Converter-Based Microgrid Platform Development for Inverter-Based Resource Control Parameters Testing

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Introduction

- Power converters can be utilized to emulate components in electric power systems such as loads, generators, and transmission lines.
- Converter-based grid emulation hardware testbed (HTB) was built for evaluating future electric grids at CURENT
- HTB has actual power flow, measurements, communication, and true parallel capability.
- HTB has been utilized to study future transmission systems and microgrid systems.
- Converter-based microgrid platform has been developed to allow inverter-based resource (IBR) control parameters (PI controller) to be adjusted in real-time via an adaptive PI controller.

Microgrid Platform Development

- Banshee microgrid has been chosen to emulate in the HTB.
- The microgrid consists of generators, IBRs, a motor load, and ZIP loads.
- The microgrid in the HTB has been designed at a 100 V and 1 kW rated system for per unit implementation while the original voltage and power base values are 13.8 kV and 4 MW.
- A microgrid control center screen using LabVIEW to send commands to change values including turn on and off, power, ramp rate, and control parameters (K_p, K_i).
- Microgrid line impedances are much smaller than a typical transmission line which was first emulated in the HTB.
- Three single phase air-core inductors have been built to emulate 3-phase microgrid system.
- The adaptive PI controller with time-varying gains can help to track the predefined PQ trajectory.
- The adaptive PI controller has been implemented solely in the PQ regulator since the output of the power regulator determines the response of the PQ.

