Features of parallel connection of power supplies
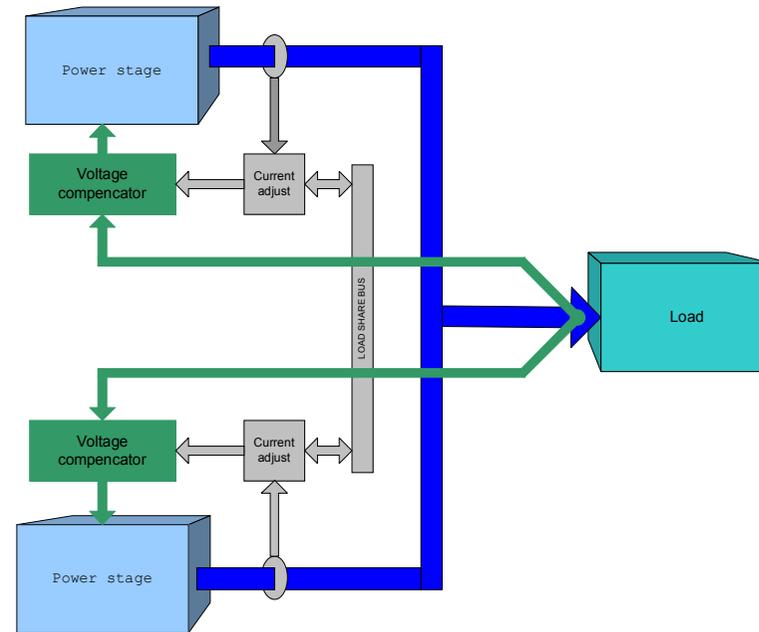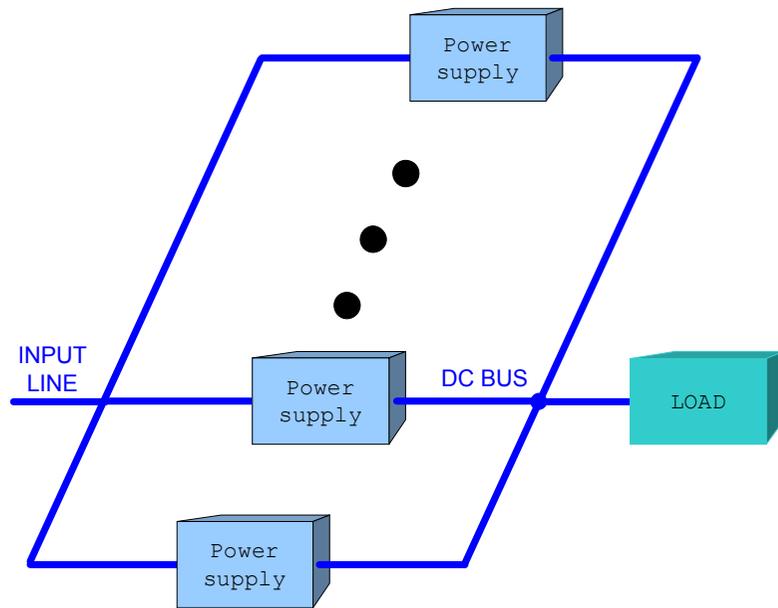
16.10.2013   N. Kalugin

Introduction

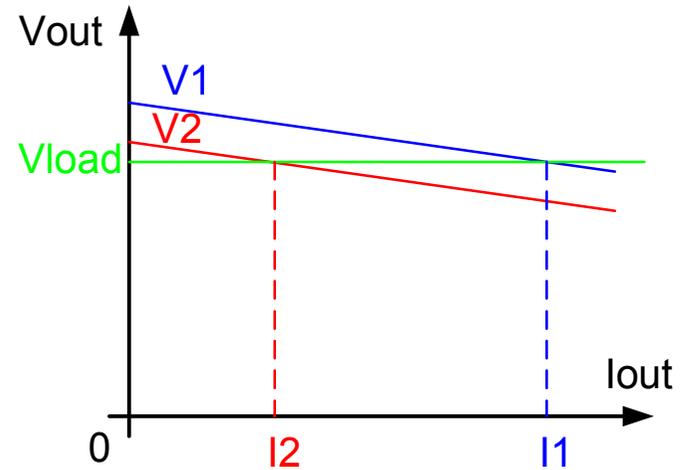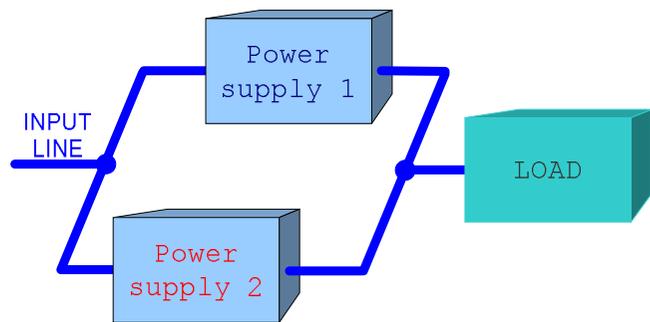# Load share techniques

