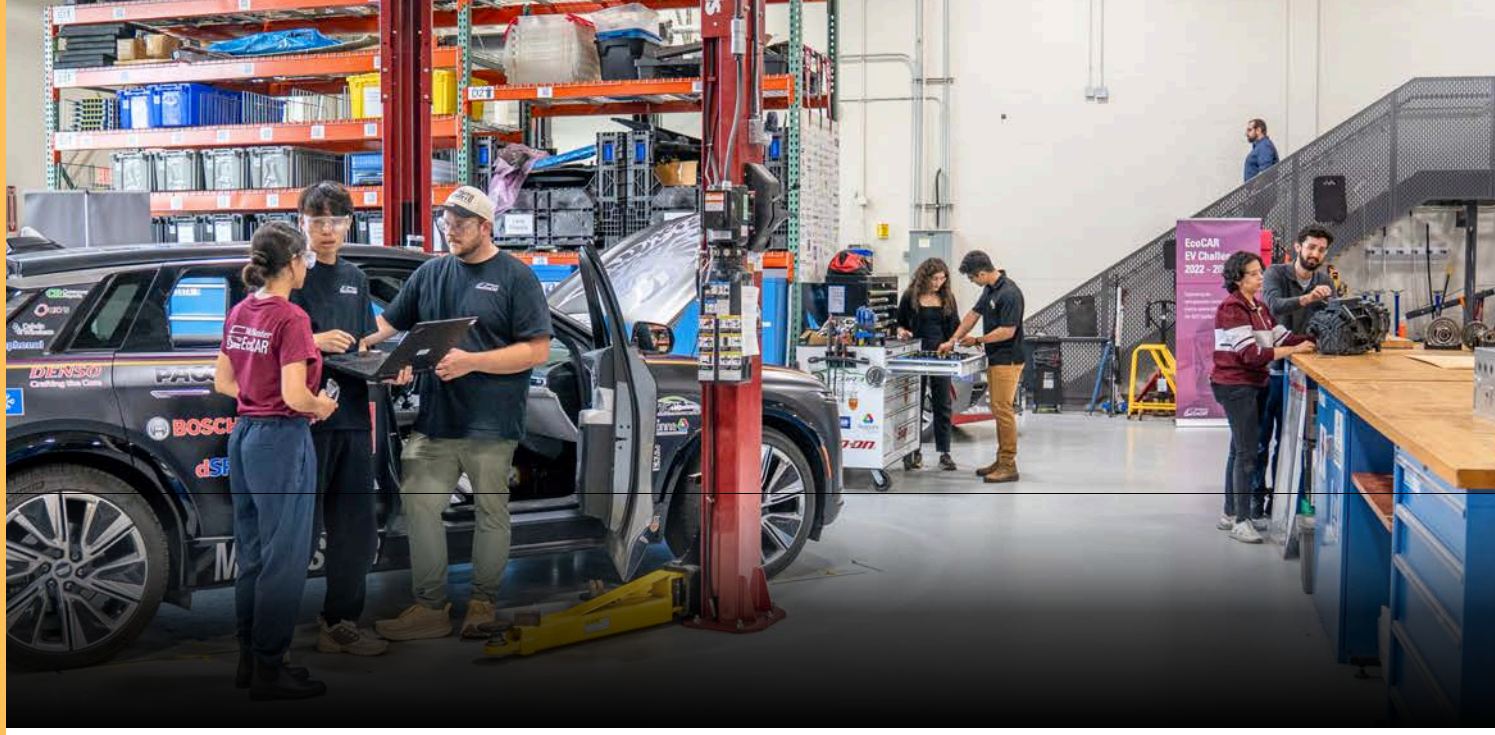
McMaster University | Engineering

Transportation Electrification & Smart Mobility at MARC

McMaster Automotive Resource Centre (MARC).
Driving the next generation of electrified and autonomous vehicles.
A global leader in transportation electrification and smart mobility.



Driving the Future of Mobility

Pioneering sustainable, energy efficient solutions in:

- Advanced electric motors
- Power electronics
- Energy management systems
- Controls for electrified powertrains, EVs, and autonomous systems

We are active contributors to major industry projects, supported by world-class labs, technologies, and facilities – including the digital environments, simulators, dynamometers, and lab services outlined in this document.

Facilities

Three-Machine Powertrain Dyno
High-Speed Electric Machine Dyno
MARCdrive Chassis Dyno
MARCdrive Driving Simulator
NVH Simulator
VR/XR Lab
SoftAuto Lab
Energy Storage Lab
Power Electronics & Motor Drives Lab
Automotive / Aerospace Electrification Lab
Motor Control & Power Electronics Lab
High Bay Lab
EMI Testing & PCB Prototyping Lab

Services

Research & development
Industry sponsored projects
Contract design & development
Modeling, simulations, & analysis
Hands-on education & training
Workforce development
Collaborative workshops for short courses & strategic / technical brainstorming
Hardware & software testing
Benchmarking & characterization
Prototyping

