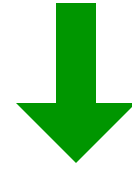


# Structured Electronic Design

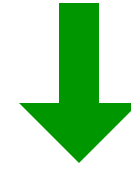
## Orthogonal Design of Negative Feedback Amplifiers

# **Orthogonal** transistor-level design of negative feedback amplifiers

order of  
designing

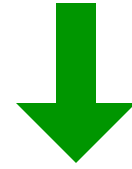


independent  
performance aspects



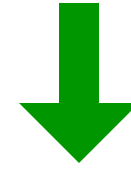
# **Orthogonal** transistor-level design of negative feedback amplifiers

order of  
designing



1

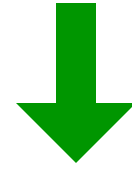
independent  
performance aspects



type

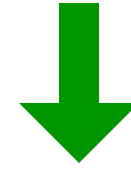
## **Orthogonal** transistor-level design of negative feedback amplifiers

order of  
designing



1  
2

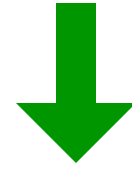
independent  
performance aspects



type  
gain

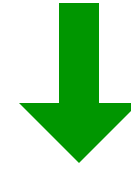
## **Orthogonal** transistor-level design of negative feedback amplifiers

