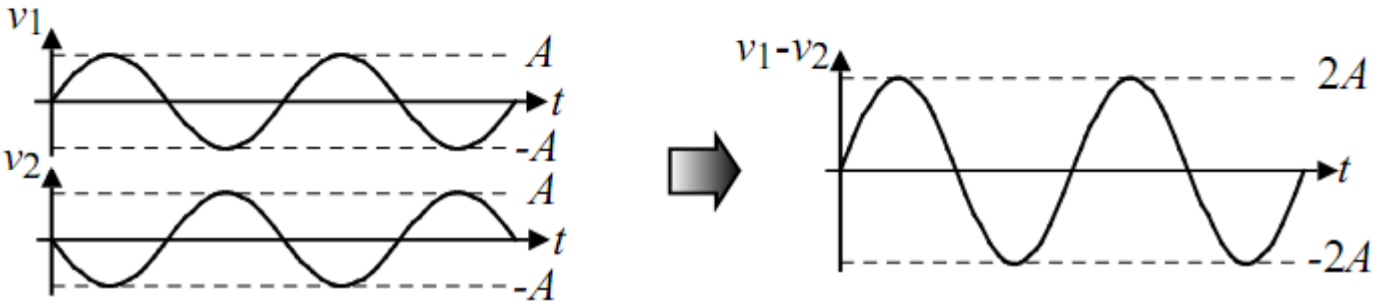
Fully-differential operational amplifier

Apinunt Thanachayanont

Why differential opamp?

- Cancellation of common mode signals including clock feedthrough
- Increased signal swing



- Cancellation of even-order harmonics

Symbol:

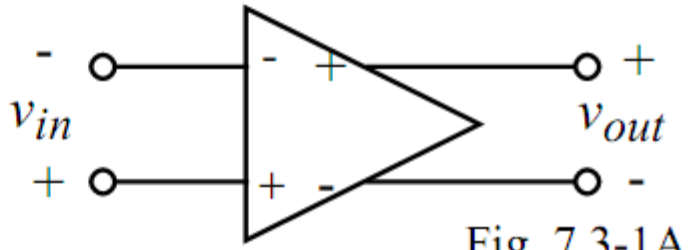


Fig. 7.3-1A

2-stage fully-differential opamp

Note that the upper ICMR is $V_{DD} - V_{SGP} + V_{TN}$

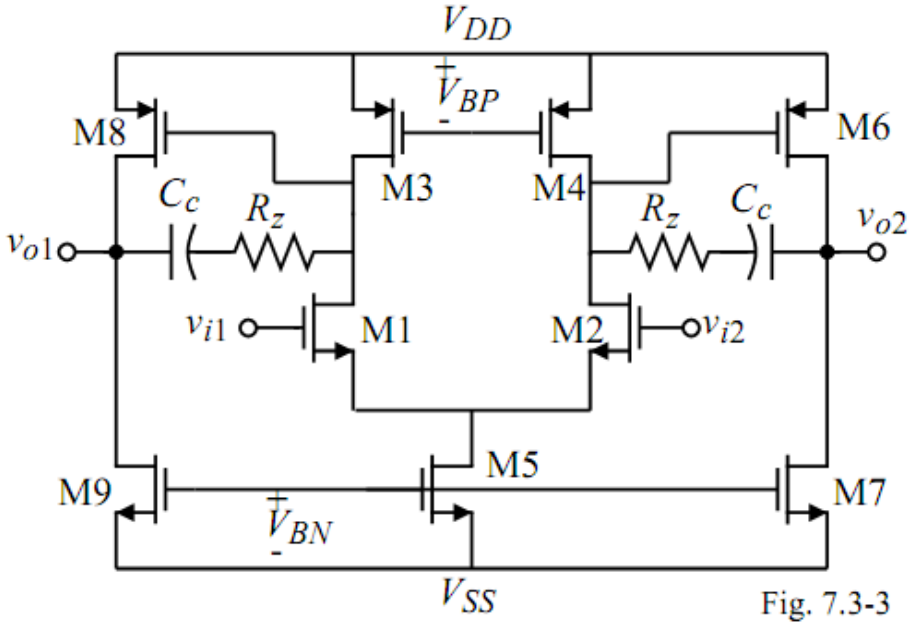


Fig. 7.3-3

Output common mode range $(OCMR) = V_{DD} + |V_{SS}| - V_{SDP}(\text{sat}) - V_{DSN}(\text{sat})$

The maximum peak-to-peak output voltage $\leq 2 \cdot OCMR$

Conversion between differential outputs and single-ended outputs:

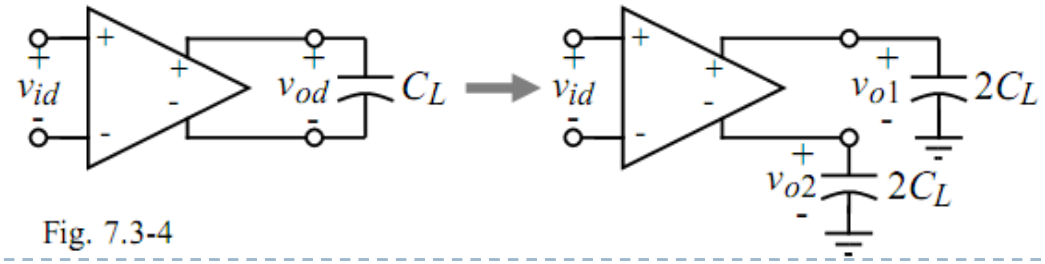


Fig. 7.3-4

2-stage fully-differential opamp with push-pull output

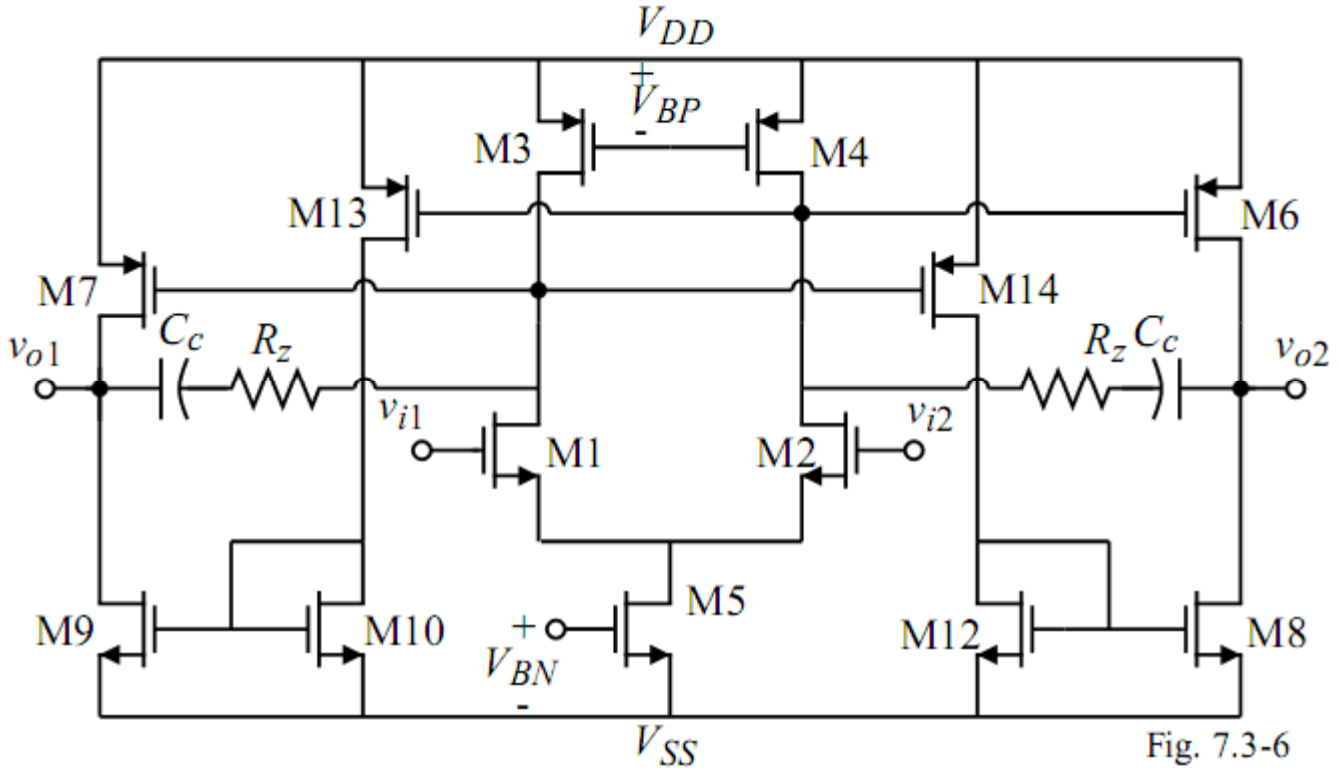
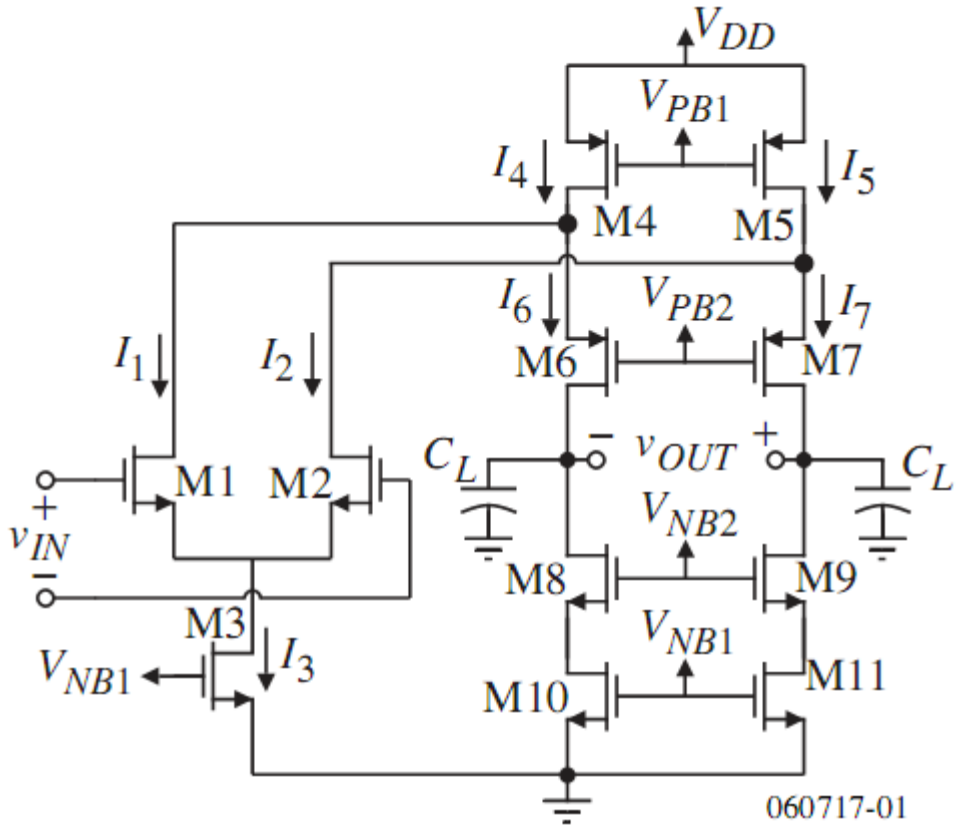