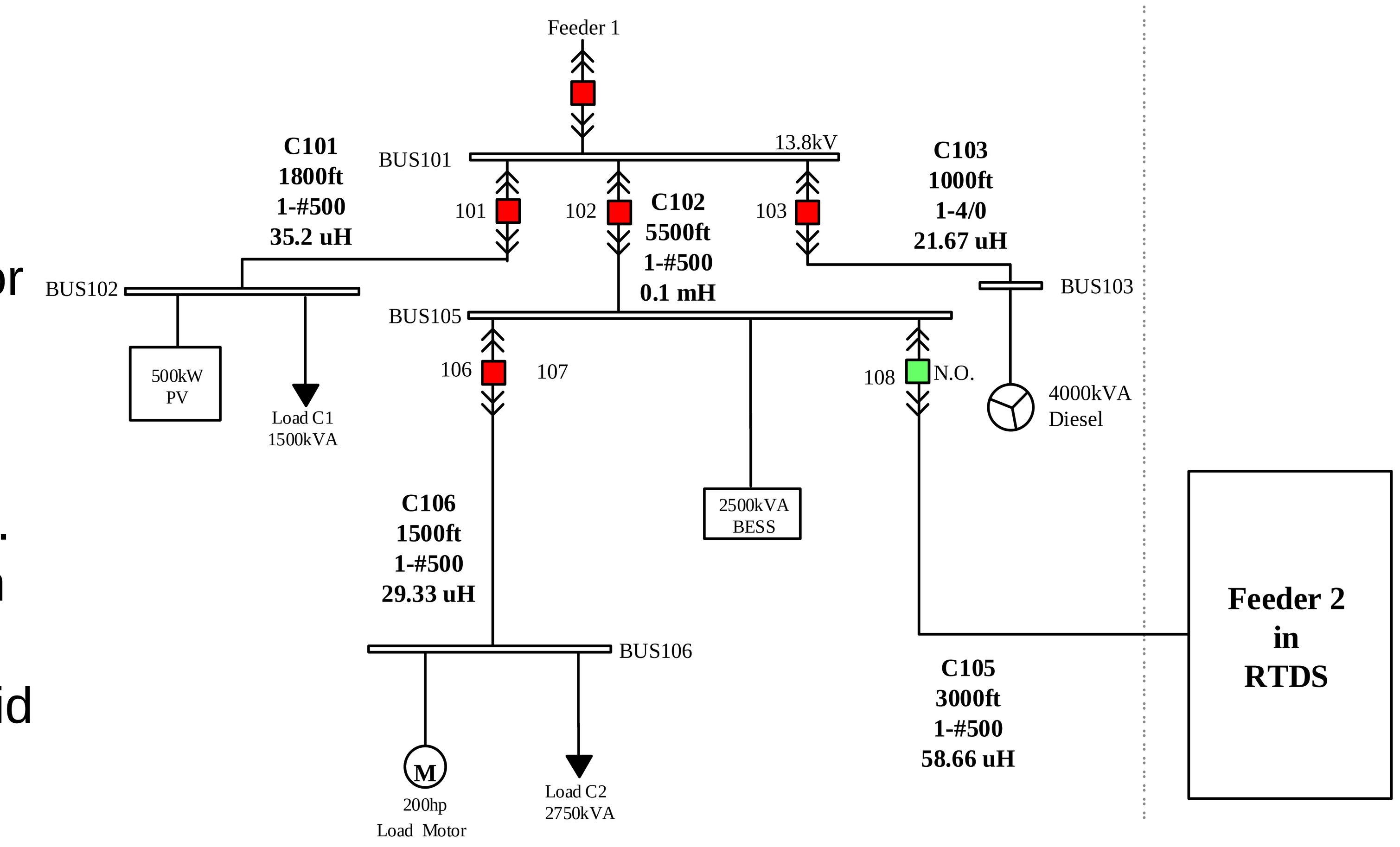


Fig. 1. Banshee microgrid.

$$K_p(t) = K_{p0} + K_{p1} e^{\frac{-t}{T'}}$$

$$K_i(t) = K_{i0} + K_{i1} e^{\frac{-t}{T'}}$$

Where K_{p0} and K_{p1} are fixed K_p gains
K_{i0} and K_{i1} are fixed K_i gains
T' = decay time constant
t = adaptive sampling time

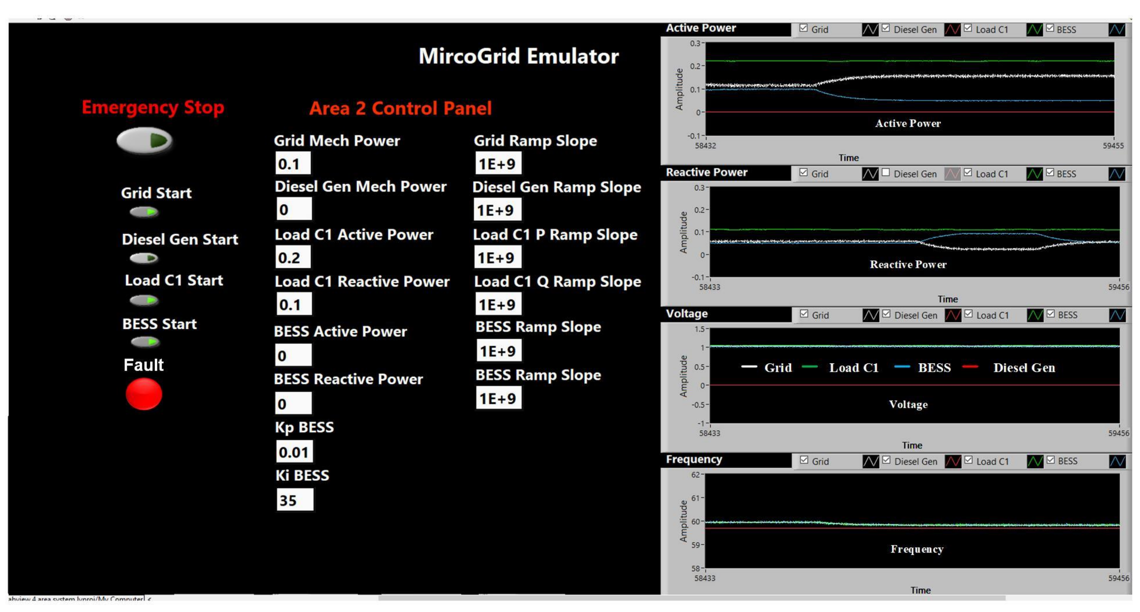


Fig. 2. Microgrid control screen.