Lab Equipment

- 24 kW Chiller (-5° C - +80° C)
- dSPACE MicroAutoBox (x3)
- dSPACE HIL
- PLECS RT Box
- Thermal camera
- 10 kHz - 1.5 GHz Spectrum analyzer
- 20 kHz Function generator
- 3 kW AC Power source
- Low voltage DC power supplies
- Oscilloscopes
- Solder stations
- LCR/ESR Meter
- Voltmeters
- Current clamp meters
- Milliohm meters
- Digital thermometers
- Current probes
- High voltage differential probes
- Multimeters
- Full array of shop tools for general use

Bidirectional DC Power Supplies (x3)

- 0 - 800 V
- 0 - 500 A, 100 kW
- Parallel connection up to 1500 A, 300 kW
- Serial connection up to 1600V, 500 A, 200 kW

Bidirectional DC Power Supplies (x3)

- 0 - 1500 V
- 0 - 240 A, 108 kW
- Parallel connection Up to 720 A, 324 kW

Bidirectional Grid Simulator (x1)

- 24 kW, 63 kVA, (AC or DC)
- 0 - 350 $V_{AC\text{-}RMS}$, 400 V_{DC}
- 30 - 880 Hz
- 60 $A_{DC\text{-}RMS}$ per phase
- Parallel for 180 $A_{DC\text{-}RMS}$

Bidirectional DC Power Supplies (x3)

- 0 - 2,000 V_{DC}
- ±30 A, 20 kW
- Parallel connection Up to 60 kW, ±90 A_{DC}

DC Power Supplies (x2)

- 0 - 200 V
- 0 - 210 A, 15 kW
- Parallel connection Up to 420 A, 30 kW

Transportation Electrification
at McMaster University

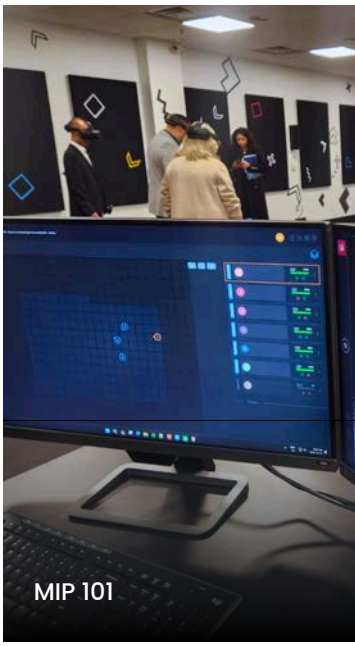
McMaster is home to one of the largest transportation electrification research groups in North America. With 500+ researchers and over $250 million in programs and initiatives.

This work is anchored at the **McMaster Automotive Resource Centre (MARC)**, a 120,000 ft^2 facility located within McMaster Innovation Park. MARC houses four world class research clusters under one roof and provides a unique environment for collaboration with major OEMs, Tier 1 / 2 / 3 suppliers, start-ups, tech companies, along with partners and stakeholders from the public and private sectors.

MARC 117

Control Room Dimensions: 10 x 3 m, 323 ft^2
Simulator Room Dimensions: 10 x 7 m, 753 ft^2

MARC 117



MIP 101

MARC 117

Static Driving Simulator

Hardware

- Full vehicle assembly
- 210^0 FOV, 7 m Ø screen
- 3x Projectors (2,560 x 1,600 @ 120 Hz)
- 3D Surround sound system
- Tunable steering feedback
- Complete brake hydraulics
- Pneumatic active seat
- Active 5-point seatbelt

Software

- VI CarRealTime
- SimWorkbench
- Matlab / Simulink
- VIRES Virtual test drive

Testing

- Drive-before-build
- Energy management systems
- Drivability
- Vehicle dynamics
- Human machine interface
- Autonomous systems
- Human-machine transition
- Driver behavior
- Driving conditions
- Model integration
- Component validation

Funded by

Ontario Ministry of Research and Innovation and McMaster University (PI: Dr. Ali Emadi)

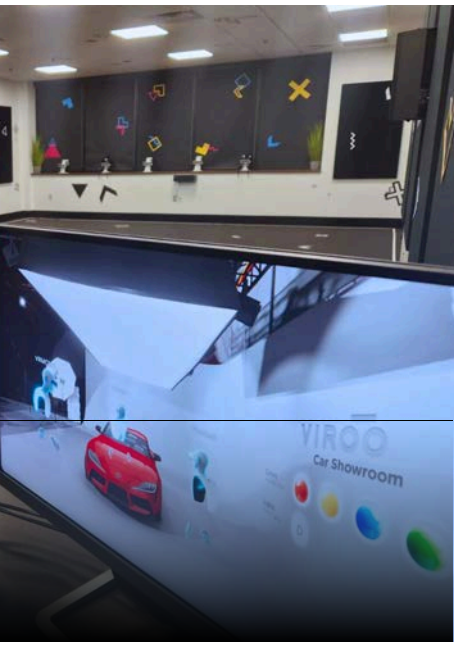
System Supplier

VI-Grade GmbH

NVH Simulator

Hardware	Testing
• Interactive NVH simulation with wheel, pedals, gear shift • Calibrated, accurate sound • Calibrated, accurate, multi-point vibration • Immersive visuals • Immersive environment	• On-Road NVH simulator • VI-NVHSim in a real vehicle • Real driving experience with virtual sound • Exterior sound simulator • Simulate & experience exterior sound at the desktop

