SkillsUSA
2010 Contest Projects

Electronics Technology

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Electronics Technology
No oscilloscopes, multimeters or calculators will be provided by the technical committee.

TECHNICAL MANUAL

Electronics Technology

SkillsUSA
Champions at Work®

Contestant Handout

2010

Nida Corporation
300 John Rodes Blvd.
Melbourne, Florida 32904

Technical Manual

TABLE OF CONTENTS

THEORY OF OPERATION

General Description – Switched-mode power supplies have the advantage over linear power supplies of requiring less power input for the amount of power output. Linear power supplies require an "overhead" voltage, meaning the power supply itself requires 1 to 3 volts of input more than the required regulated output just to maintain regulation. Should a high demand be placed on a linear supply and the demand pull the output voltage below the required voltage plus the overhead voltage, regulation is lost.

Switched-mode power supplies can be found in almost every electronic device with circuit demands greater than 2 amperes. Switched-mode supplies are more complicated, and therefore, more expensive to manufacture; but they have proven to be more reliable than their linear counterparts in high-current applications. Switched-mode power supplies operate at much higher frequencies than 60 Hz, which reduces the size of required filtering capacitors.

The switched-mode power supply used in the competition uses Pulse Width Modulation (PWM) to provide output voltage regulation. The PWM switching power supply resides on the Skills07-1 and Skills07-2 circuit cards. The power supply output is adjustable between 1.5 and 10 VDC.

The Skills07-3 circuit card is used to provide a load with varying current demands but operates only within a narrow span of DC voltage. The load placed on the power supply is constantly changing, and varies between 50 mA and 150 mA.

The following circuit descriptions are presented in both a simplified block diagram, or systems version, and a detailed schematic signal flow version down to the component level. It is recommended that you read and understand both presentations.

Block Diagram Circuit Descriptions – Each circuit card (PWM Switching Power Supply I, PWM Switching power Supply II, and Load) will be described as it relates to the circuits.

PWM Switching Power Supply I. The PWM Switching Power Supply I circuit card (Skills07-1) consists of the B1, B2, B3, and B4 blocks. See Figure 1 on the next page.

The PWM Switching Power Supply I circuit card provides several functions to the switching power supply. Each is totally separate from the others but all are required for the proper operation of the circuit. Following is an explanation of each of the sections:

Block B1 is the rectifier block. The AC input is converted to unregulated filtered DC voltage. The single output, a DC voltage between 15 and 19 volts, can be verified at test point TP1. This voltage is also present at the circuit card output plug, J1, on pin 1.

Block B2 contains an oscillator and buffer circuit. The block is powered by regulated 10 VDC from block B3, the amplitude control circuitry. The output of the circuit, a 10 volt square wave with an 80% duty cycle, is measured at TP8. When the circuit is properly set up, this waveform has a frequency of 100 kHz.

PWM Switching Power Supply I, continued

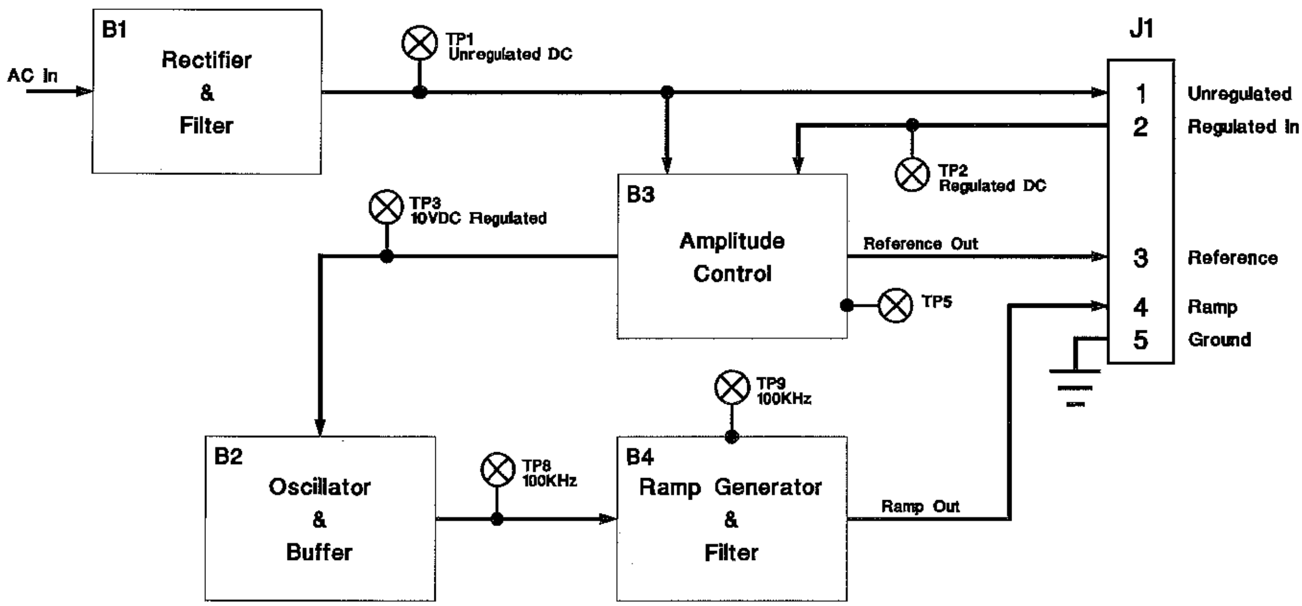


Figure 1. PWM Switching Power Supply I Block Diagram

Block B3, labeled Amplitude Control, contains an operational amplifier circuit configured as a differential amplifier. A sample of the regulated output voltage from the power supply enters the circuit card at J1 pin 2. This voltage is compared to a known internally-regulated DC voltage. The output of the differential amplifier, the correction signal for the switching power supply, labeled "Reference", is present at J1 pin 3. This output, a varying DC voltage of about 10 VDC, can be verified at TP5. A fixed 10 VDC output at TP3 powers block B2.

Block B4 contains a ramp generator circuit. The input to the circuit is the 100 kHz waveform output from block B2. This square wave input is converted to a ramp signal matching the duty cycle of the incoming waveform. This ramp signal can be viewed at TP9. A DC offset voltage of about 10 volts is added to the ramp signal, and the resulting composite signal, "Ramp", exits the circuit card at J1 pin 4.

PWM Switching Power Supply II. The PWM Switching Power Supply II circuit card (Skills07-2) consists of five blocks, B5 through B9. See Figure 2 on the next page.

The PWM switching power supply II circuit completes the switching power supply and has several functions. The five blocks making up the PWM switching power supply II circuit are B5 (PWM modulator & switch), B6 (current limiter), B7 (output filter), B8 (onboard load), and B9 (over-voltage protection). Following is an explanation of each block:

PWM Switching Power Supply II, continued

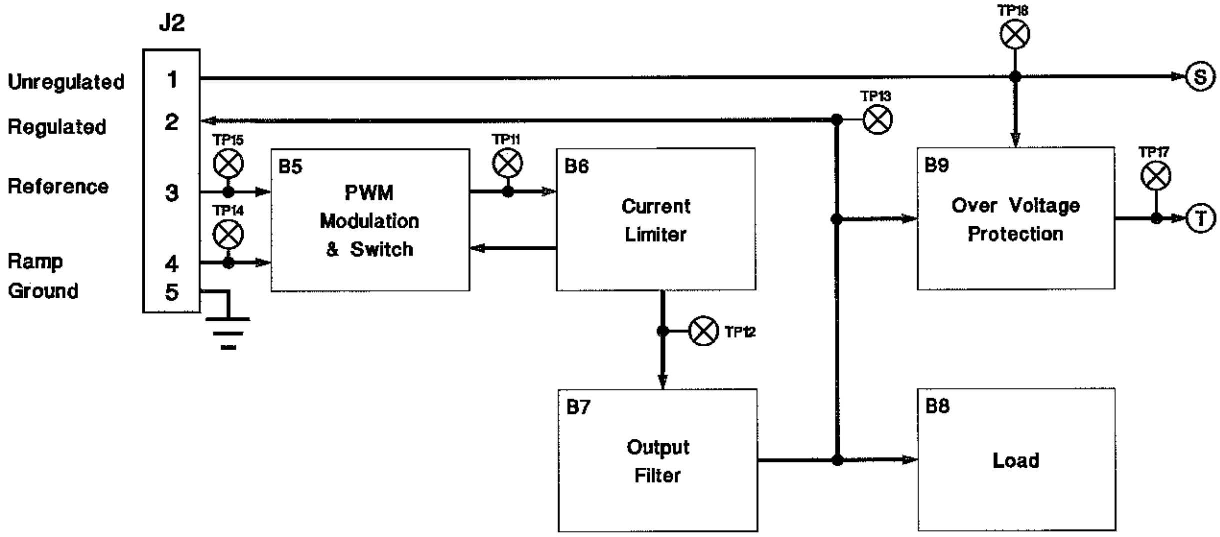


Figure 2. PWM Switching Power Supply II Block Diagram

Block B5 provides the pulse width modulation and switching. Regulation is provided by comparing the Reference and Ramp signals from the PWM switching power supply I circuit card.

TP14 allows the view of the composite Ramp signal and TP15 is used to verify the Reference signal. TP11 is the block 5 output, a 100 kHz square wave with slight rounding of the waveform at the top. The pulse width (duty cycle) will vary with the load. The pulse width will increase under higher current demand conditions.

Block B6, the current limiter, has a passive role in normal operation. Should the output loads fail in a way as to increase the current demand, the circuit activates and shuts down the power supply by disabling the switching signal in block B5. When the high current demand is removed, the current limiter again assumes the passive role as the power supply resumes normal operation.

TP12 is used to monitor the current limiter output. In normal use, the waveform at TP12 should be identical to the waveform at TP11, the block B5 output.

Block B7 is the output filter circuit. The input to the circuit is the switching square wave from block B6 common to TP12. The output of block B7 is the output for the switching power supply and can be measured at TP13. This output is applied to the over-voltage protection circuit and the loads; it also provides feedback for comparison in block B3 on the PWM Switching Power Supply I circuit card via J1 pin 4.

Block B8 has a voltage output indicator LED and a switched load.

Block B9 is an over-voltage protection circuit for the external load. Should the output of the switching power supply exceed a preset limit, the circuit trips, and the voltage to the external load is removed from the output terminal T. The output voltage can be measured at TP17.

Load. The Load circuit card (Skills07-3) consists of four blocks: B10, B11, B12, and B13. See Figure 3.

The purpose of the Load circuit card is to provide an external varying load for the PWM switching power supply.

