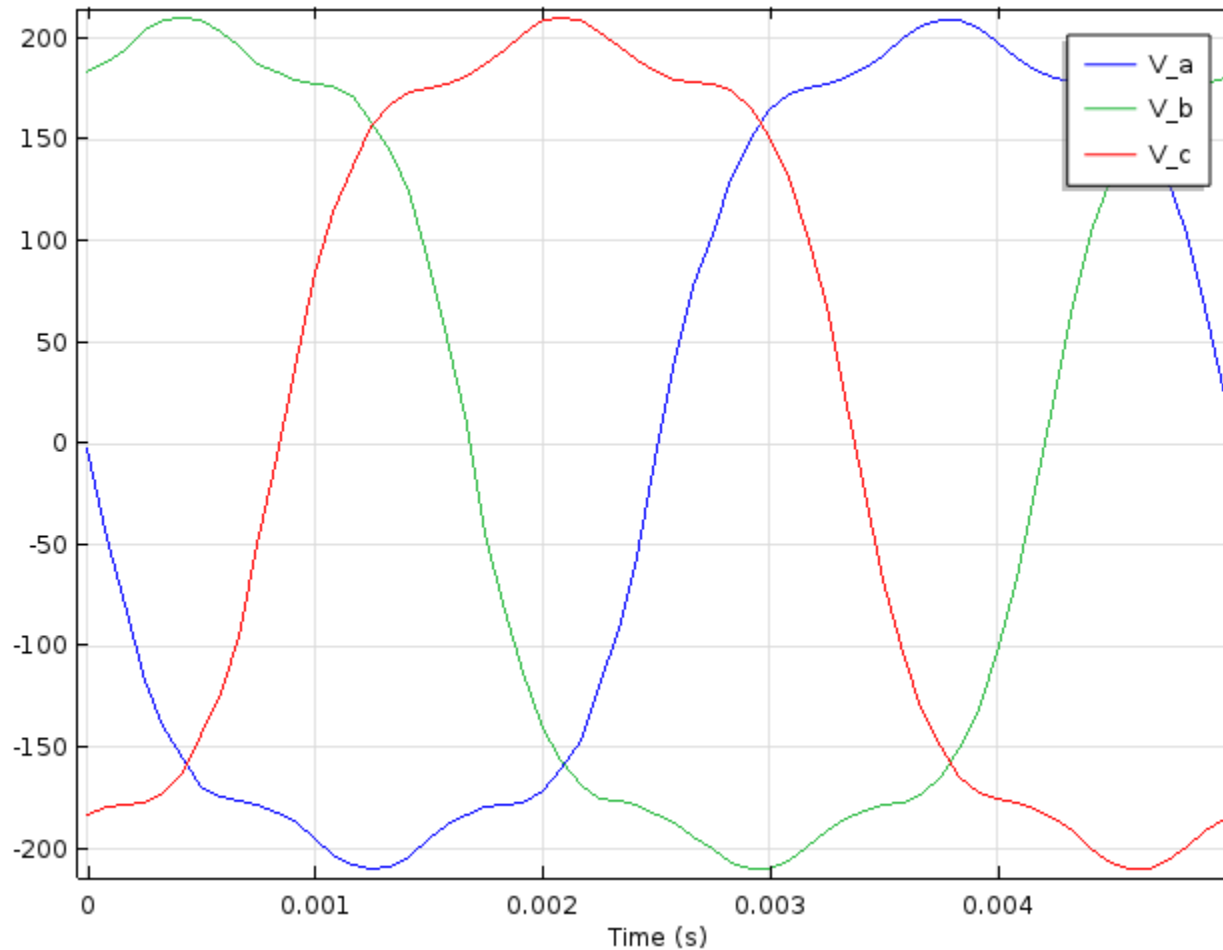
# Analysis

## I-Shaped IPM



# Analysis

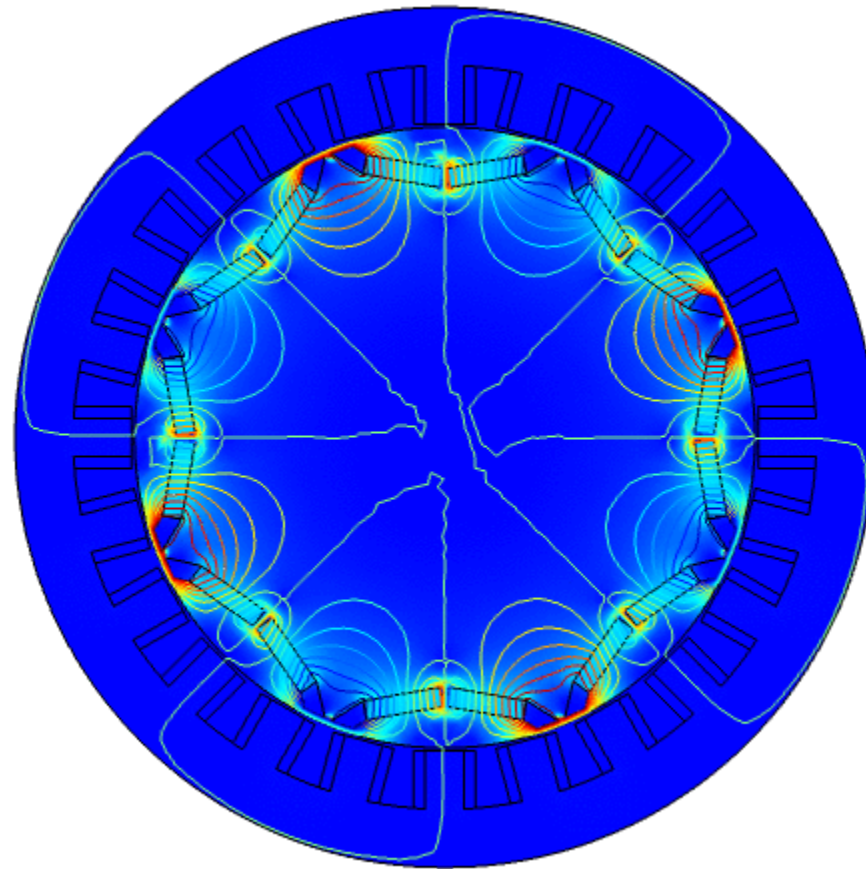
## I-Shaped IPM Voltage Waveform



# Analysis

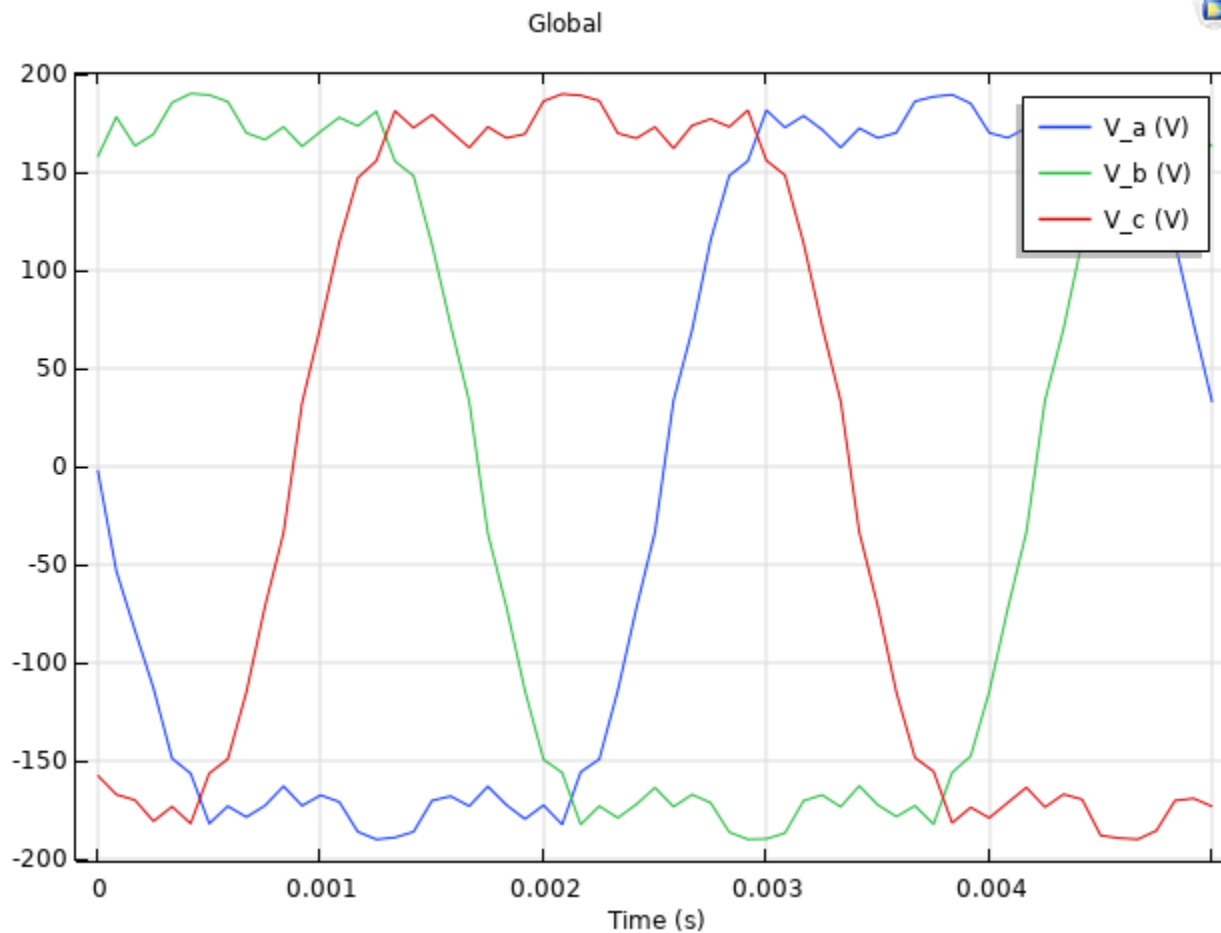
## V-Shaped IPMSG

### Magnetic Flux Density & Magnetic Vector Potential



