## INDEX

### POWER SUPPLIES
- DC POWER SUPPLY  DL 2555ALG
- AC POWER SUPPLY  DL 2555ALA
- POWER SUPPLY FOR DIGITAL ELECTRONICS  DL 2203DB
- POWER SUPPLY  DL 1004

### DISCRETE COMPONENTS LINEAR ELECTRONICS
- BJT VOLTAGE AMPLIFIERS  DL 2155AT
- BJT POWER AMPLIFIERS  DL 2155APT
- BJT FEEDBACK AMPLIFIERS  DL 2155ART
- FET-MOSFET  DL 2155FET
- TRANSISTOR BASED VOLTAGE REGULATORS  DL 2155RTD
- HIGH FREQUENCY OSCILLATORS  DL 2155OSA
- LOW FREQUENCY OSCILLATORS  DL 2155OSB
- QUARTZ OSCILLATORS  DL 2155OSX

### INTEGRATED COMPONENTS LINEAR ELECTRONICS
- TRANSISTOR MULTIVIBRATORS  DL 2155MVB
- SCHMITT TRIGGER AND NE555  DL 2155TRG
- OPERATIONAL AMPLIFIERS  DL 2155AOP
- ACTIVE FILTERS  DL 2155FIL
- FUNCTION GENERATORS  DL 2155GEF
- DIFFERENTIATORS, INTEGRATORS, SAMPLE AND HOLD CIRCUITS AND PEAK DETECTORS  DL 2155DIS
- COMPARATORS  DL 2155COM
- AC AMPLIFIERS AND DC INSTRUMENT AMPLIFIERS  DL 2155AMP
- ANALOG SWITCHES AND MULTIPLEXERS  DL 2155SMA
- VOLTAGE REGULATORS WITH INTEGRATED CIRCUITS  DL 2155RTI
- DIGITAL-TO-ANALOGUE CONVERTERS  DL 2155DAC
- ANALOGUE-TO-DIGITAL CONVERTERS  DL 2155ADC

### APPLICATIONS
- SWITCHING POWER SUPPLIES  DL 2155AC
- THRISTORS, TRIACS AND THEIR APPLICATIONS  DL 2316
- TEMPERATURE CONTROL  DL 2155RGT
- SPEED CONTROL OF A DC MOTOR  DL 2155RGM
- STEP MOTOR CONTROL  DL 2208
- PROCESS SIMULATOR WITH PID CONTROL  DL 2330
- POWER ELECTRONICS BOARD  DL 2317SR
- MOTOR BOARD  DL 2318SR

### DIGITAL ELECTRONICS
- COMBINATORY LOGIC  DL 2203C
- SEQUENTIAL LOGIC  DL 2203S
- HCT – ECL – CMOS  DL 22035FL
- ADVANCED SEQUENTIAL LOGIC  DL 2205INL
- PROGRAMMABLE LOGIC  DL 2205PRL
- DIGITAL BOARD  DL 22035R
## DISCRETE COMPONENTS LINEAR ELECTRONICS

<table>
<thead>
<tr>
<th>CODE</th>
<th>BOARD</th>
<th>DL 2555ALG</th>
<th>DL 2555 ALA</th>
<th>DL 2203 DB</th>
<th>MAINS SUPPLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL 2155AT</td>
<td>BJ T voltage amplifiers</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155APT</td>
<td>BJ T power amplifiers</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155ART</td>
<td>BJ T feedback amplifiers</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155FET</td>
<td>FET-MOSFET</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155RTD</td>
<td>Voltage regulators</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155OSA</td>
<td>High frequency oscillators</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155OSB</td>
<td>Low frequency oscillators</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155OSX</td>
<td>Quartz oscillators</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## INTEGRATED COMPONENTS LINEAR ELECTRONICS

<table>
<thead>
<tr>
<th>CODE</th>
<th>BOARD</th>
<th>DL 2555ALG</th>
<th>DL 2555 ALA</th>
<th>DL 2203 DB</th>
<th>MAINS SUPPLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL 2155MVB</td>
<td>Transistor multivibrators</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155TRG</td>
<td>Schmitt trigger and NE 555</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155AOP</td>
<td>Operational amplifiers</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155FL</td>
<td>Active filters</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155GEF</td>
<td>Function generators</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155DIS</td>
<td>Differentiators, integrators...</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155COM</td>
<td>Comparators</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155AMP</td>
<td>AC and DC amplifiers</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155SMA</td>
<td>Analogue switches, multiplexers</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155RTI</td>
<td>Voltage regulators</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## APPLICATIONS