order of  
designing



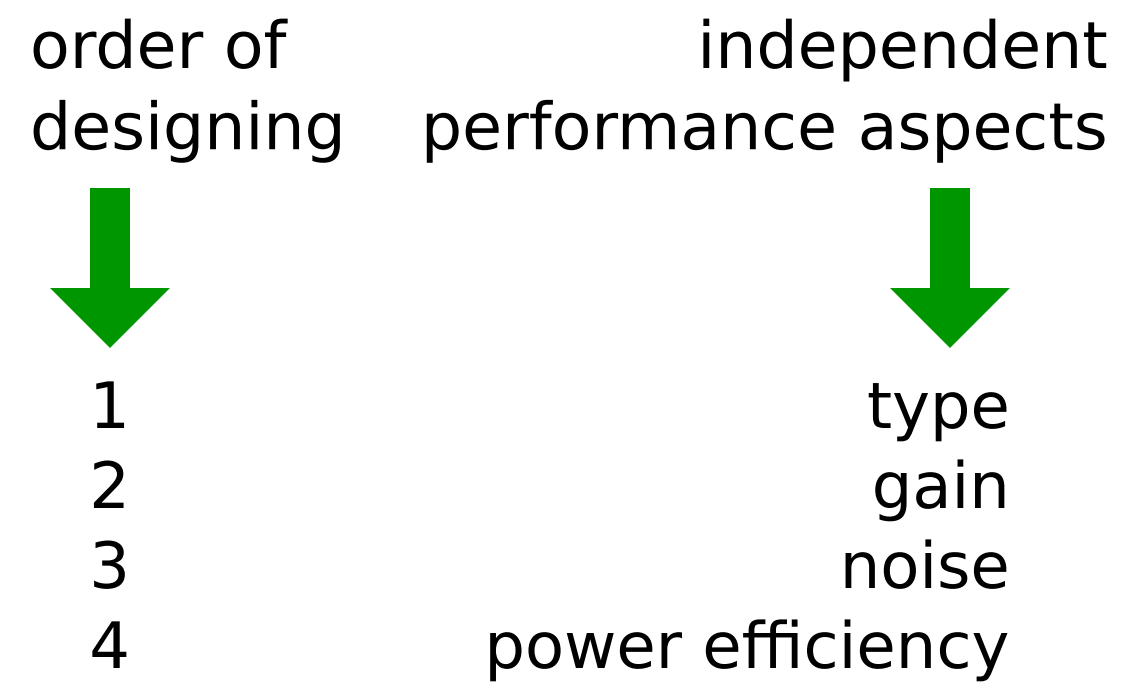
1  
2  
3

independent  
performance aspects

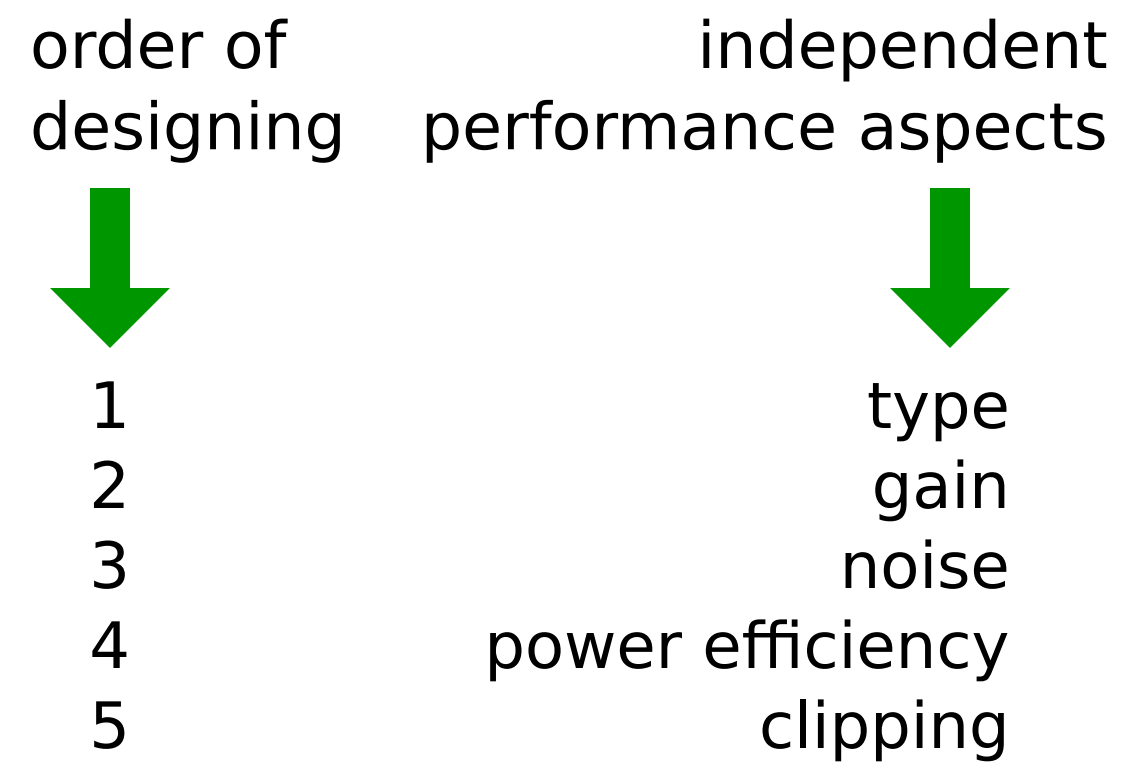


type  
gain  
noise

## **Orthogonal** transistor-level design of negative feedback amplifiers

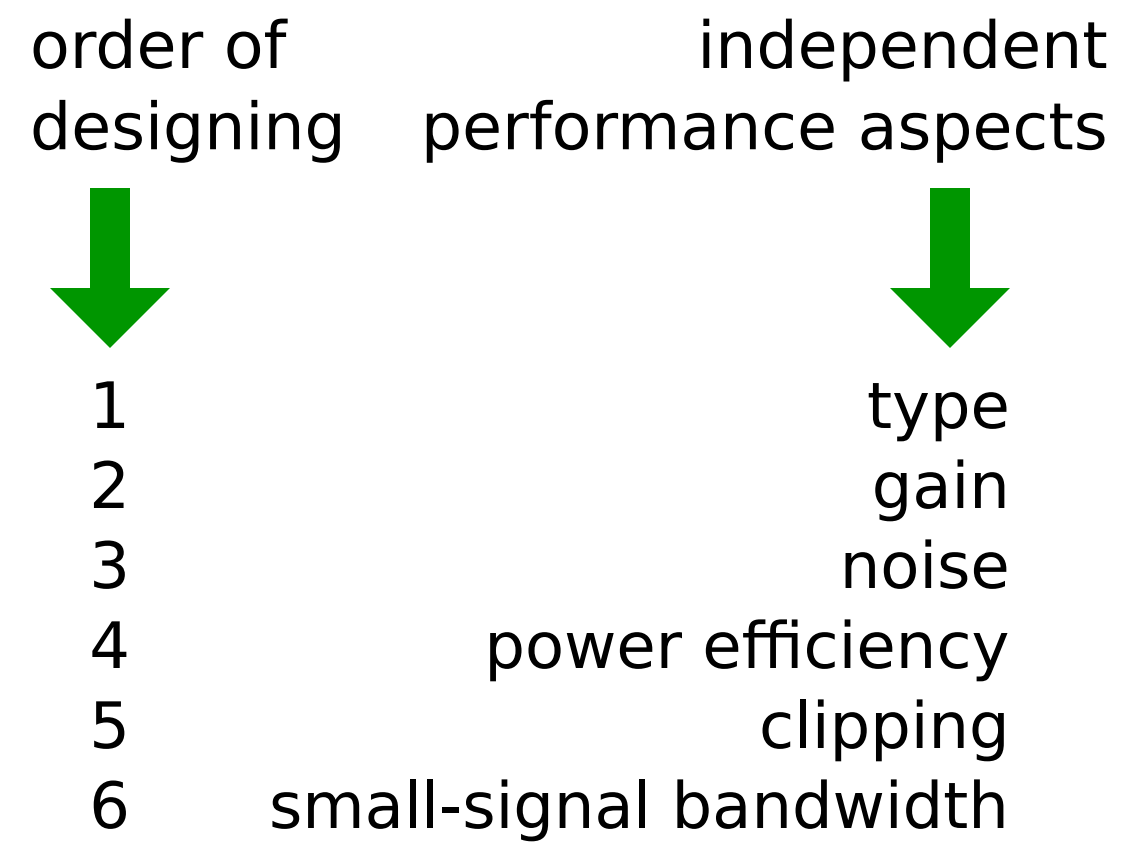


## **Orthogonal** transistor-level design of negative feedback amplifiers

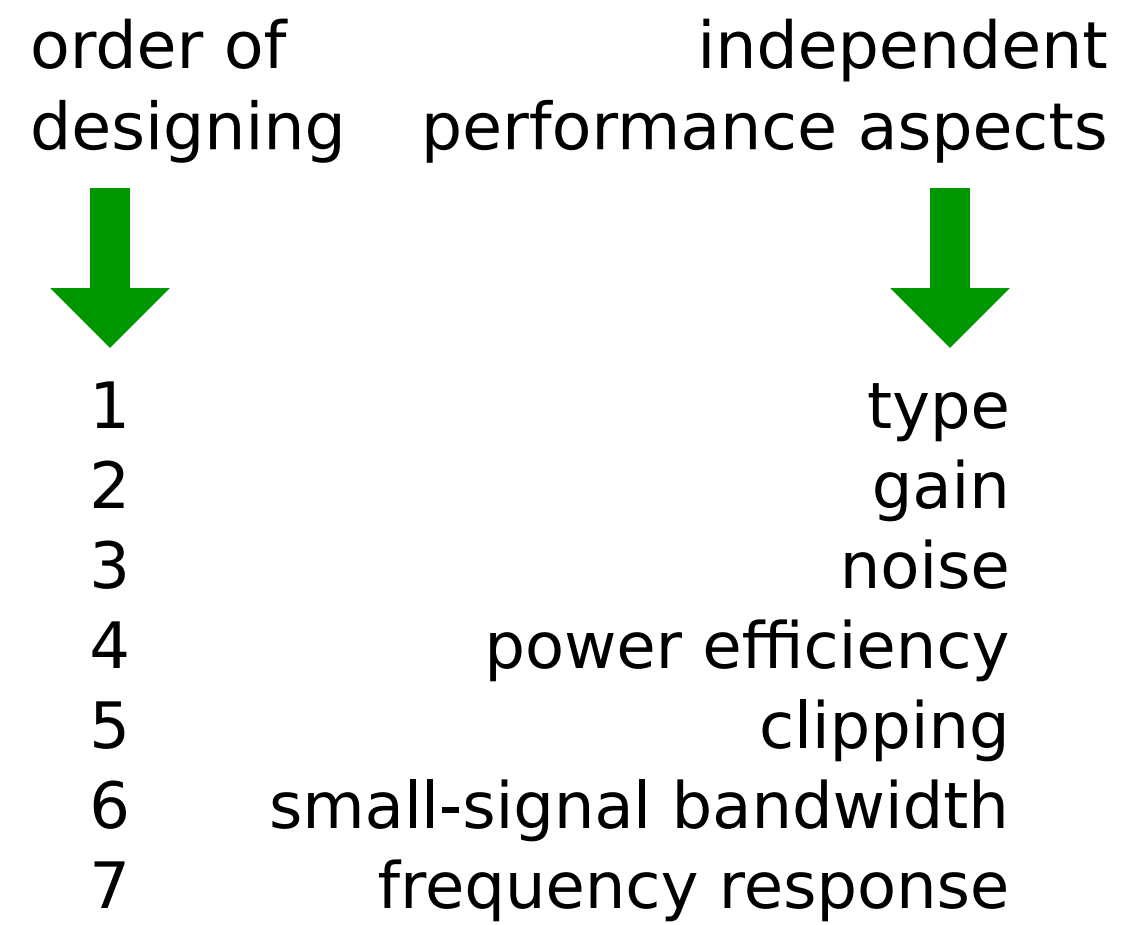


## **Orthogonal** transistor-level design of negative feedback amplifiers

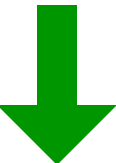





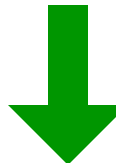

## **Orthogonal** transistor-level design of negative feedback amplifiers



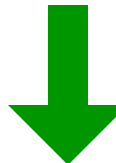

## **Orthogonal** transistor-level design of negative feedback amplifiers

order of designing	independent performance aspects
	
1	type
2	gain
3	noise
4	power efficiency
5	clipping
6	small-signal bandwidth
7	frequency response
8	weak nonlinearity

## Orthogonal transistor-level design of negative feedback amplifiers

order of designing	independent performance aspects
	
