

Index

A

Active building block, 59

B

Biomedical applications

- bootstrap technique, 138, 139
- bio potential signals, 137
- CMFB, 138
- current-mode circuits, 137
- DC component, 137
- very low input noise voltage, 140–142

Bootstrap technique

- CCII, 138, 140
- input impedance, 139
- positive feedback, 138

Bridge excitation source, 36

Bridge linearization, 36

Buffers, 62, 64, 66, 68

Burr-Brown/Texas Instruments, 34

C

Cascaded amplifier, 6

Common-mode cancellation

- Azhari and Fazlalipour CMIA, 67, 68
- Galanis CMIA, 65, 66
- Gift CMIA, 68, 69
- Gkotsis CMIA, 66
- Khan CMIA, 63, 64
- Koli CMIA, 66, 67
- Su and Lidgely CMIA, 64, 65

Common mode feed-back (CMFB), 87, 88, 138

Common-mode gain, 3, 5, 16, 19, 59–60
CDTRA, 113

DVCC, 90

ECCII, 107, 108

input currents, 74, 76, 77

matching, 123

SI-MO COA, 119

Common-mode rejection ratio (CMRR), 16, 26, 60, 64, 66–68, 167

cascaded stages, 5

CCCI1 and CCCII2, 104

definition, 4

differential-mode gain error, 73, 75

ECCII1 and ECCII2, 109

EX-CCCII, 112

mismatch effect, 128, 131

OFCC, 86

Op-Amps, 146

open loop gains, 135

OTRA, 82, 85

resistors and β_1 and γ_2 parameters, 78, 79

resistors matching, 119, 123

rule, 7

three-stage amplifier, 6

voltage signals, 3

Current controlled current conveyor (CCCII)

bipolar, 101

CMIA, 101, 103, 104

CMRR, 104

internal circuit, 102

symbolic representation, 101

voltage output, 101

Current Controlled Current Conveyor

Transconductance Amplifier
(CCCCTA), 98–100

Current Controlled Differential Voltage

Current Conveyor (CCDVCC),
95–97

- Current conveyor
 - second-generation (*see* Second-generation current conveyor (CCII))
 - Current Differencing Buffered Amplifier (CDBA), 49, 71, 73
 - Current differencing transconductance amplifier (CDTA), 47
 - advantage, 49
 - BJT realization, 48
 - Current Differencing Trans-Resistance Amplifier (CDTRA), 112, 113
 - Current differential block, 65, 66, 68
 - Current excitation, 32, 33
 - Current feedback operational amplifier (CFOA)
 - I-I, 73–75
 - V-V, 92, 93
 - Current follower differential input transconductance amplifier (CFDITA), 114, 115
 - Current input-current output (I-I), 12
 - CDBA-based, 71, 72
 - CFOA-based, 73–75
 - OFCC-based, 75, 76
 - Current input-voltage output (I-V), 12
 - OFCC-based, 77–80
 - OTRA-based, 79, 82
 - Current mirrors, 66
 - Current-mode
 - current conveyors (*see* Second generation current conveyor (CCII))
 - Current-mode instrumentation amplifiers (CMIA), 19, 21–24, 26–27
 - classification, 12
 - features, 11–12
 - sensor applications (*see* Sensor applications)
 - Current-mode signal processing, 1
 - Current-mode technique, 12
 - Current-Mode Wheatstone Bridge (CMWB), 36
 - advantage, 38
 - linearization, 39
 - nonlinearity compensation, 40
 - principle, 37
 - read-out circuits, 40–53
 - signal conditioning circuits, 37
 - Current operational amplifier (COA), 43
- D**
- Differential capacitive sensors
 - capacitive value, 162
 - CCII, 163
 - interface, 162
 - overlapping area, 162
 - parameters, 161
 - parasitic impedances, 163
 - resolution problems, 162
 - signal conditioning, 164
 - Differential difference current conveyor (DDCC), 88
 - CMRR, 87, 88
 - input signals, 86
 - offset cancellation, 88
 - output voltage, 89
 - V-V CMIA, 87
 - Differential-mode gain, 5, 6, 9, 12, 21, 61, 66, 68
 - DVCC, 90, 91
 - electronically controlled, 99, 113
 - I-I
 - CDBA-based, 72, 73
 - CFOA-based, 75, 76, 78
 - I-V
 - OTRA-based, 81
 - SI-MO COA, 119
 - V-V CMIA, 87
 - Differential voltage current conveyor (DVCC), 89–91
 - symbol and internal circuit, 147
 - transmission gate based chopper switching, 146
- E**
- Electrocardiogram (ECG), 138–140
 - Electroencephalogram (EEG), 138–140
 - Electronically Current Gain Controlled Second-Generation Current Conveyor (ECCII)
 - circuit implementation, 108
 - CMIA, 107
 - CMRR, 109
 - KCL analysis, 107
 - symbolic representation, 107
 - Electronic controllability
 - CCCCTA, 98–100
 - CCCII, 100, 101, 104
 - CCDVCC, 95, 97
 - CDTRA, 112, 113
 - CFDITA, 114, 115
 - ECCII
 - circuit implementation, 108
 - CMIA, 107
 - CMRR, 109
 - KCL analysis, 107
 - symbolic representation, 107
 - EX-CCCII, 110, 111
 - SI-MO COA