<table>
<thead>
<tr>
<th>CODE</th>
<th>BOARD</th>
<th>DL 2555ALG</th>
<th>DL 2555 ALA</th>
<th>DL 2203 DB</th>
<th>MAINS SUPPLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL 2155DAC</td>
<td>Digital-analogue converters</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155ADC</td>
<td>Analogue-digital converters</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155AC</td>
<td>Switching power supplies</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2316</td>
<td>Thyristors, triacs, ...</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155RGT</td>
<td>Temperature control</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155RGM</td>
<td>DC motor speed control</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2208</td>
<td>Step motor control</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>DL 2330</td>
<td>Process simulator with PID</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2317SR</td>
<td>Power electronics board</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2318SR</td>
<td>Motor board</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## DIGITAL ELECTRONICS

<table>
<thead>
<tr>
<th>CODE</th>
<th>BOARD</th>
<th>DL 2555ALG</th>
<th>DL 2555 ALA</th>
<th>DL 2203 DB</th>
<th>MAINS SUPPLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL 2203C</td>
<td>Combinatory logic</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2203S</td>
<td>Sequential logic</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2203FL</td>
<td>HCT-ECL-CMOS</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2205INL</td>
<td>Advanced sequential logic</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2205PRL</td>
<td>Programmable logic</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2205SR</td>
<td>Digital board</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
POWER SUPPLIES

**DC Power Supply**

The module gives the direct power supplies that are necessary for the operation of the experiment boards.

**Output voltages**
- ± 15 Vdc, 1 A
- ± 5 Vdc, 1 A

Protection against short circuits

Supply voltage: single-phase from mains.

**AC Power Supply**

The module gives the alternating power supplies that are necessary for the operation of the experiment boards.

**Output voltages**
- 24 Vac, 2 A

Supply voltage: single-phase from mains.
Power Supply for Digital Electronics

DL 2203DB

It supplies the power necessary for the operation of the boards of digital electronics.

Technical features:
- 3 stabilized and protected dc outputs
- +12V/500mA, +5V/2A, -5.2V/500mA
- 1 CLK1 square wave generator, 5V amplitude, variable frequency from 1Hz to 1kHz
- 1 CLK2 pulse generator, 5V amplitude, variable frequency from 1Hz to 1kHz, rise edge synchronized with CLK1
- 8 logic variable (true and false) generators
- 9 LED for visualization of the logic states

Power supply: single phase from mains

Power Supply

DL 1004

Designed for electronics laboratories. Its main purpose is to realize a power supply source with high safety features and remarkable electric performance.

Output voltages:
- 2 independent stabilized supplies: 0÷30V, 0÷2 A, complete with digital instrument for voltage and current. Possibility of tracking.
- Fixed dual supply: ± 5V/1A
- Fixed dual supply: ± 12V/1A
- Fixed dual supply: ± 24V/1A
- 2 ac power supplies: 0÷250V/1A and 0÷25V/2A isolated from the mains
- Series of sockets: 220 V, 10/16A

The output connecting terminals are of unloseable type. The outputs are protected by means of a general magnetothermal-differential switch.

Supply voltage: single-phase from mains.
The board allows a first approach to the theoretical-practical study of the static and dynamic operation of the BJT (Base-emitter Junction Transistor), used as a voltage amplifier.

The board affords the problems associated to the use of the transistors in the three basic configurations: CE (Common Emitter), CC (Common Collector) and CB (Common Base).

Firstly, the bias and the working point stabilization problems are considered. Then, the typical features of the three configurations are analyzed: input resistance, output resistance, voltage gain and current gain.

In the second section of the board typical applications are studied, such as the bootstrap effect bias and the Darlington connection.

The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ±15 Vdc, 250 mA

The board represents an extremely useful tool for studying the power amplifier of A class and B class. In fact, it provides 4 amplification architectures among the most common in preamplifiers (A class) and final amplifiers (B class), with the possibility of analyzing the power stage and/or the drivers.