System Supplier VI-Grade



IMSRV@MAC VR/XR Lab

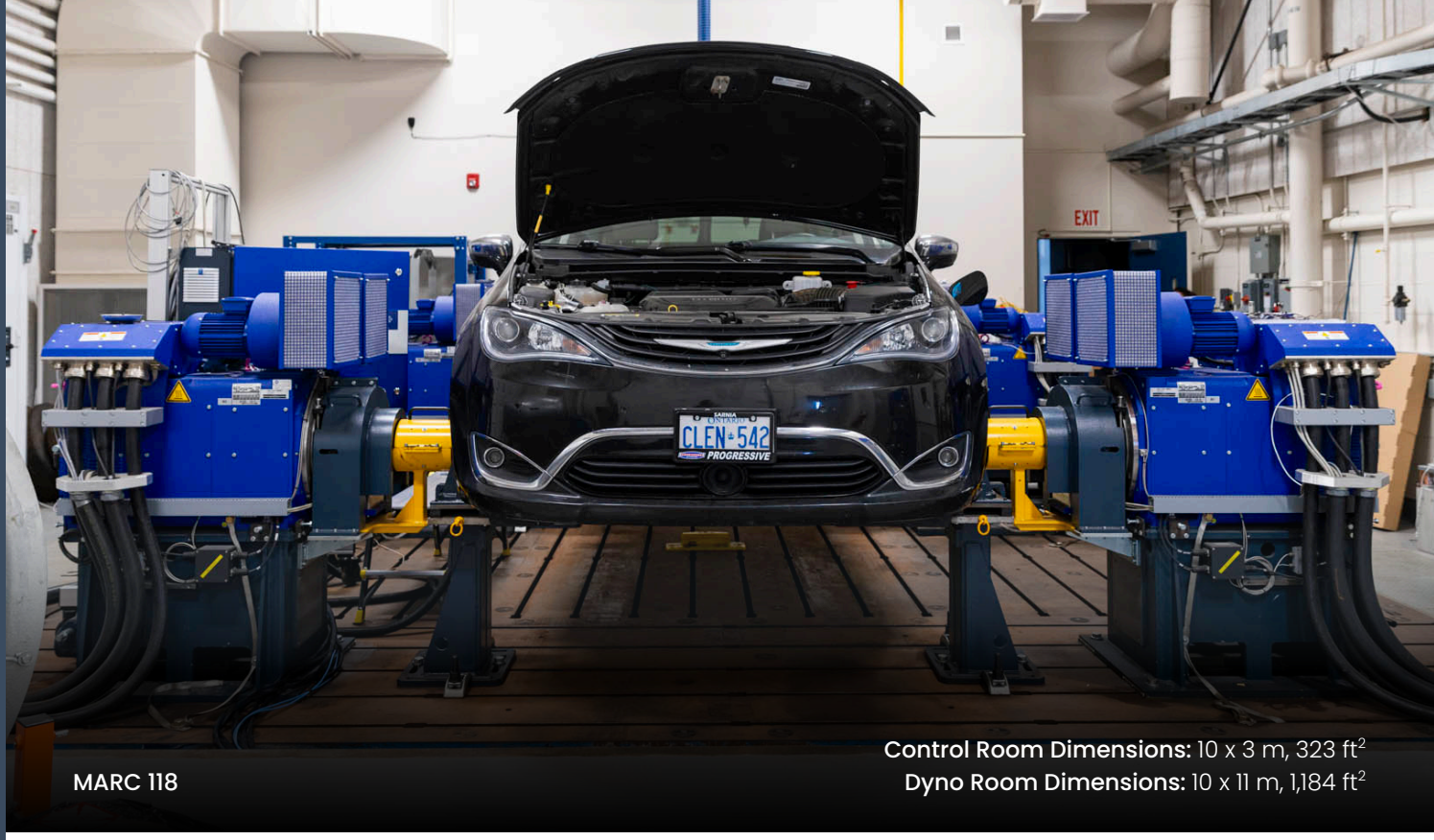
Facility	Testing
• 100m^2 free-roam immersive lab • Up to six users to connect & interact in the same physical room • Unlimited remote users in the same VR environment	• Human-in-the-loop scenarios • Wayfinding validation • Intersection behavior testing • Virtual multi-user design evaluation • Accessibility design validation • Human-vehicle interaction

In Partnership with and Led by Vitualware

World-Sim Digital Twin

Testing & Features
• Fully customizable digital-twin environment • Realistic traffic & sensor behavior • ADAS & autonomous vehicle testing • Traffic system algorithm testing • Intersection behaviour modeling • Comprehensive library of popular sensors • AI-driven actors

System Supplier VI-Grade



MARC 118

Control Room Dimensions: 10 x 3 m, 323 ft^2
Dyno Room Dimensions: 10 x 11 m, 1,184 ft^2