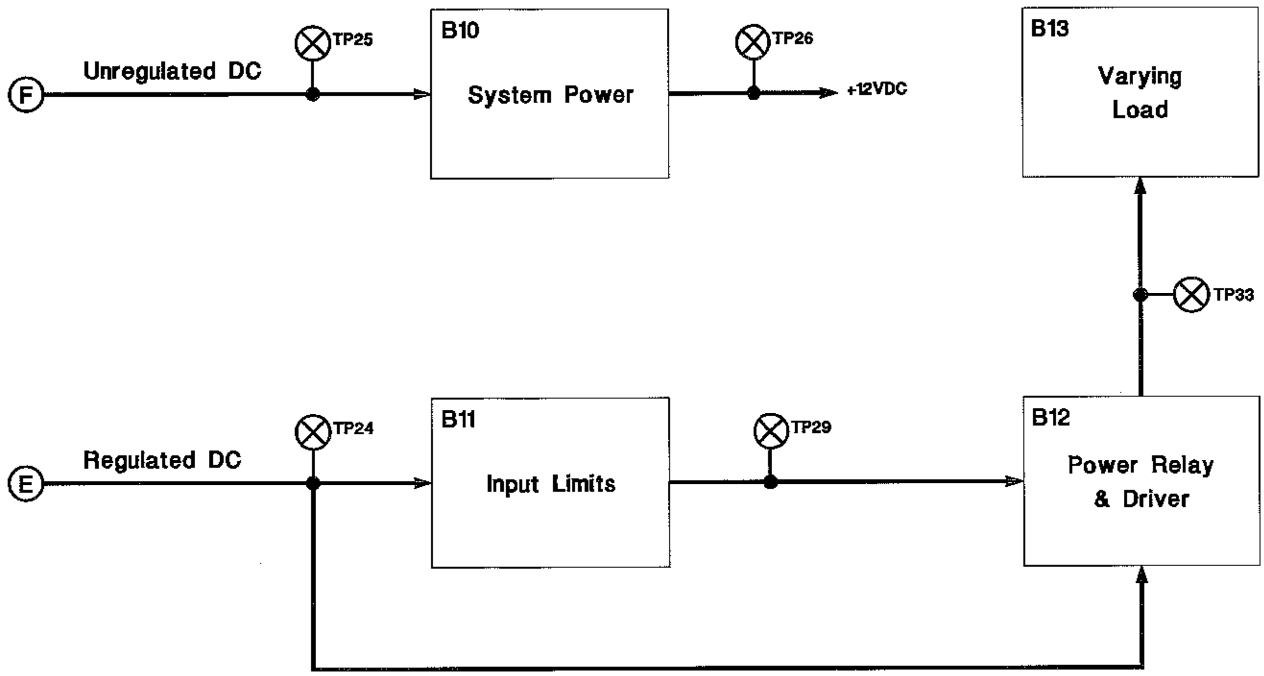


Figure 3. Load Block Diagram

Block B10 contains the system power supply. The protection and relay circuitry require a fixed operating voltage higher than the regulated output of the PWM switching power supply. Block B10 has a small low-current, single IC, linear power supply with a fixed +12 VDC output to power blocks B11 and B12.

The voltage source for block B10 is the unregulated DC voltage output from block B1, measured at TP25. The output for block B10 can be checked at TP26.

Block B11, Input Limits, monitors the regulated 8.5 VDC input voltage from block B9 on the PWM Switching Power Supply II circuit card. The input voltage can be verified at TP24. Should the regulated input voltage be above or below set limits, the circuitry will pull a normally-HIGH output at TP29 LOW, disabling the power relay and driver circuit in block B12.

Block B12 has the power relay and driver circuitry. A HIGH input at TP29 allows the circuitry to switch the PWM power supply regulated input to block B13, the Varying Load block. A LOW input at TP29 causes the circuitry to shut down, removing the power to block B13.

Load, continued

Block B13 contains the varying load for the PWM switching power supply. Eighteen LEDs, arranged in 3 groups of 6 LEDs each, are turned on and off at different speeds. This causes the load to vary constantly. When regulated voltage is present at TP33, the circuit should be operating with the LEDs flashing at different rates.

Schematic Diagram Circuit Descriptions – Schematic diagrams provide the greatest detail for circuit analysis and troubleshooting; they also give component values and identification numbers. The parts location pictorial and test point list for each circuit card are located after the Operational Check. The schematic diagrams are at the end of this document.

PWM Switching Power Supply I (Skills07-1)

The PWM Switching Power Supply I circuit card makes up one-half the overall pulse width modulated (PWM) switching power supply. There are four different blocks on the circuit card. Each block on the circuit operates independently but all are required for the proper operation of the power supply.

Two separate 60 Hz AC voltages 180° out of phase enter the circuit card in block B1 at pins B, C, G, and H. Pins C and G are grounded and provide ground return for the B and H inputs. Diodes D1 and D2 make up a full-wave bridge, converting the AC inputs to DC voltage. When S1 is in the ON position, the DC voltage is applied to C1, a 1,000 µF electrolytic capacitor, which filters out most of the AC ripple from the DC voltage.

The DC voltage at this point is unregulated, and can be verified at test point TP1. The voltage will measure between 15 and 19 VDC. The AC ripple at the top of the DC voltage can be as high as 1 Vpp, or about 1/3rd volt RMS. DS1 is a power indicator.

The unregulated DC is applied to blocks B3 and B4 on the PWM Switching Power Supply I circuit card; it also powers other blocks on the PWM Switching Power Supply II and Load circuit cards via plug J1 terminal 1.

An oscillator in block B2 made up of U1E and U1F develops a square wave digital signal with a tapered trailing edge. The waveform can be viewed at TP7, will be 10 Vpp, and will vary in frequency between 80 kHz and approximately 150 kHz with the adjustment of R11, the Frequency control. The oscilloscope probe may load the circuit in the x1 setting; it is best to use the x10 setting on the oscilloscope probe.

During normal operation, R11 is set to produce a 100 kHz waveform. 100 kHz translates to a waveform of 10 µs duration, and it can be verified by setting the oscilloscope Time/Div control to the 1 µs position. The waveform should extend completely across the oscilloscope display when the frequency is set properly.

PWM Switching Power Supply I (Skills07-1), continued

The output of the U1E / U1F oscillator is buffered in two stages: first by U1A, and then by U1B, U1C, and U1D in parallel. The resultant waveform is an almost perfect square wave with an 80% duty cycle. The waveform can be viewed at TP8. See Figure 4 for a sample. The sample in Figure 4 can be duplicated by setting the oscilloscope Time/Div control to 2 μs.

Because the supply voltage can affect the output of an RC oscillator circuit, block B2 receives a regulated 10 VDC supply voltage from block B3. Components C5, R10, R11, and D5 make up the RC timing circuit.

Block B3 contains U2, an operational amplifier set up in the differential mode that is used to compare the regulated output of the PWM switching power supply to a known voltage source. A difference output signal, termed "Reference", is developed at the output of U2 at pin 6. This signal is used as a correction signal for the power supply. The Reference signal, which can be viewed at TP5, departs the circuit card at J1 terminal 3.

The PWM Switching Power Supply sample output voltage enters the circuit card at J1 terminal 2 and can be measured at TP2. The voltage enters U2 at pin 2, the negative input to the op-amp, through R3. The configuration of R3 and R6, the feedback resistor, sets the gain of the op-amp at 10.

The fixed input to U2 is derived from the unregulated DC voltage at TP1. A voltage divider and regulator circuit consisting of R2, R4, and D3, a zener diode, drops and maintains the voltage at TP3 to 10 VDC. R4, a 5 kΩ variable resistor, sets the fixed voltage level to pin 3, the positive input to U2. The fixed 10 VDC at TP3 is applied to block B2 as the oscillator and buffer power source.

U2 compares the voltages at pins 2 and 3, the negative and positive inputs, and develops the difference signal as the Reference output signal. In normal working conditions when properly set, the Reference signal at TP5 is 10.5 to 11.5 VDC with a minor ripple at the top. The ripple is caused by the unregulated DC ripple and voltage correction changes made by U2.

The inputs to U2 can be verified at TP4, common to the positive input, and TP6, which is common to the negative input. When operating correctly, these voltages should be equal and just slightly higher than the regulated output of 8.5 VDC at 8.6 to 9 VDC.

Variations in the measured voltages at TP4 and TP6 are due to component tolerances, but they should measure with the multimeter to be equal in voltage. The voltage at TP4 is fixed, and the sample voltage at TP6 is adjusted at a 100 kHz rate by the power supply circuitry to be equal to the reference voltage at TP4.

Block B4 contains a simple ramp circuit consisting of an RC timing circuit, R8 and C3. R8, a 1 kΩ resistor, and C3, a 0.01 μF capacitor, make up a 10 μs (100 kHz) timing circuit. As the 80% duty-cycle square wave input from block B2 goes HIGH, C3 begins charging through R8.

PWM Switching Power Supply I (Skills07-1), continued

The charging of C3 through R8 causes the output signal at TP9 to form a voltage ramp during the HIGH portion of the square wave input. Since the input waveform does not have a 100% duty cycle, the ramp never reaches the full potential of the square wave; it cuts off when the square wave goes LOW at the 80% charged mark.

C3 has charged to 7 to 8 volts the instant the incoming square wave goes LOW. This forward biases D4, causing a quick discharge of C3 through D4, and a sharp drop LOW in the ramp waveform. C3 discharges down to the point where D4 is no longer forward biased, about 0.7 VDC. When the incoming square wave goes HIGH, the process starts over again and continues at the rate of 100 kHz. Figure 4 compares the original square wave at TP8 to the ramp signal at TP9.

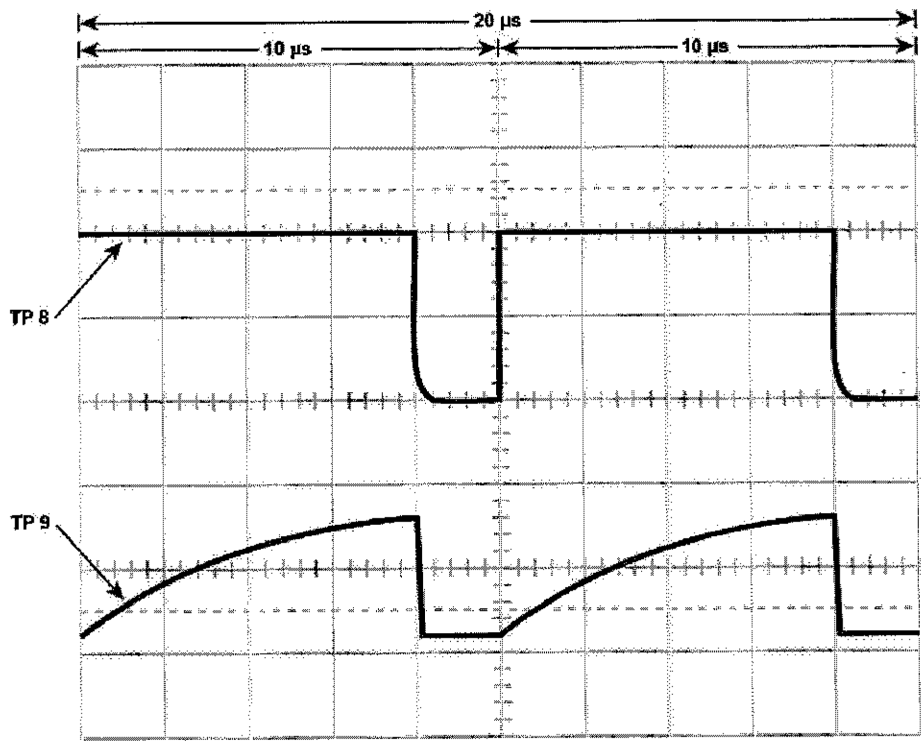


Figure 4

The unregulated DC voltage is used through R7 to provide a DC offset voltage to the ramp waveform signal. R9 and C4 comprise a low pass filter to remove high frequency noise. The resulting composite signal is the Ramp signal. The Ramp signal exits the circuit card at J1 terminal 4. See Figure 5 for a view of the Ramp signal.

J1 has three outgoing voltages or signals: the unregulated DC voltage at terminal 1, the Reference signal at terminal 3, and the Ramp signal at terminal 4. There is one incoming voltage on J1 terminal 2: the feedback DC voltage from the output filter circuit in block B7 on the PWM Switching Power Supply II circuit card. Terminal 5 of plug J1 is ground.

PWM Switching Power Supply II (Skills07-2)

The Reference signal from J2 terminal 3 and the 100 kHz Ramp signal from J2 terminal 2 are applied to U3A in block B5. The Reference signal, a changing DC voltage, can be viewed at TP15. The Ramp signal is available at TP14. U3A is one-half an LM393, a voltage comparator, and is powered from the unregulated DC voltage at J2 terminal 5.