The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ±15 Vdc, 1 A
**ELECTRONICS**

**BJT Feedback amplifiers**

The board is designed to afford the problems connected to the introduction of negative feedback into an amplifier, and to its influence on the different parameters: amplification, bandwidth, input and output resistances, noise. The different feedback configurations are theoretically analyzed and experimentally checked: series voltage, parallel voltage, series current, parallel current. Single stage and multistage amplifiers are used, the latter in direct coupling. The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual. Power supply: +15 Vdc, 750 mA

**Experiments**

- Analysis and study of an amplifier with series or parallel voltage feedback and with series or parallel current feedback
- Analysis and study of multistage amplifiers with direct coupling
- Influence of feedback in the amplifier: study of the amplifier with connected/unconnected feedback

**FET-MOSFET**

The board provides a full support concerning the elementary amplification configurations. It affords the problems related to the use of FET and MOSFET in the three basic configurations: common source, gate and drain. Firstly, the bias and working point stabilization problems are considered. Then, the typical features of the configurations are analyzed: voltage gain, input and output resistances. The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual. Power supply: +15 Vdc, 750 mA

**Experiments**

- FET and MOSFET bias in the different configurations
- Measurement of typical configuration parameters
- Bootstrap effect in common drain configuration
**ELECTRONICS**

**Transistor Based Voltage Regulators**

The board analyzes the components normally used in cascade to transformer and filter to realize stabilized power supply units with bipolar technology. For all configurations the input and output characteristics can be measured.

The board is arranged in 4 modules that allow the study of:
- Zener voltage regulator
- Zener voltage regulator with series and parallel transistor
- Voltage regulator with variable output
- Voltage regulator with short-circuit protection and Darlington transistor

The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: +15 Vdc, 750 mA

**High Frequency Oscillators**

The board allows the study and the successive experimental verification of the most widespread circuit configurations for high frequency sinusoidal oscillators.

The panel includes the Colpitts, Hartley and Meissner oscillators carried out with discrete components that are usually used as radiofrequency signal generators, i.e. for frequencies between 100 kHz and 1 GHz.

The three analysed configurations could also be operated outside the above mentioned limits but their use is limited from the size and the values of the reactive components that should be used as resonant elements.

The board is supplied complete with a set of stackable, plug-in suitable lengths and colours and with a training manual.

Power supply: +15 Vdc 100 mA
Low Frequency Oscillators

The board allows to carry out functional verifications on the most widespread low frequency sinusoidal oscillators. The RC phase-shift transistor-based oscillators and the Wien bridge oscillators are afforded in the two transistor and operational amplifier configurations. Moreover, in the Wien bridge version the possibility of adjusting the amplitude and the frequency of the oscillation is analysed. The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15 Vdc, 750 mA

DL 2155OSB

Experiments
- Operation of a transistor-based RC phase shift oscillator
- Operation of a Wien bridge oscillator in the transistor and operational amplifier configurations
- Wien bridge oscillator with FET stabilization network
- Wien bridge oscillator with regulation of the oscillation amplitude and frequency

Quartz Oscillators

The need of accurate-value, time stable and temperature-stable oscillators can be seen in a wide range of applications: instrumentation and military, industrial and consumer equipment. To satisfy these requirements, quartz oscillators are normally used. The carrying out of both sinusoidal oscillators and square-wave oscillators is of significant interest.

The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: + 15 Vdc and + 5 Vdc, 100 mA

DL 2155OSX

Experiments
- Square wave and sinusoidal transistor-based quartz oscillator
- CMOS quartz oscillators with not inverting amplifier
- CMOS quartz oscillator of PIERCE type
- Measurement on quartz time base
The board is designed to study and experimentally check the most popular configurations of transistor-based multivibrating circuits. The board is divided into three main sections. The first section deals with bistable multivibrators in fixed bias and self-biased configurations. The various set, reset and trigger controls are analyzed. The second section affords the study of monostable multivibrators with fixed bias and self bias and the relevant controls. The third section is dedicated to the astable multivibrators. The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual. Power supply: ± 15 Vdc, 100 mA

Schmitt Trigger and NE555

The board allows to analyze the operation of Schmitt trigger and NE 555 integrated circuit. It is composed of two sections. The first section allows the study and the experimental checking of the Schmitt trigger. Also two typical applications of this circuit are analyzed: threshold detector and clipper. The second section is dedicated to the study of the 555 integrated circuit. This is a flexible and widely used integrated circuit. It is used to generate delays, pulse trains and adjustable duty-cycle square waves. The board allows to analyze the block diagram and to experimentally check the most widespread applications. The board is supplied complete with a set of stackable, plug-in suitable lengths and colours and with a training manual. Power supply: + 15 Vdc, 50 mA
Operational Amplifiers