1	type
2	gain
3	noise
4	power efficiency
5	clipping
6	small-signal bandwidth
7	frequency response
8	weak nonlinearity
9	DC (temperature) stability

## Orthogonal transistor-level design of negative feedback amplifiers

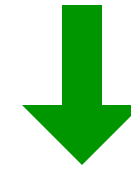
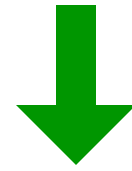
order of designing	independent performance aspects
	
1	type
2	gain
3	noise
4	power efficiency
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6	small-signal bandwidth
7	frequency response
8	weak nonlinearity
9	DC (temperature) stability

 design  
aspects

## Orthogonal transistor-level design of negative feedback amplifiers

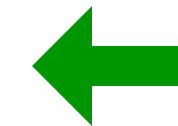
order of  
designing

independent  
performance aspects



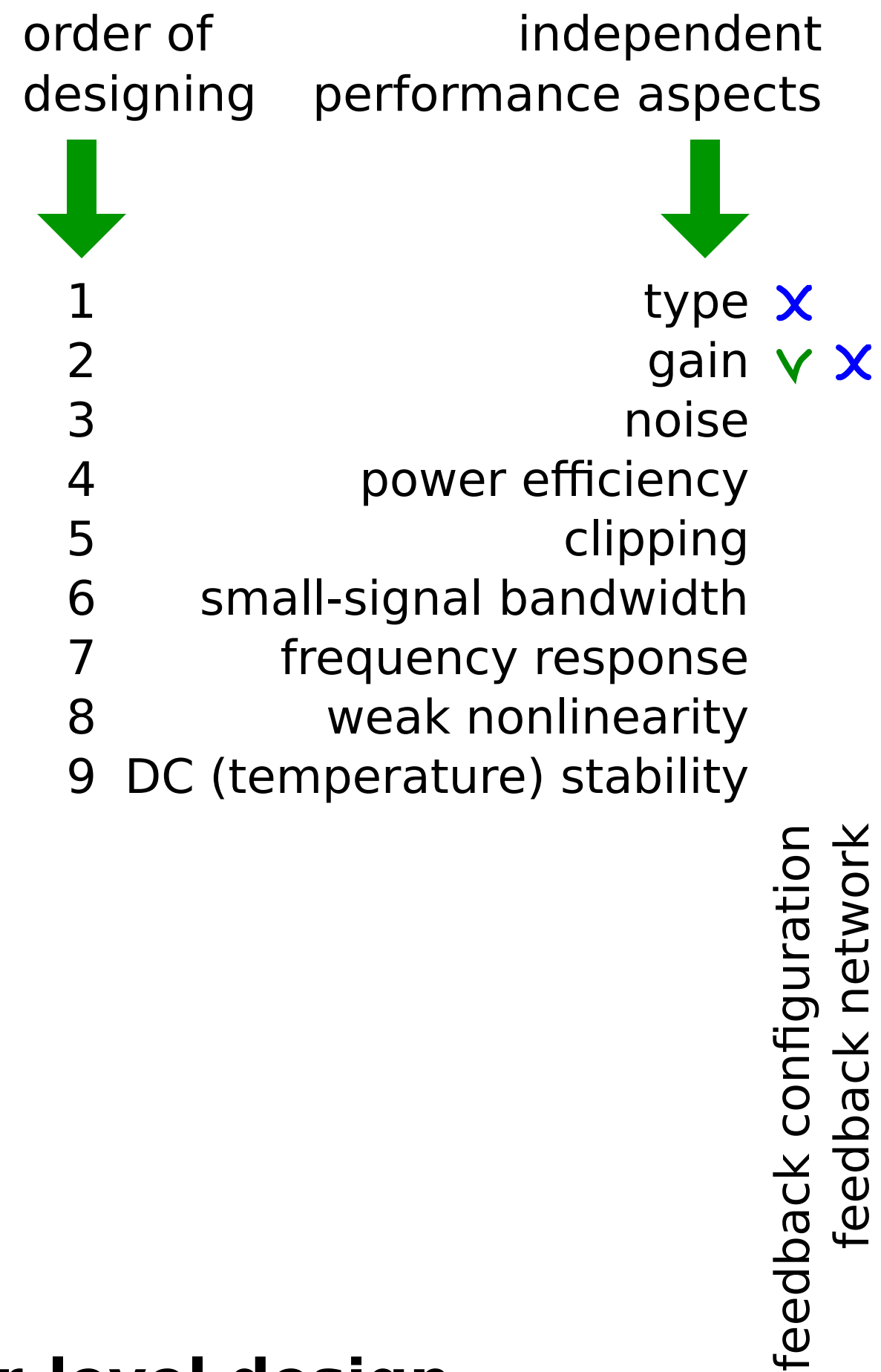
- 1 type x
- 2 gain
- 3 noise
- 4 power efficiency
- 5 clipping
- 6 small-signal bandwidth
- 7 frequency response
- 8 weak nonlinearity
- 9 DC (temperature) stability