# Analysis

## V-Shaped IPM Voltage Waveform

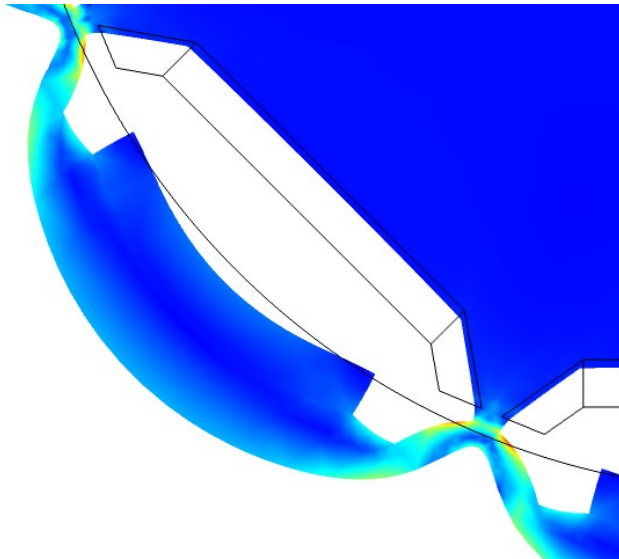




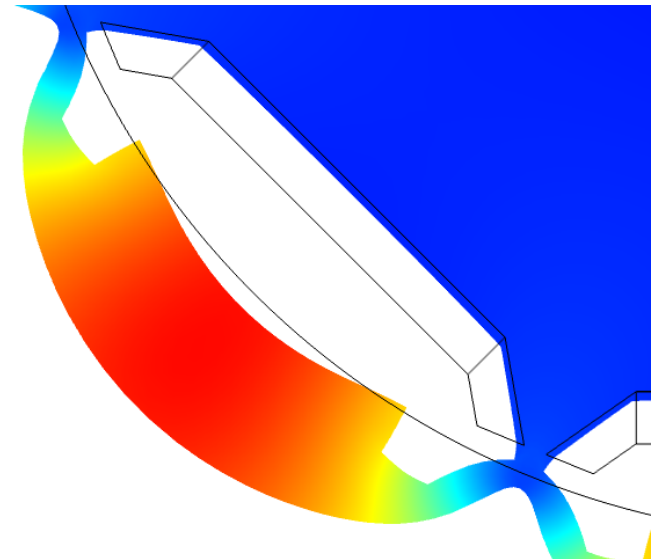
# I-Shape

## Maximum Stress & Maximum Displacement

Mechanical Properties	Metric
Hardness, Brinell	146
Hardness, Rockwell A	49
Hardness, Rockwell B	79