The board is designed for a first approach to operational amplifiers. It is divided in two sections. The first section includes a transistor based differential amplifier and allows the general and full study of the input stage of a monolithic operational amplifier. The concepts of inverting and non-inverting inputs, common mode and differential amplification and common mode feedback are considered. The second section shows three different monolithic operational amplifiers and a set of active and passive components, allowing to check and to compare the features of the three amplifiers and the study of the different application fields. The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15 Vdc, 750 mA

Active Filters

The board allows the study and the functional check on active filters carried out with operational amplifiers. The board is divided in five sections, and in each one there are more than one filter of the same kind. It is possible to study, respectively:

• low-pass filter VCVS of the first and second order
• high-pass filter VCVS of the first and second order
• multiple feedback band-pass filter
• universal filter of variable-state type
• dual T band-stop filters

The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15 Vdc, 750 mA
**Function Generators**

The board allows to perform functional checking of the simplest and most popular square wave generators, pulse generators, triangular wave generators, saw tooth generators and step generators. All generators are realized with operational amplifiers. For some generators circuitual arrangements have been used to allow adjustment of output signal frequency, duty-cycle, slope and offset.

It is therefore possible to perform an in depth study of increasing difficulty and complexity level of the function generator circuits.

The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15 Vdc, 750 mA

---

**Differentiators, Integrators, Sample and Hold Circuits and Peak Detectors**

The board is designed to analyze important circuits for analogue signal processing which are widely used in process controls.

In particular, it is possible to analyze circuits for signal acquisition like sample-holds or peak detectors and circuits for signal processing like differentiators and integrators.

The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15 Vdc, 750 mA
Comparators

The board is designed to study the operating principle of voltage comparators and to perform experimental checking of the most popular and important circuits realized with these components.

The board is divided into four sections for the study of, respectively:
- hysteresis comparator
- zero crossing detector
- window comparator
- amplitude level classifier

The outputs of the comparators are provided with LED to show their electrical state.

The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15 Vdc, 750 mA

AC Amplifiers and DC Instrument Amplifiers

The board is arranged in two separate sections allowing the study of DC instrument amplifiers and AC signal and power amplifiers.

The first section includes three amplifiers allowing the realization of different configurations of DC differential amplifiers with high input impedance.

The same section also includes several resistances and a potentiometer for connection to a Wheatstone bridge for functional checking of balanced input amplifiers.

The second section includes active and passive components that allow the realization of different signal amplifier circuits.

Moreover the board includes a power amplifier realized with a complementary symmetry reverse phase transistor.

The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15 Vdc, 750 mA
ELECTRONICS

Analog Switches and Multiplexers

DL 2155SMA

Experiments

- Analysis of analogue switches operations and performances
- Analysis of some typical applications of analogue switches as adjustable gain amplifiers, inverting/non inverting configuration, programmable amplifiers and programmable attenuators
- Analysis of a multiplexer with four analogue inputs
- Analysis of a demultiplexer with four analogue outputs

The board is designed to study the problems related to the application of analog switches. These switches, and the multiplexers, find a wide application in data acquisition systems, telephone systems, process controls and in all the situations where low power signals have to be switched with high switching speed. The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15 Vdc and + 5 Vdc, 750 mA

Voltage Regulators with Integrated Circuits

DL 2155RTI

Experiments

- Analysis and functional checking of a three-terminals positive/negative voltage regulator with fixed output
- Adjustment of output voltage in three-terminals regulators
- Analysis and functional checking of a dual voltage regulator with separately adjustable voltages
- Measurements of input and output characteristics of previous regulators
- Analysis and operating modalities of a general-purpose monolithic regulator

The board is designed to study the regulators, in particular the voltage regulators, with integrated circuits. The board is arranged into several modules that allow the study of three terminals positive and negative voltage regulators with either fixed or adjustable output voltage. Then, a dual voltage regulator and a general-purpose regulator integrated circuit are analyzed. The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15 Vdc, 750 mA
Digital-To-Analogue Converters

This board allows the study of the operating principle and of the main characteristics of a digital-to-analogue converter.