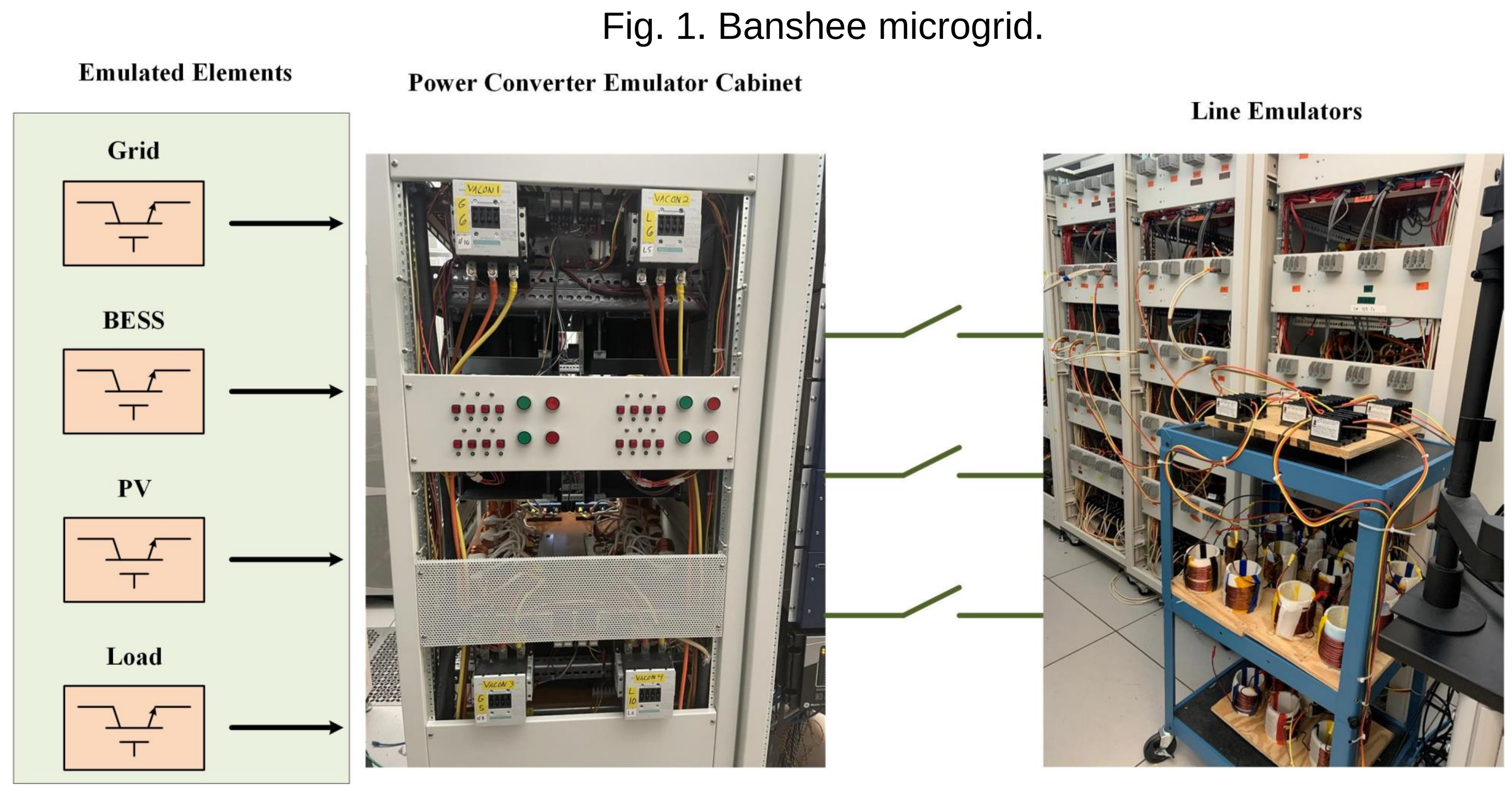