feedback configuration



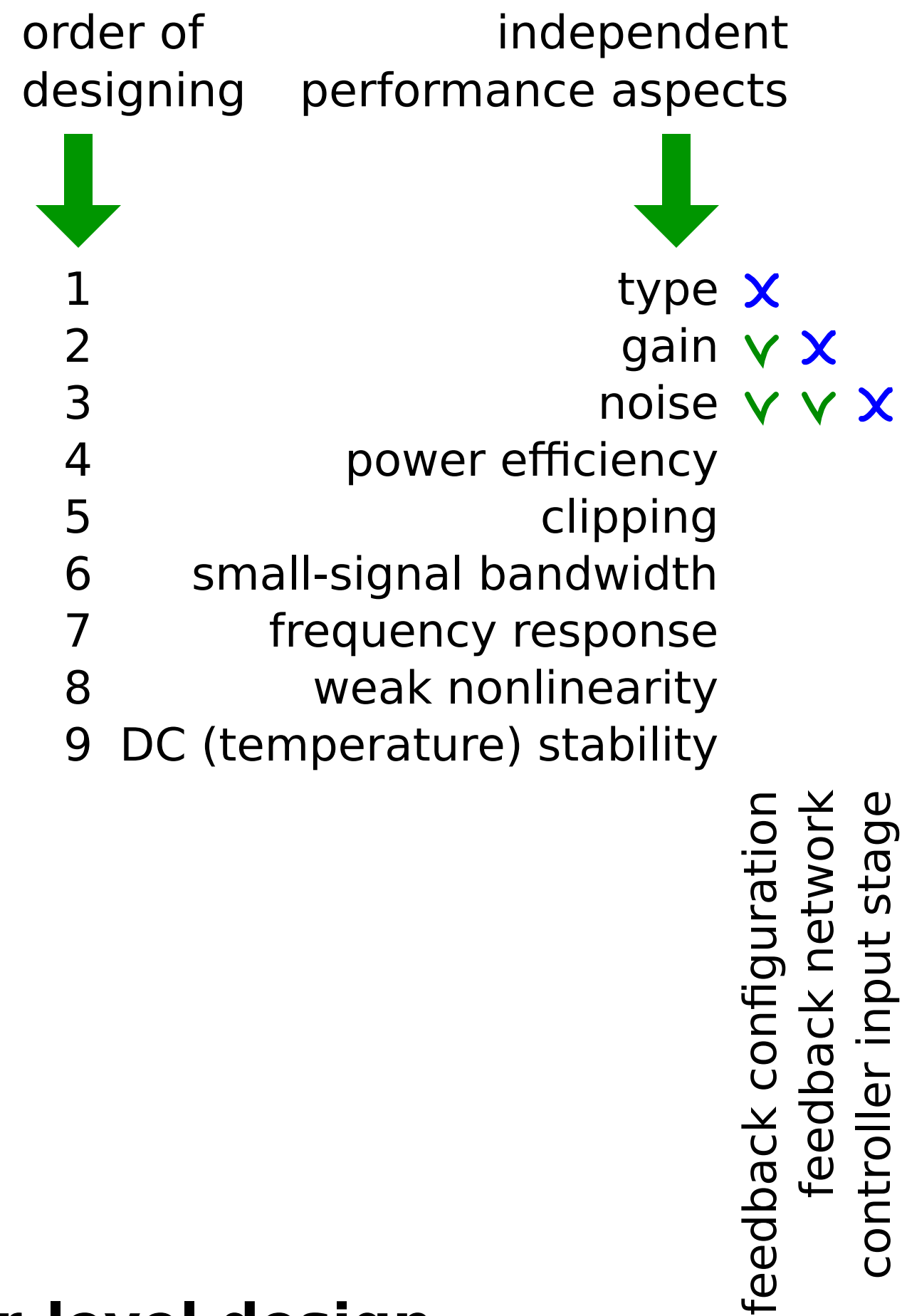
design  
aspects

## **Orthogonal** transistor-level design of negative feedback amplifiers



design  
aspects

## Orthogonal transistor-level design of negative feedback amplifiers



←

design aspects

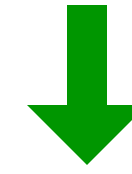
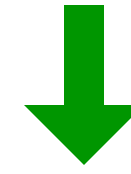
# Orthogonal transistor-level design of negative feedback amplifiers