The board is composed of 3 independent sections:
- a weighed resistances discrete components D/A converter
- a discrete components D/A converter in a R-2R network
- a monolithic 11 bit D/A converter

While the first two sections are used to highlight the operating principle of two different D/A converters, the third one is used to analyse the operating modes and the characteristics of the converters that are commercially available.

The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15 Vdc, 200 mA and + 5Vdc, 200mA

Analogue-To-Digital Converters

This board allows the study of the operating principle and of the main characteristics of analogue-to-digital converters.

The board is divided in 2 sections: in the first one a discrete component realization is provided of a ramp A/D counter converter, while in the second section there is a monolithic converter.

The first section is used to highlight the operating principle of an A/D converter, while the second one is mainly used to analyse the operating modes and the characteristics of the converters that are commercially available.

The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15 Vdc, 100 mA and + 5Vdc, 200mA
Switching Power Supplies

DL 2155AC

Experiments
- Analysis of the operation of a flyback power supply
- Analysis of the operation of a feed-forward power supply
- Regulation of the output voltage as a function of the load or of the input voltage
- Limitation characteristics
- Detection of the typical parameters of the power supplies (ripple voltage, efficiency, etc.)

During the latest years the switching power supplies technology has been significantly developed due to the features of smaller size and higher efficiency of these power supplies when compared to the traditional ones.

This board is basically composed of two sections:
- a BJT-based flyback power supply, with output voltage adjustable from 12V to 18V by means of a potentiometer and rated current 0.5A
- a MOSFET-based feed-forward power supply, with output voltage adjustable from 15V to 18V by means of a potentiometer and rated current 0.5A

Both power supplies are provided with a current limiting circuit and with a shut-down device to switch off the voltage from the load without deactivating the power supplies control circuits. This board also includes resistive loads of different values for the detection of the output characteristics.

The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: 24Vac, 1A, 50/60Hz.
Thyristors, Triacs and their Applications

DL 2316

This system has been designed in 3 boards to allow both the theoretical and the practical study of thyristors and triacs for what concerns the control techniques and their typical applications within the control systems.

Power and Control Board

DL 2316A

Experiments

- SCR control with alternating voltage synchronous and in phase with the anode voltage
- SCR control with alternating voltage synchronous and in phase with the anode voltage supplying the gate with and without flywheel diode
- Half-wave rectifiers with ohmic-inductive load with and without flywheel diode
- Half controlled single-phase rectifier bridge (B2H)
- Half controlled single-phase rectifier bridge with (B2HKF) and without (B2HK) flywheel diode
- Fully controlled single phase rectifier bridge
- Control of full-wave rectification with ohmic load and with ohmic-inductive load
- Half-wave ac/ac converter
- Full-wave ac/ac converter
- Triac control in quadrant I
- Triac control in quadrant III
- Mains alternating voltage regulation
- Pulse train control
- Triac controlled rectifier

It allows the autonomous study of the thyristors in the main single-phase bridge circuit configuration (semi-and totally-controlled) and in the ac/ac converters as well as the study of the triac in the control of the alternating voltage and in the controlled rectification. The power section includes: 4 thyristors, 1 triac, 4 diodes, 1 flywheel diode and 1 ohmic-inductive load.

The control section allows the realization of: proportional control, on-off control or phase control, both on the positive and negative semiswewave. Furthermore, there is a potentiometer for the manual control of the devices activation. The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: 24Vac, 1A, 50/60Hz
**Light and Temperature Control**

This board contains two independent systems, for the control of the light and of the temperature respectively, each one complete with reference block, error amplifier, transducer and actuator. Together with the DL 2316A board, that contains the power circuits complete with relevant piloting, it is possible to realize an open and closed loop control both of the lighting system (24V, 15W lamp and photoresistor) and of the heating system (47 Ω, 25W heating element and integrated circuit sensor). The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15Vdc, 100mA

**Experiments**
- DC operated lamp
- AC operated lamp
- Full-wave triac control
- Proportional control

---

**Speed and Position Control**

This board contains two independent systems, for the control of the position and of the speed respectively, each one complete with reference block, error amplifier, transducer and actuator. Together with the DL 2316A board, that contains the power circuits complete with relevant piloting, it is possible to realize an open and closed loop control both of the position system (geared motor coupled to a potentiometer) and of the speed system (variable load generator dc motor with optical transducer associated to an F/V converter). The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.