Hardness, Vickers	150
Tensile Strength at Break	540 MPa
<b>Tensile Strength, Yield</b>	<b>50.0 MPa</b>
	@Strain 0.500 %
Modulus of Elasticity	200 GPa
Bulk Modulus	166 GPa
Poissons Ratio	0.291
Shear Modulus	77.5 GPa



최대 응력(립) : 29[Mpa]

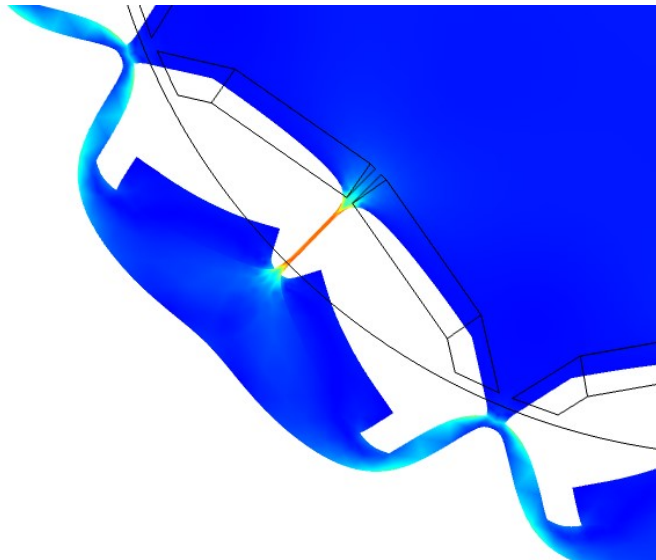


4.35[ $\mu$ m]