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| Load share techniques |

Open loop technique	Master-slave technique	Automatic technique
•Droop method	•Dedicated master •External controller	•Average current •Highest current •Lowest current

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Load share techniques. Droop technique

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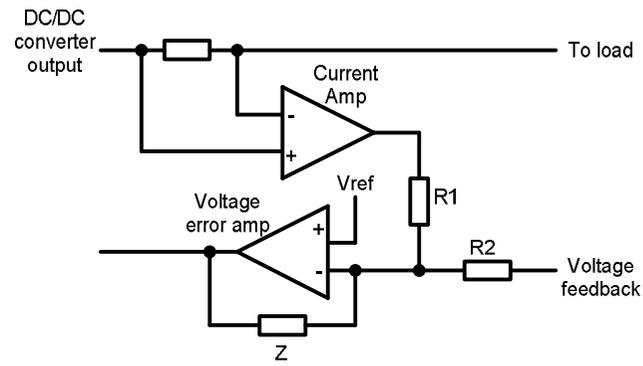
Load share techniques. Master-slave technique

Dedicated master

External controller

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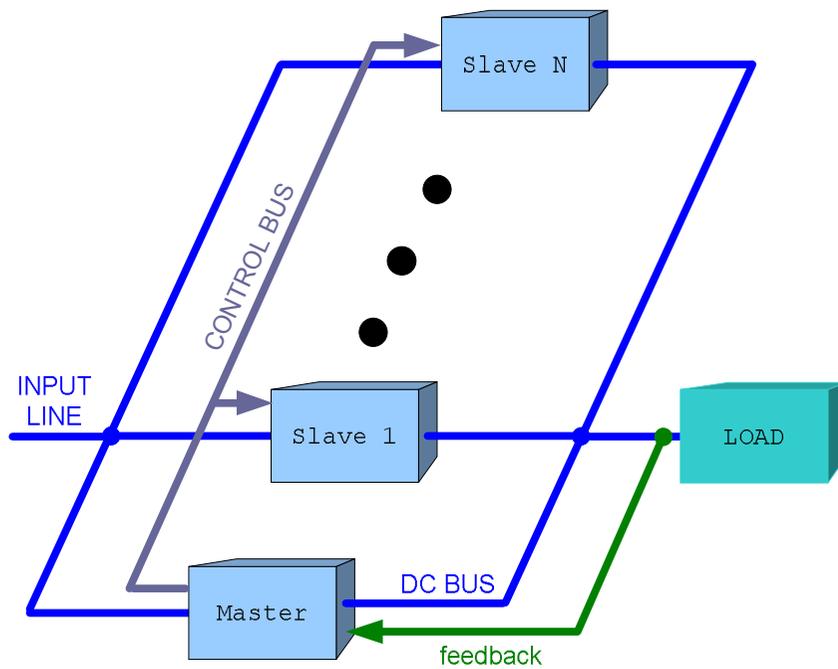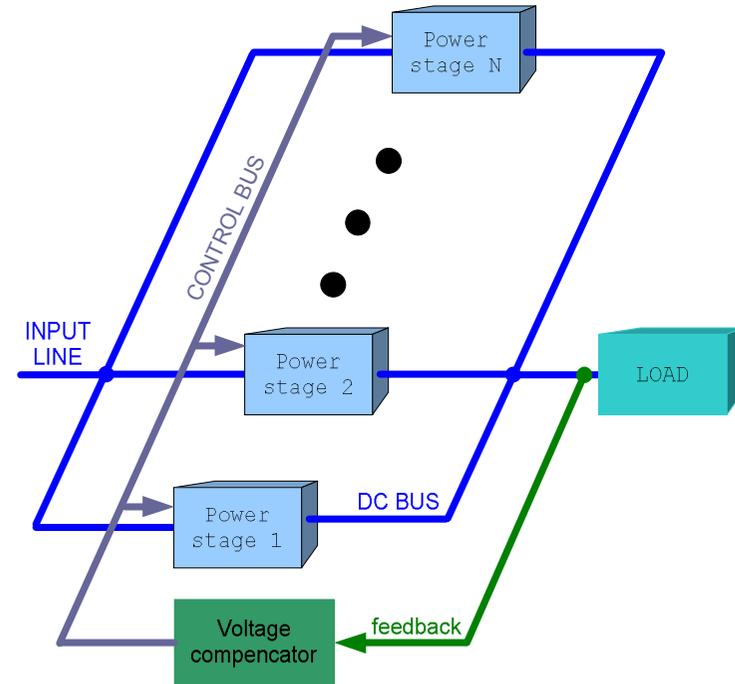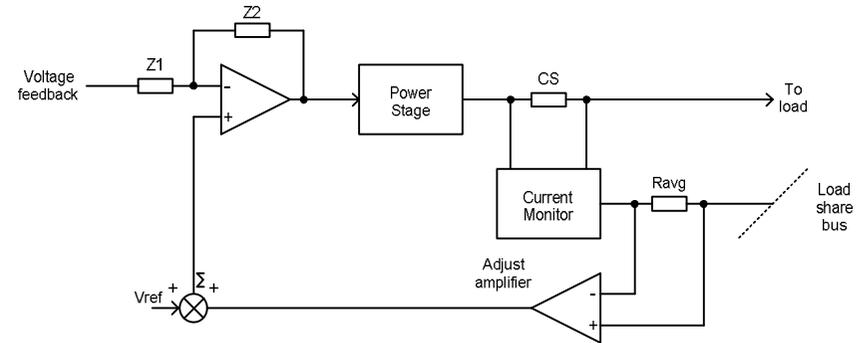
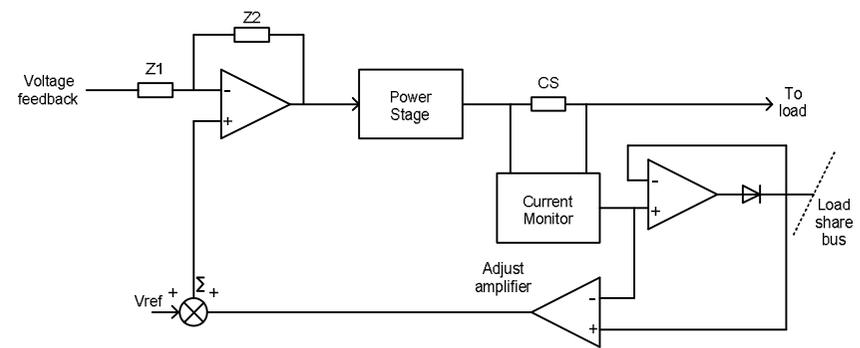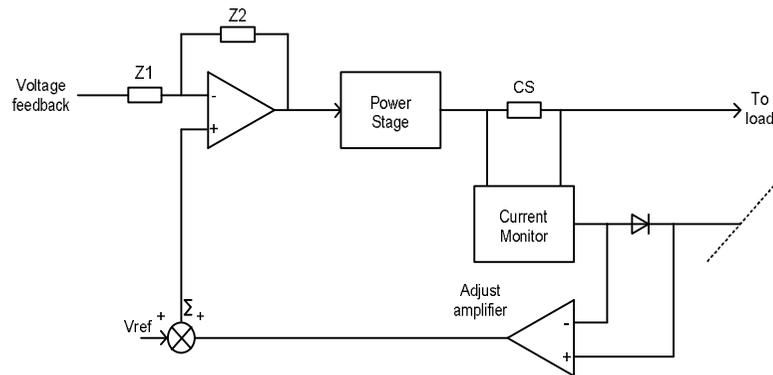# Load share techniques. Automatic load share
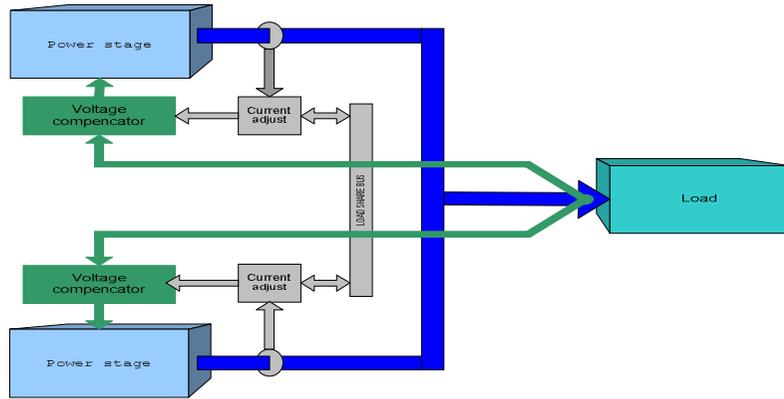
Average current technique.