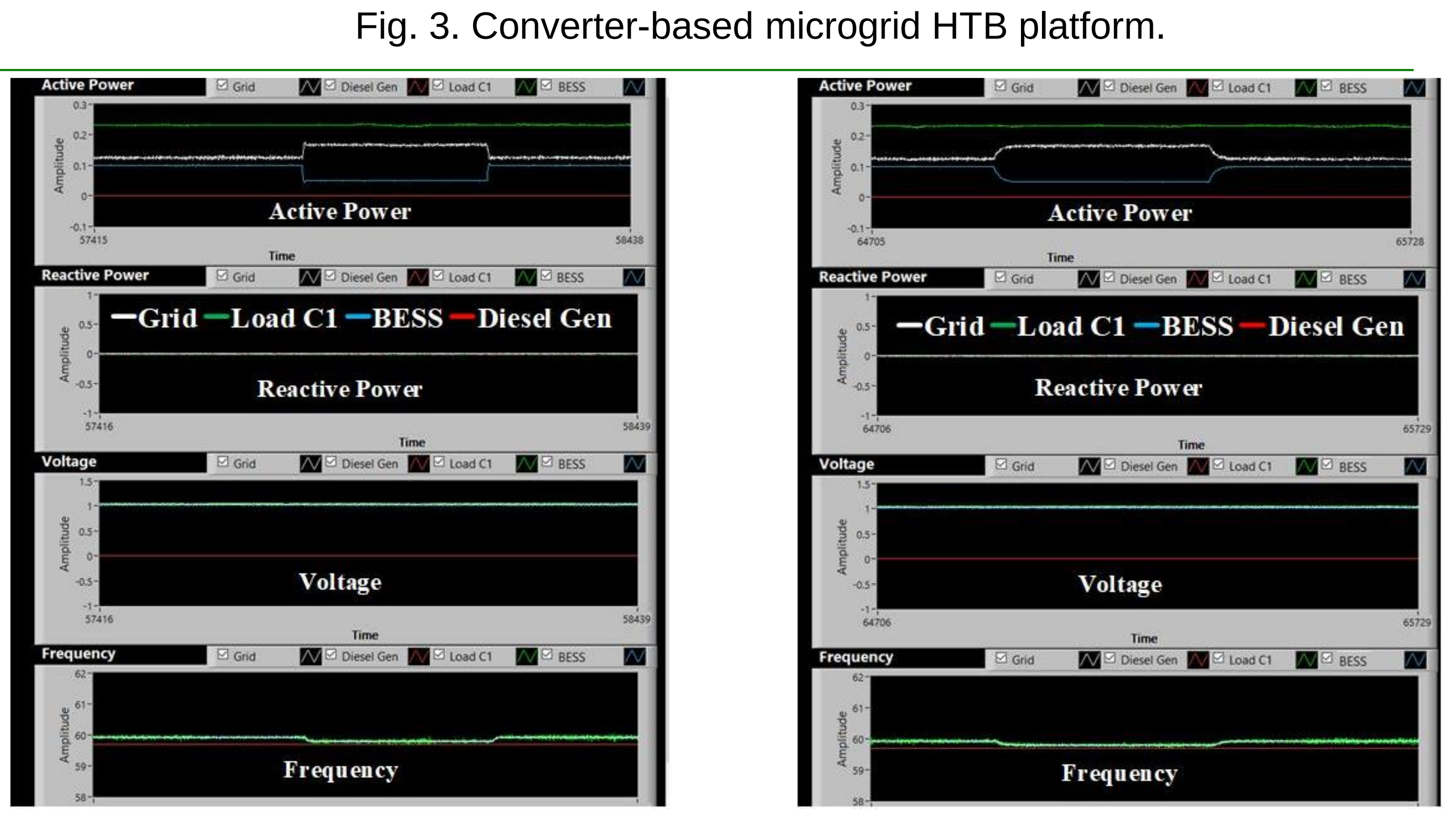