## order of designing

independent  
performance aspects



1

type **x**

x

2

gain ✓ ✗



x

3

noise ✓ ✓ ✗



✓



4

power efficiency ✓ ✓ ✓ ✗



—

✓



5

# clipping



—

✓



6

small-signal bandwidth

7

# frequency response

8

weak nonlinearity

9

## DC (temperature) stability

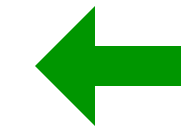
## feedback configuration

## feedback network

## controller input stage

controller output stage type

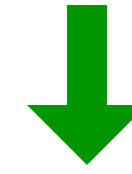
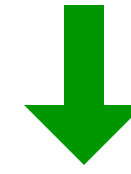
controller output stage biasing



design  
aspects

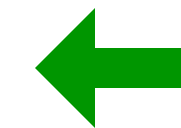
# Orthogonal transistor-level design of negative feedback amplifiers

order of designing      independent performance aspects



1	type	x						
2	gain	✓	x					
3	noise	✓	✓	x				
4	power efficiency	✓	✓	✓	x			
5	clipping	✓	✓	✓	✓	x		
6	small-signal bandwidth	✓	✓	✓	✓	✓	x	
7	frequency response							
8	weak nonlinearity							
9	DC (temperature) stability							

- feedback configuration
- feedback network
- controller input stage
- controller output stage type
- controller output stage biasing
- loop gain poles product

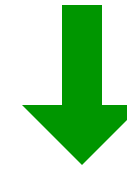
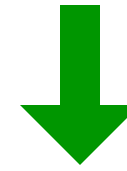


design  
aspects

# Orthogonal transistor-level design of negative feedback amplifiers

order of  
designing

independent  
performance aspects



1	type	X						
2	gain	✓	X					
3	noise	✓	✓	X				
4	power efficiency	✓	✓	✓	X			
5	clipping	✓	✓	✓	✓	X		
6	small-signal bandwidth	✓	✓	✓	✓	✓	X	
7	frequency response	✓	✓	✓	✓	✓	✓	X
8	weak nonlinearity							
9	DC (temperature) stability							

feedback configuration

feedback network

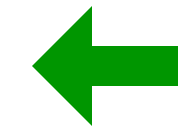
controller input stage

controller output stage type

controller output stage biasing

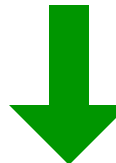
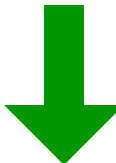
loop gain poles product

frequency compensation



design  
aspects

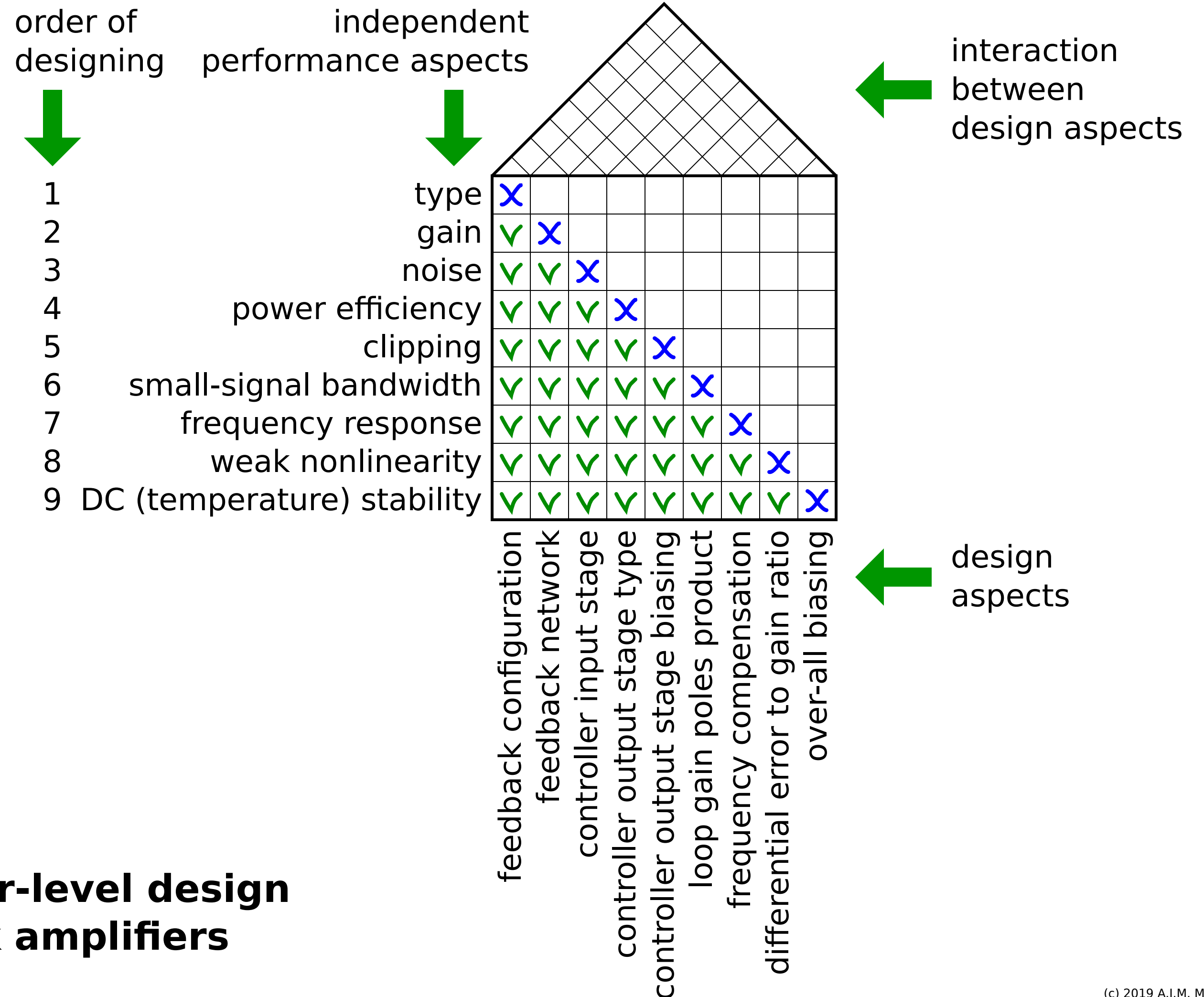
## Orthogonal transistor-level design of negative feedback amplifiers