US Patent 4,717,833 Jan 1988

Highest current technique.

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Automatic load share. Highest current

Implementations of the method for ready to use power supplies
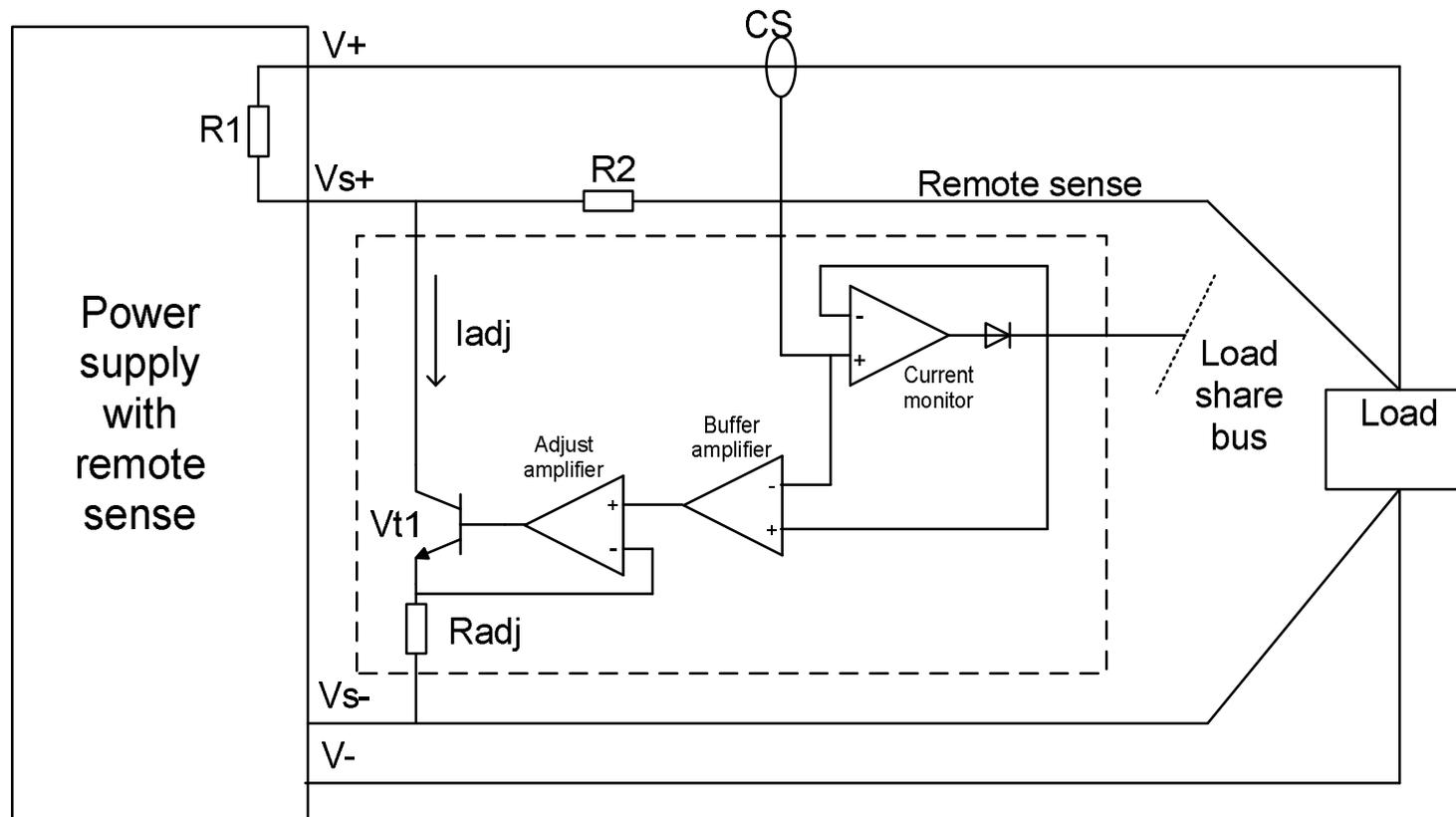
Master/slave methods

- Good accuracy and transient response
- Poor redundancy
- Multiphase approaches are widely used for compact designs (for ex. CPU power supplies)

Automatic methods

- Good accuracy
- Transient response slower than in master/slave systems
- Widely used in IT systems like cPCI, VME.