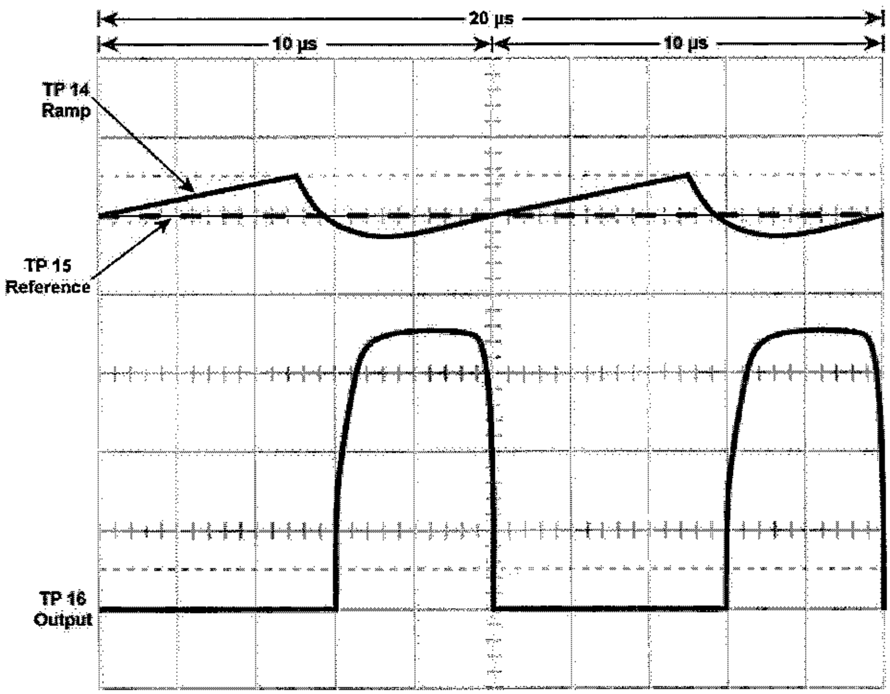


Figure 5

See Figure 5, the timing chart for U3A. U3A compares the voltage levels of the Reference signal at the positive input, pin 3, and the Ramp signal at the negative input, pin 2. As long as the Ramp signal is equal to or greater than the Reference signal, the output of U3A at TP16 remains LOW. However, when the Ramp signal is less than the Reference signal, the output of U3A goes HIGH.

The Ramp signal is very static and does not change. The Reference signal, a DC voltage, is developed from U2, the op-amp in block B3. The reference signal changes with the overall power supply output voltage in a reciprocal fashion.

If the power supply output voltage decreases, the reference voltage increases. If the power supply output voltage increases, the reference voltage decreases. The Ramp and Reference signal levels are constantly compared by U3A.

If the output current should rise, causing the output voltage to reduce, the Reference signal is increased, causing more of the Ramp signal to be below the Reference line. This increases the duty cycle of the output waveform, causing the output signal to be HIGH for more time during the 10 µs cycle.

PWM Switching Power Supply II (Skills07-2), continued

Likewise, should the output current demand drop, causing the voltage to increase, the Reference signal reduces, and less of the Ramp signal is below the Reference level. This reduces the duty cycle of the output at TP16. R17 provides negative feedback to prevent the comparator from going into oscillations caused by stray capacitance.

The correction of the output voltage occurs at the ramp frequency of 100 kHz, or once every 10 µs. Small correctional changes in the Reference level and the output waveform duty cycle can be noted as the load conditions change.

The output at TP16 is applied to the base of Q2. Q1 and Q2 are arranged in a Darlington Pair. A Darlington Pair consists of two transistors in tandem arranged so the current amplified by the first transistor (Q2) is further amplified by the second transistor (Q1). The Darlington Pair configuration offers higher current switching than a single device.

The output of the Q1/Q2 pair is the emitter of Q1, where a series of positive pulses at 100 kHz can be found. The waveform, viewed at TP11, follows the timing of the waveform at TP16.

The pulse width (duty cycle) of the waveform at TP11 will vary based on the current demand, longer during high current demands, and shorter when less output current is required. The waveform will have a tapered trailing edge under low current demand conditions. The peak voltage will be at the unregulated DC voltage level.

The output of Q1 flows through R12, a 1.5Ω, 3W resistor. TP11 is common to one side of R12; TP12 is common to the other. All the output current from the power supply flows through R12.

The power supply output current can be calculated by measuring the voltage drop across R12, and then dividing the voltage drop by 1.5Ω, the R12 value. The calculated answer will be the output current, usually 50 to 150 mA in normal operation.

Across R12 is Q3, the current limiting transistor. The base of Q3, at the TP11 side of R12, will be more positive than TP12, common to the emitter due to the voltage drop of R12. The voltage drop, and the voltages at Q3's base and emitter junction, will increase or decrease with the current demanded by the load.

Should the voltage drop across R12 increase to 0.6 VDC, the load is pulling too much current. At this point Q3 becomes forward biased and conducts. When Q3 conducts, the collector is pulled down to the emitter voltage, which forward biases D7. This also pulls the output of U3A LOW, disabling the switching power supply until the high load is removed, reducing the R12 voltage drop and preventing Q3 from conducting.

PWM Switching Power Supply II (Skills07-2), continued

The large circular device dominating the PWM Switching Power Supply II circuit card is inductor L1. L1 and C7 make up a low-pass filter arrangement, which filters the 100 kHz output from Q1 into steady DC voltage. The frequency of the switching power supply, 100 kHz, allows the relative small size for C7. The DC voltage at TP13, the power supply output, is 8.5 VDC for this application but is adjustable between 1.5 and 10 VDC using R4 in block B3.

Block B8 contains a visual indicator for power supply output, DS2. R14 provides current limiting for DS2, holding the current flow through DS2 down to about 15 mA. R15, switched on by S2, adds a load to the power supply if no external load is applied; or it can be used to provide additional load with an external load. DS3 illuminates when S2 is closed and R15 is added as a load.

An over-voltage protection circuit is in block B9. Should the output voltage exceed set limits, the circuit activates, removing the switching power supply output from the external load. The power supply output voltage leaves the circuit card at terminal T and can be measured at TP17.

The over-voltage protection circuit is powered by the unregulated DC voltage source at TP18. Operating like U3A in block B5, another voltage comparator, U4B in block B9 compares a known voltage to a sample voltage to determine if the sample voltage is above the set limit.

The known voltage is also derived from the unregulated DV voltage, through R19, but fixed to 5.1 VDC by D9, a zener diode. R23 taps the fixed 5.1 VDC, allowing a user-variable voltage input at pin 6, the negative input. The negative input to U4B, the reference voltage for the voltage comparator, can be measured at TP20 and adjusted by R23. The voltage will be 1 to 2 VDC with an 8.5 VDC output.

The regulated power supply output from TP13 in block B7 is the source for the positive input to U4B. The regulated voltage is reduced by the R20/R26 voltage divider to provide the sample voltage input. This input can be verified at TP19. The voltage at TP19 must be less than the voltage at TP20 for the circuit to operate normally.

The output of U4B, at pin 7, remains at less than 0.25 VDC. Should the sample voltage at the positive input exceed the reference voltage at the negative input, U4B activates and the output at pin 7 will increase to over 1 VDC. This voltage can be viewed at TP21.

When the U4B output voltage at TP21 increases, it forward biases the base-emitter junction of Q4. This pulls the collector LOW, energizing relay K1. When the relay is energized, the regulated output voltage at the normally-closed relay contact removes the voltage to the external load and TP17. LED DS4 provides a visual indication of the over-voltage condition. Diode D8 is placed across K1 to eliminate inductive kickback when the relay power is removed.

Load (Skills07-3)

The Load circuit card provides a constantly-changing load for the PWM Switching Power Supply.

Block B10 is an onboard linear power supply using a 78L12 single IC regulator, IC1. R27 provides isolation and minor circuit protection from the power source, the unregulated DC output from block B1. C11 and C12 eliminate noise at the input and output of IC1. The output, +12 VDC, can be verified at TP26. The regulator supplies power to blocks B11 and B12.

Block B11 contains two voltage comparators, U5A and U5B. Both comparators monitor the input regulated voltage from the PWM Switching Power Supply. U5A monitors the incoming voltage for a too low condition. U5B monitors the incoming voltage for a too high condition. Should the incoming voltage be too high or too low, one of the comparators will activate, disconnecting the voltage to the load circuitry in block B13.

A single output measured at TP29 in block B12 can be used to determine the condition of the incoming DC voltage. TP29 will be HIGH, at +12 VDC, and LOW at about 1.5 VDC when either U5A or U5B have determined the incoming DC voltage is out of tolerance and switches ON to protect the Load circuitry.

Both U5A and U5B are in the single IC labeled U5. Each voltage comparator operates independently but has almost identical circuitry. You will note the only difference between U5A and U5B is the reversal of the input voltage sample and the reference voltage inputs at the negative and positive inputs.

U5A has the input voltage sample at the positive input, pin 3, and the reference voltage derived from the +12 VDC power supply in block B10 at the negative input, pin 2. R40 sets the lower limit reference voltage. When properly set up, pin 1, the output of U5A, will be normally HIGH, about +12 VDC but will go LOW, to less than 1 VDC, when the comparator activates because the sample voltage at the positive input drops lower than the reference voltage at the negative input.

U5B has just the opposite inputs: the input voltage sample at the negative input, pin 6, and the reference voltage at the positive input, pin 5. R40 sets the upper limit reference voltage. When properly set up, the output at pin 7 will be HIGH normally, but go LOW when the comparator activates because the sample voltage at the negative input rises above the reference voltage at the positive input.

The outputs of the U5A and U5B comparators have output indicators, DS5 and DS6, to indicate an input voltage that is out of tolerance. A LOW at either comparator output will illuminate the associated diode.

Load (Skills07-3), continued

The comparator outputs are connected to the cathodes of switching diodes D11 and D12. Diodes D11 and D12 are not conducting in normal conditions with both the cathodes and the anodes HIGH at +12 VDC. When either comparator output goes LOW, the cathode voltage of the associated diode drops to 0.5 VDC and the diode becomes forward biased, causing the output at TP29 to drop LOW to about 0.5 VDC.

TP29 is the input to block B12 containing the power relay and driver. TP29 is common to the negative input of another voltage comparator, U6A, at pin 2. The positive input, pin 3, is fixed at about 6 VDC, half the +12 VDC supply voltage from block B10. In this configuration, U6A has a LOW (1 - 1.5 VDC) output at pin 1 under normal conditions. The output condition of U6A can be confirmed at TP31.

The U6A output rises HIGH should either of the U5 comparators activate, pulling pin 2 of U6A LOW. A HIGH output at U6A pin 1 reverse biases DS7, extinguishing the Relay On LED, but also reverse biases the base-emitter junction of Q5.

Q5 is a PNP transistor, the driver for relay K2. In normal operation, Q5 has proper bias and keeps K2 energized. When the U6A output goes HIGH, Q5 is reverse biased and current stops flowing in the relay K2 coil. The load in block B13 is then removed from the circuit through the action of K2. The collector of Q5 can be measured at TP32. A HIGH condition (+12 VDC) at TP32 indicates Q5 is reverse biased.

The load for the PWM Switching Power Supply is a group of 18 LEDs, DS8 through DS26. The LEDs are configured in three different sized concentric circles of 6 LEDs. Each circle is also made up of different colored LEDs.

The smallest circle, configured of red LEDs, switches on and off at the fastest rate. The next circle, made up of yellow LEDs, is larger and switches at a slower rate. The largest circle, of green LEDs, flashes at the slowest rate. All the LEDs are configured so that only half of each circle (3 LEDs) is illuminated at one time.

The flash rate and LED selection is done by U7, a 14-stage ripple counter IC with an onboard clock. The clock speed is controlled by an RC circuit consisting of R35, R42, R45, and C15. R35 is a variable resistor, allowing frequency adjustments. The clock frequency is 100 Hz.

Two test points are provided in the clock timing circuit, TP37 and TP38. TP38 provides a clean square wave of 100 Hz at 8.5 VDC with a 55% duty cycle.