- CMIA, 117
 - common-mode equivalent circuit, 118
 - differential-mode gain, 119
 - implementation, 120
 - KCL analysis, 117
 - negative feedback configuration, 119
 - symbolic representation, 116
 - variable resistor, 117
 - two MOS transistors
 - saturation region, 120, 121
 - triode region, 122–124
 - variable gain current mirror, 105, 106
 - Error correction technique, 68
 - Extra X current controlled current conveyor (EX-CCCII), 110, 111
- F**
- Feedback loop, 66
 - Flipped voltage follower (FVF)
 - double current sense technique, 148, 149
 - transistor-based voltage buffers, 151
 - Frequency performance, 16, 26, 27
 - Fully differential amplifier, 4
- G**
- Gain-Bandwidth product (GBW), 9, 24
- H**
- High precision temperature sensors
 - bandwidth, 168
 - chopping frequencies, 168
 - modulators, 168
 - non-idealities waveforms, 168
 - PMOS type, 168
- I**
- Input impedance, 12
 - bootstrap technique, 140
 - CCIIs, 139
 - FVF current mirror, 149
 - Input noise, *see* Very low input noise voltage
 - Instrumentation amplifiers (IAs), 19
 - applications, 1, 2
 - CMOS technologies, 1
 - current conveyors (*see* Second generation current conveyor (CCII))
 - high differential-mode gain, 1
 - high input impedance, 2
 - I-I (*see* Current input-current output (I-I))
 - infinite CMRR, 1
 - input and output signals, 1
 - input referred noise and offset, 2
 - noises and disturbance, 1
 - voltage output, 2
 - Ion sensitive field effect transistor (ISFET)
 - characteristics, 166
 - ion concentration, 164
 - linear region, 165
 - miniature reference electrodes, 166
 - OFCC (*see* Operational Floating Current Conveyor (OFCC))
 - pH determination, 166
 - threshold voltage, 164
- K**
- Kirchhoff current law, 15
- L**
- Linearization technique, 47
 - Load resistors, 59
 - Low-power consumption, 1
 - Low-power operation, 1
 - Low-voltage low-power CMIAAs
 - IA, 140
 - rail-to-rail input/output
 - CCII, 142, 143
 - supply current sensing technique, 144–146
 - transmission gate chopper switching, 146–148
- M**
- Matching, 60, 61
 - current mirrors, 19
 - halves of circuit, 24
 - and Op-Amps, 21
 - Op-Amps and current-mirrors, 27
 - parasitic capacitances and finite output resistances, 26
 - PSRRs, 26
 - resistors, 23
 - Mismatch, 79, 87
 - against robust performance, 133–135
 - A_{VTH} and A_{β} variations, 128, 129
 - CMRR, 128, 130, 131
 - current mirror, 132
 - design rules, 132
 - drain source current, 133
 - MOS transistors, 127
 - random variations, 127, 128
 - supply current sensing CMIA, 132
 - transistors parameters, 132
 - Mixed- Mode approach, 54

- Mixed-mode Wheatstone Bridge, 54
- MOS transistor length, 127, 128
- MOS transistor width, 128

- N**
- Negative feedback technique, 36
- Negative impedance converter (INIC), 51

- O**
- Offset compensation, 66
- Op-Amp based amplifier, 43
- Op-Amp power supply current sensing technique
 - balanced structure, 23
 - bandwidth, 15
 - bootstrapping technique, 26
 - CA3096 transistor arrays, 25
 - CMIA, 19, 21, 22
 - CMRR, 19
 - common-mode bootstrapping technique, 19
 - DC, 20
 - differential-mode gain, 21
 - equivalent circuit, 16
 - first generation, 24
 - frequency performance, 27
 - limitation and design, 18
 - Op-Amp operates, 15
 - operational amplifiers, 15
 - performance analogue building-blocks, 15
 - PSRR, 17, 19
 - P-Type and N-Type, 18
 - second generation, 26
 - single-output structure, 19, 20
 - transimpedance amplifier, 27
- 3-Op-Amp instrumentation amplifier, 6
- Op-Amp 741 transistor level model, 26
- Op-Amp Voltage-mode, 27
- Operational Amplifiers (Op-Amp), 15, 62, 64
 - based CMIA, 23
 - and CMRR, 23
 - CMWB, 51
 - common-mode gain, 16
 - finite PSRR, 17
 - input terminal, 17
 - instrumentation amplifier, 19, 20
 - mismatches, 27
 - performance parameters, 24
 - read-out circuit, 51
 - resistors, 50
 - sources, 51
 - transimpedance amplifier, 21
- Operational Conveyors (OCs), 62
- Operational floating amplifier (OFA), 158, 160
- Operational floating current conveyor (OFCC), 40, 153, 154
 - CMRR, 167
 - five terminal current-mode, 166
 - I-I, 75, 76
 - I-V, 77–80
 - linearization, 42
 - open-loop transimpedance gain, 166
 - output currents, 40
 - pH variation, 167
 - read-out circuit, 41
 - V-I, 82, 83
 - V-V, 83, 85, 86
- Operational transconductance amplifiers (OTA), 114
- Operational Trans-Resistance Amplifier (OTRA), 79, 82, 122
- Output impedance, 2, 62, 66, 68
- Output voltage, 51