Chassis Dynamometer

Auxiliary Hardware

- Vehicle cooling fan (up to 130 km/h)
- Stahle remote pedal actuator
- Full vehicle mounting system
- Mobile vehicle lift
- Mobile IO box
- 5-ton Overhead crane
- Cast fixture bedplate

Testing

- Full vehicle tests
- Machines & inverters
- Vehicle-To-Grid
- Differential wheel torques & speeds
- Vehicle & powertrain controls

Chassis Dyno

4 Independent low inertia machines:

- 4 x 250 kW Max power
- 4 x 3,000 Nm Max torque
- 4 x 3,000 rpm Max speed
- ≈1 kgm^2 Inertia
- 0.05% Measurement accuracy

Three Phase Power Access

- 480 V, 40 A (x3)

Communication & Measurement

- Direct IO & CAN connection to Driving simulator
- CAN up to 1kHz
- 32 Thermocouple inputs
- 16 General purpose analog inputs
- Vector CAN hardware

Software & Control

- AVL Puma 2.0
- Lynx
- AVL Concerto
- Vector CANoe

Battery Emulator / Tester / Fast Charger

- 8 - 800 VDC
- •±600 A, ±160 kW
- ±0.1% Accuracy
- J1772 Combo, 500 A
- 20 cu.ft. Thermal chamber

Funded by

Ontario Ministry of Research and Innovation and McMaster University (PI: Dr. Ali Emadi)

System Supplier

AVL List GmbH

MARCdrive

MARC 132

Room Dimensions: 4 x 4 m, 172 ft^2

High-Speed Electric Dynamometer

Auxiliary Hardware

- 24 kW Liquid cooling / heating system
- Main & pre-charge contactors
- Switched 12 V 60 A supply
- 400 & 700 ARMS Inverters for machine characterization

Testing

- Electric machines
- High power inverters
- Integrated machines & inverters
- Controls

Dyno Machine

- 250 kW Max power
- 500 Nm Max torque
- 22,000 rpm Max speed
- 60,000 rpm/s Max acceleration
- 0.05% Measurement accuracy

Communication & Measurement

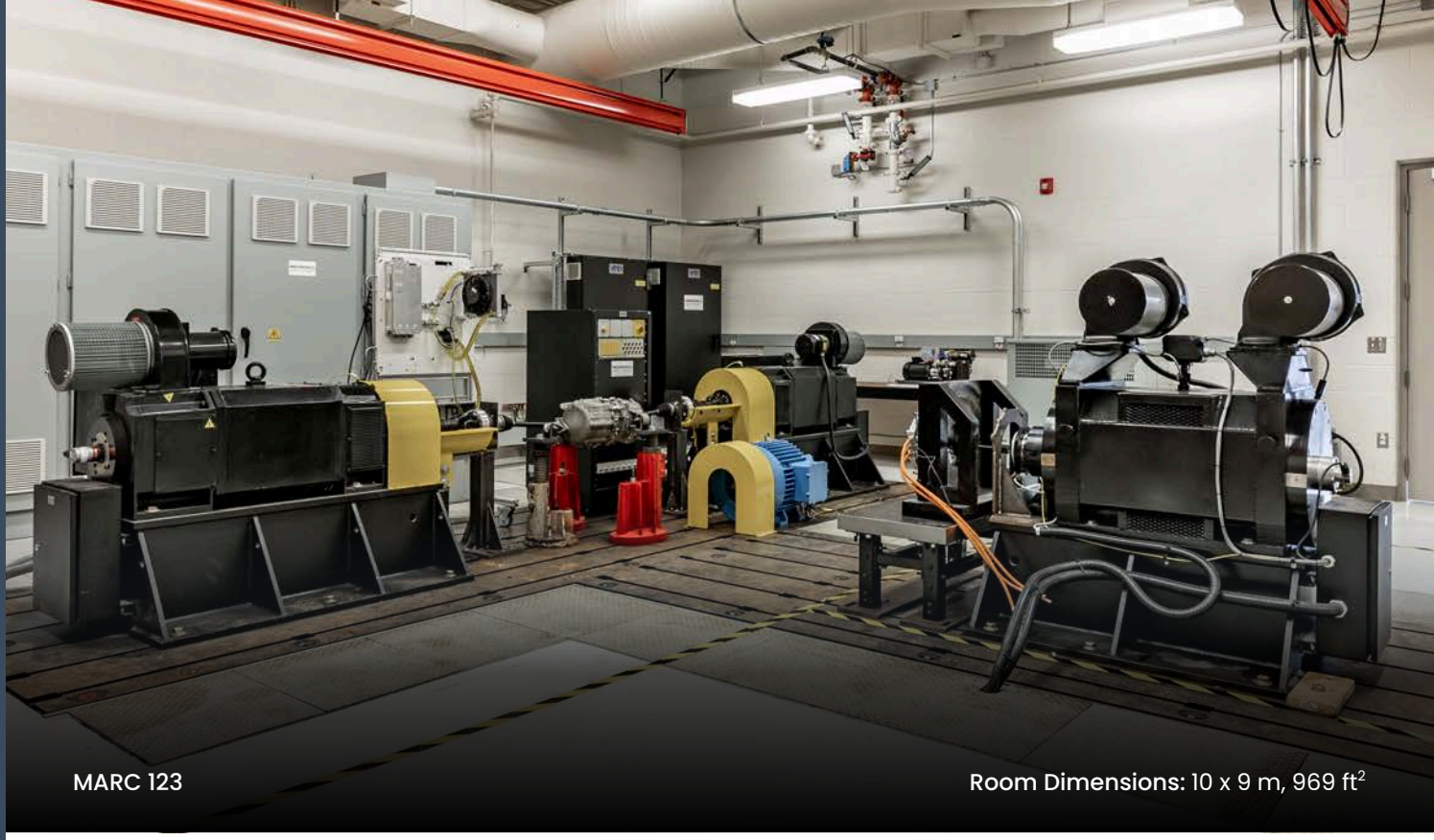
- CAN up to 1 kHz
- 16 High voltage inputs (1,000 V)
- 32 General purpose analog inputs (thermocouple, RTD, etc)
- Zimmer LMG671 power analyzer