Power supply: ± 15Vdc, 100mA

**Experiments**
- Thyristor bidirectional converter
- Open-loop operation
- Closed-loop operation half-controlled bridge
- Closed-loop operation fully-controlled bridge
Temperature Control

**DL 2155RGT**

This system has been designed for the study of a model of a temperature industrial control; it is composed of two boards.

---

**Control Board**

This board includes a small oven with a heating element and three temperature sensors (thermocouple, thermistor, and thermo-resistance) with relevant interface circuits. Complete with error amplifier that can be configured for on-off or proportional control, and with a piloting circuit of the power stage with triac. The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual. Power supply: 24Vac, 1A, 50/60Hz and ± 15Vdc, 100mA

---

**Experiments**

- $V = f(t^*)$ characteristics of a thermocouple, with relevant linearization, of the thermistor and of the thermo-resistance
- Analysis of the operation of an on-off control
- Analysis of the operation of a proportional control

---

**Temperature Control**

**DL 2155RGT2**

This board includes two reference signal generators, a comparison node and the three terms network (proportional, integral and derivative). Complete with digital temperature indicator 100mV/°C. This board is an option to the board DL 2155RGT1 since it uses its oven, the heating element and the temperature transducers. The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual. Power supply: ± 15Vdc, 100mA and +5Vdc, 150mA

---

**Experiments**

- Analysis of the operation of a proportional, proportional-derivative and proportional-integral control
- PID control circuits
- PID controllers calibration
ELECTRONICS

Speed Control of a DC Motor

This board has been designed to highlight the speed control techniques of a direct current motor. The board is basically divided in two sections: the first one allows the study of the open loop speed control, while the second section deals with an actual closed loop speed control of the system. The group under test, composed of a motor, a dynamometer and a speed optical transducer, is placed on the board. The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual. Power supply: 12Vac, 2A, 50/60Hz and 15Vdc, 300mA.

DL 2155RGM

Experiments
- Study of open loop and closed loop speed control systems
- Analysis of the static and dynamic operation of an open loop controller
- Analysis of the static and dynamic operation of a closed loop controller
- Measurement of the speed through an optical transducer connected to a F/V converter or through a tachogenerator

Step Motor Control

This board is designed to provide a valid support for the study of the operation and of the application criteria of these important electromechanical components. It allows the students performing study and experimentation concerning the driving of a step motor, unipolar or bipolar. The rotation can be performed with increments of a single step or with continuity, at a variable speed. Position and direction are indicated by a disk. An LCD display allows showing the number of steps, the number of turns, the rpm, the rotation direction and the selected parameters of the controller.

DL 2208

Technical Features
- Step angle: 1.8°
- Number of phases: 4
- Max. power: 16 W
- Sense of rotation: reversible
- Current/phase max: 1.5 A
- Variable frequency from 20 Hz to 500 Hz through potentiometer
Power supply: 90/260 Vac, 50/60 Hz

Experiments
- Analysis of the operation of a step motor
- Analysis of the control criteria and of the power modules
- Full step or half step
- Variable speed rotation control
- Inversion of the rotation direction
- Study of an incremental position encoder
Process Simulator with PID Control

DL 2330

This system has been designed with the objective of providing the student with a simple, although effective tool for the simulation and the control of physical systems through the identification of the mathematical model, the definition of the parameters and the calibration of the control network.

The system is composed of two boards.

Process Simulator

DL 2330A

This board is basically structured in two sections:
- a linear process simulation, with two summing amplifiers, three blocks with proportional, integral, derivative transfer functions, offset and drift generators
- a hysteresis non-linear simulation, dead band and threshold
It includes a digital voltmeter.
The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.
Power supply: ±15Vdc, 300mA

Experiments
- Analysis and simulation of linear processes
- Open and closed loop control of linear systems
- Behaviour of the control system against fixed or time variable disturbances
- Steady state error
- System with two time constants
- Calibration of a control system and criteria for the optimum setting of the PID parameters
- Transfer function of the PID controllers
- Method of permanent oscillation
- Method of damped oscillations
- Experimental study of the PI controller
- Experimental study of the PD controller
- Experimental study of the PID controller
- Analysis and study of typical non-linear elements (saturation, threshold, hysteresis)

PID Controller

DL 2330B

This board is basically structured in two sections:
- variable frequency square and triangular wave reference signal generation
- three terms regulator with variable parameters and two summing amplifiers
It includes a digital voltmeter.
The board is supplied complete with a set of stackable, plug-in cables of suitable lengths and colours and with a training manual.
Power supply: ±15Vdc, 300mA
Power Electronics Board

DL 2317SR
This board allows the study of several power electronics circuits, as detailed here under.