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Digital methods

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Digital method. Average current

Power Stage → Vout

PWM

ADC

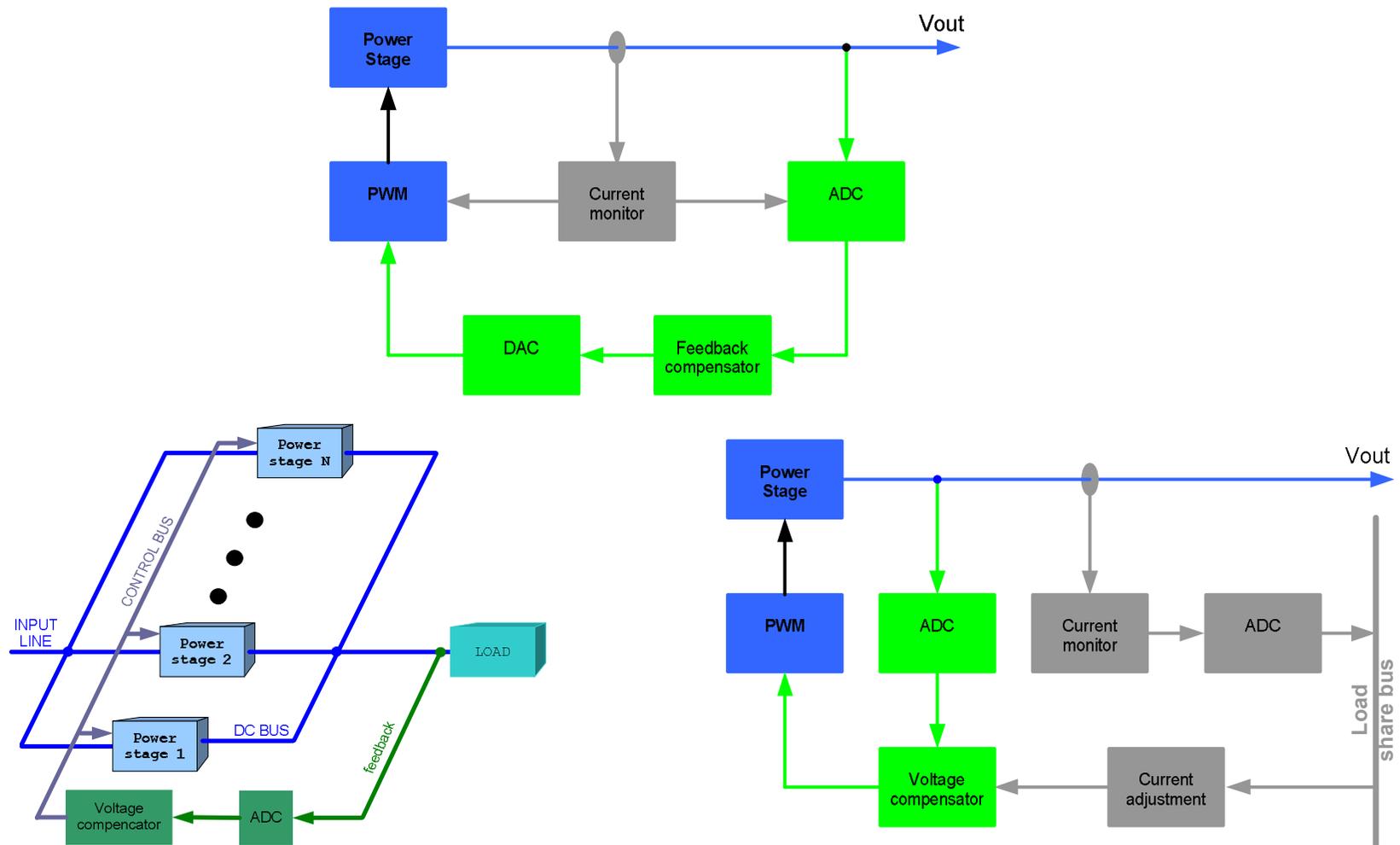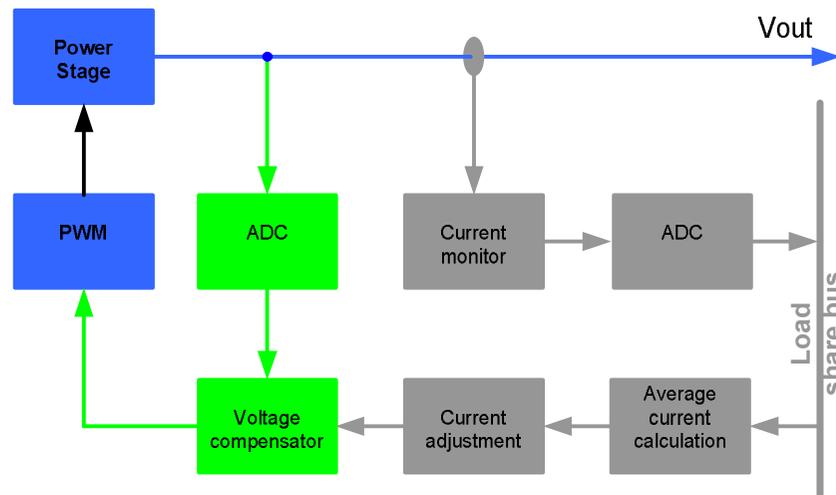Current monitor → ADC