Funded by

Canada Foundation for Innovation (CFI), Ontario Ministry of Economic Development and Innovation, & McMaster University (PI: Dr. Saeid Habibi; Co-PI: Dr. Ali Emadi)

System Supplier

AVL List GmbH



MARC 123

Room Dimensions: 10 x 9 m, 969 ft^2

Three-Machine Powertrain Dyno

Auxiliary Hardware

- 20 kW Liquid cooling / heating system
- Main & pre-charge contactors
- Switched 12 V, 60 A supply
- 400 & 700 A_{RMS} Inverters for machine characterization
- Procyon / Andromeda (HIL)
- Yokogarva WT1800 power analyzer

Testing

- HEV drivetrains
- Electric machines
- Electric vehicle drivetrains
- Differentials
- Gearboxes

Load Machines (Output Dynos)

- 157 kW_{cont} 220 kW_{peak}
- 2,500 Nm_{cont} 3,500 Nm_{peak}
- 600 RPM_{corner} 4,300 RPM_{peak}
- Total axle load: up to 440 kW

Engine Emulator (Input Dyno)

- 210 kW_{cont} 294 kW_{peak}
- 1,003 Nm_{cont} 1,404 Nm_{peak}
- 2 $kRPM_{corner}$ 8 $kRPM_{peak}$

Communication & Measurement

- CAN
- Thermocouples (16ch, Type K)
- Analog inputs (16ch, 0 - 10 V)
- Pressure (8ch)
- Torque & speed sensors on each machine

Three Phase Power Access

- 480 V, 200 A (x1)
- 208 V, 20 A (x3)
- 208 V, 30 A (x2)

Battery Emulator

- 150 kW, ±250 A_{DC}, 0 - 600 V_{DC}

Regenerative Grid Connection

- 185 kW, 480 V_{AC} 3-phase

Funded by

The Canada Foundation for Innovation (CFI), Ontario Ministry of Research, Innovation, and Science, & McMaster University (PI: Dr. Ali Emadi)

System Supplier

A&D Technology Inc.

Energy Storage Lab

Facility

- Fire suppression & gas sensing equipment integrated with chamber & cyclers

Prototyping Equipment

- High voltage toolbox
- Cell tab welder
- 1 kW Chiller
- BMSs & DAQs
- Stocked components
- High & low voltage battery packs (x7)

Three Phase Power Access

- 208 V, 30 A (x1)
- 208 V, 30 A (x3)
- 208 V, 50 A (x1)
- 480 V, 60 A (x1)

Testing & Prototyping

- Li-ion batteries
- Supercapacitors
- Cells & packs
- Battery management systems
- Thermal management systems
- Characterization & aging tests

Battery Cycles

- Digatron cell tester (8 x 75 A / 5 V)
- Arbin cell tester (8 x 60 A / 5 V)
- Custom cell tester w/ EIS (1 x 120 A / 6 V)
- AVL pack tester (1 x 600 A / 800 V / 160 kW)

Thermal Chambers

- 3x -40° to 70° C (104 ft^3, 16 ft^3", 8 ft^3)
- 1x 5° to 94° C (1.37 ft^3)

Automated Safety Systems

- Explosive gas detection & explosion proofing
- CO_2 fire suppression system tied to building