- P**
- Parasitics, 64
- Piezo-resistive sensors
 - advantages, 157
 - current subtraction node, 158
 - effects, 157
 - errors
 - CMIA, 161
 - temperature, 161
 - tracking, 160
 - feedback configurations, 159
 - flip-flop, 160
 - four-terminal current-mode, 158
 - interface, 158
 - mixed-mode bridge configuration, 158
 - OFA, 159
 - principle, 157
 - signal conditioning circuit, 158
- Piezo-resistors, 160
- Power supply rejection ratio (PSRR), 16, 17, 19, 25, 26

- R**
- Rail-to-rail input/output
 - CCII, 142, 143
 - supply current sensing technique, 144–146
 - transmission gate chopper switching, 146, 148
- Read-out circuit
 - CDBA and CCCII, 49–50
 - CDTA, 47

- CMRR, 35
 - CMWB, 45
 - COA, 43
 - INIC, 51
 - mixed-mode Wheatstone Bridge, 54
 - Op-Amps, 50
 - time-based approach, 32
 - VCII, 51–53
 - Resistive dividers, 37
 - Resistor-based current mirror, 152
- S**
- Second-generation current conveyor (CCII)
 - bootstrapped CMIA, 138, 139
 - common-mode cancellation
 - (*see* Common-mode cancellation)
 - current conveyor, 67
 - gift CMIA, 62, 63
 - input impedance, 139
 - rail-to-rail input, 142, 143
 - Wilson current-mode instrumentation amplifier (*see* Wilson CMIA)
 - Second generation voltage conveyor (VCII), 51
 - CMWB, 53
 - concept, 51
 - read-out circuit, 52
 - sensor applications, 53
 - symbol representation, 52
 - types, 52
 - Sensor applications
 - differential capacitive sensors (*see* Differential capacitive sensors)
 - high precision temperature sensors (*see* High precision temperature sensors)
 - ISFET (*see* Ion sensitive field effect transistor (ISFET))
 - piezo-resistive sensors (*see* Piezo-resistive sensors)
 - Single-ended amplifier, 5
 - Single-input multiple output current operational amplifiers (SI-MO COA)
 - CMIA, 117
 - common-mode equivalent circuit, 118
 - differential-mode gain, 119
 - implementation, 120
 - KCL analysis, 117
 - negative feedback configuration, 119
 - symbolic representation, 116
 - variable resistor, 117
 - Single output, 19, 20, 23
- Supply current sense technique
- FVF
 - double current sense, 148, 149
 - transistor-based voltage buffers, 151
 - NFET based low voltage current mirrors, 150
 - resistor-based current mirror, 152
 - super transistor-based voltage buffers, 151
- Supply current sensing CMIA, 132
- Supply current sensing technique, 144–146
- T**
- Temperature-dependent offset signal, 160
 - Time-based approach, 32
 - Transmission gate chopper switching, 146–148
 - Triode region MOS operation, 116–120
 - Two Current Controlled CCII (CCCII), 49
 - Two MOS transistors
 - saturation region, 120, 121
 - triode region, 122–124
- V**
- Variable gain current mirror, 105, 106
 - Variable resistor
 - OTRA, 123
 - two MOS transistors
 - saturation region, 120, 122
 - triode region, 122, 123
 - Variance, 127
 - Very low input noise voltage, 140–142
 - Voltage buffers, 85–87, 89, 92
 - Voltage excitation, 29–30
 - Voltage input-current output (V-I), 12, 82
 - Voltage input-voltage output (V-V), 12
 - DDCC, 86–89
 - DVCC, 89–91
 - OFCC, 83, 85
 - Voltage-mode wheatstone bridge (VMWB)
 - circuit, 29
 - configurations, 29
 - excitation source, 32
 - INA118, 34
 - linearization, 35–36
 - Op-Amp based amplifier, 43
 - read-out circuit, 34
 - time interval, 32
 - time-based approach, 32
 - traditional, 33
 - voltage excitation, 31
 - voltage-based approach, 34

W

Wheatstone Bridge configuration, 2

Wilson CMAs

current conveyors non-idealities, 60–62

operation

active building block, 59

CCII⁺s, 59, 60

common-mode gain, 60

load resistors, 59

matching, 60

voltage gain, 60

structure, 142