Technical Features
The following components are available on the board:
• Diodes for circuit M1U, M2U, M3U, M6U
• SCR for circuit M1C, M2C, M3C, M6C
• H bridge with MOSFET
• Pulse generator for SCR control
• Generator for H bridge control (PWM)
• Function Generator
• Three-phase generator (12 Vpp)
• Single-phase source (12 Vpp)
Built-in power supply.

Experiments - DL 2317SR
• Single-phase uncontrolled rectifier M1U and B2U
• Single-phase controlled rectifier M1C and B2C
• Three-phase, single wave, uncontrolled rectifier B3U
• Three-phase, single wave, controlled rectifier B3C
• Three-phase, full wave, uncontrolled rectifier B6U
• Three-phase, full wave, controlled rectifier B6C
• Pulse Width Modulation (PWM) circuit to control direct current
• PWM to control a motor with a H bridge
• PWM on H bridge to understand the principle of inverter

Experiments ON THE DC SUPPLY
• Basic pulse width modulation (PWM) circuits
• PWM with H-circuit, DC-evaluated
• PWM with H-circuit, sine-evaluated

Experiments WITH THE GTO (GATE-TURN-OFF)
• Firing pulse conditioning for the GTO
• The GTO as a DC actuator

Motor Board

DL 2318SR
Universal speed control system.
• With integrated four-quadrant display
• With variable centrifugal mass
• Dual-channel encoder
• Built-in four-quadrant amplifier

Technical features
• Linear H bridge to have full motor control
• Dual optical sensor for speed and direction
• Main Motor/Generator 12 V, 3000 rpm, 1.2 A, 3.2 Ncm
• Load to be connected to the secondary Motor/Generator
• Shunt to limit and measure the current
Combinatory Logic

This board allows the study of the following combinatorial circuits: adders, substractors, multipliers, code converters, multiplexers and demultiplexers. The board is composed of:

- 4 AND (2-input)
- 3 AND (3-input)
- 12 NAND (2-input)
- 4 NAND (4-input)
- 2 NAND TRIGGER (4-input)
- 4 OR (2-input)
- 2 OR (3-input)
- 1 OR (4-input)
- 4 NOR (2-input)
- 2 NOR (4-input)
- 4 EX-OR (2-input)
- 6 inverters
- 2 AOI (2 and 3 input)
- 12 silicon diodes
- 8 resistances
- 1 dual-in-line 16-pin socket

Power supply: 5Vdc, 3W

Sequential Logic

This board allows the study of the following subjects: MSI circuits in TTL logic, synchronous and asynchronous counters, shift registers, astable and monostable multivibrators, seven segment displays. The board is composed of:

- 4 JK/MS flip-flop
- 2 D flip-flop
- a BCD synchronous counter
- a binary 4-bit synchronous counter
- a BCD asynchronous counter
- a binary 4-bit asynchronous counter
- 2 monostable multivibrators
- a shift register, 8-bit SI-SO
- 2 BCD 7-segment decoders
- 2 7-segment displays
- 2 BCD rotating switches
- 8 capacitors
- 2 linear potentiometers

Power supply: 5Vdc, 5W
### HCT – ECL – CMOS

This board allows the study of the following subjects:
- electrical characteristics of the integrated circuits of the various logic families: ECL, CMOS, HCT
- laws and principles for the assembling of interface circuits among the families
- logic gates
- multiplexed counters
- programmable shift registers
- bidirectional transmission gates
- level translators

The board is composed of three sections:
- the HCT section
- the ECL section
- the CMOS section

In each section various types of integrated circuits of the three different logic families are assembled.
Power supply: +5Vdc, +12Vdc, -5.2Vdc

### Advanced Sequential Logic

This board allows the study of the following circuits: counters, frequency dividers, cyclic programmable timers, data transfer between two shift registers. Furthermore, the board includes interface circuits and a connector to allow for direct and easy interfacing to systems, devices and circuits prepared by the students.