Load (Skills07-3), continued

The waveform at TP37 will also be 100 Hz, but the waveform will reflect the charge and discharge action the square wave has on C15. Placing the oscilloscope on TP37 without setting the oscilloscope probe to x10 mode will excessively load the circuit and shut down the oscillator. With the oscilloscope probe at x10, the probe might still load the circuit enough to change the frequency slightly.

A ripple counter is a series of flip-flops strung together with the input of each stage connected to the output of the preceding stage. Each stage toggles on the negative transition, and the output frequency of each stage is one-half the input frequency.

So, the initial clock frequency of 100 Hz is divided to 50 Hz by stage 1, 25 Hz by stage 2, 12.5 Hz by stage 3, etc. The outputs used to illuminate the LEDs are the 5th, 6th, and 7th stages with frequencies of about 3 Hz ($100Hz/2^5$), 1.5 Hz ($100Hz/2^6$), and 0.75 Hz ($100Hz/2^7$). This translates to waveform times of 320 ms (red), 640 ms (yellow), and 1.28 s (green) for one full cycle, or 160 ms (red), 320 ms (yellow), and 640 ms (green) for the ON time for the LEDs.

The switching waveforms for the LED outputs can be viewed at TP34, TP35, and TP36. The LEDs are configured so 3 LEDS are illuminated when each output is HIGH and then the other 3 are illuminated when the output is LOW.

OPERATIONAL CHECK

1. System Setup

Refer to the circuit card illustrations following these instructions for the locations of test points, LEDs, and variable resistors.

a. Verify that the circuit cards Skills07-1 (PWM Switching Power Supply I), Skills07-2 (PWM Switching Power Supply II), and Skills07-3 (Load) are installed on the Nida 130E Test Console in positions PC1, PC2, and PC3, respectively.

b. Verify the short 5-pin jumper cable between J1 and J2. Do not twist the cable; the wires should not cross over each other.

c. Set all variable resistors in the PWM Switching Power Supply and Load to the middle position.

d. Set S1 and S2 on the Skills07-1 and Skills07-2 circuit cards to the ON (UP) position.

e. Press the AC Power switch  on the PC1 position. Verify that the PC1 AC LED is illuminated.

f. Verify the DS1 LED in Block 1 and the Output LED in Block 8 are illuminated. Ignore any other illuminated LEDs at this time.

OPERATIONAL CHECK, continued

2. **Circuit Set-up**

   a. Using the multimeter, adjust R40, the Lower Limit control, for 8.25 VDC at TP27.

   b. Using the multimeter, adjust R30, the Upper Limit control, for 8.75 VDC at TP28.

   c. Using the oscilloscope, adjust R11, the Frequency control, for a 100 kHz (10 μs) waveform at TP8.

   d. Using the multimeter, adjust R4, the Output control, for 9.25 VDC at TP13.

   e. Set R23, the Level control, fully counterclockwise. Then, slowly adjust R23 in a clockwise direction just until DS4, the Over (voltage) LED in Block 9, illuminates.

   f. Readjust R4, the Output control, for 8.5 VDC at TP13. The Varying Load LEDs should be flashing.

   g. Using the oscilloscope, adjust R35, the Clock control, for 100 Hz (10 ms) square wave at TP38. The PWM Switching Power Supply and Loads circuitry should be functioning normally. Complete the Operational Check by Performing the Limit Verification check.

3. **Limit Verification Check (Low, High, and Over)**

   a. Using the multimeter, monitor the voltage at TP13.

   b. Slowly adjust R4 counterclockwise until the Low LED illuminates. Voltage at TP13 should be approximately 8.25 VDC and the Varying Load LEDs should not be flashing.

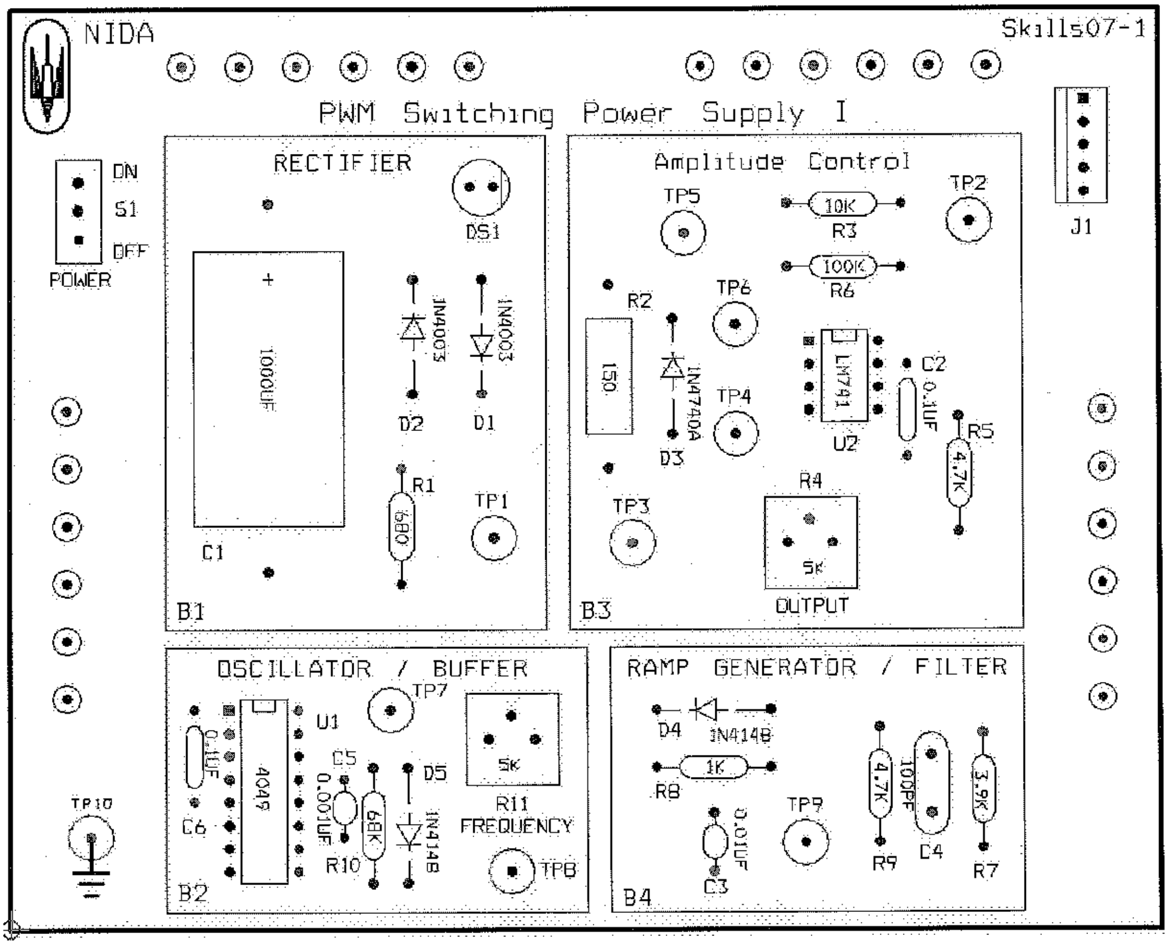
   c. Slowly adjust R4 clockwise until the High LED illuminates. Voltage at TP13 should be greater than 8.75 VDC and the Varying Load LEDs should again, not be flashing.

   d. Slowly continue to adjust R4 clockwise until the Over LED illuminates. Voltage at TP13 should be greater than 9.00 VDC and voltage to the Load circuit is removed and the Low LED illuminates.

   e. Readjust R4, the Output control, for 8.5 VDC at TP13. The Varying Load LEDs should be flashing.

End of Operational Check.

CIRCUIT CARD PICTORIALS & TEST POINT LIST

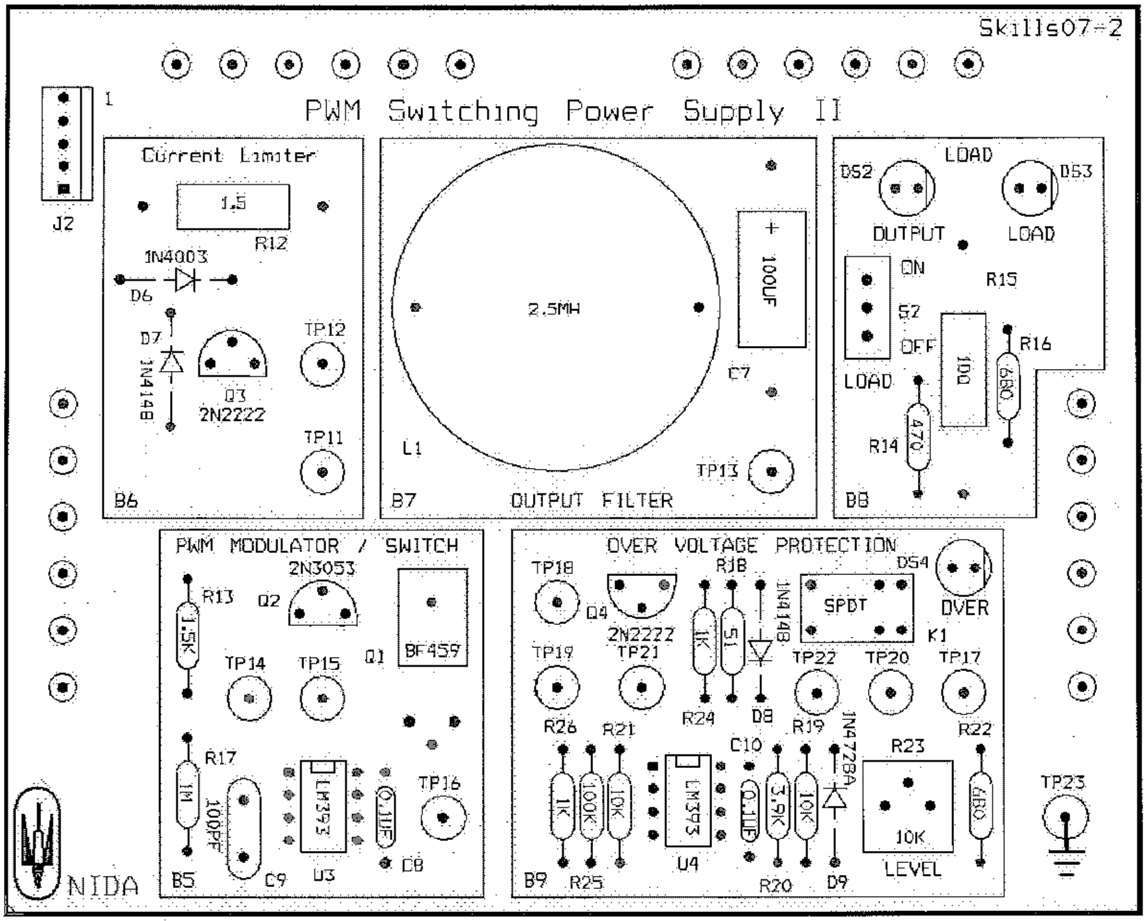


PWM Switching Power Supply I

Test Point	Description	Normal Condition
TP1	DC Unregulated	15 – 19 VDC
TP2	DC Regulated	8.5 VDC
TP3	Fixed +10 VDC	10 VDC
TP4	Reference Input (+)	8.6 – 9 VDC
TP5	Reference	10.5 – 11.5 VDC
TP6	Sample Input (-)	Equal to TP4
TP7	Oscillator	100 kHz
TP8	Buffer Output	100 kHz Square Wave
TP9	Ramp Output	100 kHz Ramp Wave
TP10	Ground	Ground

