

Contents

1	Breadboard techniques and simple circuits.	5
1.1	Introduction to the workbench.	5
1.2	Errors introduced by the instruments	5
1.3	Low-pass filter	5
1.4	Observing phase shift with Lissajous patterns	6
1.5	Shielding and induced signals	7
2	Operational Amplifiers: Basic Concepts	9
2.1	Null voltage measurement	9
2.2	Voltage follower	10
2.3	Follower with gain	11
3	Building circuits with op-amps	13
3.1	Current-to-voltage converter	13
3.2	Inverting amplifier	14
3.3	Summing amplifier	14
3.4	Op-amp characteristics	15
4	Advanced op-amp designs	16
4.1	Op-amp integrator	16
4.2	Op-amp differentiator	17
4.3	Difference amplifier	17
4.4	Instrumentation amplifier	19
4.5	Logarithmic amplifier	19
4.6	Analog multiplier	20
5	Active filters and tuned amplifiers	22
5.1	Active filter	22
5.2	Notch filter	24
5.3	Lock-in amplifier	24
6	Using microcomputers in a physics laboratory	27
7	Building and using a digital thermometer	31
A	Resistor colour code	33