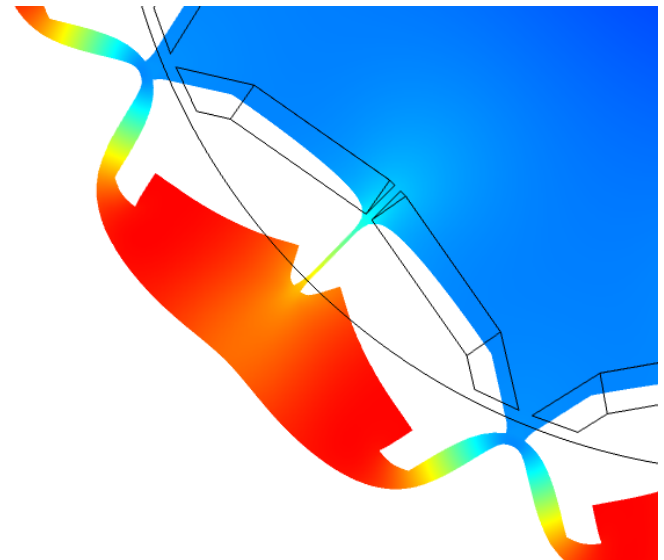
# V-Shape

## Maximum Stress & Maximum Displacement

Mechanical Properties	Metric
Hardness, Brinell	146
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Hardness, Rockwell B	79
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<b>Tensile Strength, Yield</b>	<b>50.0 MPa</b>
	@Strain 0.500 %
Modulus of Elasticity	200 GPa
Bulk Modulus	166 GPa
Poissons Ratio	0.291
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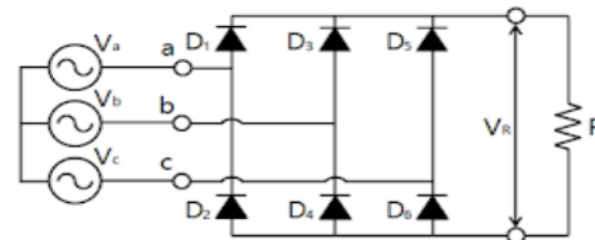
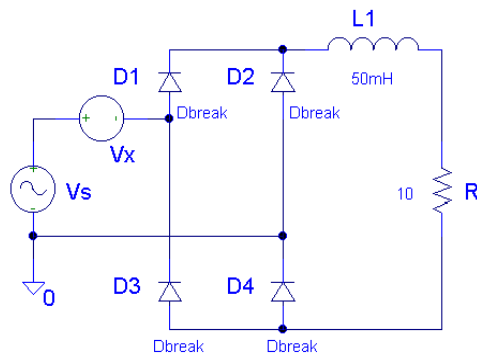
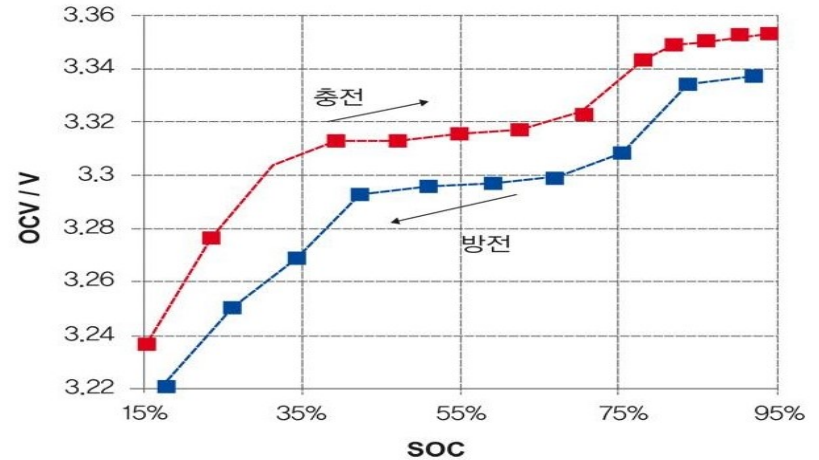
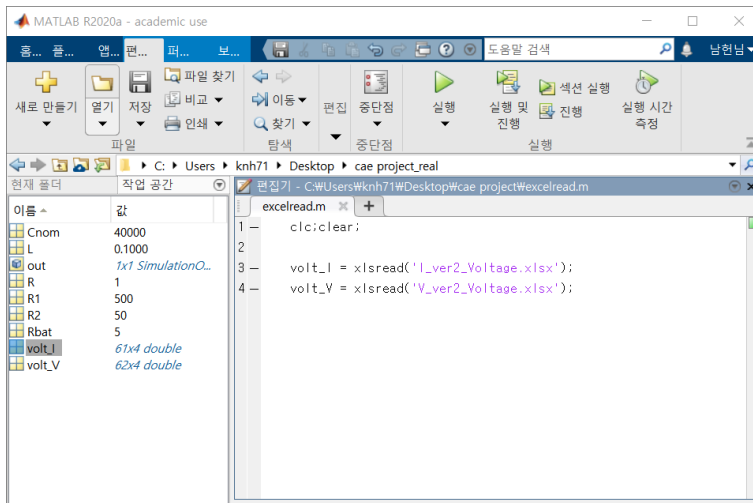
최대 응력(센터포스트) : 23.8[MPa]  
응력(립) : 9[MPa]



1.33[ $\mu\text{m}$ ]