Fig. 7.3-6

Comments:

- Able to actively source and sink output current
- Output quiescent current poorly defined

Folded-cascode differential opamp



Common-mode output voltage stabilization

If the common mode gain not small, it may cause the common mode output voltage to be poorly defined.

Illustration:

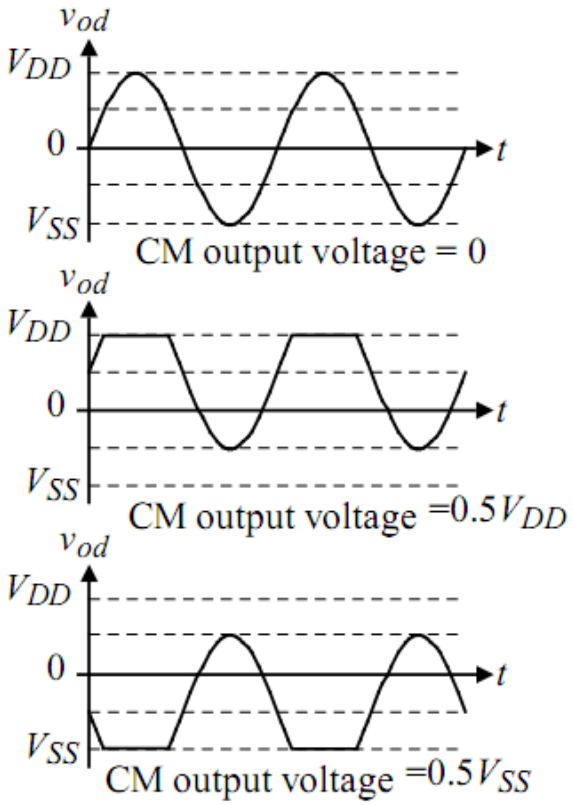
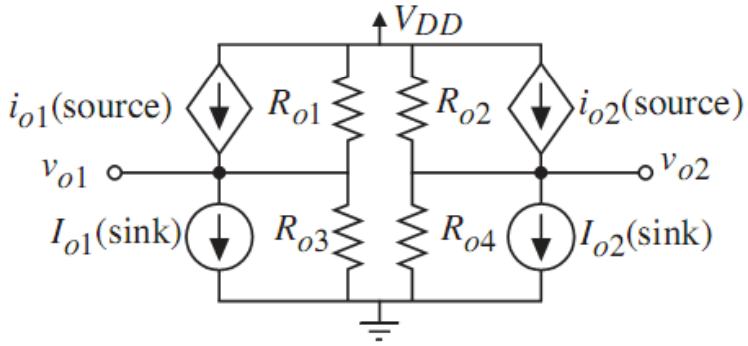


Fig. 7.3-2

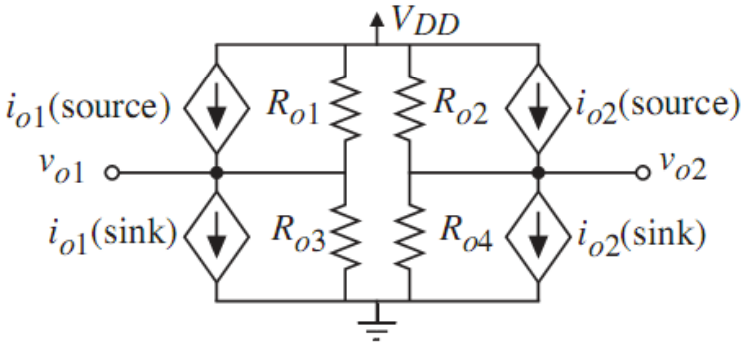
Common-mode output voltage stabilization

Because the common mode gain is undefined, any common mode signal at the input can cause the output common mode voltage to be improperly defined. The common mode output voltage is stabilized by sensing the common mode output voltage and using negative feedback to adjust the common mode voltage to the desired value.