The board is composed of:
- 4-bit comparators (2 off )
- 4-bit BCD counters (2 off )
- 4-bit shift registers (2 off )
- 8-to-1 line multiplexer
- 1-to-8 line demultiplexer
- NOT with open collector output (4 off )
- Optoisolators (4 off )
- a 22-pole connector, step 3.96 mm

Power supply: 5Vdc
Programmable Logic

This board allows the study of RAM memories and circuits using RAMs for storing logic information and for data transfer to a BUS. The board is composed of:
- 4 + 4 buffers with three-state output
- 8-bit latch register (type D)
- 4-to-10 line decoder
- RAM 1024 x 4
- hexadecimal keypad
- coder for hexadecimal keypad
- 8-bit digital-to-analogue converter
- 8-bit analogue-to-digital converter
- multiturn potentiometer for generating voltages between 0 and 10V
Power supply: 5Vdc

Digital Board

This board allows the study of several digital circuits. Technical features:
- 4-bit comparator
- 4 JK-flip flops, can also be used as RS flip flops
- 4 D-flip flops
- 2 adders (4-bit), with input and output carry
- Multiplexer, 4 channels
- Demultiplexer, 4 channels
- Shift register (4-bit), parallel and serial operation possible, bi-directional
- ALU, for conducting 16 arithmetic and 16 logical computing operations with 4-bit dual numbers
- Binary counter (4-bit), up/down counter
- 2 inverters
- 2 Schmitt triggers, inverting
- Units complements for negating a 4-bit binary number
- Antivalence and equivalence gates
- EEPROM
- AD/DA converter 8-bit
- Auxiliary section on board:
  - 8 switches with led to generate logic level
  - 8 logic probes with led for high and low level
  - 2 seven segment led displays with BCD decoder
Built-in power supply
# TABLE OF INSTRUMENTATION

<table>
<thead>
<tr>
<th>CODE</th>
<th>BOARD</th>
<th>DIGITAL MULTIMETER</th>
<th>DUAL TRACE OSCILLOSCOPE</th>
<th>LF SIGNAL GENERATOR</th>
<th>FREQUENCY COUNTER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DISCRETE COMPONENTS LINEAR ELECTRONICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155AT</td>
<td>BJT voltage amplifiers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>DL 2155APT</td>
<td>BJT power amplifiers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>DL 2155ART</td>
<td>BJT feedback amplifiers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>x 2</td>
</tr>
<tr>
<td>DL 2155FET</td>
<td>FET-MOSFET</td>
<td>X 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155RTD</td>
<td>Voltage regulators</td>
<td>x 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155OSA</td>
<td>High frequency oscillators</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>DL 2155OSB</td>
<td>Low frequency oscillators</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155OSX</td>
<td>Quartz oscillators</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>INTEGRATED COMPONENTS LINEAR ELECTRONICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155MVB</td>
<td>Transistor multivibrators</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>DL 2155TRG</td>
<td>Schmitt trigger and NE</td>
<td>X</td>
<td>X</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>DL 2155AOP</td>
<td>Operational amplifiers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>DL 2155FIL</td>
<td>Active filters</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155GEL</td>
<td>Function generators</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155DLS</td>
<td>Differentiators, integrators...</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>DL 2155COM</td>
<td>Comparators</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155AMP</td>
<td>AC and DC amplifiers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>DL 2155SSA</td>
<td>Analogue switches, multiplexers</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>DL 2155RSL</td>
<td>Voltage regulators</td>
<td>x 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>APPLICATIONS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155DAC</td>
<td>Digital-analogue converters</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155ADC</td>
<td>Analogue-digital converters</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155AC</td>
<td>Switching power supplies</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2316</td>
<td>Thyristors, triacs, ...</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155GRT</td>
<td>Temperature control</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2155CRM</td>
<td>DC motor speed control</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2200B</td>
<td>Step motor control</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2330</td>
<td>Process simulator with PID</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>DL 2317SR</td>
<td>Power electronics board</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2318SR</td>
<td>Motor board</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DIGITAL ELECTRONICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2203C</td>
<td>Combinatory logic</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2203S</td>
<td>Sequential logic</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2203FL</td>
<td>HCT-ECL-CMOS</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2205LNL</td>
<td>Advanced sequential logic</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2205LPL</td>
<td>Programmable logic</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DL 2203SR</td>
<td>Digital board</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>