# Analysis

## I-shaped V-shaped Charging time compare



3상 전파 정류 회로

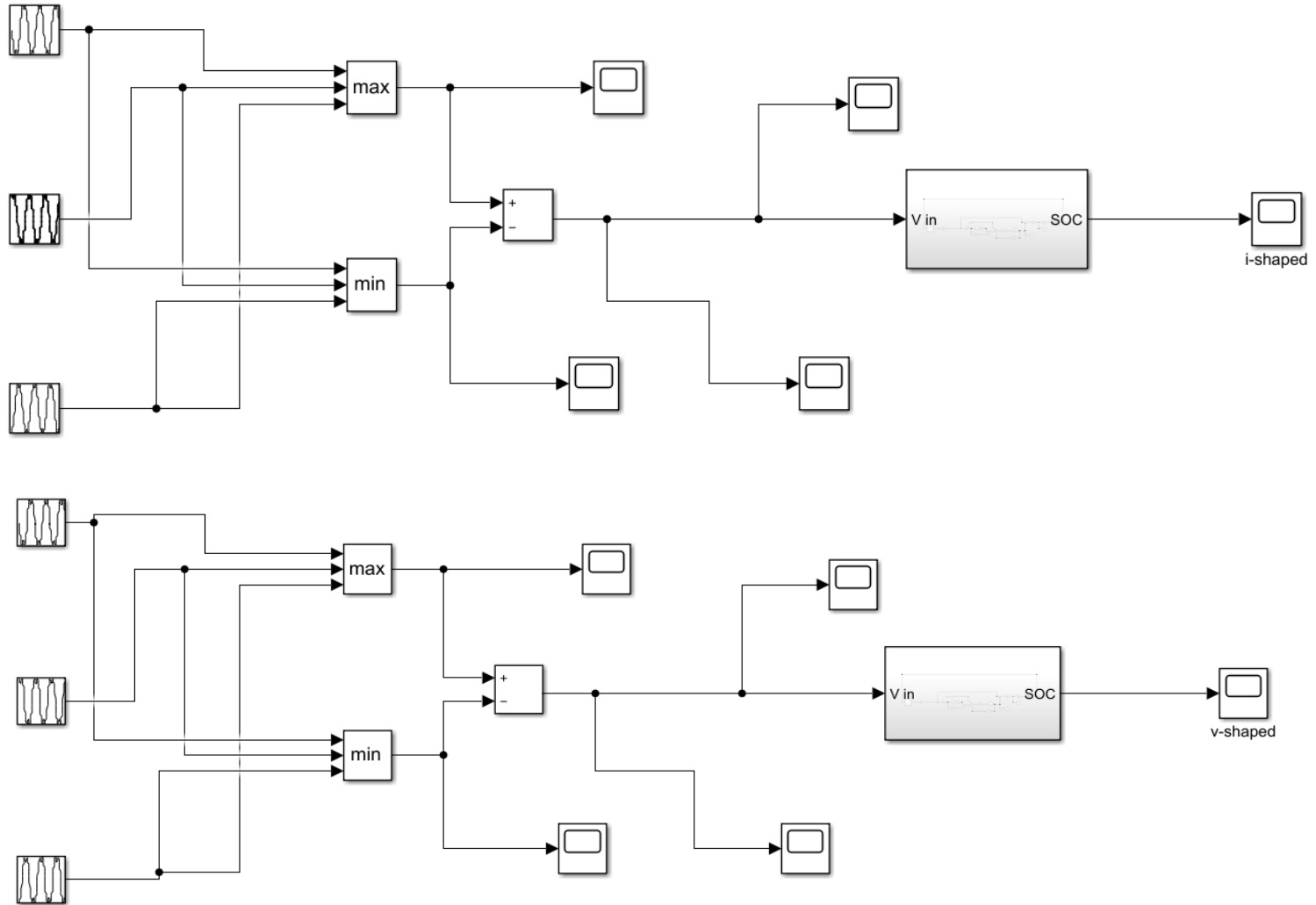
[도심형 배터리 팩 어셈블리]

항목	제원
셀 구성	90셀
정격 전압 (V)	324 (225~387)V