Model for the Output of Differential Output Op Amps:



Class A Output



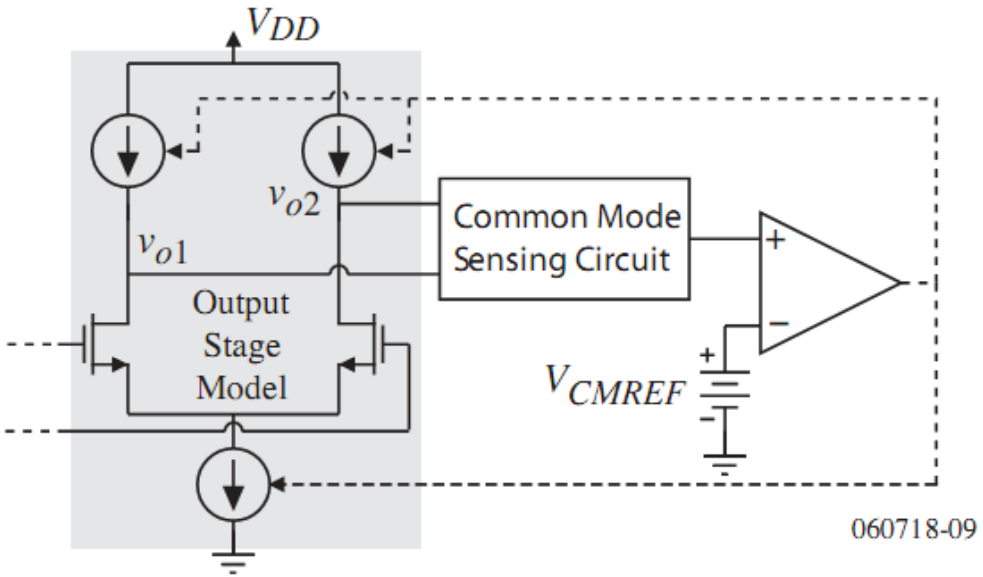
Push-Pull Output 060718-08

R_{oi} represents the self-resistance of the output sink/sources.

1.) If the common mode output voltage increases the sourcing current is too large.

2.) If the common mode output voltage decreases the sinking current is too large.

CMFB concept



Function of the common-mode feedback circuit:

1.) If the common-mode output voltage increases, decrease the upper currents sources or increase the lower current sink until the common-mode voltage is equal to V_{CMREF}.

2.) If the common-mode output voltage decreases, increase the upper currents sources or decrease the lower current sink until the common-mode voltage is equal to V_{CMREF}.