MARC 130

Room Dimensions: 4 x 7 m, 301 ft^2

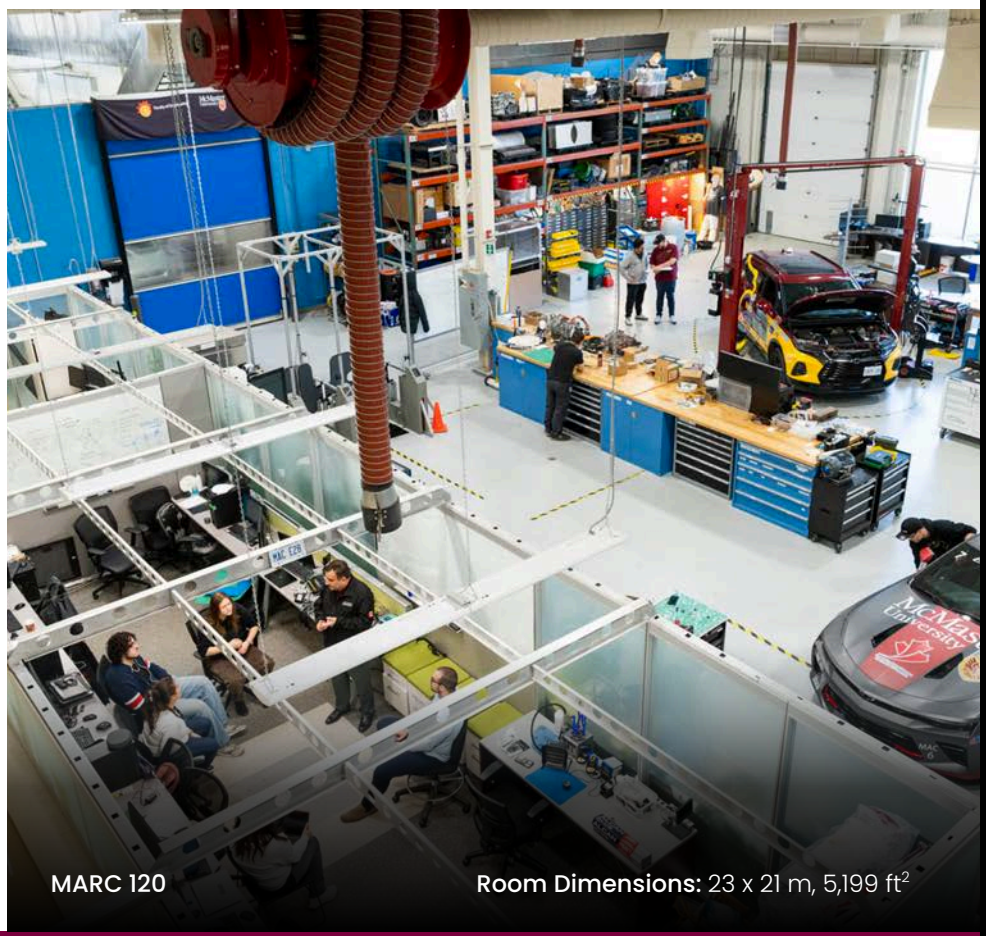
High Bay Lab

Facility

- Hydraulic car lift (x2)
- Power electronics testing workstations (x1)
- Wooden work bench (x6) dimensions 3 x 0.75 m
- Exhaust extractor (x4)
- Car jack
- Short jack stands (x2)
- Tall jack stands
- Transmission jack
- Air hookup

Testing & Prototyping

- Inverters
- DC/DC converters
- Battery chargers
- Solid state switches
- Electric machines



MARC 120

Room Dimensions: 23 x 21 m, 5,199 ft^2

Power Electronics & Motor Drives Lab

Facility

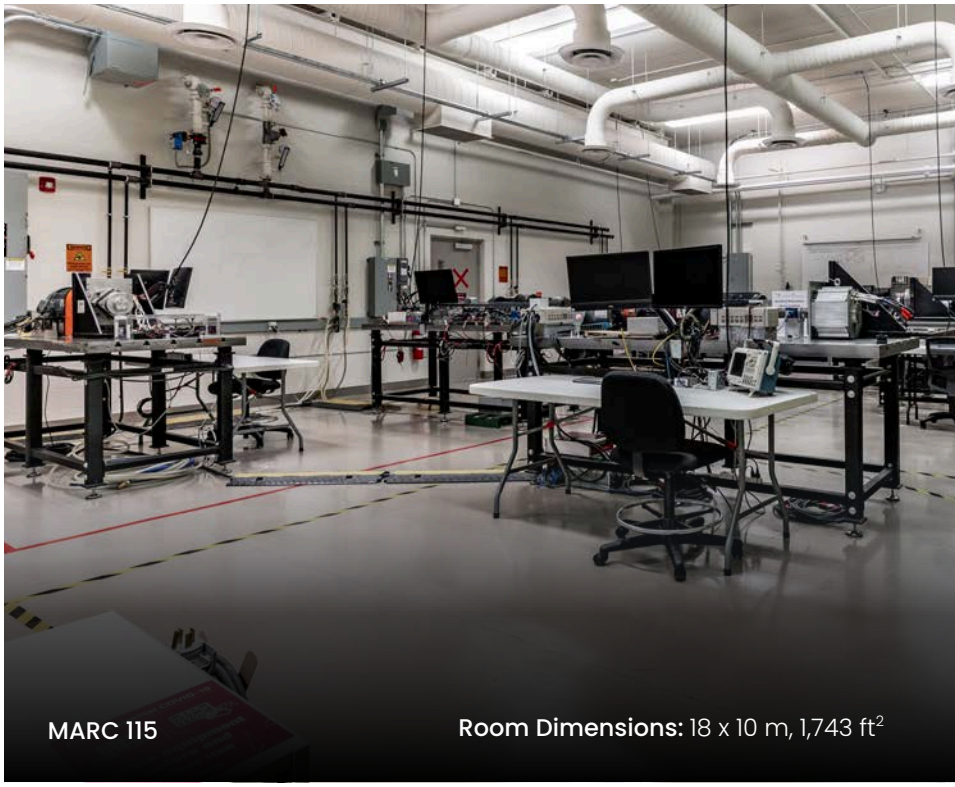
- T-slot electric machine dyno tables (x8)
- Power electronics testing workstations (x5)