PWM Switching Power Supply I Test Point List

CIRCUIT CARD PICTORIALS & TEST POINT LIST, continued

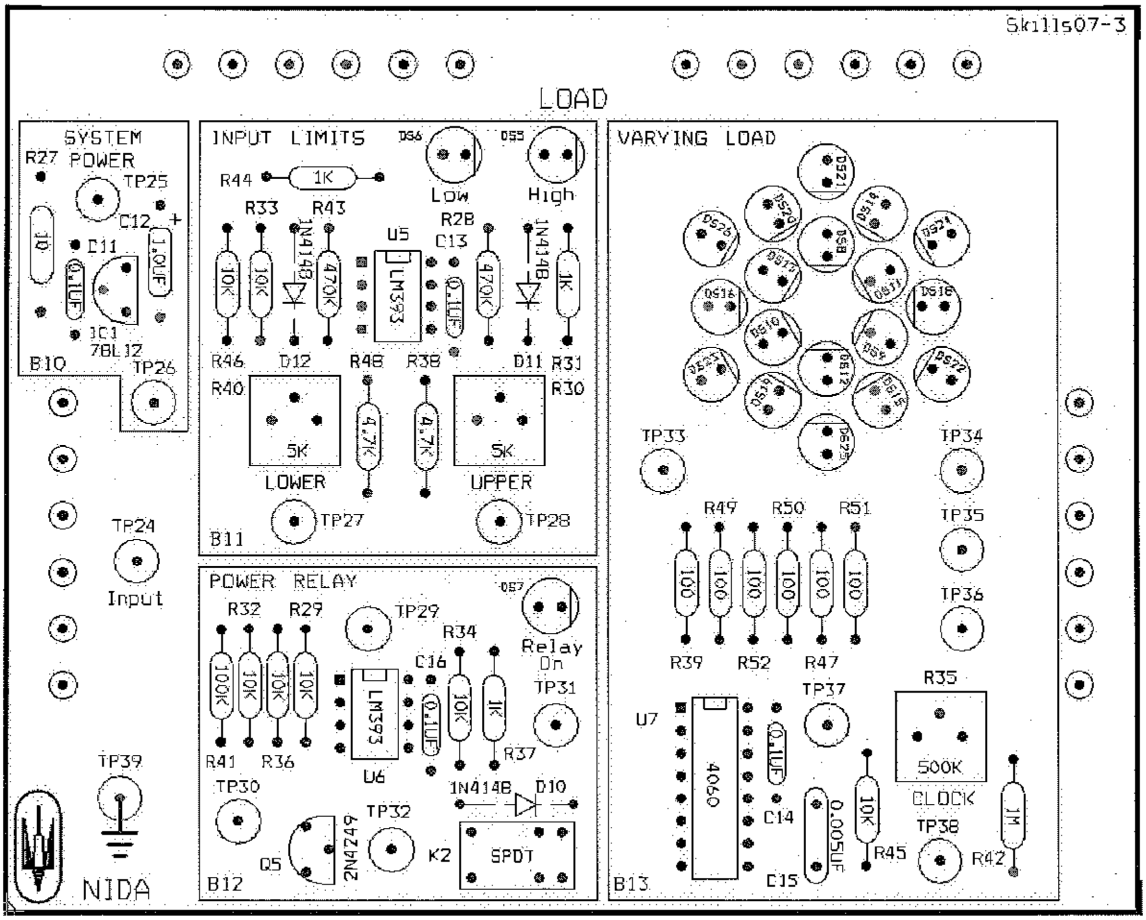


PWM Switching Power Supply II Logic Circuit Card

Test Point	Description	Normal Condition
TP11	Switch Output	100 kHz Switch Output
TP12	Limiter Output	100 kHz Switch Output
TP13	Filter Output	8.5 VDC
TP14	Ramp Input (-)	100 kHz Ramp Signal
TP15	Reference Input (+)	10.5 – 11.5 VDC
TP16	Comparator Output	100 kHz Switch Signal
TP17	Over-Voltage Output	8.5 VDC
TP18	Unregulated DC	15 – 19 VDC
TP19	Regulated Input (+)	1.5 – 2 VDC
TP20	Reference Input (-)	Higher than TP19
TP21	Comparator Output	Less than 0.25 VDC
TP22	Relay Drive	14 – 19 VDC
TP23	Ground	Ground

PWM Switching Power Supply II Test Point List

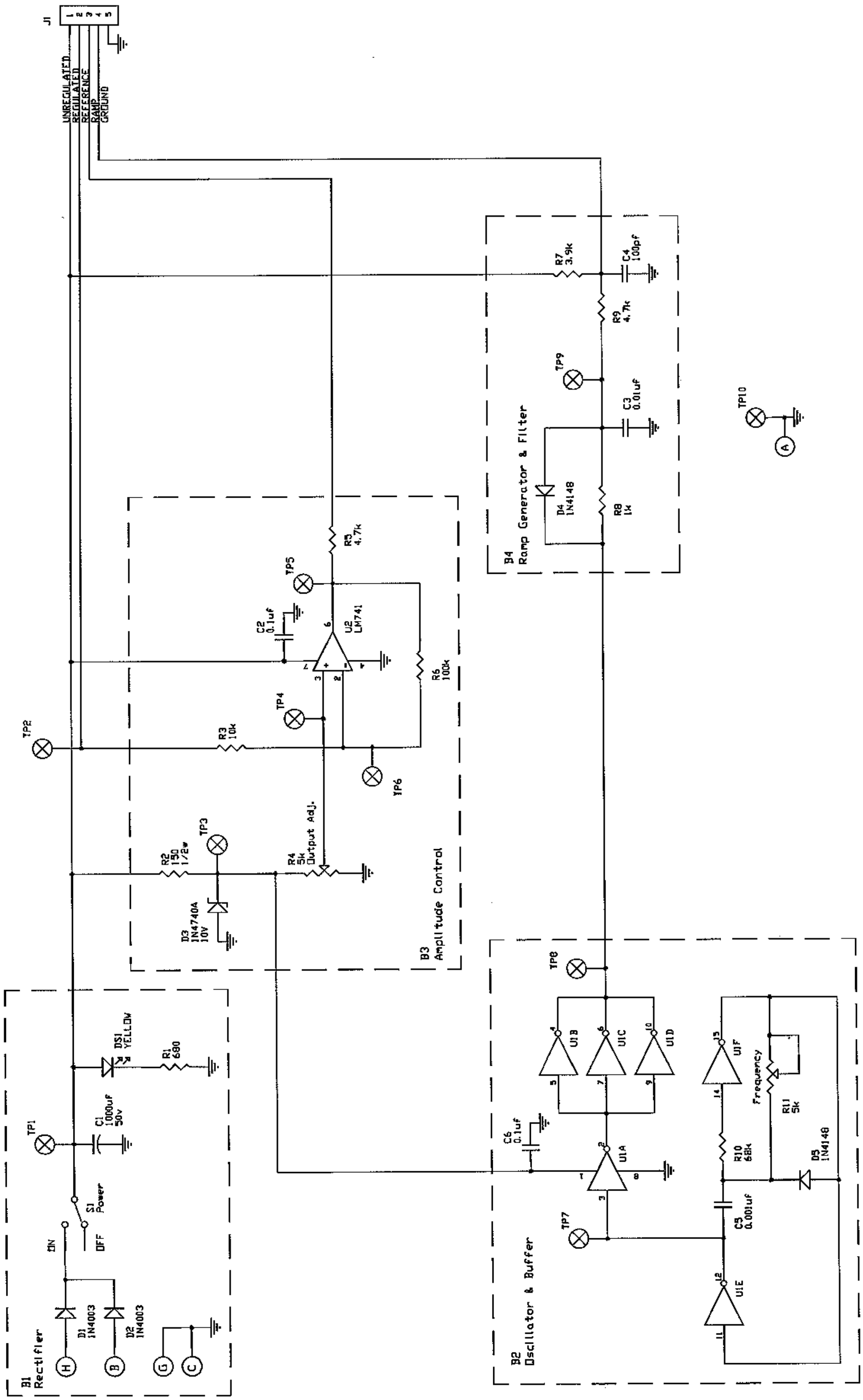
CIRCUIT CARD PICTORIALS & TEST POINT LIST, continued



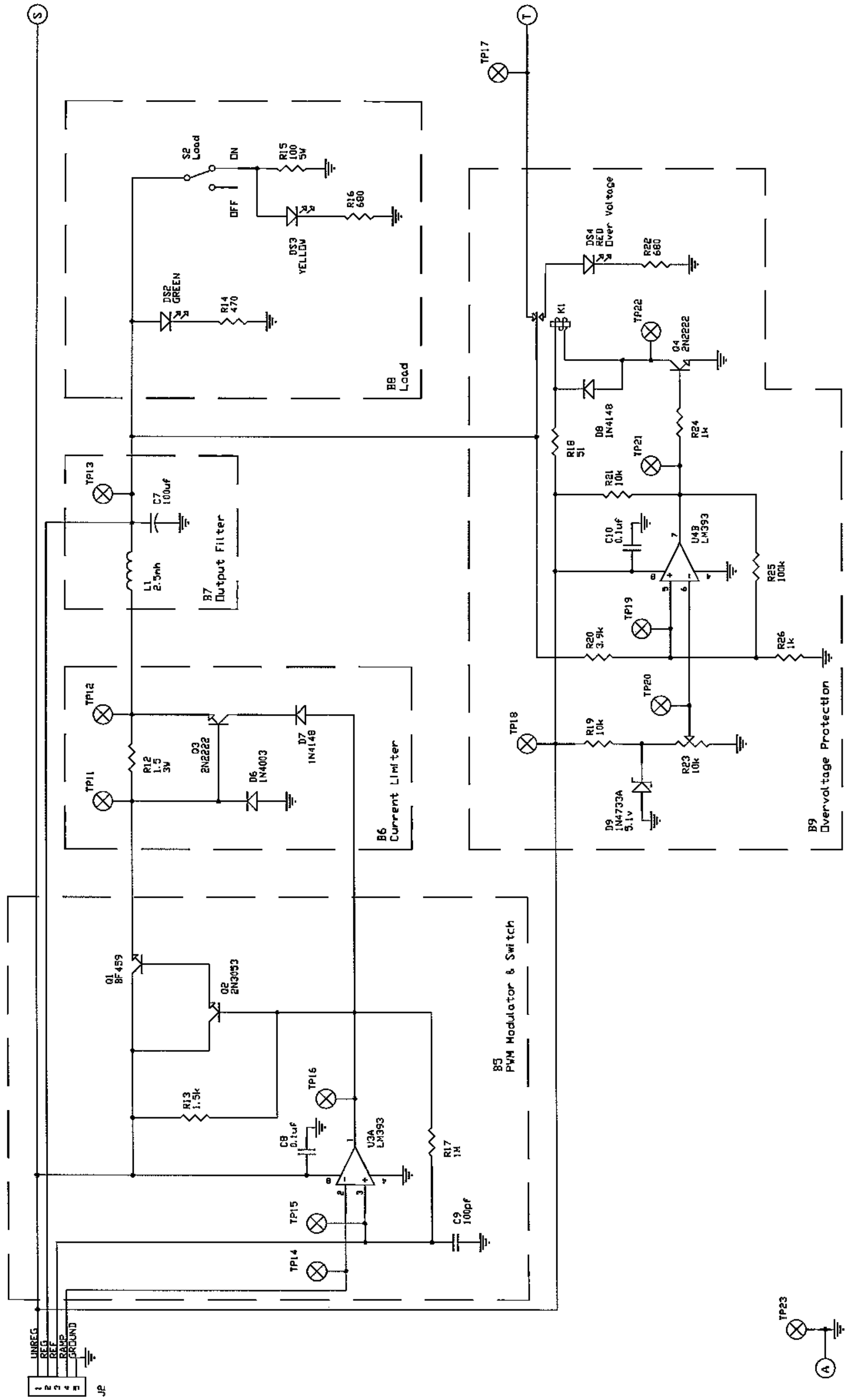
Load Circuit Card

Test Point	Description	Normal Condition		Test Point	Description	Normal Condition
TP24	DC Input	8.5 VDC		TP32	Emitter of Q5	0.6 VDC Over TP31
TP25	Unregulated DC	15 – 19 VDC		TP33	Load Input	8.5 VDC
TP26	System Power Output	12 VDC		TP34	U7 Q5 Output	3 Hz Square Wave
TP27	Lower Limit Input (-)	8.25 VDC		TP35	U7 Q6 Output	1.5 Hz Square Wave
TP28	Upper Limit Input (+)	8.75 VDC		TP36	U7 Q7 Output	0.75 Hz Square Wave
TP29	Comparator Output	12 VDC		TP37	100 Hz Clock Source	100 Hz Spiked ± Ramp
TP30	Comparator Input (+)	6 VDC		TP38	100 Hz Clock Output	100 Hz Square Wave
TP31	Base of Q5	1 – 1.5 VDC		TP39	Ground	Ground