Voltage compensator ← Current adjustment ← Average current calculation

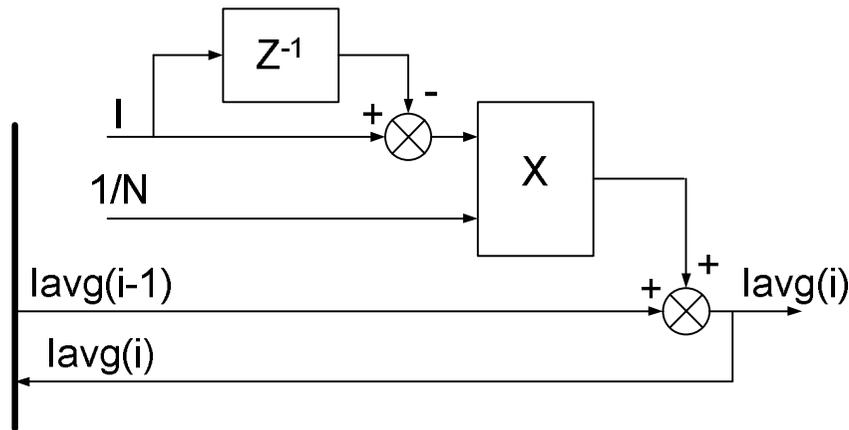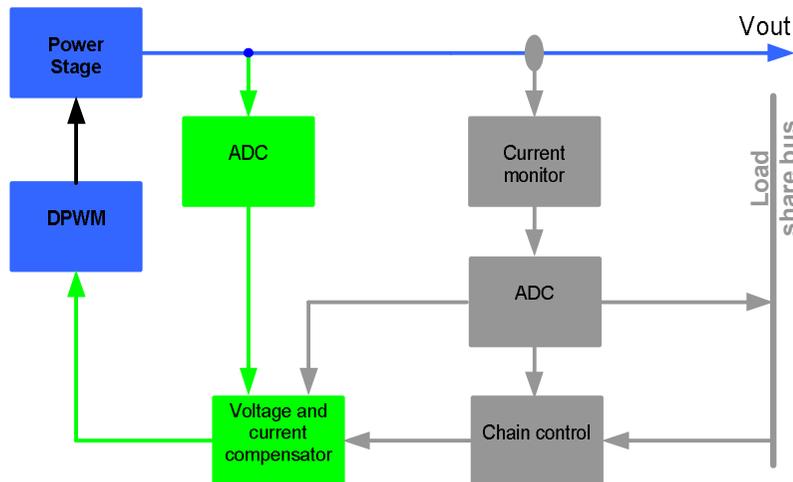Load share bus