Testing & Prototyping

- Inverters
- DC/DC converters
- Battery chargers
- Solid state switches
- Electric machines

Three Phase Power Access

- 208 V, 50 A (x3)
- 480 V, 20 A (x1)
- 480 V, 40 A (x3)
- 480 V, 80 A (x1)
- 480 V, 200 A (x1)



Automotive / Aerospace Electrification Lab

Facility

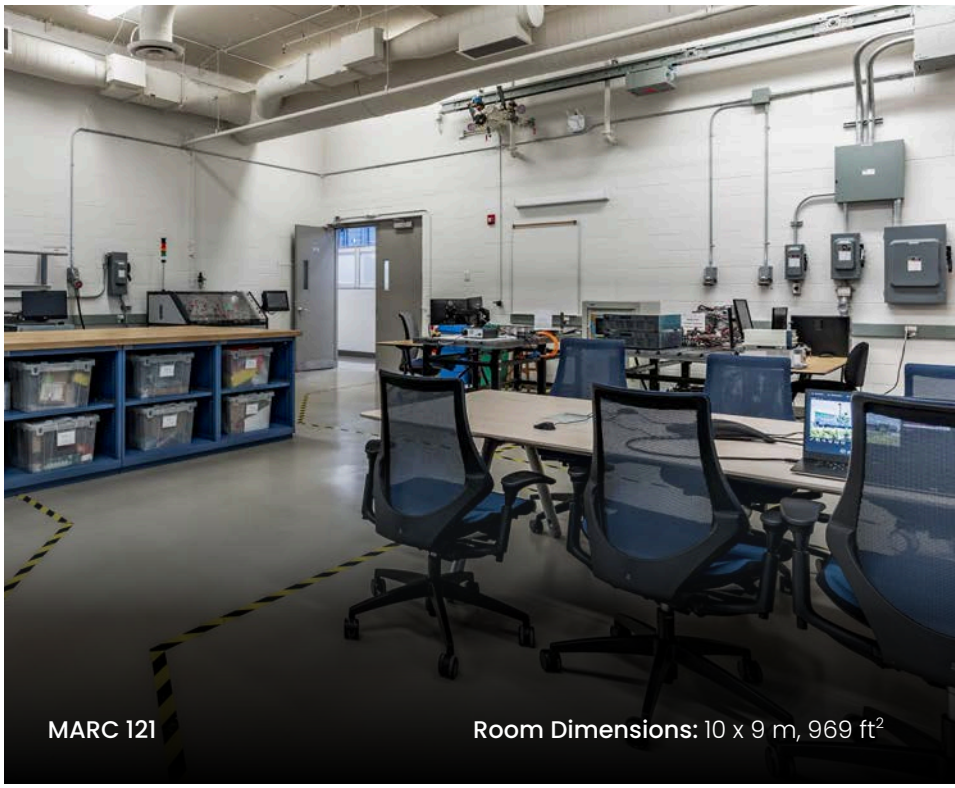
- T-slot electric machine dyno tables (x2)
- 90 kW 8,000 rpm Dynamometer
- Building liquid cooling loop access (up to 30 kW)

Testing & Prototyping

- Inverters
- DC/DC converters
- Battery chargers
- Solid state switches
- Electric machines

Three Phase Power Access

- 208 V 50 A (x1)
- 208 V 70 A (x1)
- 480 V 20 A (x1)
- 480 V 40 A (x3)
- 480 V 50 A (x1)
- 480 V 200 A (x1)