order of designing	independent performance aspects							
								
1	type		✗					
2	gain	✓	✗					
3	noise	✓	✓	✗				
4	power efficiency	✓	✓	✓	✗			
5	clipping	✓	✓	✓	✓	✗		
6	small-signal bandwidth	✓	✓	✓	✓	✓	✗	
7	frequency response	✓	✓	✓	✓	✓	✓	✗
8	weak nonlinearity	✓	✓	✓	✓	✓	✓	✗
9	DC (temperature) stability							
		feedback configuration	feedback network	controller input stage	controller output stage type	controller output stage biasing	loop gain poles product	frequency compensation
								differential error to gain ratio

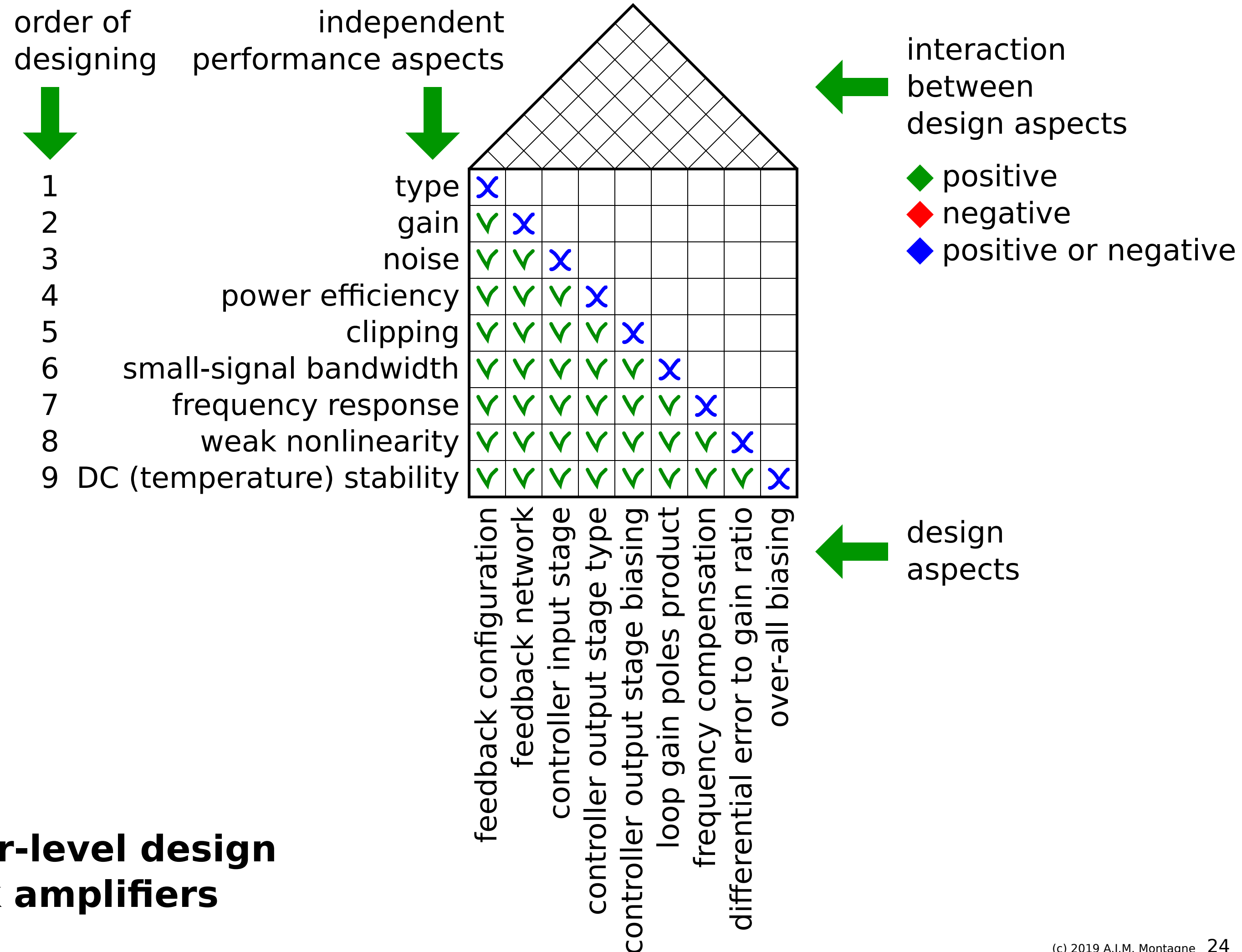
 design aspects

## Orthogonal transistor-level design of negative feedback amplifiers





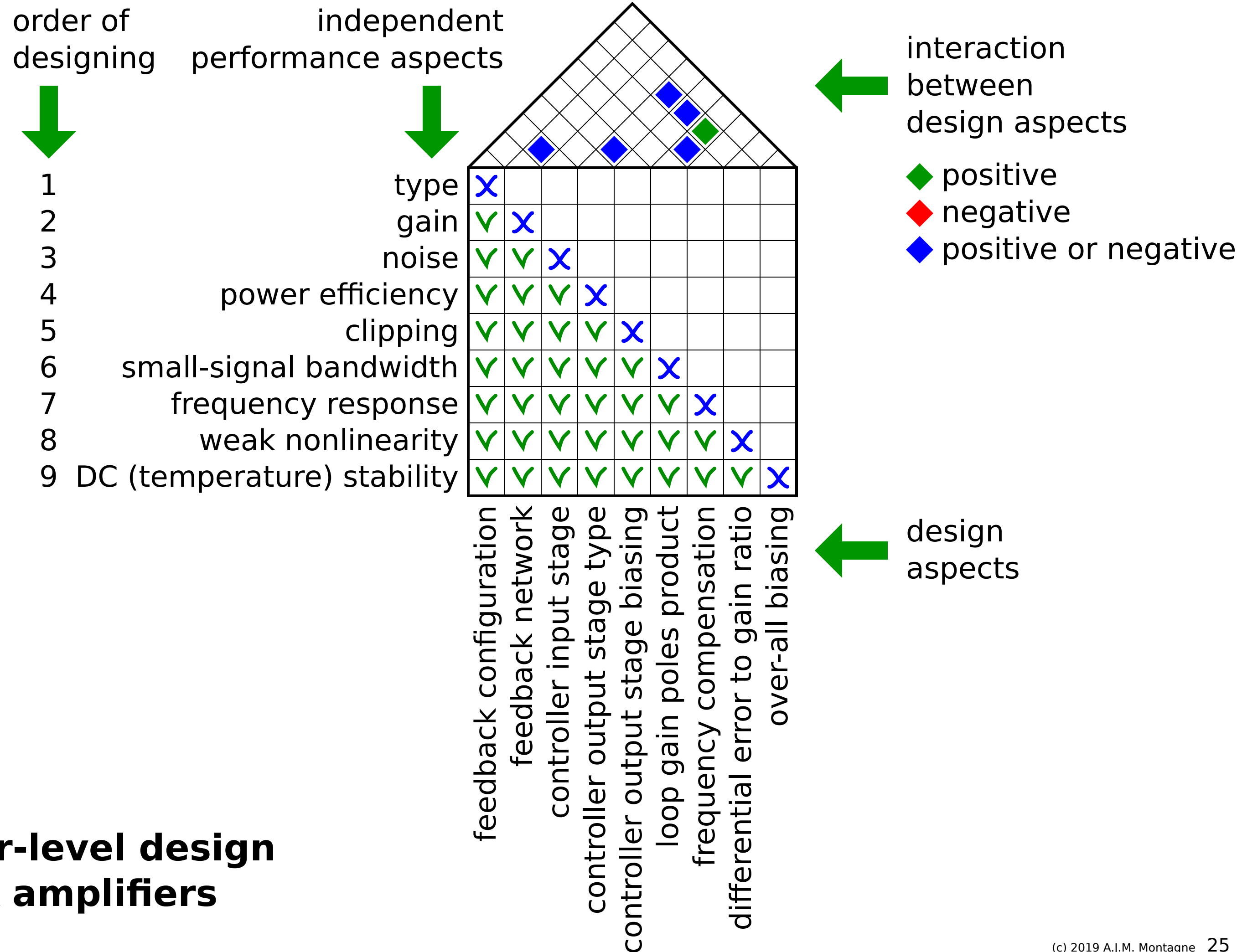
## Orthogonal transistor-level design of negative feedback amplifiers



## Orthogonal transistor-level design of negative feedback amplifiers



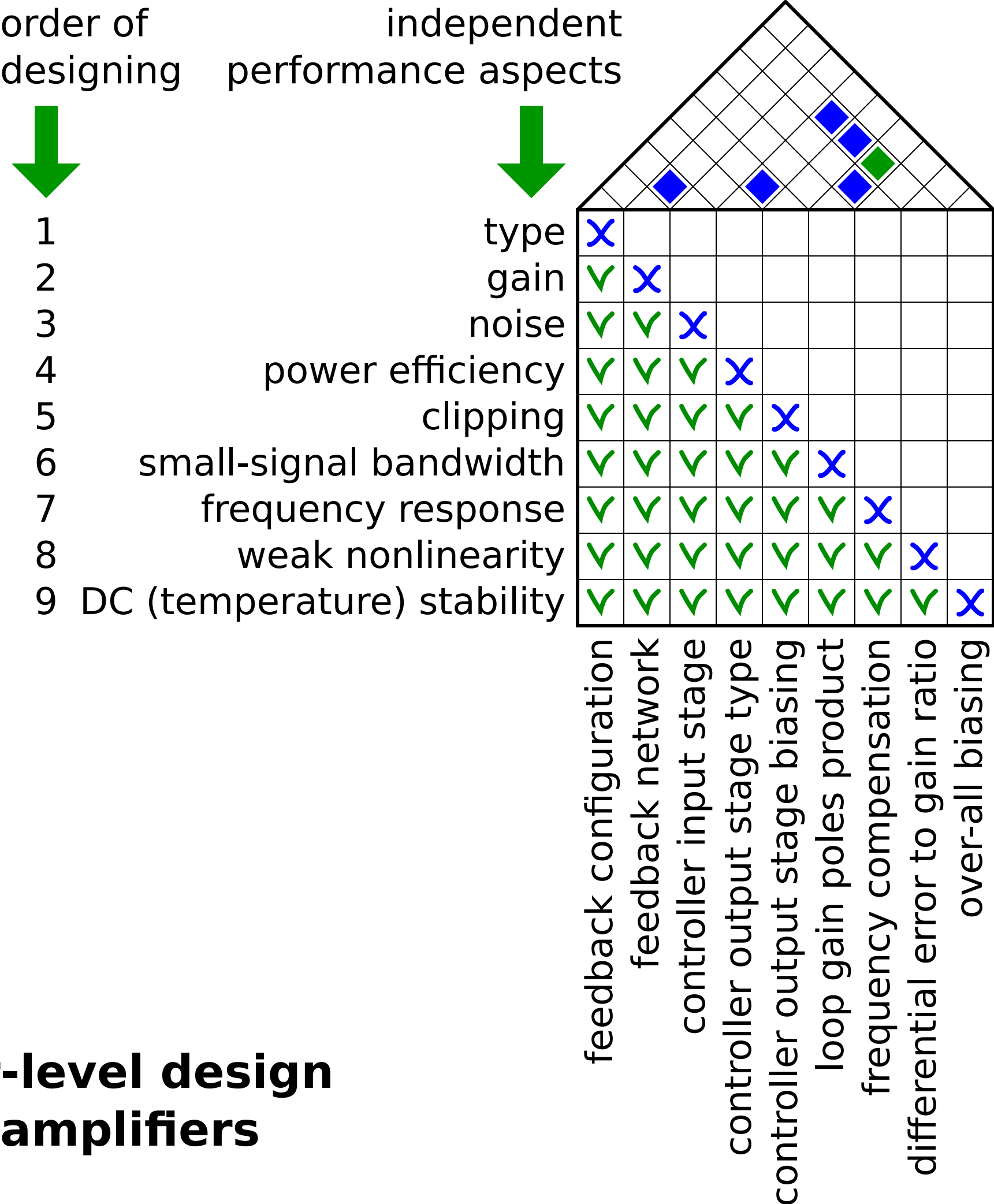
# Orthogonal transistor-level design of negative feedback amplifiers