- CAN bus as digital load share bus
- Current is periodically broadcasted
- Data on load share bus is used to calculate average current
- 208us for one packet of data at 1Mbit
- (N-1) currents have to be stored to calculate average current
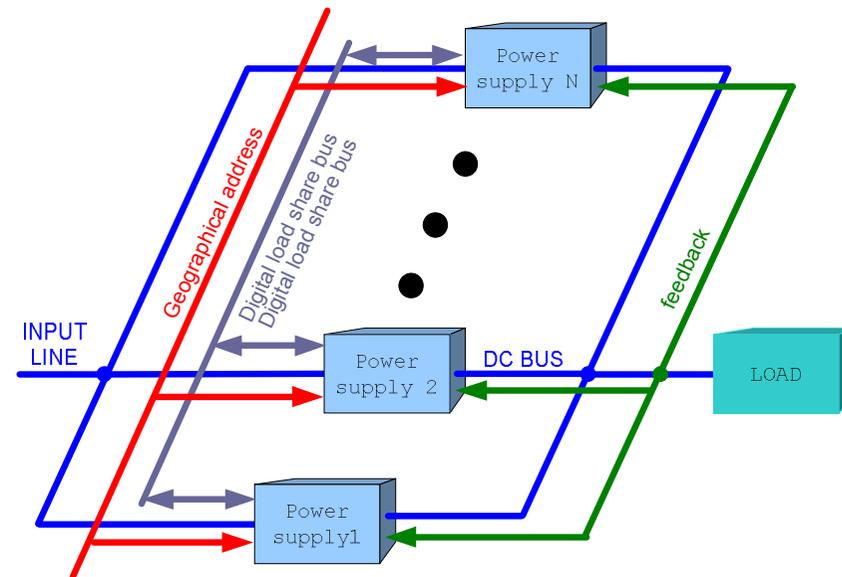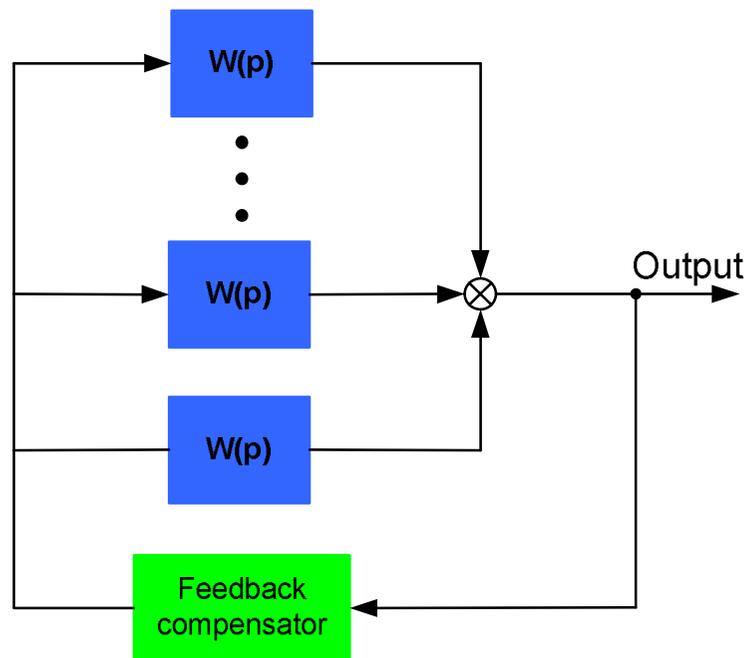
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Digital chain current share

$$Iave[1](i)=[I[1](i)+I[2](i-1)+I[3](i-1)+ .. +I[N](i-1)]/N$$

$$Iave [i] = Iave[i-1] - I[i][j-1] / N + I[i][j]/N$$

Vout

• Average current have to be calculated in sequence

• Additional filter is required to improve transient response

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Digital method. Automatic master detection

Digital load share. Automatic master detection

- Geographical address sets the ID of the device
- Power supply with highest GA becomes master
- Power supply that lost arbitration goes into slave mode
- Master controls number of slaves
- At master-power-down slaves start master detection procedure

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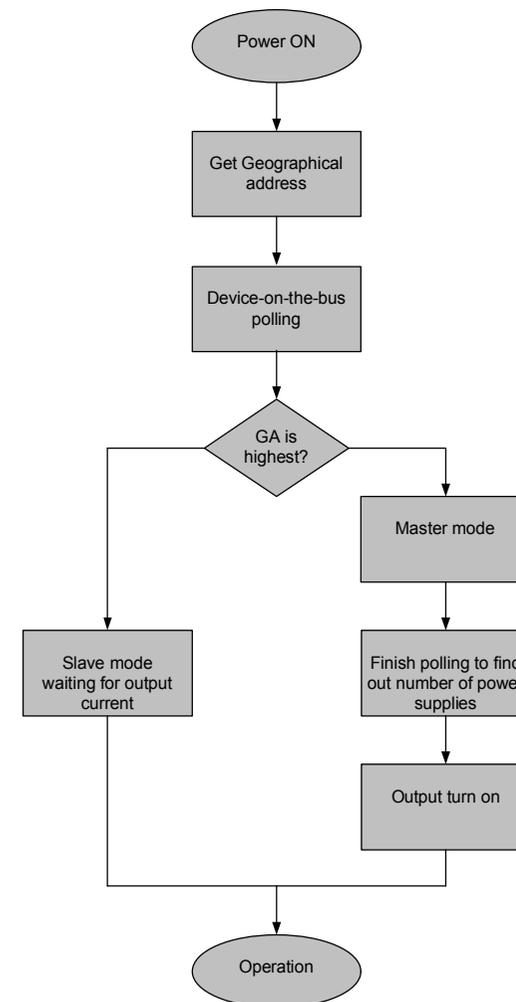
Digital method. Automatic master detection