2-stage opamp with CMFB

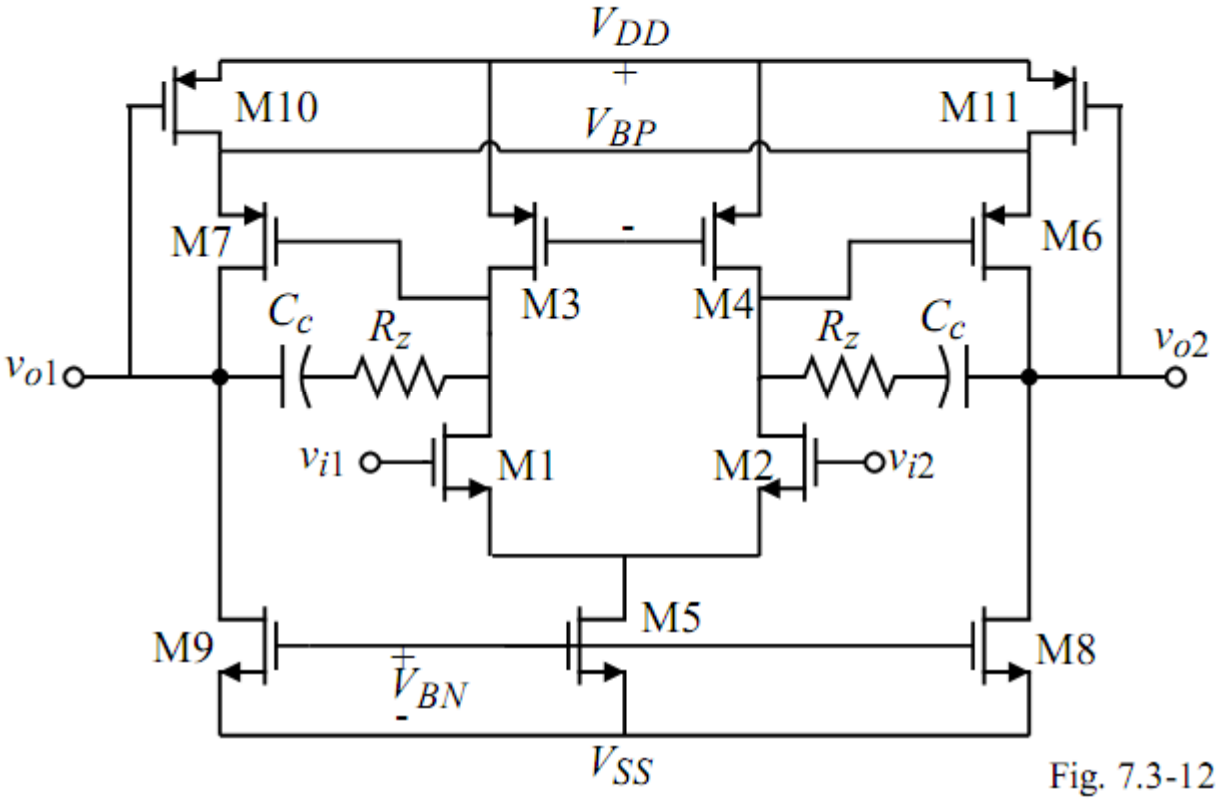
