EE445/545 Laboratory
Power Electronic System Design I

This lab is worth 10% of the total grade, 10% for the hardware demonstration and 10% for the group report due at the time of the hardware demonstration.

Aim: To build and observe the operation in CCM and DCM of a basic PWM switching dc-to-dc converter.

Hardware Demonstration

Each group, as assigned in class, needs to build and demonstrate correct operation of a basic switching dc-to-dc converter. The circuit schematic distributed in class may be used as a guideline. Determine suitable \( V_s \), \( T_s \) and \( D \) values and keep these constant for the purposes of the report which is discussed below. Be sure to include these values in your report. In the demonstration, your group needs to show correct operation in CCM as well as in DCM. To change modes of operation, vary the load resistance only.

Group Report

The group report should contain at least the following:

1) your schematic diagram with actual component values used,
2) a brief description of the circuit,
3) an evaluation of the voltage conversion ratio in CCM with a comparison with the experimentally determined conversion ratio,
4) an evaluation of the output voltage ripple in CCM, based on component and input source values used,
5) a sketch of the actual voltage ripple giving the peak-to-peak value of the ripple. A comparison with (4) and, if necessary, an explanation of any discrepancy with (4) should also be provided.
6) an evaluation of the \( R_{crit} \) boundary between CCM and DCM.
7) an evaluation of the DC voltage conversion ratio in DCM operation with a comparison with the experimentally determined conversion ratio.
Grading of the lab demonstration will be based on:

1) Control circuit functionality
2) Converter functionality
3) Control circuit construction
4) Converter circuit construction
5) Smooth verbal presentation (all group members should speak)
6) Knowledge of equipment use

Report:

1) Full schematic diagram of constructed control circuit and converter (on a single 8½" x 11" sheet) with all component values shown (show MOSFET and diode part numbers)

2) No equation derivations are necessary. However, if included, put them in an Appendix.
14A, 100V, 0.160 Ohm, N-Channel Power MOSFETs

These are N-Channel enhancement mode silicon gate power field effect transistors. They are advanced power MOSFETs designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation. All of these power MOSFETs are designed for applications such as switching regulators, switching converters, motor drivers, relay drivers, and drivers for high power bipolar switching transistors requiring high speed and low gate drive power. These types can be operated directly from integrated circuits.

Formerly developmental type TA17411.

Features

- 14A, 100V
- $R_{DS(ON)} = 0.160\Omega$
- Single Pulse Avalanche Energy Rated
- SOA is Power Dissipation Limited
- Nanosecond Switching Speeds
- Linear Transfer Characteristics
- High Input Impedance
- Related Literature
  - TB334 "Guidelines for Soldering Surface Mount Components to PC Boards"

Ordering Information

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>PACKAGE</th>
<th>BRAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRF530</td>
<td>TO-220AB</td>
<td>IRF530</td>
</tr>
</tbody>
</table>

NOTE: When ordering, use the entire part number.

Symbol

Packaging

JEDEC TO-220AB
12A, 100V, 0.300 Ohm, P-Channel Power MOSFETs

These are P-Channel enhancement mode silicon gate power field effect transistors. They are advanced power MOSFETs designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation. All of these power MOSFETs are designed for applications such as switching regulators, switching converters, motor drivers, relay drivers, and drivers for high power bipolar switching transistors requiring high speed and low gate drive power. The high input impedance allows these types to be operated directly from integrated circuits.

Formerly developmental type TA17511.

Ordering Information

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<th>PART NUMBER</th>
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<td>IRF9530</td>
<td>TO-220AB</td>
<td>IRF9530</td>
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<tr>
<td>RF1S9530SM</td>
<td>TO-263AB</td>
<td>RF1S9530</td>
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</table>

NOTE: When ordering, use the entire part number. Add the suffix 9A to obtain the TO-263AB variant in the tape and reel, i.e., RF1S9530SM9A.

Features

- 12A, 100V
- $r_{DS(ON)} = 0.300\Omega$
- Single Pulse Avalanche Energy Rated
- SOA is Power Dissipation Limited
- Nanosecond Switching Speeds
- Linear Transfer Characteristics
- High Input Impedance
- Related Literature
  - TB334, "Guidelines for Soldering Surface Mount Components to PC Boards"

Symbol

Packaging

JEDEC TO-220AB

JEDEC TO-263A
NPN General Purpose Amplifier

This device is for use as a medium power amplifier and switch requiring collector currents up to 500 mA. Sourced from Process 19.

Absolute Maximum Ratings*   $T_A = 25^\circ C$ unless otherwise noted

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Units</th>
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<tbody>
<tr>
<td>$V_{CEO}$</td>
<td>Collector-Emitter Voltage</td>
<td>40</td>
<td>V</td>
</tr>
<tr>
<td>$V_{CEO}$</td>
<td>Collector-Base Voltage</td>
<td>75</td>
<td>V</td>
</tr>
<tr>
<td>$V_{EBO}$</td>
<td>Emitter-Base Voltage</td>
<td>6.0</td>
<td>V</td>
</tr>
<tr>
<td>$I_C$</td>
<td>Collector Current - Continuous</td>
<td>1.0</td>
<td>A</td>
</tr>
<tr>
<td>$T_A$, $T_{stg}$</td>
<td>Operating and Storage Junction Temperature Range</td>
<td>-55 to +150</td>
<td>°C</td>
</tr>
</tbody>
</table>

*These ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

**NOTES:**
1) These ratings are based on a maximum junction temperature of 150 degrees C.
2) These ratings are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

Thermal Characteristics   $T_A = 25^\circ C$ unless otherwise noted

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Characteristic</th>
<th>PZT2222A</th>
<th>MMBT2222A *</th>
<th>PN2222A</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_D$</td>
<td>Total Device Dissipation</td>
<td>625 mW</td>
<td>350 mW</td>
<td>1,000 mW</td>
<td>5.0</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td>Derate above 25°C</td>
<td>5.0</td>
<td>2.8</td>
<td>8.0</td>
<td></td>
<td>mW/°C</td>
</tr>
<tr>
<td>$R_{JAC}$</td>
<td>Thermal Resistance, Junction to Case</td>
<td>83.3 °C/W</td>
<td>2.8 °C/W</td>
<td>8.0</td>
<td></td>
<td>°C/W</td>
</tr>
<tr>
<td>$R_{JAM}$</td>
<td>Thermal Resistance, Junction to Ambient</td>
<td>200 °C/W</td>
<td>357 °C/W</td>
<td>125</td>
<td></td>
<td>°C/W</td>
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</table>

*Device mounted on FR-4 PCB 1.6" X 1.6" X 0.06".

**Device mounted on FR-4 PCB 38 mm X 18 mm X 1.5 mm; mounting pad for the collector lead min. 6 cm².

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11.0 Connection Diagrams

Metal Can Package

![Metal Can Package Diagram]

Note: Pin 4 connected to case

Top View
Order Number LM111H, LM111H/883(Note 21), LM211H or LM311H
See NS Package Number H08C

Dual-In-Line Package

![Dual-In-Line Package Diagram]

Top View
Order Number LM111J-8, LM111J-S/883(Note 21), LM311M, LM311MX or LM311N
See NS Package Number J08A, M08A or N08E

Dual-In-Line Package

![Dual-In-Line Package Diagram]

Top View
Order Number LM111J/883(Note 21)
See NS Package Number J14A or N14A

Order Number LM111W/883(Note 21), LM111WG/883
See NS Package Number W10A, WG10A

Note 21: Also available per JM38510/10304