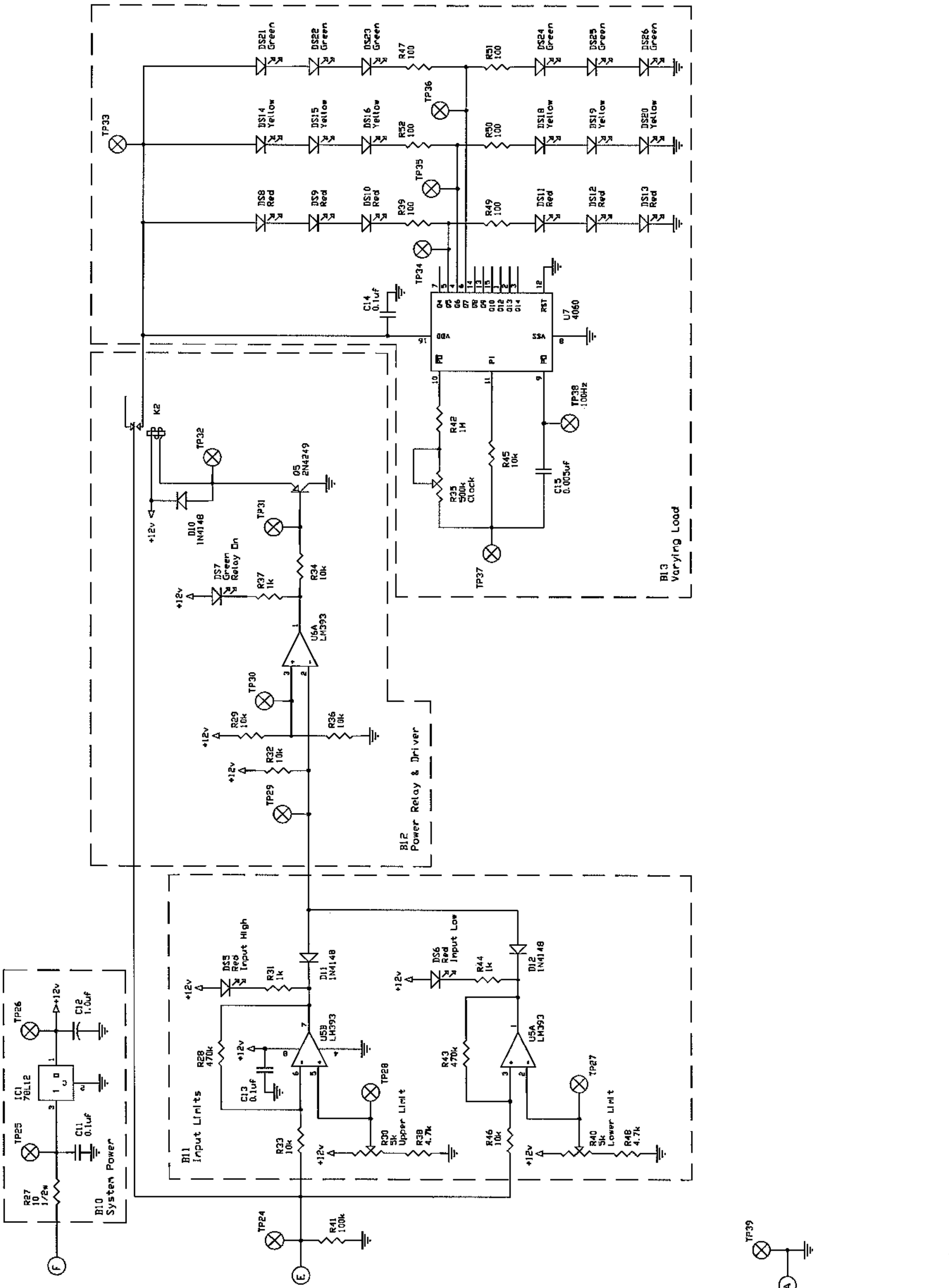
Load Circuit Card Test Point List


J1
UNREGULATED
REGULATED
REFERENCE
RAMP
GROUND
R7 3.9k
C4 100pf
R9 4.7k
TP9
C3 0.01uf
TP10
A
D4 1N4148
R8 1k
B4 Ramp Generator & Filter
R5 4.7k
TP5
C2 0.1uf
U2 LM741
R6 100k
TP4
TP2
R3 10k
TP6
TP3
R2 150 1/2w
R4 5k Output Adj.
D3 1N4740A 10V
B3 Amplitude Control
TP8
U1B
U1C
U1D
U1F
Frequency
R11 5k
R10 68k
D5 1N4148
C6 0.1uf
U1A
TP7
C5 0.001uf
U1E
B2 Oscillator & Buffer
DS1 YELLOW
R1 680
TP1
C1 1000uf 50v
S1 Power
ON
OFF
D1 1N4003
D2 1N4003
H
B
G
C
B1 Rectifier

Skills07-1


B8 Load
B7 Output Filter
B6 Current Limiter
B5 PWM Modulator & Switch
B9 Overvoltage Protection
UNREG
REG
REF
RAMP
GROUND
JP

Skills07-2


B13
Varying Load
B12
Power Relay & Driver
B11
Input Limits
B10
System Power
U7
4060
IC1
78L12

Skills07-3

BREADBOARDING PROJECT

Electronics Technology

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Contestant Handout

2010

Nida Corporation
300 S. John Rodes Boulevard
Melbourne, Florida 32904

BREADBOARDING PROJECT

Instructions

The total time allowed for this competition is 120 minutes. You will be scored on your ability to:

1. Read and follow instructions.
2. Interpret a circuit design drawing.
3. Identify and correct design flaws.
4. Construct a variable DC power supply and a random number generator.

Judges are **NOT** permitted to answer questions during the competition. Should you encounter a technical problem, assistance may be requested by pressing the "H" key on the console. All technical problems will be corrected by the Judge and no demerits will be assessed.

Judges **WILL** assess a 2 point demerit for each violation of the following. Demerit points will be used as a discriminating factor in breaking ties.

1. Unwarranted requests for assistance (2 points)
2. Identifying good equipment as faulty (2 points)
3. Failure to follow instructions (2 points)
4. Safety violations (2 points)
   - ✓ Wearing jewelry
   - ✓ Not wearing safety glasses
   - ✓ Improper use of soldering iron

Materials Required

Breadboarding Project Contestant Handout
Reference Manual (Data Sheets)
Part 1 Breadboarding Pre-packaged Design Kit
PC130X (single) Design Board
VICA03-1 Power Supply Circuit Board
Oscilloscope
Multimeter
Nida Screwdriver
Nida Model 130E Test Console
Miscellaneous Tools as Required

Procedure

1. **Log-in.** Observe the display on the Nida Model 130E Test Console and ensure that it looks like the example shown in Figure 1. Verify that your contestant number replaces the [--- **xx** ---] shown in the example.

BREADBOARDING
- - - xx - - -
Part 1
Judge's Code : ___

Figure 1

2. You will be required to breadboard two circuits, the first consisting of a Bar Graph Voltmeter. You will be scored on your ability to follow instructions, interpret schematic drawings, and produce a breadboard circuitry layout that meets the criteria of neatness, design, and operation. If any circuit fails your checks and you determine that a component displays symptoms of a factory defect, press the "**H**" key on the console and a Judge will respond. The Judge will assess the situation and determine the appropriate solution.

3. You will start with Part 1 and breadboard the Bar Graph Voltmeter circuit. When you are ready to begin, turn the page to "Worksheet 1" and carefully follow all instructions. Use the information provided in the Reference Manual (Data Sheets) as needed.

Begin when ready!

WORK SHEET #1

Part 1

1. **Verification.** Using the Parts List provided below, verify the Bar Graph Voltmeter parts kit (green dot) is complete and all components are visibly serviceable. If you identify any discrepancy, press the "H" key on the console and a Judge will respond.

PARTS LIST

DESIGN COMPONENTS		
PART NO.	DESCRIPTION	QUANTITY
05930024	IC, LM3914	1
51020004	LED, RED RECTANGULAR	10
11223030	RES, 1.2k 1/4w	1
13923030	RES, 3.9k 1/4w	1
12026882	RES, 2k VAR	1
15026882	RES, 5k VAR	1
41030003	SLIDE SW, SPDT	1
81131001	Wire	2 ft

2. **Design.** Using the PC130-X (single) Design Board, pre-packaged design kit, the Reference Manual (Data Sheets), and the circuit shown in Figure 3, construct the Bar Graph Voltmeter circuit.

3. **System Setup.** Perform the System Setup.

4. **Operational Check.** Perform the Operational Check to verify functionality.

SYSTEM SETUP

1. Bar Graph Voltmeter (PC130X)

   a. Install the PC130X circuit card containing your Bar Graph Voltmeter in the PC2 position of the Nida Model 130E Test Console.

   b. Set resistors R1 and R2 on the Bar Graph Voltmeter to the mid (halfway) position.

   c. Set slide switch S1 on the Bar Graph Voltmeter to the 5 Volt position.

2. Power Supply Circuit (VICA03-1)

   a. Install the VICA03-1 Power Supply circuit card in the PC1 position of the Nida Model 130E Test Console.

   b. Set S1 on the VICA03-1 Power Supply circuit card to the Off (down) position.

   c. Set R4 and R7 on the VICA03-1 Power Supply circuit card to the mid (halfway) position.

3. Nida Model 130E Test Console

   a. Set the test console Positive Power Supply to +5 VDC.

   b. Press the DC Power switch  on the PC2 position of the test console and verify that the LED illuminates.

   c. Press the AC Power switch  on the PC1 position of the test console and verify that the LED illuminates.

OPERATIONAL CHECK

1. Power Supply Circuit (VICA03-1)

   a. Using a multimeter, adjust R4 on the VICA03-1 Power Supply circuit card for +12 VDC at TP2.

   b. Using a multimeter, adjust R7 on the VICA03-1 Power Supply circuit card for +5 VDC at TP3.

   c. Move S1 on the VICA03-1 Power Supply circuit card to the On (up) position.

2. Bar Graph Voltmeter (PC130X)

   a. Adjust R2 on the Bar Graph Voltmeter so that LED's 1 through 5 are illuminated.

