

# Output Voltage Ripple Reduction for Current-Mode Resonant Converter

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3A-05

## 1. Objective

LLC current-mode resonant converter

1. EMI noise reduction

Noise spectrum spread

2. Modulation ripple reduction

Dual-phase configuration

Reverse phase modulation

## 2. Background

EMI noise generation by current flow

Conventional noise reduction

Analog filter

Shield case



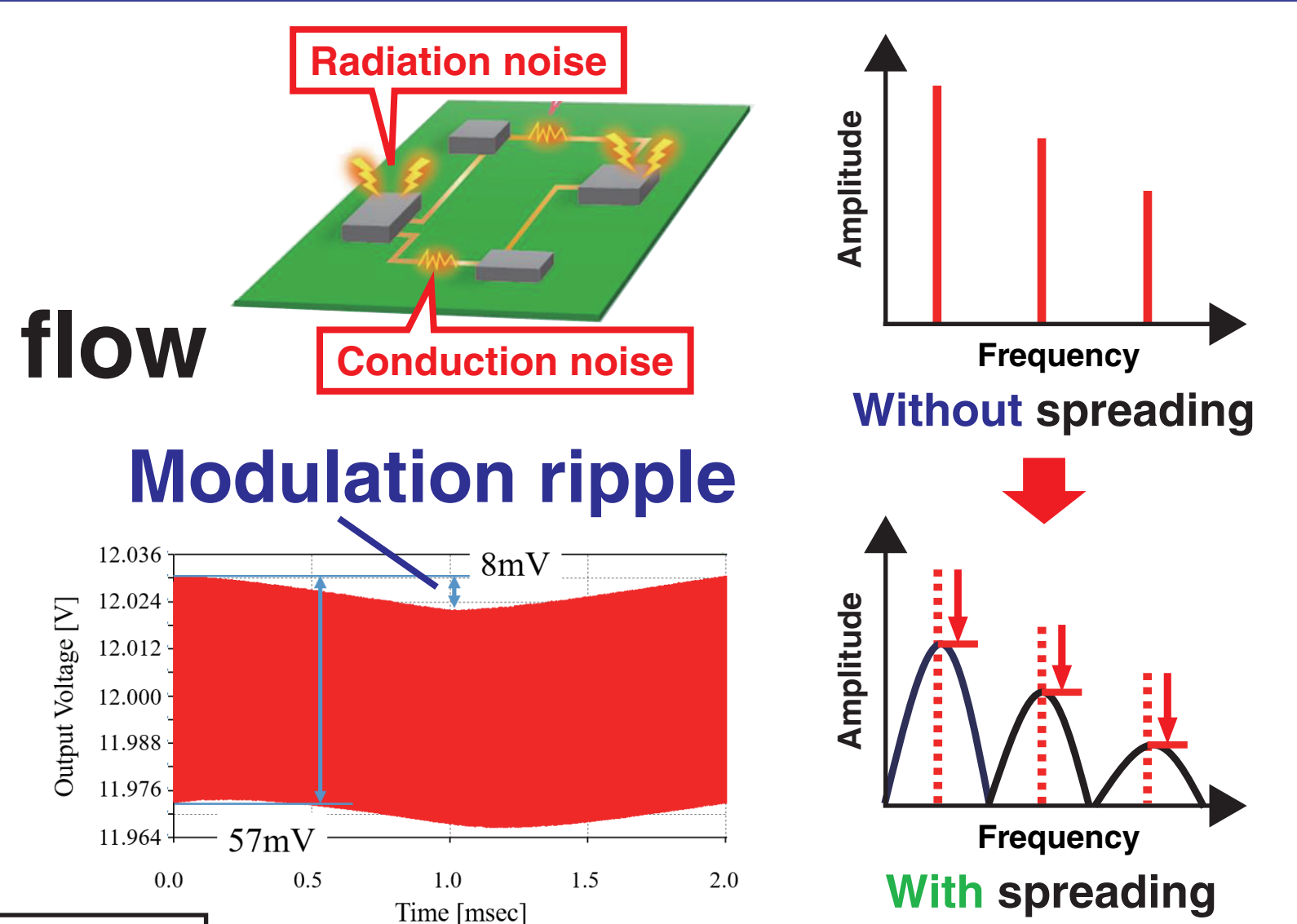
Large scale  
High cost

Proposed noise reduction

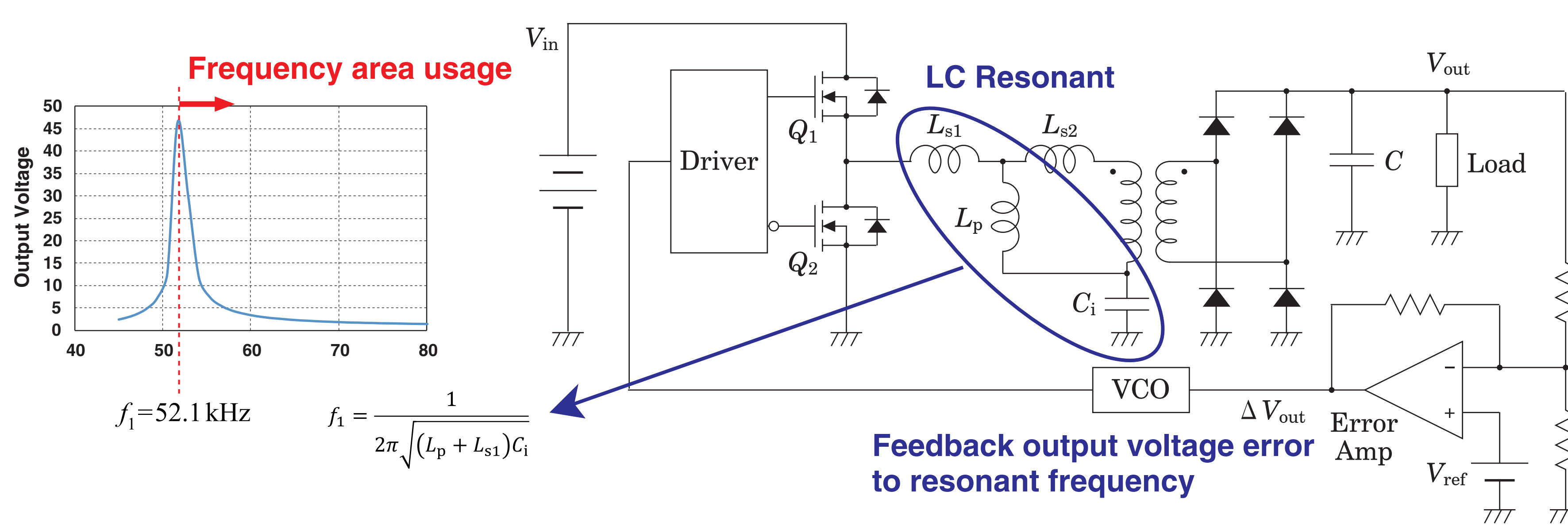
Noise spectrum spread

Goal

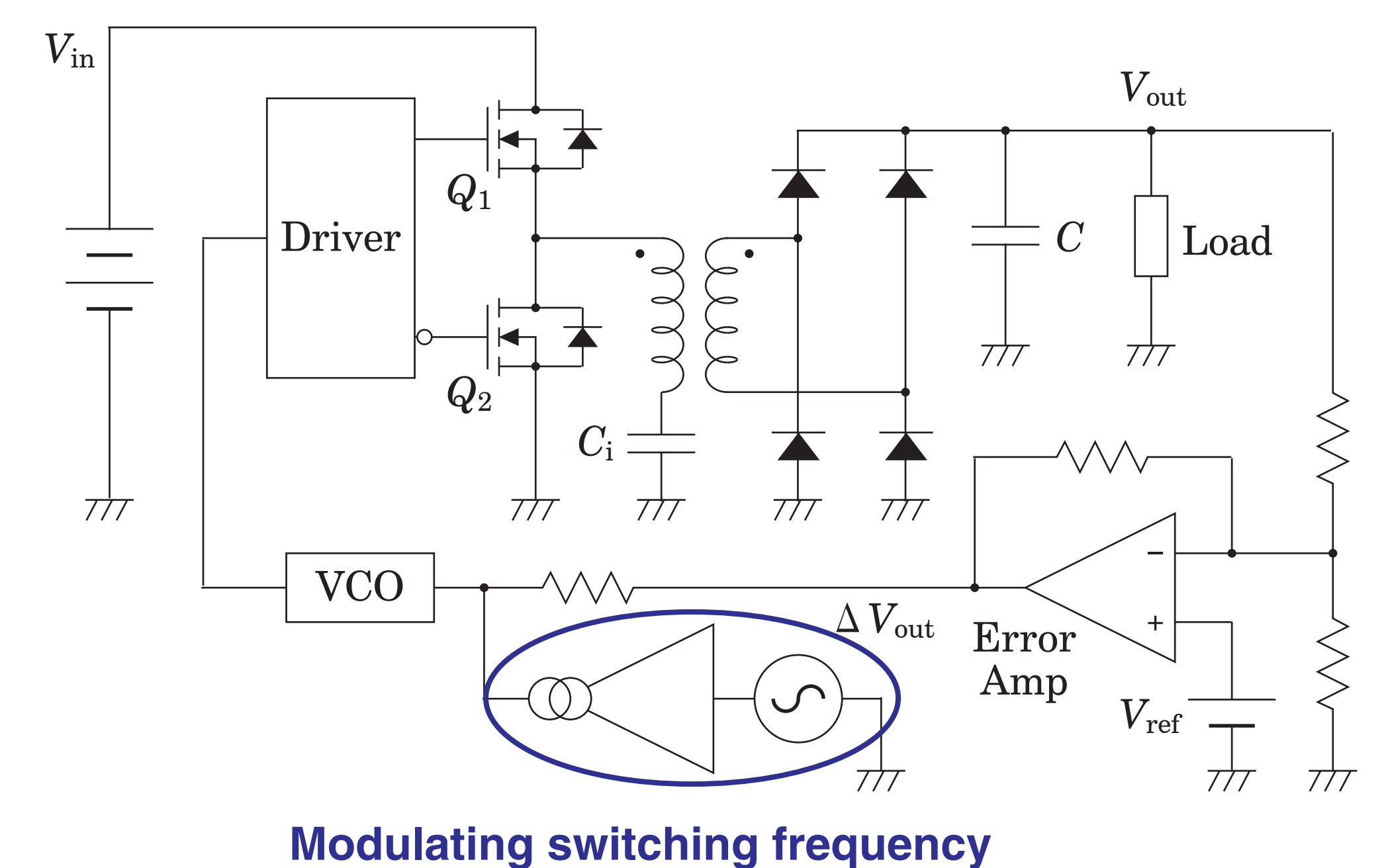
Modulation ripple reduction



## 3. LLC Resonant Converter

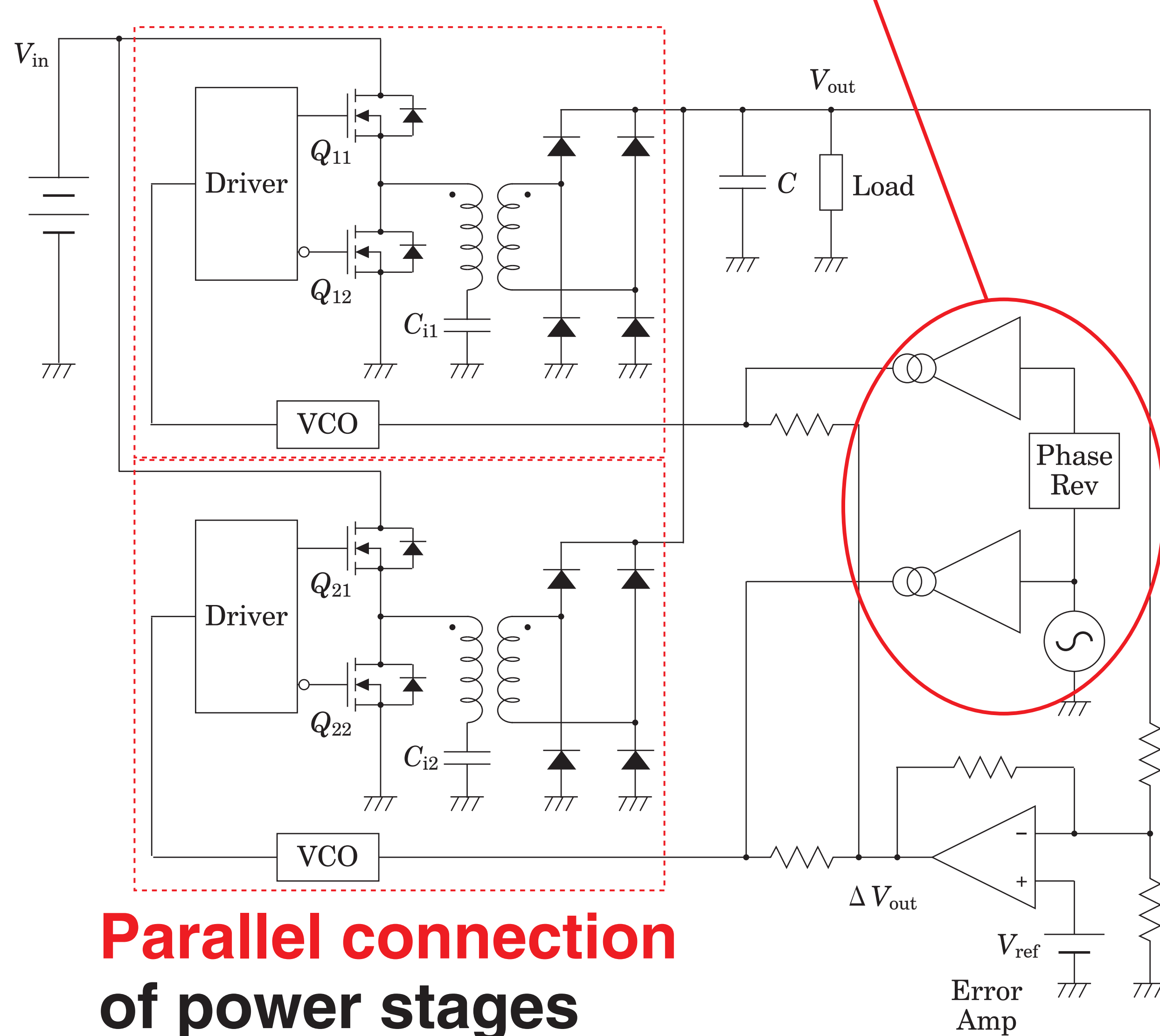