Motor Control & Power Electronics Lab

Facility

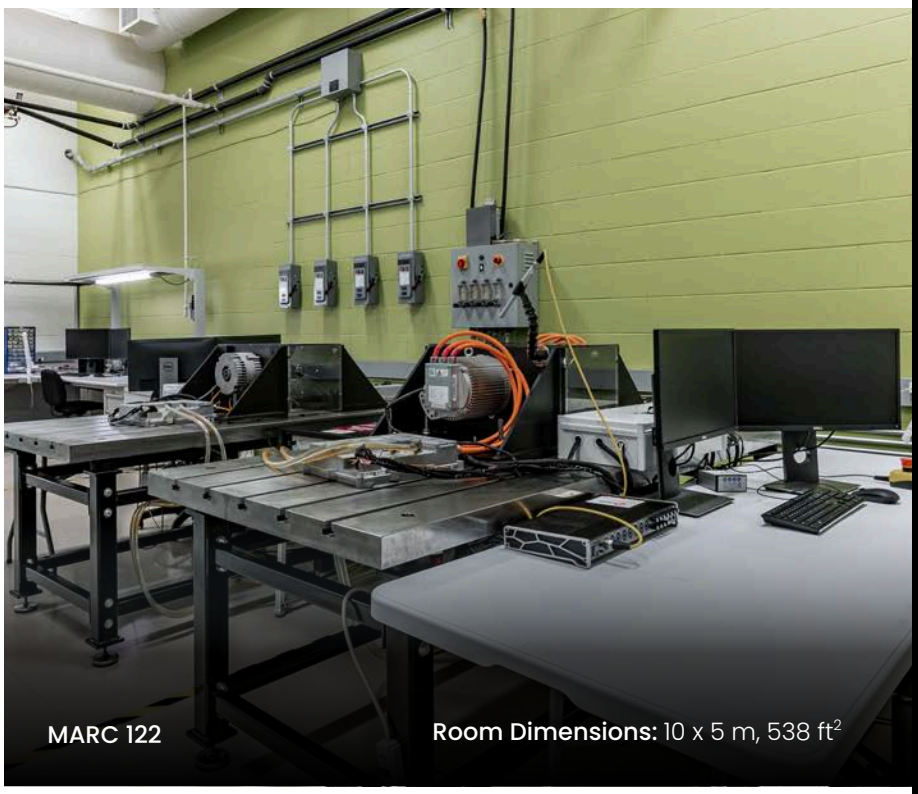
- 100kW 12,000 rpm, Dynamometer
- T-slot electric machine dyno table
- Electronics and control testing workstations (x2)
- Liquid cooling system (up to 30 kW)

Testing & Prototyping

- Inverters
- DC/DC converters
- Battery chargers
- Solid state switches
- Electric machines

Three Phase Power Access

- 480 V, 200 A (x1)
- 208 V, 50 A (x2)



PCB, EMI, & Power Electronics Lab

Testing & Prototyping

PCB Prototyping

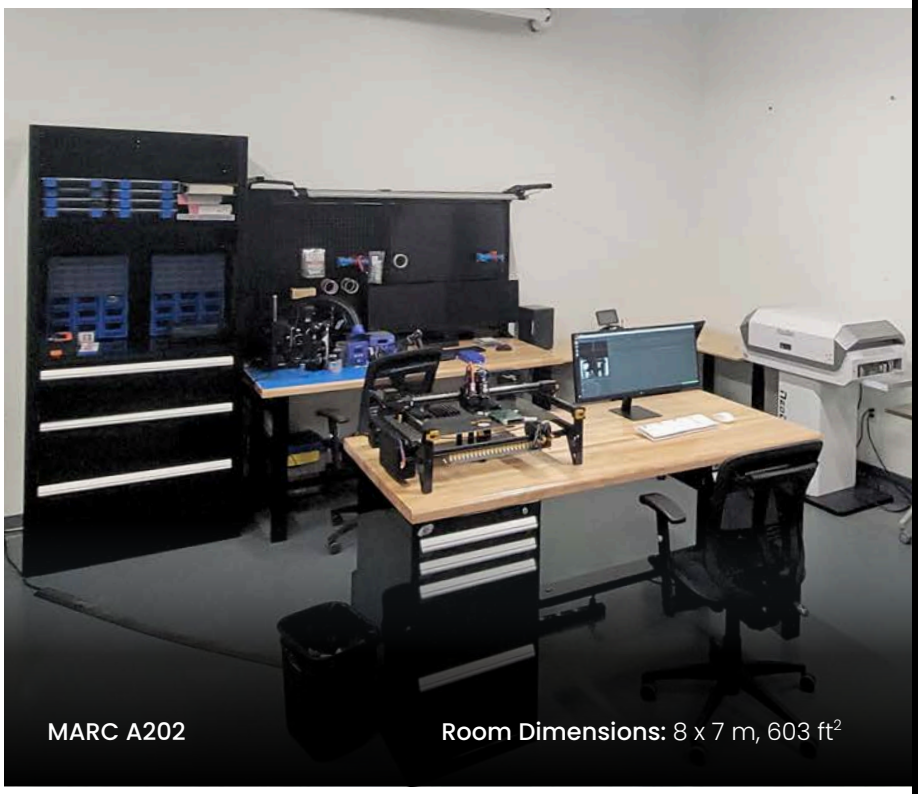
- LumenPNP: Automated pick & place
- SMTCaddy: Manual pick & place
- NeoDen IN6C: Reflow oven
- Stencil printer
- Rework station
- Microscope

EMI Testing

- Mobile Faraday tent
- 30 kHz - 4 GHz RF analyzer
- Vector network analyzer
- 30 MHz - 3000 MHz Hybrid measurement antenna
- Line impedance stabilization network
- DM/CM Separator

Three Phase Power Access

- 480 V, 200 A (x1)
- 208 V, 50 A (x4)



McMaster Automotive Resource Centre (MARC)

45 min drive
Toronto Pearson Airport

60 min drive
Downtown Toronto

90 min drive
Buffalo Airport

3 hr drive
Detroit

1 hr flight
Ottawa, Montreal, New York, & Chicago

Keep in touch

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