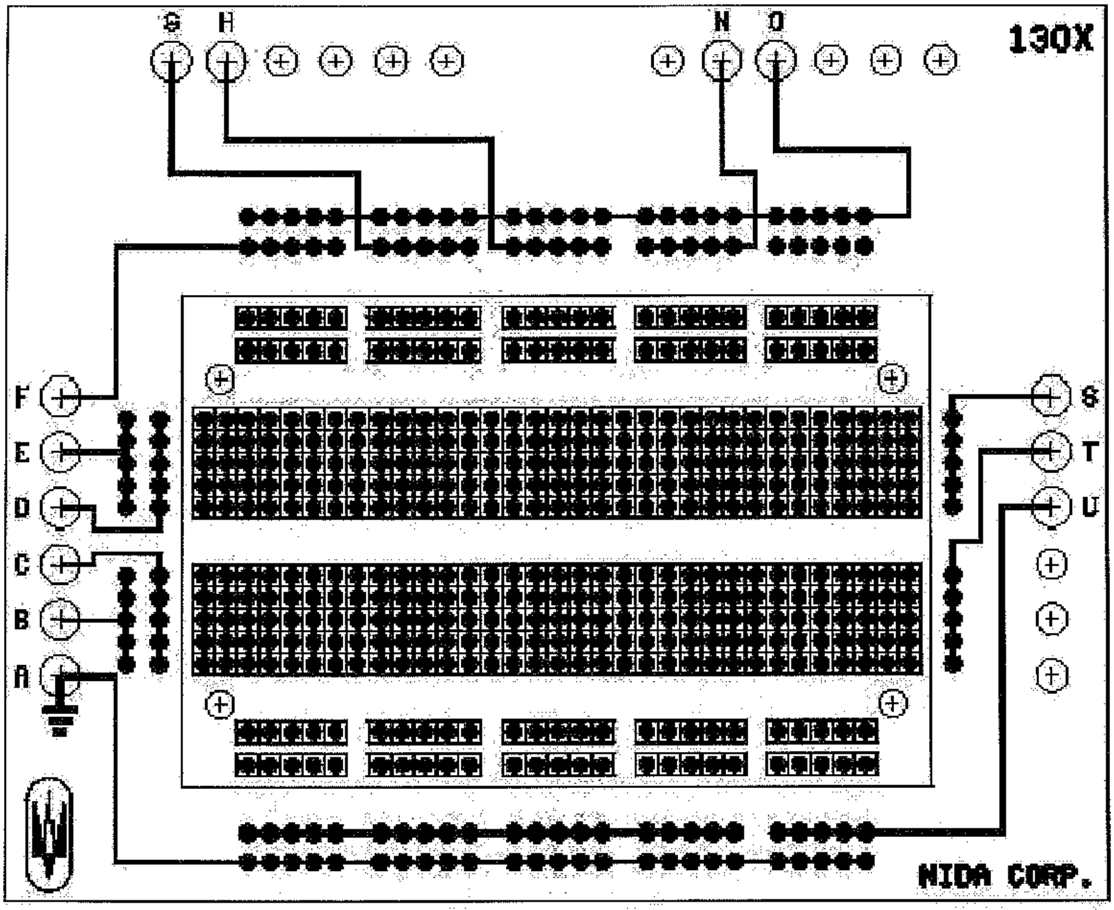
   b. Move S1 on the on the Bar Graph Voltmeter to the 12 Volt position.

   c. Adjust R1 on the Bar Graph Voltmeter so that LED's 1 through 5 are illuminated. DO NOT change the calibration of R1 and R2 after the initial adjustments.

   d. End of Operational Check.

Press the "**H**" key and then the "**ENTER**" key on the console
to request your first verification check.
*****

130X BREADBOARD DIAGRAM



PIN	TYPE
A	GROUND
B	AC
C	AC
D	INPUT
E	INPUT
F	INPUT
G	AC
H	AC
N	-DC
O	+DC
S	OUTPUT
T	OUTPUT
U	OUTPUT

Figure 2

BAR GRAPH VOLTMETER

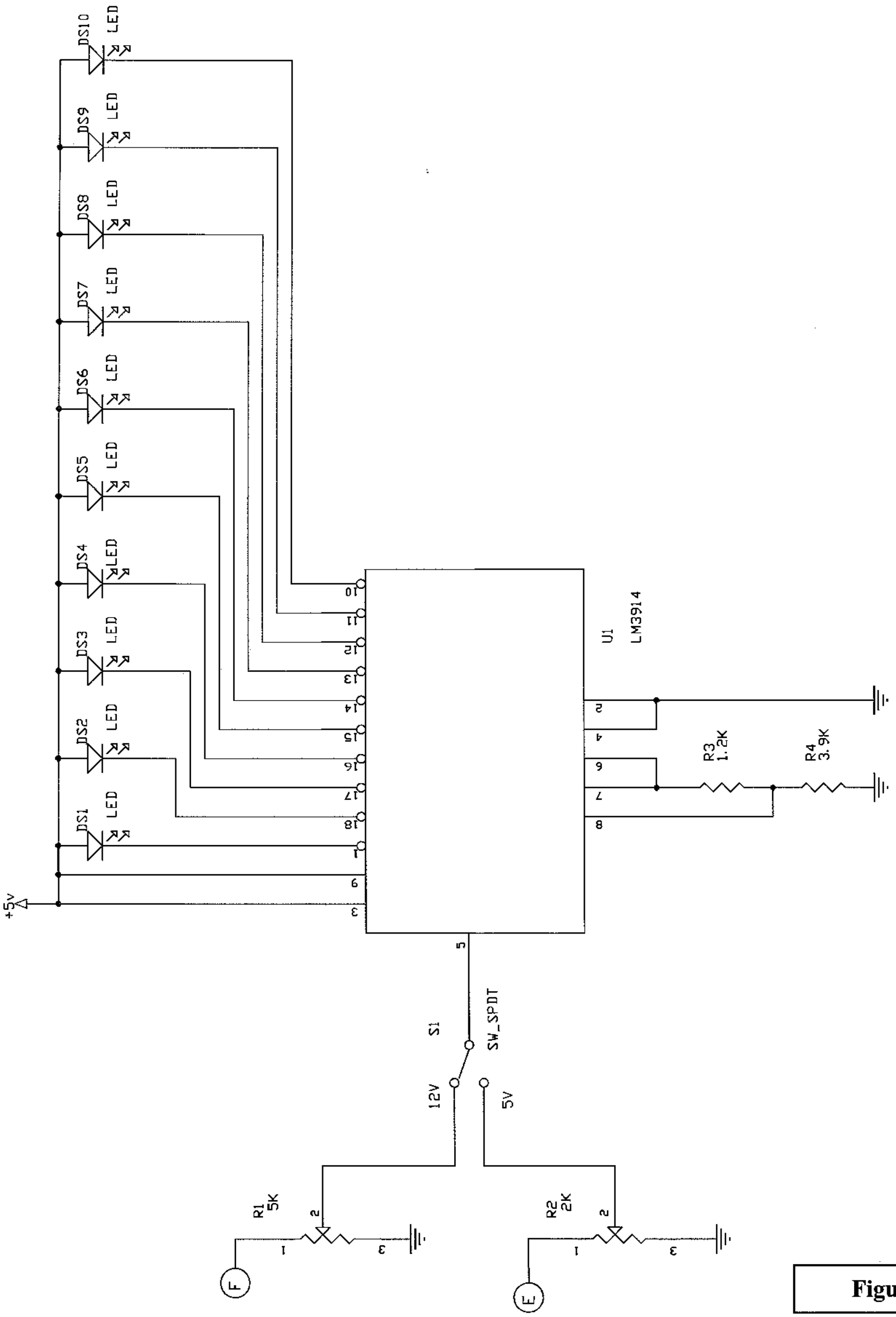


Figure 3

BREADBOARDING PROJECT

Electronics Technology

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WORKSHEET #2

WORK SHEET #2

Part 2

1. **Verification.** Using the Parts List provided below, verify the Dual Voltage Power Supply parts kit (red dot) is complete and all components are visibly serviceable. If you identify any discrepancy, press the "**H**" key on the console and a Judge will respond.

PARTS LIST

DESIGN COMPONENTS		
PART NO.	**DESCRIPTION**	**QUANTITY**
21084400	CAP, 1000uf 50V	1
21041250	CAP, 0.1uf 25V (104)	4
21053350	CAP, 1uf 35V (105)	2
00520013	DIODE, 1N4003	2
05930029	IC, LM350T	2
11004319	RES, 10 3w	1
11213030	RES, 120 1/4w	2
12213030	RES, 220 1/4w	1
13313030	RES, 330 1/4w	1
11026882	RES, 1k VAR	2
41030003	SLIDE SW, SPDT	2
81131001	Wire	3 ft

2. **Design.** Using the PC130-XX (double) Design Board, pre-packaged design kit, the circuit shown in Figure 3, and the Reference Manual (Data Sheets), construct the Dual Voltage Power Supply. NOTE: The dual voltage power supply has two DC voltage outputs and is an exact duplicate of the VICA 03-1 power supply circuit card. IC1 and IC2 are almost-identical DC voltage regulator circuits powered by the full-wave rectifier and filter circuit made of D1, D2, R1, and C1. During construction, configure R4 and R7 to produce the lowest output voltage with R4/R7 at the fully counterclockwise (CCW) position, and the most output voltage when R4/R7 is fully clockwise (CW).

3. **System Setup.** Perform the System Setup.

4. **Operational Check.** Perform the Operational Check to verify functionality.

SYSTEM SETUP

1. Duel Voltage Power Supply (PC130XX)
    a. Install the PC130XX circuit card containing your Duel Voltage Power Supply in the PC1 position of the Nida Model 130E Test Console.
    b. Set resistors R4 and R7 on the Dual Voltage Power Supply to the minimum position.
    c. Set slide switches S1 and S2 on the Dual Voltage Power Supply to the OFF position.

2. Bar Graph Voltmeter Circuit (PC130X)
    a. Install the PC130X circuit card containing your Bar Graph Voltmeter in the PC2 position of the Nida Model 130E Test Console.
    b. Set resistors R1 and R2 on the Bar Graph Voltmeter to the mid (halfway) position.
    c. Set slide switch S1 on the Bar Graph Voltmeter to the 5 Volt position.

3. Nida Model 130E Test Console
    a. Set the test console Positive Power Supply to +5 VDC.
    b. Press the DC Power switch  on the PC2 position of the test console and verify that the LED illuminates.
    c. Press the AC Power switch  on the PC1 position of the test console and verify that the LED illuminates.

OPERATIONAL CHECK

1. Dual Voltage Power Supply Circuit (PC130XX)

   a. Move S1 and S2 on the PC130XX Power Supply circuit card to the On position.

   b. Using a multimeter, adjust R4 on the PC130XX Power Supply circuit card for +12 VDC at pin "S".

   c. Using a multimeter, adjust R7 on the PC130XX Power Supply circuit card for +5 VDC at pin "T".

2. Bar Graph Voltmeter (PC130X)

   a. Adjust R2 on the Bar Graph Voltmeter so that LEDs 1 through 5 are illuminated.