공칭 용량 (Ah)	120AH
에너지 (KWh)	39.2
중량 (kg)	325
냉각 시스템	수냉식

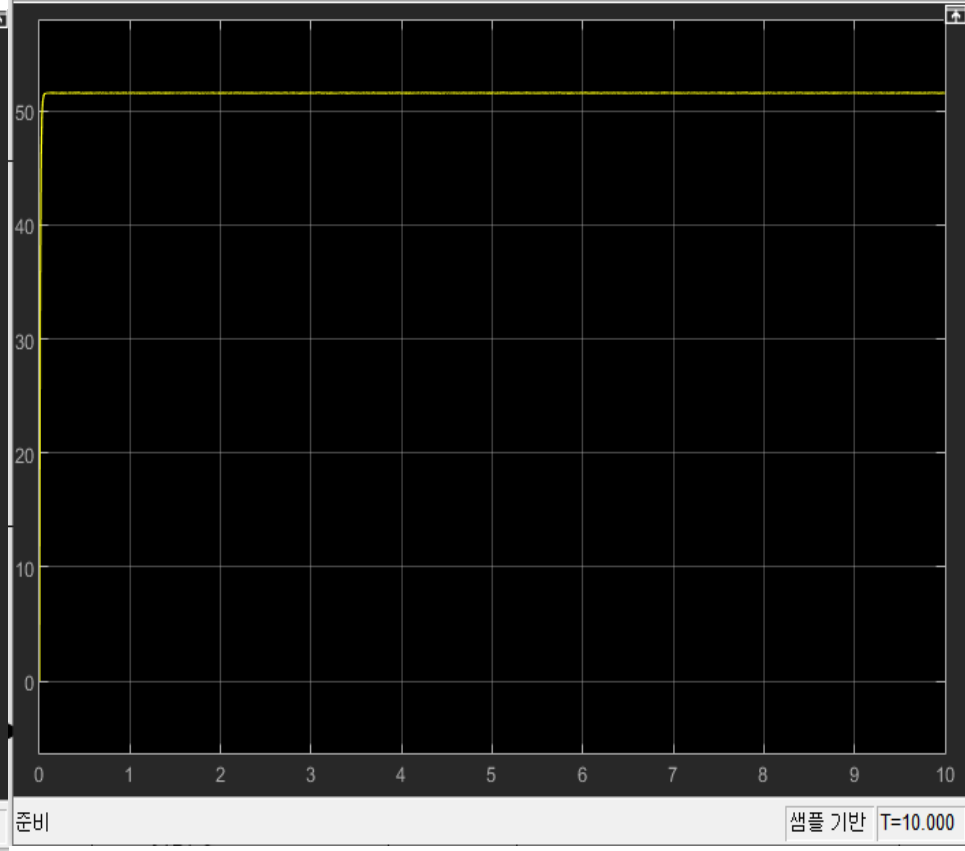
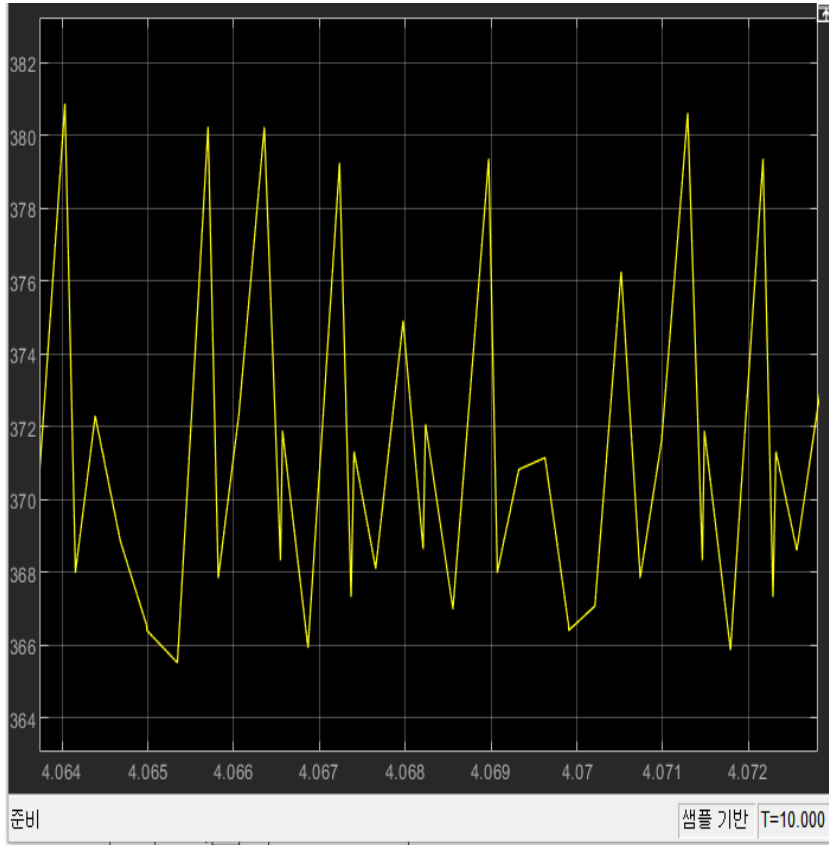
코나 EV 도심형 배터리 스펙(주행 가능 거리 복합 5.8Km/KWh)