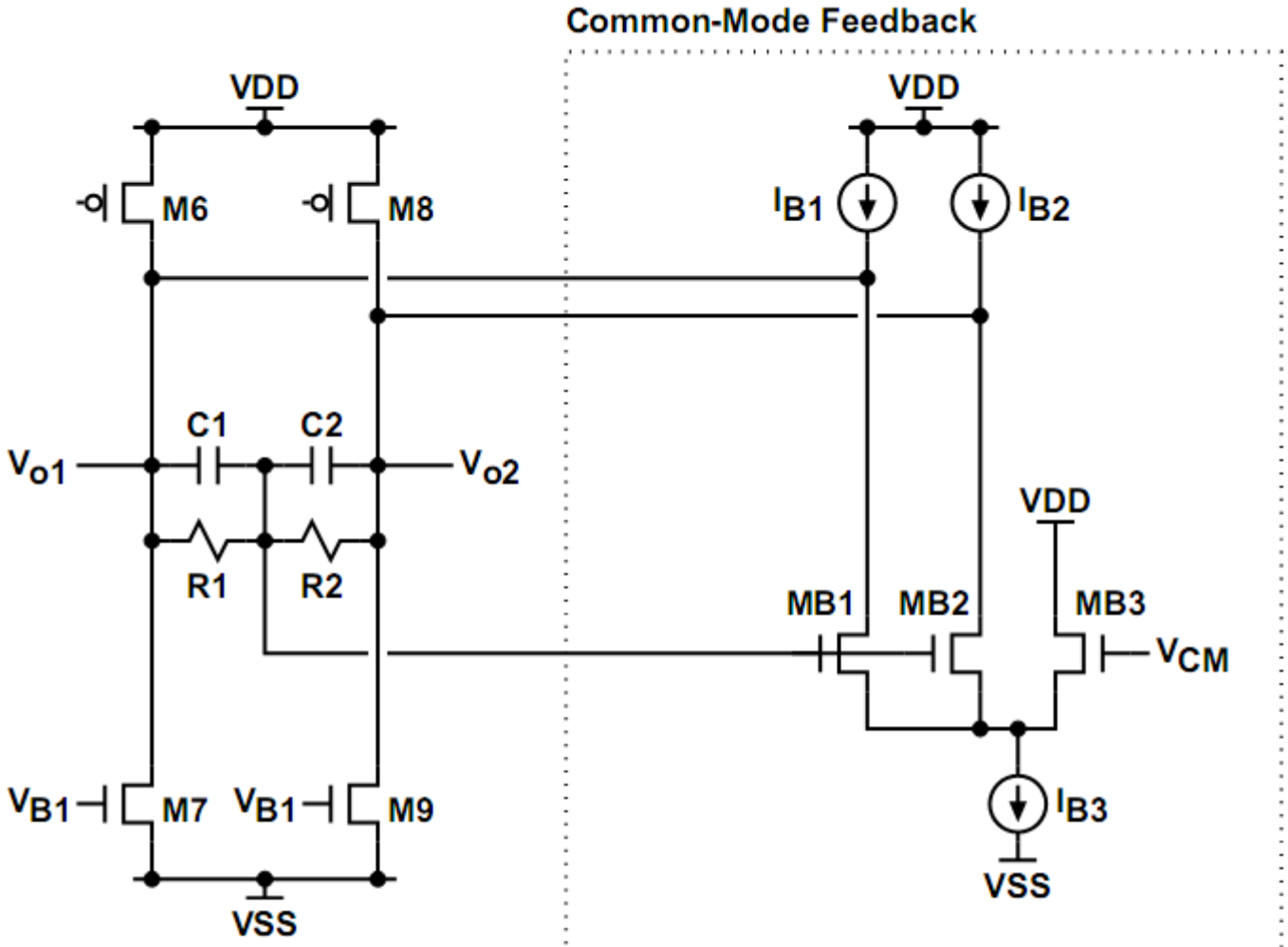
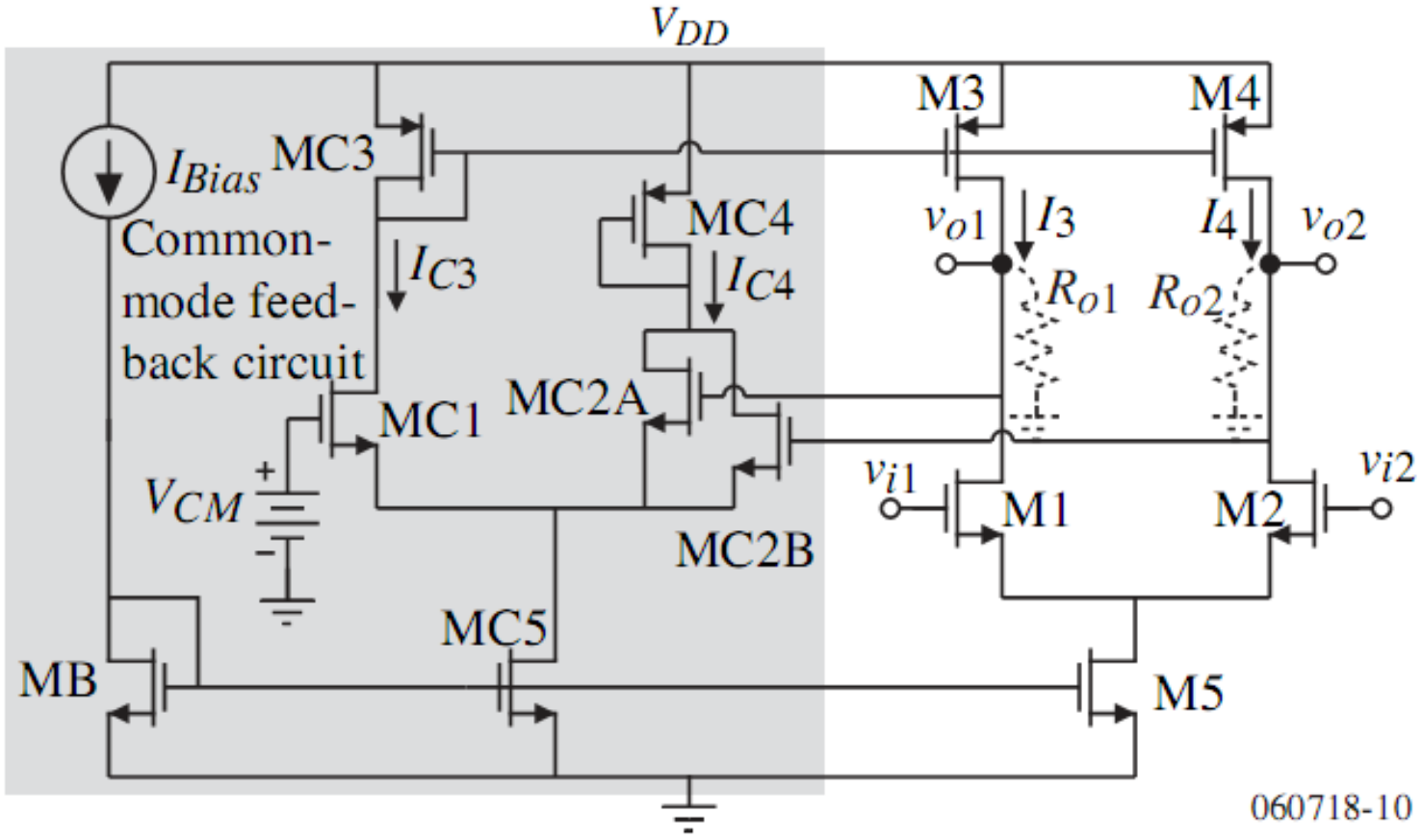