# The House Of Quality

an application of:

Quality  
Function  
Deployment



interaction between design aspects

positive  
negative  
positive or negative

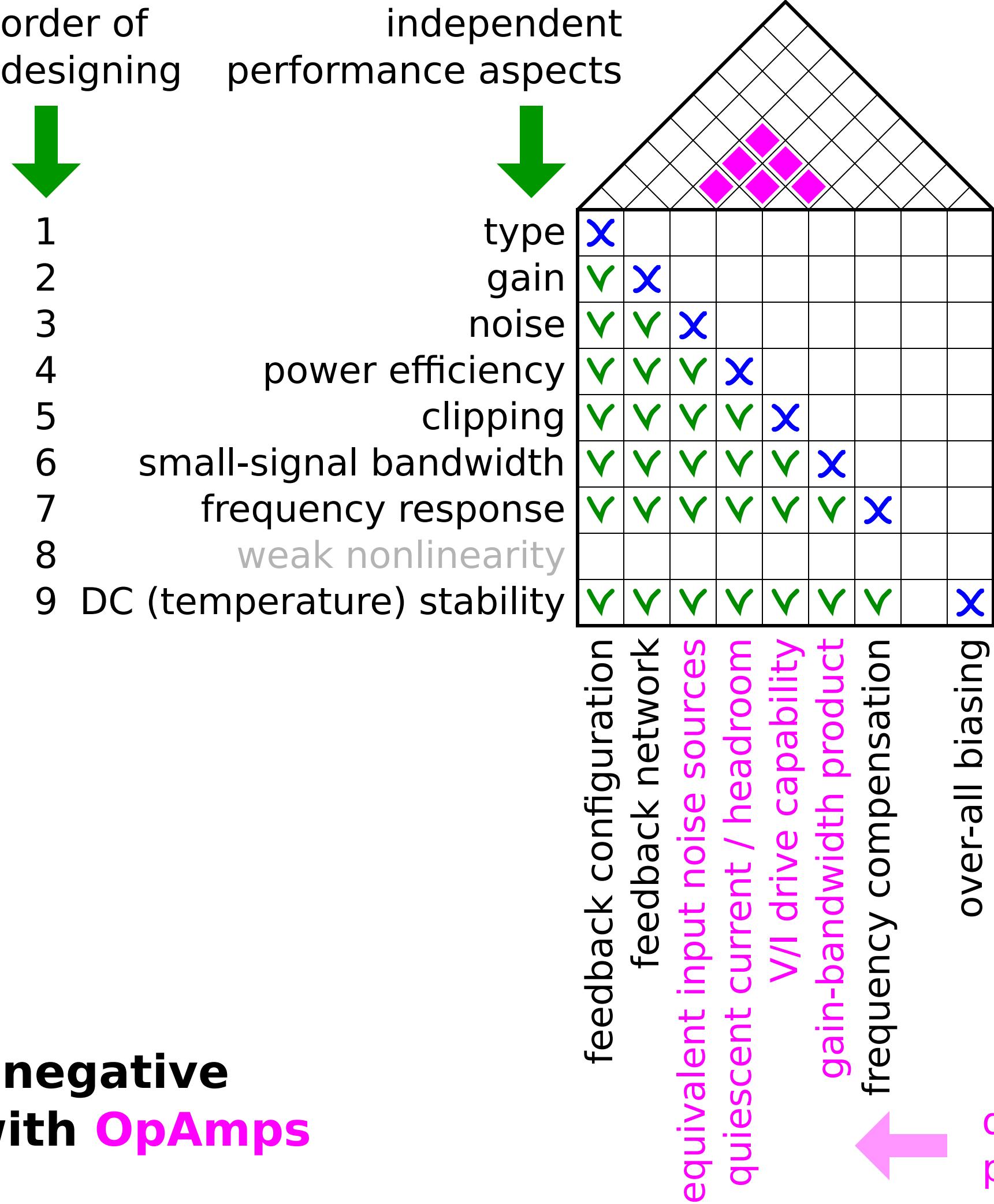
design aspects

Orthogonal transistor-level design of negative feedback amplifiers

# The House Of Quality

an application of:

- Quality
- Function
- Deployment



interaction between design aspects

◆ OpAmp type

design aspects

derive budgets for OpAmp performance aspects

Orthogonal design of negative feedback amplifiers with OpAmps