PERFORMANCE SPECIFICATIONS	
<b>Nominal Voltage</b>	12.8 volts
<b>Rated Capacity</b>	50.0 AH
<b>Cycle Life (@DOD100%)</b>	≤2000 cycles
<b>Approximate Weight</b>	14.33 lbs. (6.5kg)
<b>Internal Resistance at 50% SOC</b>	≤20.0 milliohms
<b>Max Charge Current</b>	50A
<b>Max Discharge Current</b>	50A
<b>Pulse Discharge Current</b>	150A withstand 3s
<b>Discharge Cut-Off Voltage</b>	10.0V
<b>Protection/Communication</b>	BMS and Bluetooth®
<b>Operating Temperature Range</b>	
Charge	32°F (0°C) to 113°F (45°C)
Discharge	-4°F (-20°C) to 140°F (60°C)
Recommended	59°F (15°C) to 95°F (35°C)
<b>Case</b>	Flame Retardant ABS Plastic UL94:V-0
<b>Self-Discharge Rate</b>	
Residual Capacity	≤3%/month; ≤15%/year
Reversible Capacity	≤1.5%/month; ≤8%/year
<b>Power Sonic Chargers</b>	Contact us for information on a suitable charger

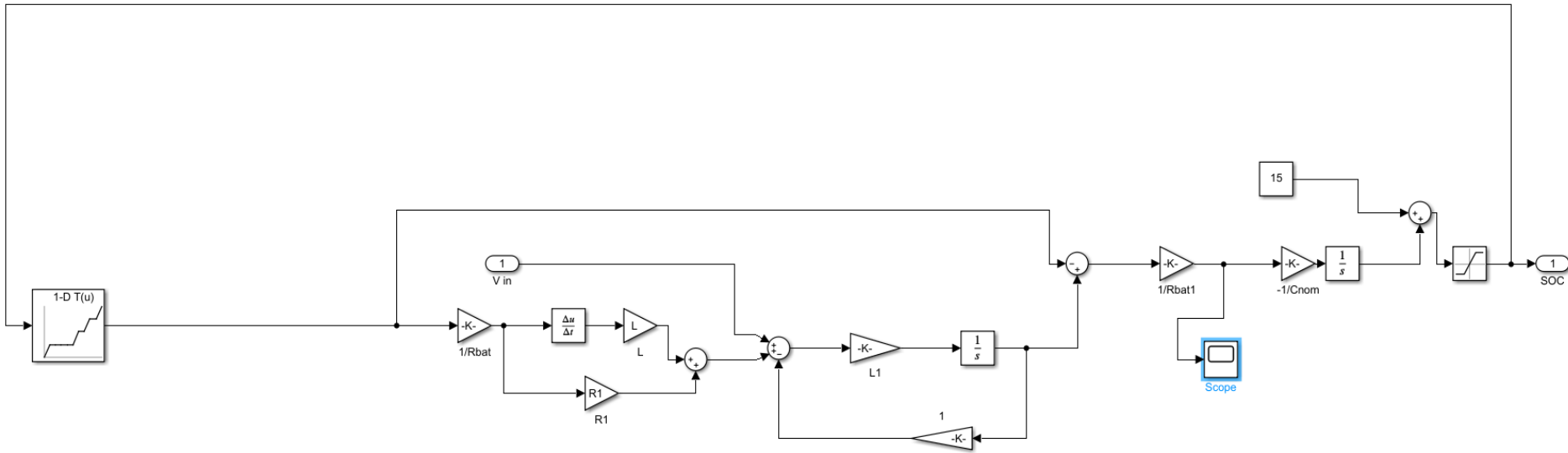
# Analysis



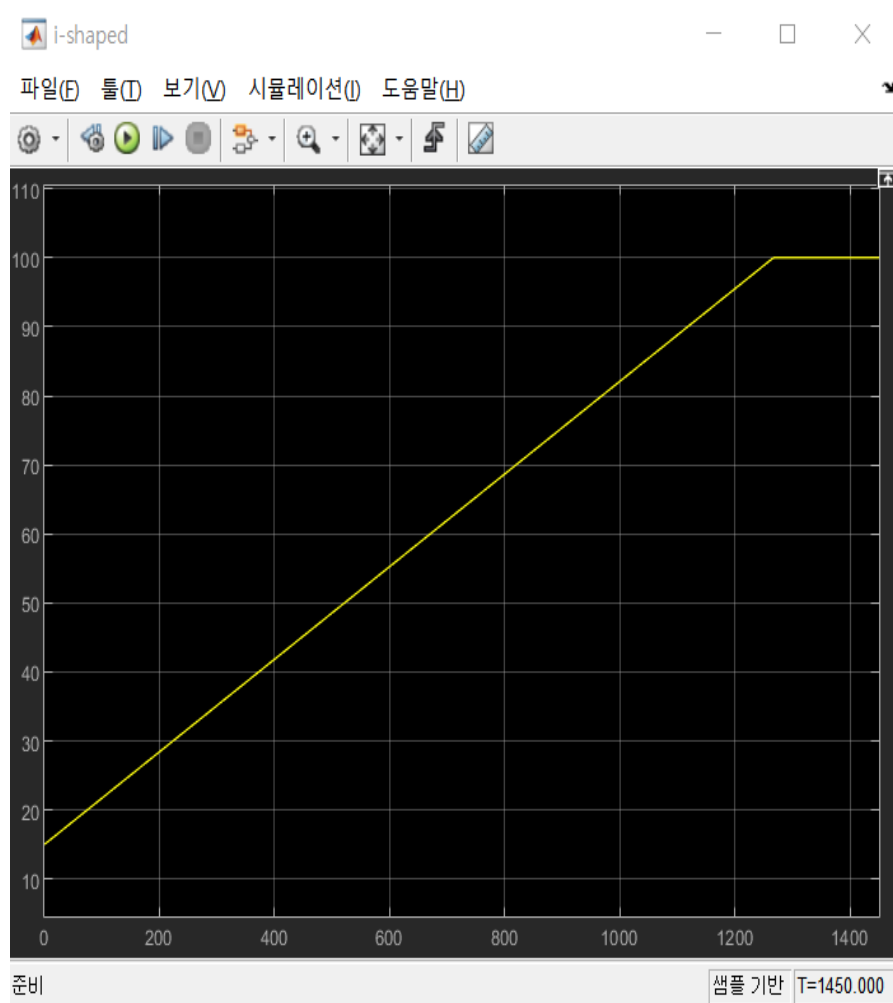