Fig. 3. Converter-based microgrid HTB platform.

Experimental Results

- Converter-based microgrid platform can test different PI control parameters of IBRs in real-time
- The dynamic capabilities of the adaptive PI controller has been implemented in the microgrid platform.

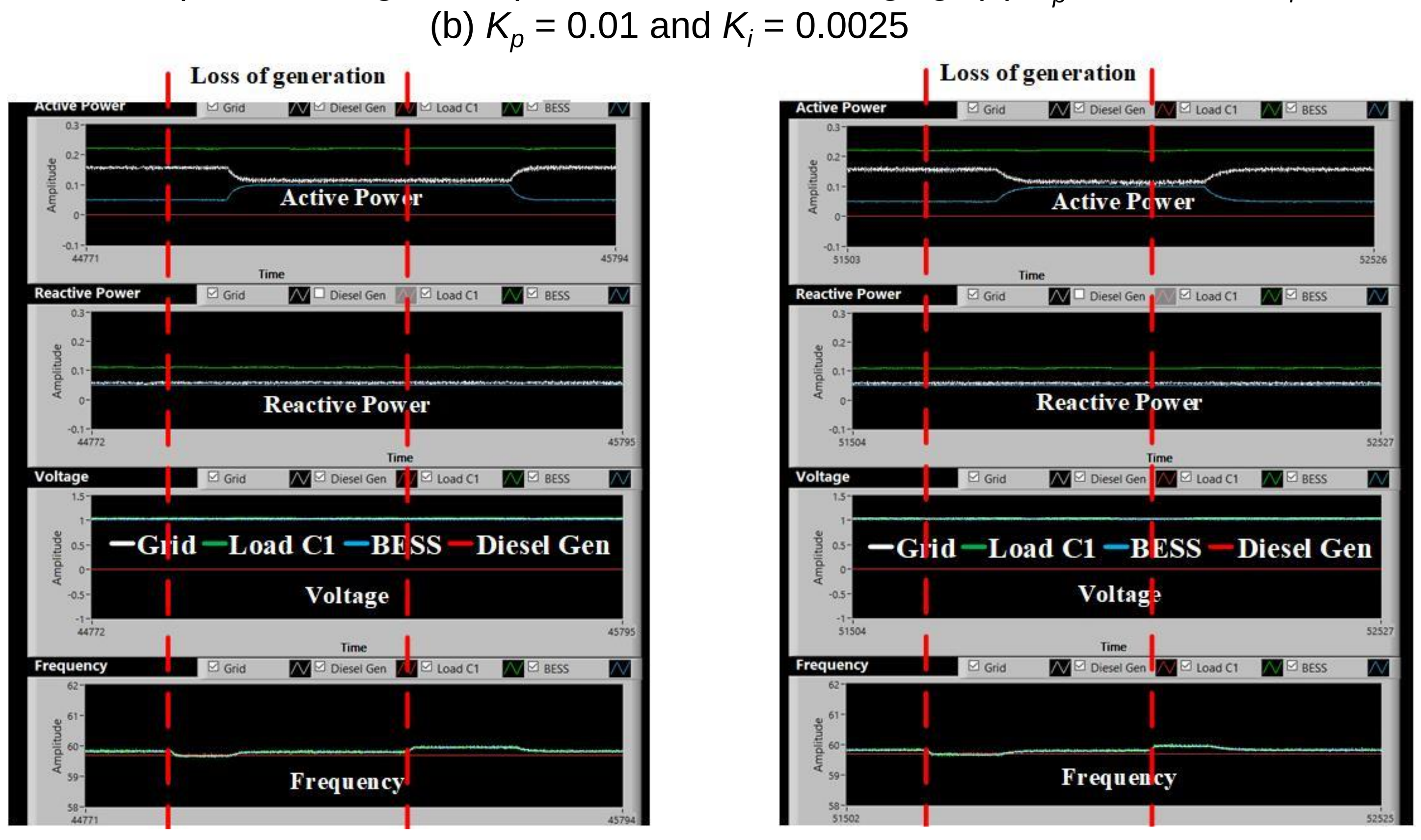


(a) (b)

Fig. 4. Inverter response during active power command changing: (a) K_p = 0.05 and K_i = 0.0025, (b) K_p = 0.01 and K_i = 0.0025

Conclusion

- Converter based microgrid platform has been developed to test inverter-based generation control parameters.
- This microgrid platform can be used to study IBR dynamic responses and its control parameters impact on microgrid systems.
- The adaptive PI controller can improve IBRs dynamic response