Fig. 7.3-12

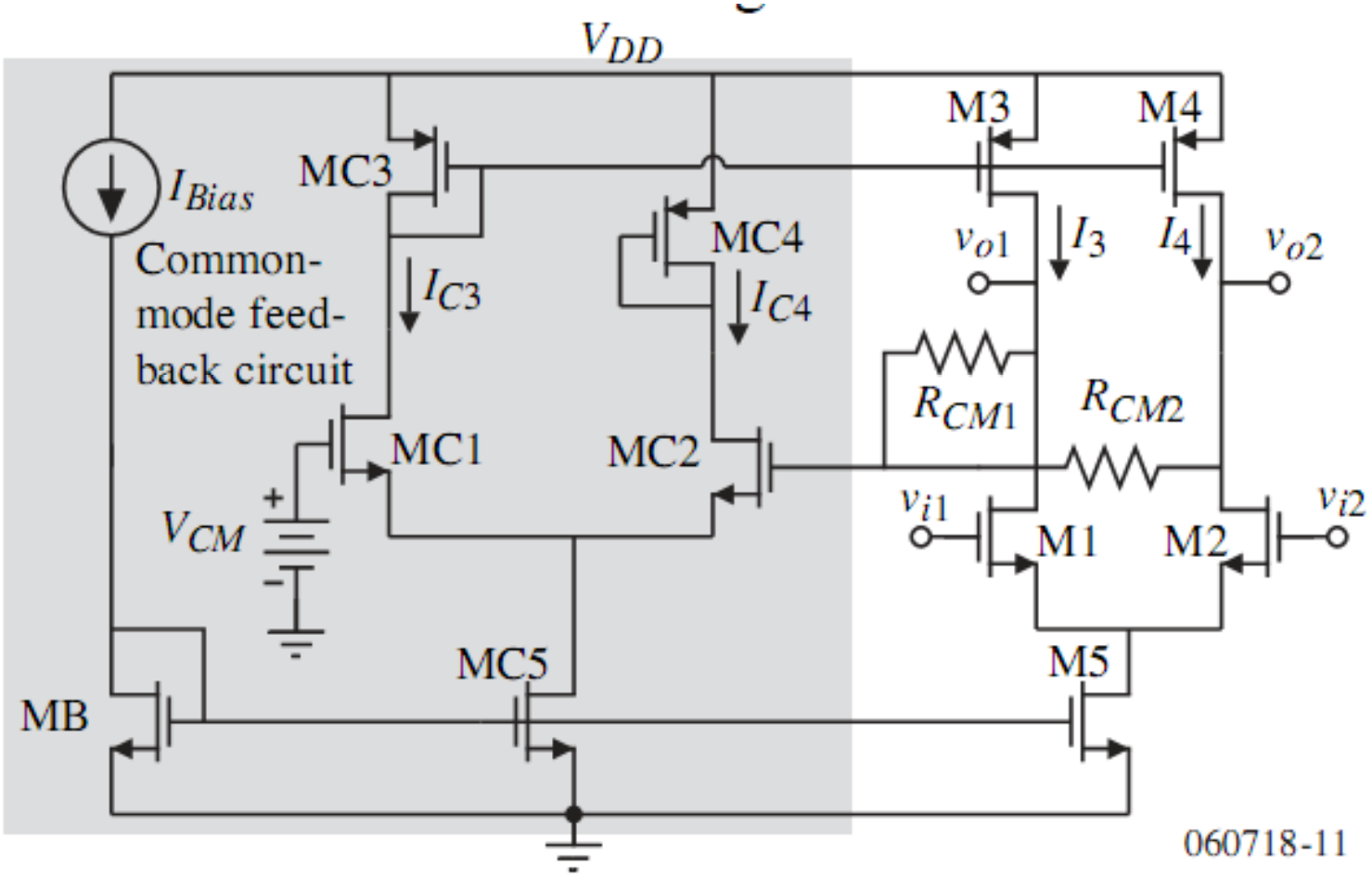
CMFB circuit using resistive divider



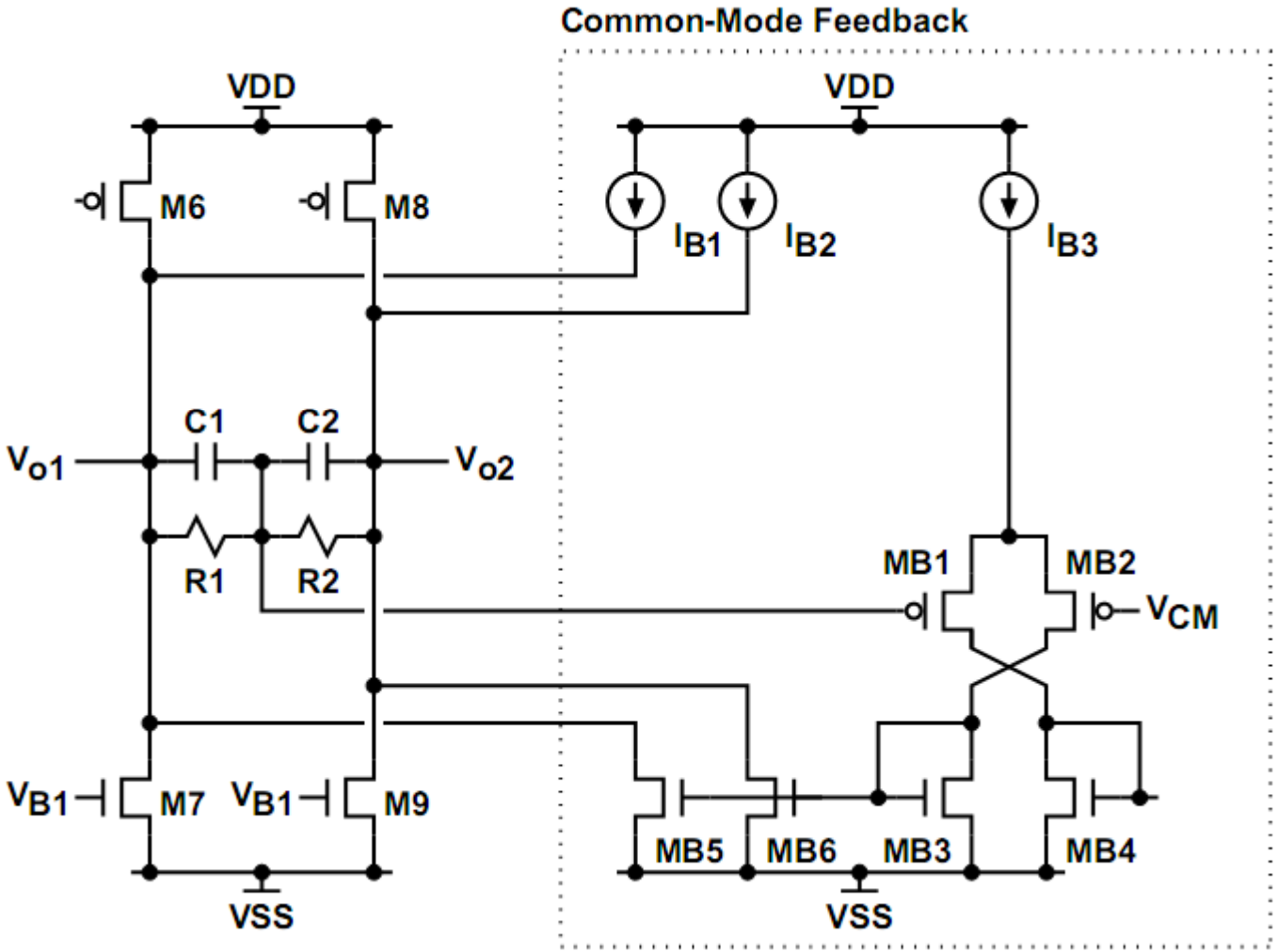
CMFB circuit (1)