# Analysis



# Analysis

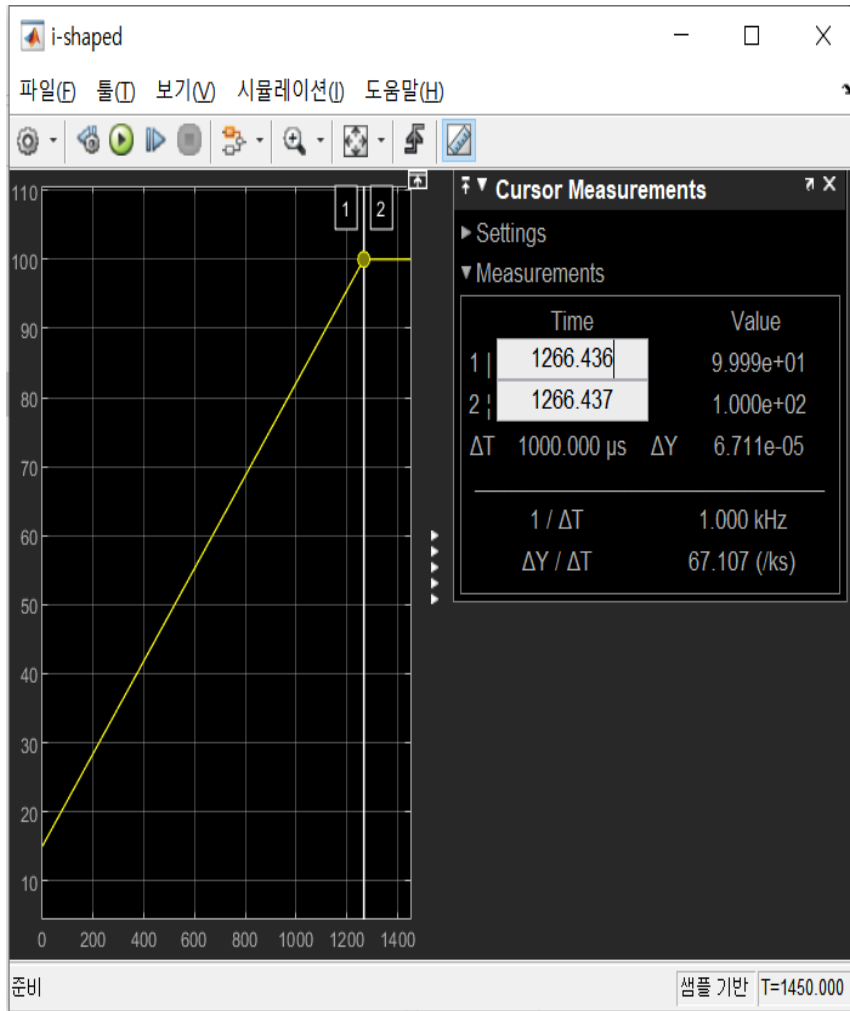


# Analysis





# Analysis

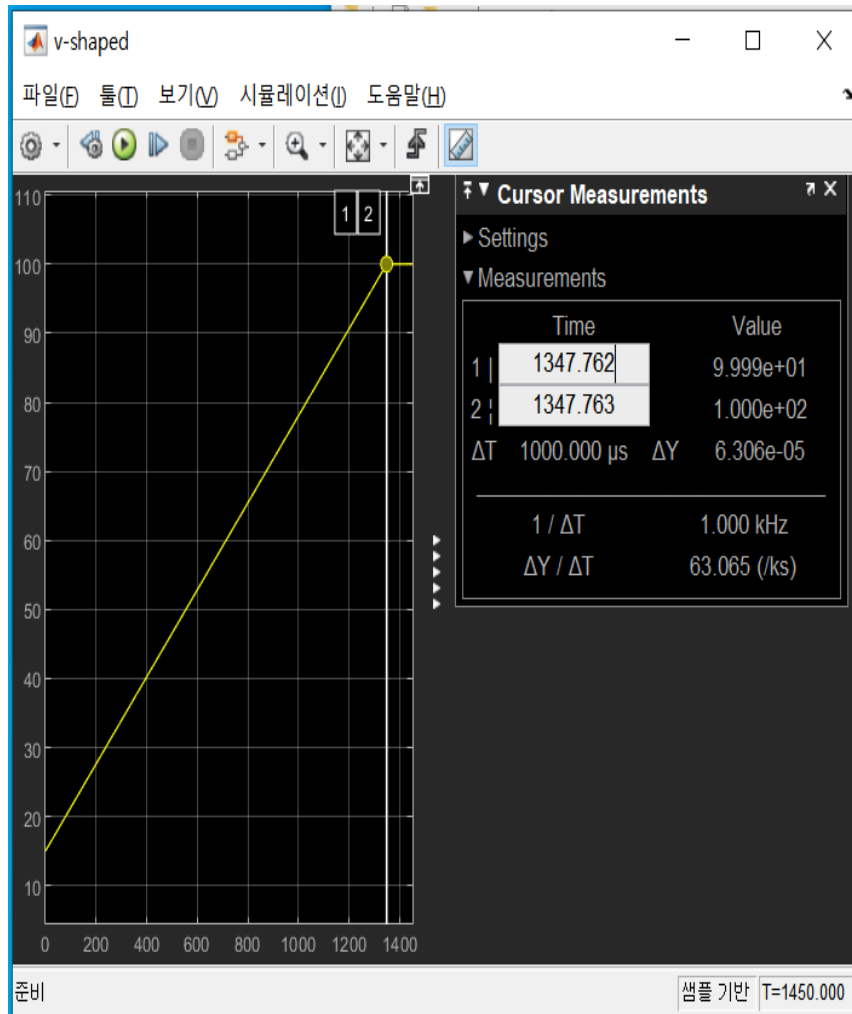


I-shape는  
약 1266초  
21분 소요!

# Analysis



# Analysis



V-shape는  
약 1347초  
22분 소요!

# Conclusion

- V-Shape 센터포스트는 누설 자속을 발생, 기구적인 측면에서는 원심력으로 인한 자석의 비산을 막아 IPMSG가 안정적으로 구동
- 전자기적으로는 I-Shape가 우세하지만 응력 조건에서 V-Shape이 유리
- V-Shape의 립 부분을 더 얇게 할 수 있다. 따라서 더 많은 구조적 이점을 취할 수 있음

## • 참고문헌

3-D K-means clustering method considering internal chemical state variation of self-discharge of Li-ion battery

-Dongho Han\* , Sanguk Kwon\* , Seungwoo Kim\* , Cheolwoo Lim\*\* , Jonghoon Kim\* Chungnam National University\* , KAIST Satellite Technology Research Center

출처: 전기자동차 주행거리 확장용 매입형 영구자석 발전기 최적 설계 (서울대학교 대학원 전기·컴퓨터 공학부 임 동 국)

도시철도차량 견인용 IPMSM의 구조 특성에 따른 회전자 형상 설계에 관한 연구 -정거철,, 박찬배, 오세영

, 이 주

# Q & A

**Thank you!**