MathLab experiment

•Combination of master/slave and automatic approaches
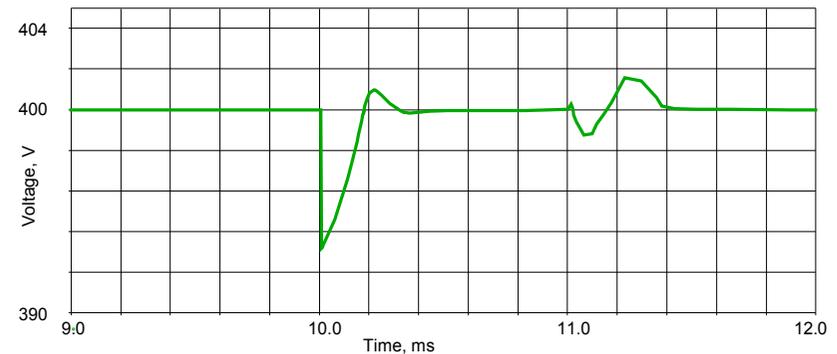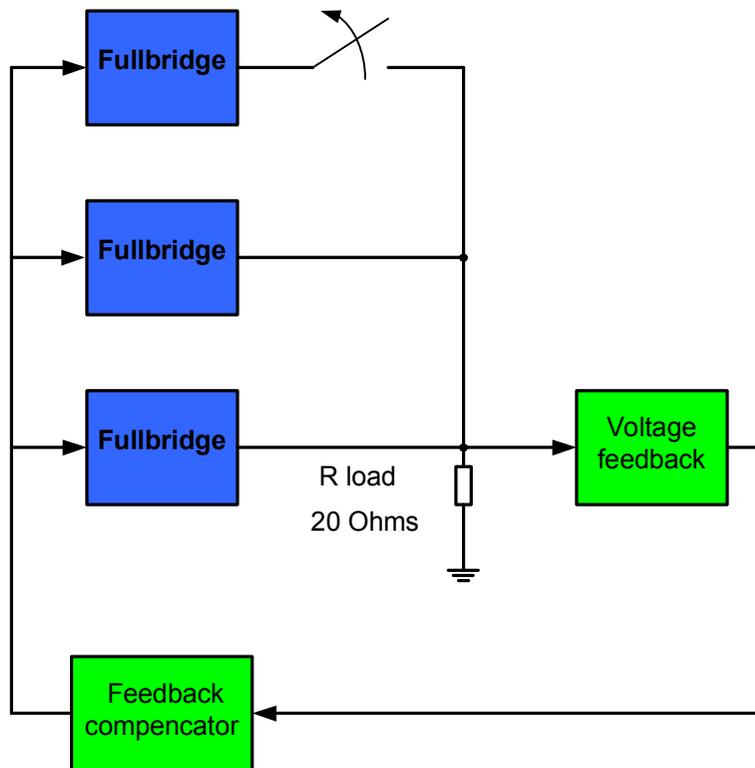•Stable at load steps and input DC voltage changes
•At power down of one module transfer functions is changed, system may goes into oscillation
•Experimental verification is needed

•Fullbridge DC/DC converter
•420VDC input
•400VDC output
•12.5A/5kW output
•100kHz switching frequency

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Digital method. Automatic master detection

- System is stable at steady state and high load

- After adjustment of voltage compensator short transient is seen

- At light load system becomes unstable after power down of one module

- Additional algorithmic features are required to prevent oscillation

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Conclusion

- Both analog and digital approaches divides into two branches: master/slave branch and automatic branch
- Master/slave demonstrates good transient response with poor redundancy
- Automatic demonstrate good redundancy but poor transient
- Digital load share method with automatic master detection is described in this presentation
- MathLab model shows good stability
- 5kW DC/DC converter with this approach is under construction at Siemens

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Thank you for your attention

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