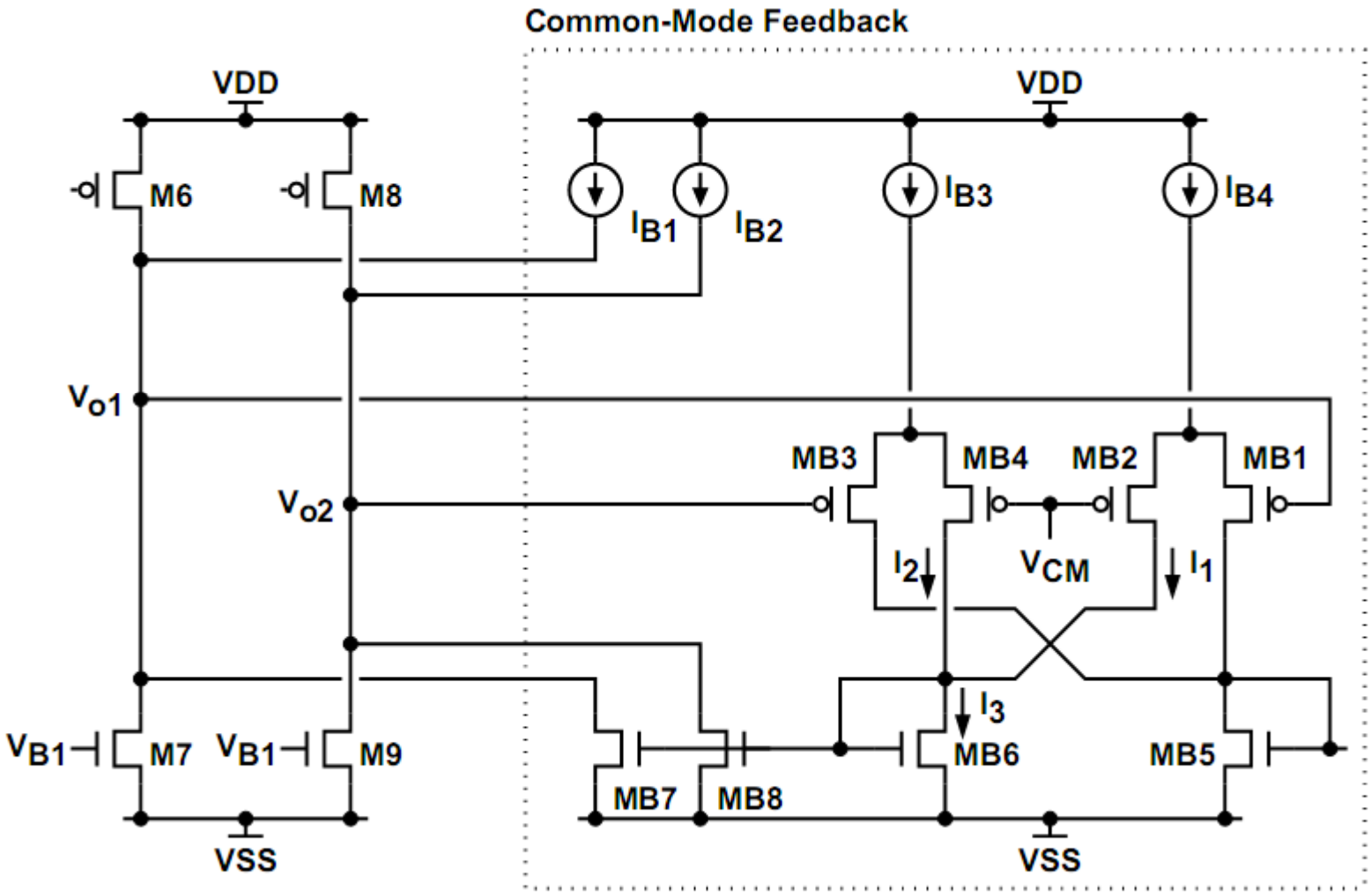
CMFB circuit using resistive divider (2)



CMFB circuit using resistive divider (1)



CMFB circuit using dual diff. pairs



CMFB circuit using triode MOSFETs