## Noise spectrum spread for LLC converter



## 4. Proposed Circuit

Reverse phase modulation  
each power stage



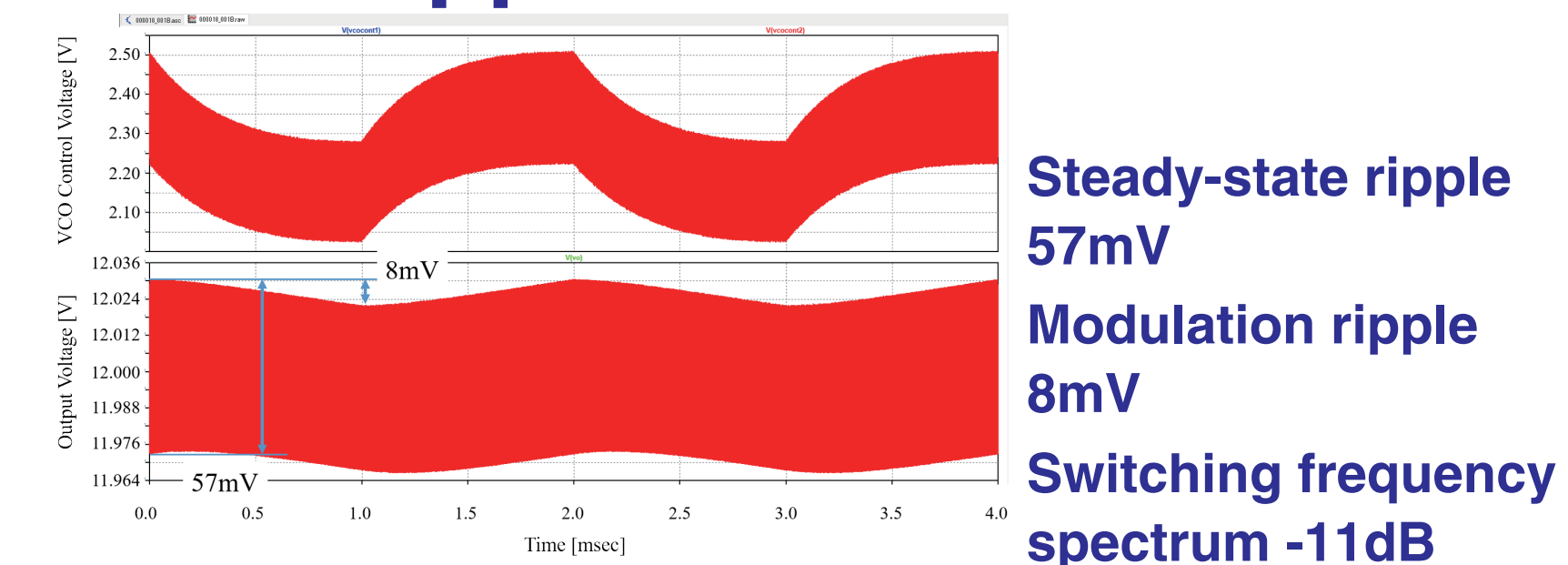
## 5. Simulation

Conditions

Switching frequency: 350kHz

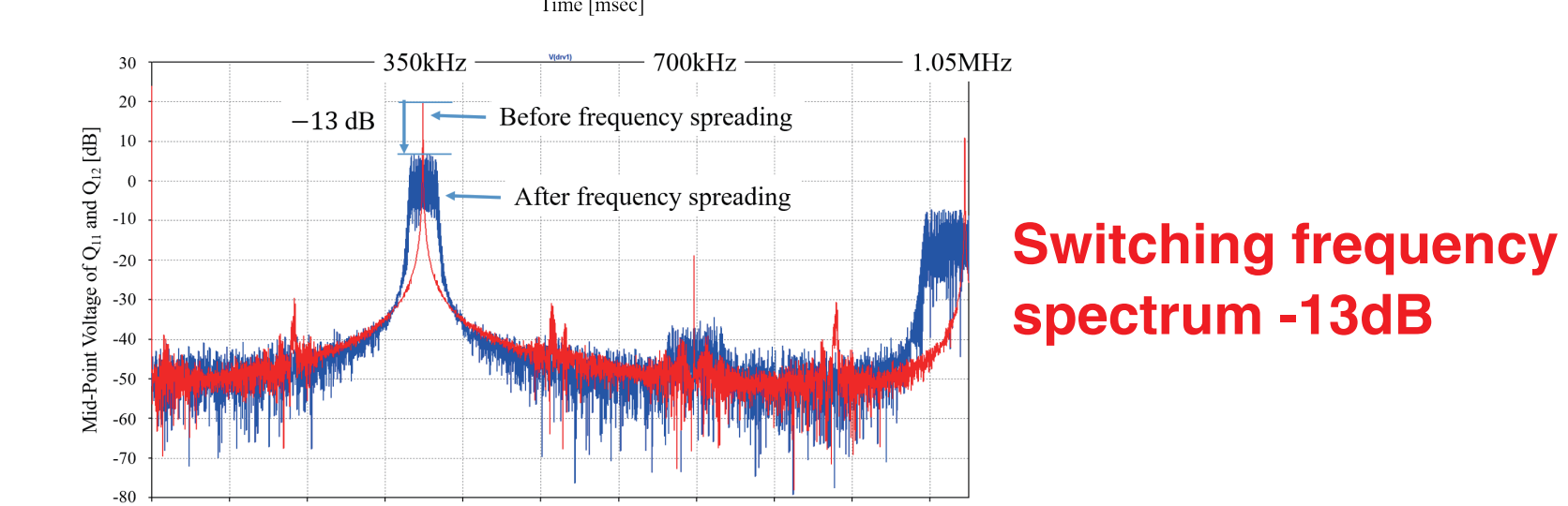
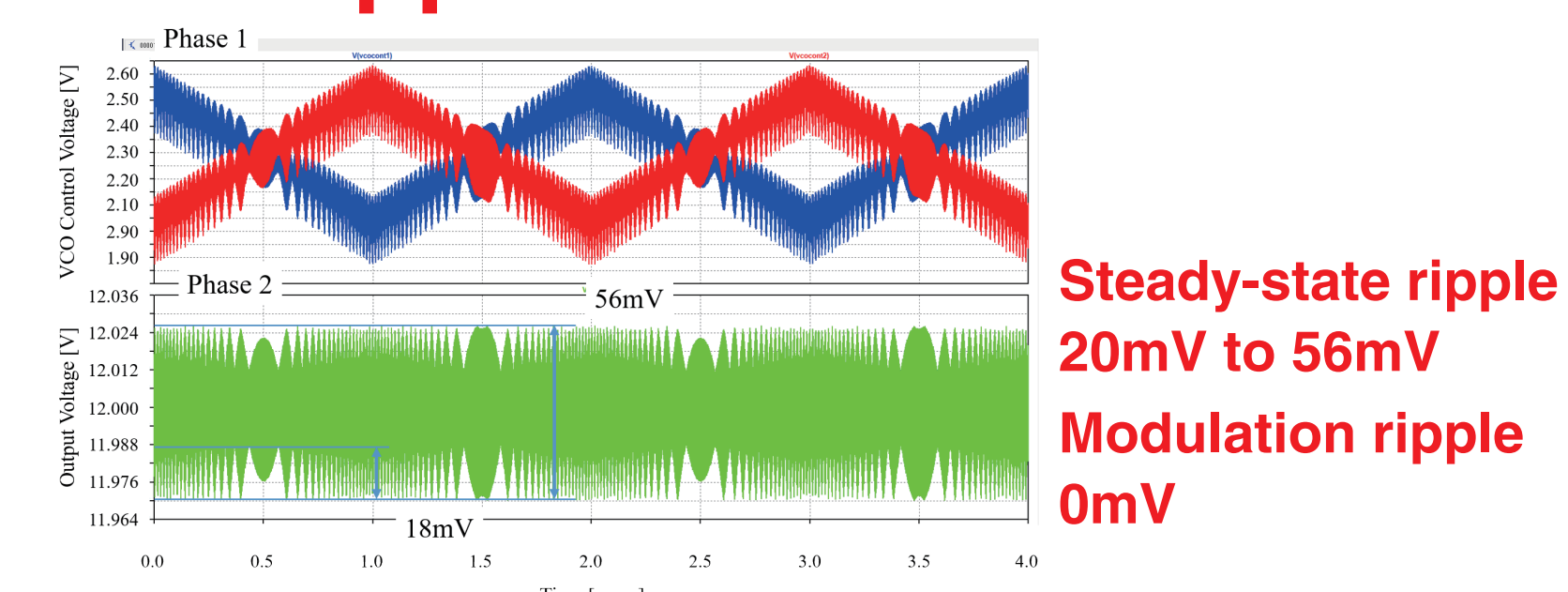
Modulation signal: 500Hz Triangular

Before ripple reduction



Reduce modulation ripple

After ripple reduction



## 6. Conclusion

LLC resonant converter

- EMI noise reduction
  - Noise spectrum spread by modulating the switching frequency
- Modulation ripple reduction
  - Dual-phase configuration LLC resonant converter
  - Each channel switching frequency modulation by reverse phase
- Simulate proposal circuit
  - Switching frequency: 350kHz
  - Modulate signal: 500Hz triangular
  - Without ripple reduction: 8mV ripple
  - With ripple reduction: 0mV ripple
  - Switching frequency spectrum: -13dB
  - Noise spectrum spread equivalent to before ripple reduction

## References

- [1] M. Ochiai, Switching Power Supplies, Ohm Publishing (2015).
- [2] D. Kawahara, S. Abe, S. Motomura, K. Domoto, Y. Ishizuka, T. Ninomiya, M. Shoyama, M. Kaga, "On the Parallel Operation of LLC Current-Mode Resonant Converters in High-Voltage DC Power Distribution System", IEICE Information and Communication Engineers, Tech. Report (2013).
- [3] K. Kawamura, T. Yamamoto, K. Hojo, "Circuit Technology of LLC Current Resonant Power Supply", Fuji Electronic Journal, Vol.87 No.4 (2014)