(a) (b)

Fig. 5. Inverter response during generation loss: (a) K_p = 0.01 and K_i = 0.0025, (b) K_p = 0.005 and K_i = 0.0025

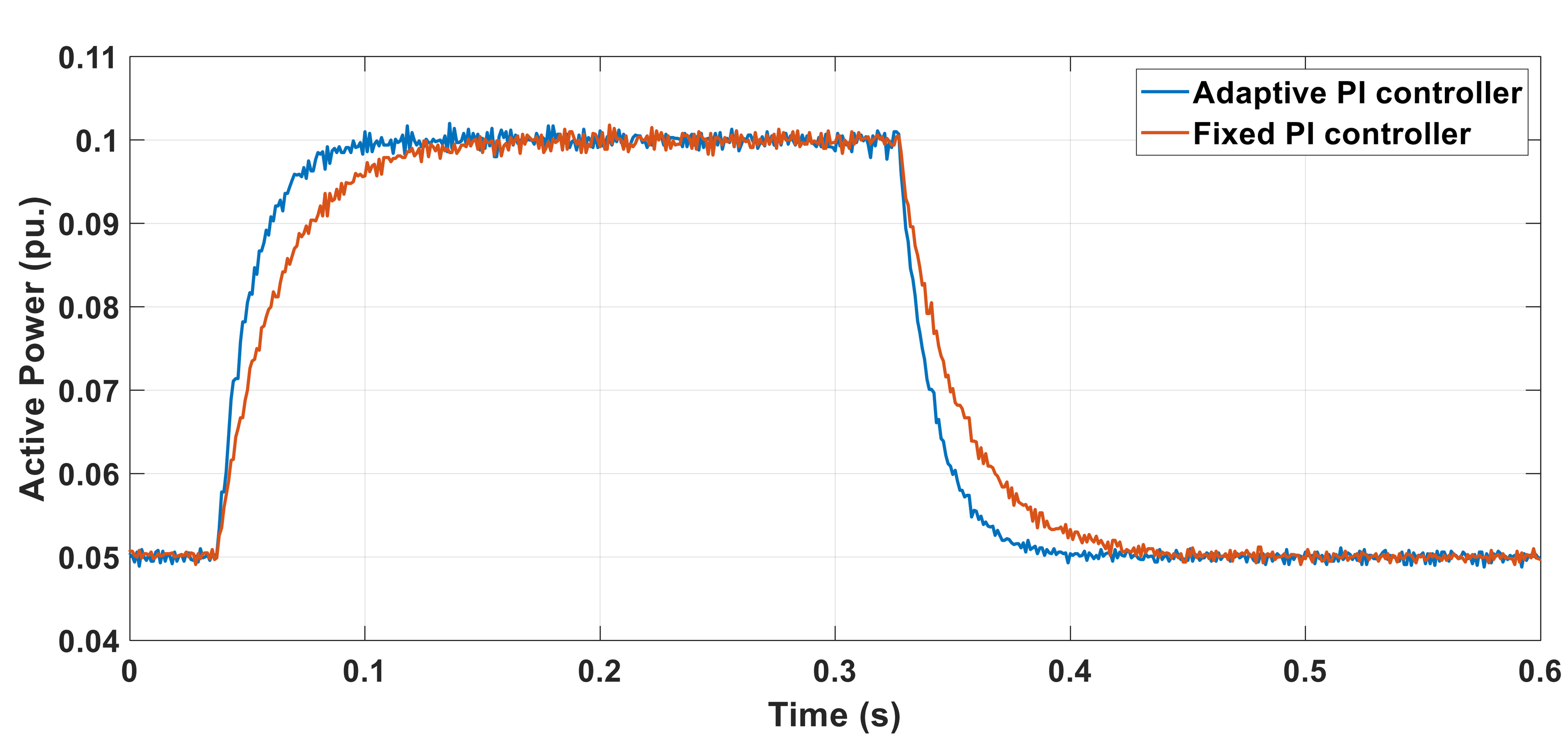


Fig. 6. Dynamic response of adaptive PI controller and fixed PI controller.