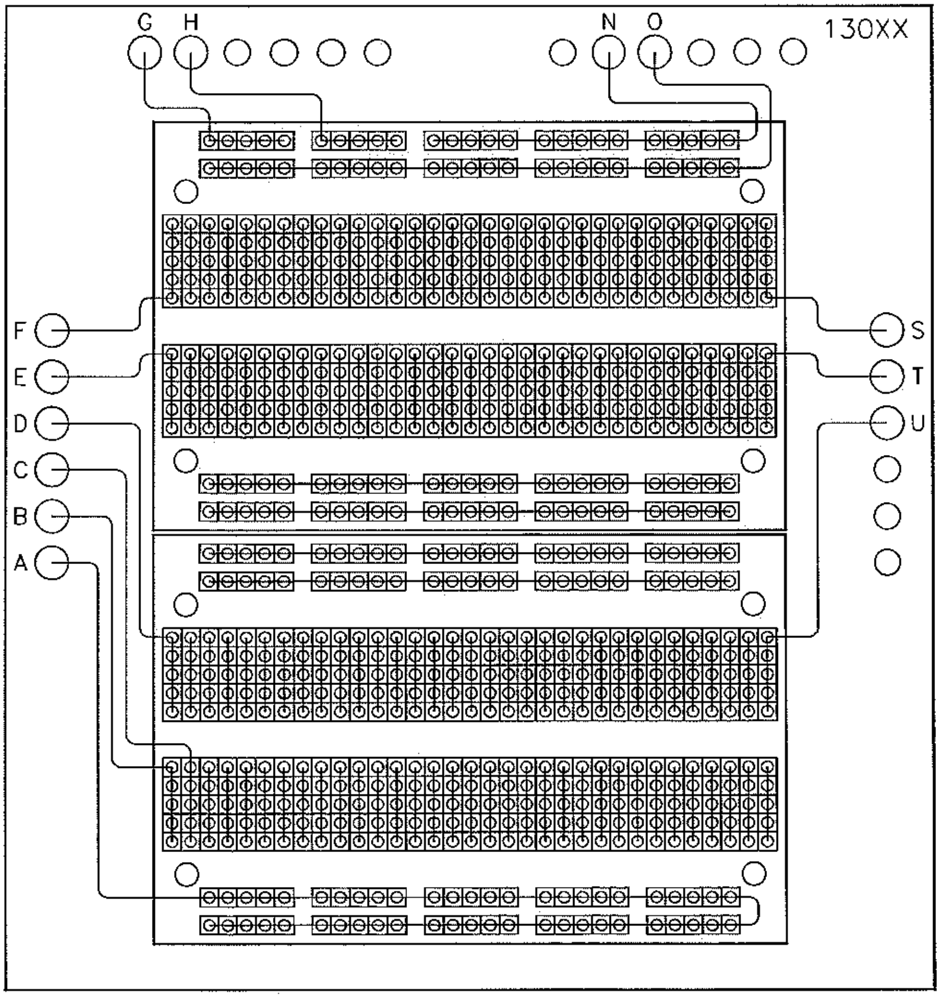
   b. Move S1 on the on the Bar Graph Voltmeter to the 12 Volt position.

   c. Adjust R1 on the Bar Graph Voltmeter so that LEDs 1 through 5 are illuminated. DO NOT change the calibration of R1 and R2 after the initial adjustments.

   d. End of Operational Check.

Press the "**H**" key and then the "**ENTER**" key on the console
to request your first verification check.
*****

130XX BREADBOARD DIAGRAM



PIN
A = GROUND
B = AC
C = AC
D = INPUT
E = INPUT
F = INPUT
G = AC
H = AC
N = NEGATIVE DC
O = POSITIVE DC
S = OUTPUT
T = OUTPUT
U = OUTPUT

Figure 2

DUAL VOLTAGE POWER SUPPLY

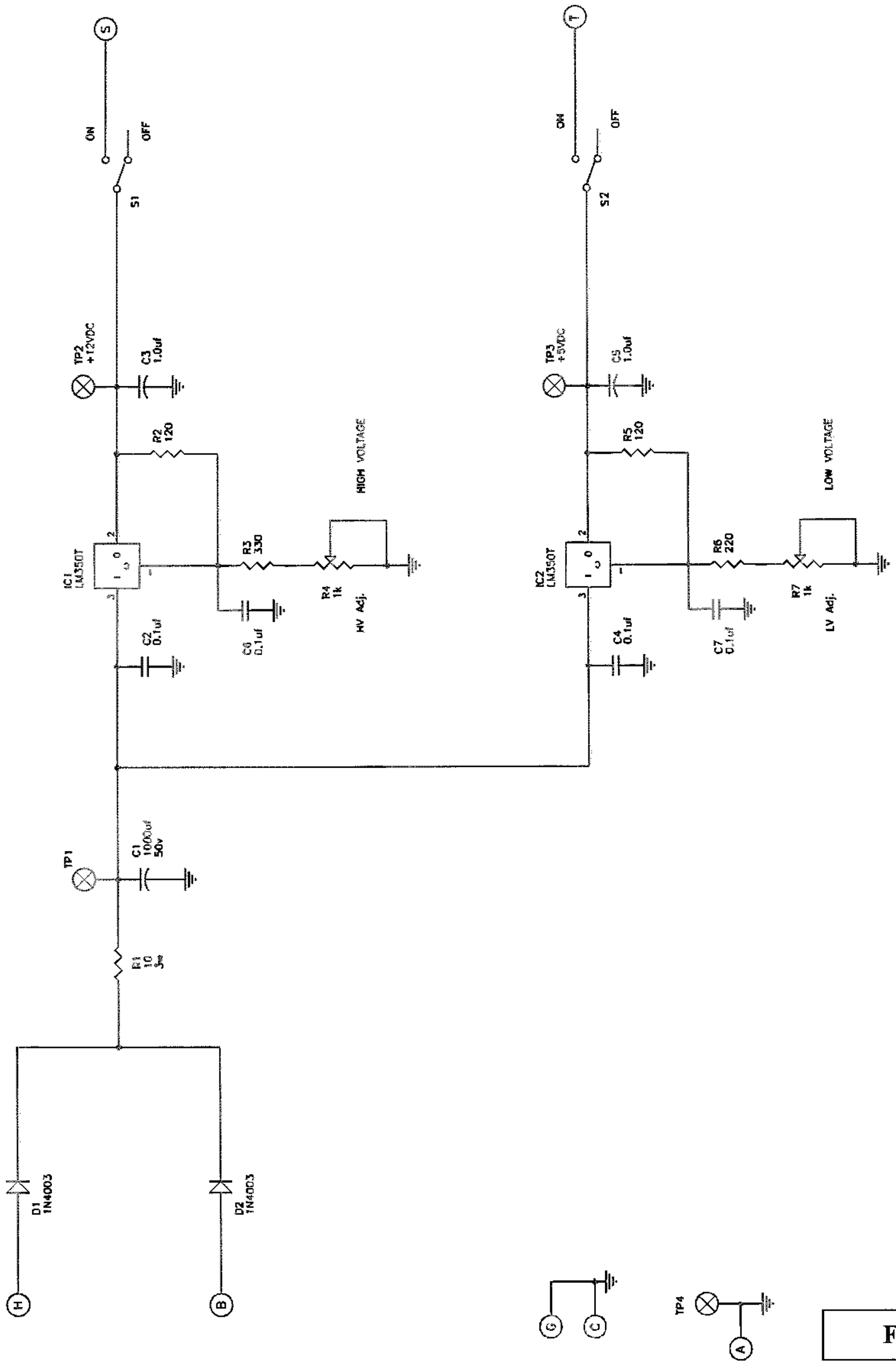


Figure 3

CUSTOMER SERVICE EXAMINATION

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Contestant Handout

2010

Nida Corporation
300 S. John Rodes Boulevard
Melbourne, Florida 32904

CUSTOMER SERVICE EXAMINATION

Instructions

The total time allowed is 45 minutes. You will be scored on your ability to:

1. Read and follow instructions.
2. Answer questions correctly.

Judges are **NOT** permitted to answer questions during the competition. Should you encounter a technical problem, you may request assistance by pressing the **"H"** key and then the **"ENTER"** key on the test console. All technical problems will be corrected by the Judge and no demerits will be assessed.

Judges **WILL** assess a 2-point demerit for each violation of the following. Demerit points will be used as a discriminating factor in breaking ties.

1. Unwarranted requests for assistance (2 points)
2. Identifying good equipment as faulty (2 points)
3. Failure to follow instructions (2 points)
4. Safety violations (2 points)

Materials Required

Customer Service Examination - Contestant Handout
Paper Test Question Booklet
Answer Sheet (last page of this manual)
Nida Model 130E Test Console
Pencil

Quick Reference Listing

[S]	Enter "S" to skip question
[R]	Enter "R" & question number to go to a specific question (example – R26).
[Y]	Enter "Y" to answer a yes question.
[N]	Enter "N" to answer a no question.
[EXIT]	Enter "EXIT" to end the test.
[A, B, C, D]	Enter these letters to identify correct answer.

Procedure

1. Observe the display on the Nida Model 130E Test Console and ensure that it looks like the example shown in Figure 1. Verify that your contestant number replaces the **[-- xx --]** shown in the example.

[-- xx --]

CUSTOMER SERVICE

Question 1 [ ]: ___

Figure 1

2. Read the question carefully and select the best answer from the choices. A correct answer is awarded 2 points. <u>An incorrect answer will result in the loss of 1 point.</u> Questions skipped (never answered) are awarded zero points.

3. If you wish to answer the question, enter the **"A, B, C, or D"** key on the Nida Model 130E Test Console keypad and press ENTER. Your response will be recorded, and the display will sequence to the next question number.

4. If you choose to skip a question, enter the letter **"S"** on the Nida Model 130E Test Console keypad and press ENTER. No response is recorded (never answered), and the display will sequence to the next question number.

5. When all 100 questions have been displayed in sequence, you will be asked if you are finished. Enter "**Y**" to end the test. Enter **"N"** to begin the review mode. You will jump to the beginning of the test. If you wish to go to a specific question number, enter "**R**" followed by the question number. For example, R26 will take you to question number 26.

6. Entering the word "EXIT" at any time during the test will end the test.

7. Questions **<u>MUST</u>** be answered using the Nida Model 130E Test Console keypad in order to receive credit. However, the scratchpad answer sheet has been provided as a reference. The scratchpad answer sheet will be destroyed at the conclusion of the test and will have no bearing on final test results. Begin when ready.

CONTESTANT SCRATCHPAD ANSWER SHEET

Total Points - 200

CONTESTANT #: ____________

1. A B C D	26. A B C D	51. A B C D	76. A B C D
2. A B C D	27. A B C D	52. A B C D	77. A B C D
3. A B C D	28. A B C D	53. A B C D	78. A B C D
4. A B C D	29. A B C D	54. A B C D	79. A B C D
5. A B C D	30. A B C D	55. A B C D	80. A B C D
6. A B C D	31. A B C D	56. A B C D	81. A B C D
7. A B C D	32. A B C D	57. A B C D	82. A B C D
8. A B C D	33. A B C D	58. A B C D	83. A B C D
9. A B C D	34. A B C D	59. A B C D	84. A B C D
10. A B C D	35. A B C D	60. A B C D	85. A B C D
11. A B C D	36. A B C D	61. A B C D	86. A B C D
12. A B C D	37. A B C D	62. A B C D	87. A B C D
13. A B C D	38. A B C D	63. A B C D	88. A B C D
14. A B C D	39. A B C D	64. A B C D	89. A B C D
15. A B C D	40. A B C D	65. A B C D	90. A B C D
16. A B C D	41. A B C D	66. A B C D	91. A B C D
17. A B C D	42. A B C D	67. A B C D	92. A B C D
18. A B C D	43. A B C D	68. A B C D	93. A B C D
19. A B C D	44. A B C D	69. A B C D	94. A B C D
20. A B C D	45. A B C D	70. A B C D	95. A B C D
21. A B C D	46. A B C D	71. A B C D	96. A B C D
22. A B C D	47. A B C D	72. A B C D	97. A B C D
23. A B C D	48. A B C D	73. A B C D	98. A B C D
24. A B C D	49. A B C D	74. A B C D	99. A B C D
25. A B C D	50. A B C D	75. A B C D	100. A B C D

SAMPLE PROJECT

Part 1

Electronics Technology

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Contestant Handout

2010

Nida Corporation
300 John Rodes Blvd.
Melbourne, Florida 32904

SAMPLE PROJECT

Introduction

This project is worth a maximum of 100 points but does not count as part of the competition. The total time allowed is 60 minutes. You will be scored on your ability to:

1. Read and follow instructions.
2. Answer questions correctly.

Judges are **NOT** permitted to answer questions during the competition. Should you encounter a technical problem, you may request assistance by pressing the **"H"** key and then the **"ENTER"** key on the test console. All technical problems will be corrected by the Judge and no demerits will be assessed.

Judges **WILL** assess a 2-point demerit for each violation of the following. Demerit points will be used as a discriminating factor in breaking ties.

1. Unwarranted requests for assistance (2 points)
2. Identifying good equipment as faulty (2 points)
3. Failure to follow instructions (2 points)
4. Safety violations (2 points)
   - ✓ Wearing jewelry
   - ✓ Not wearing safety glasses
   - ✓ Improper use of soldering iron

Materials Required

Sample Project Contestant Handout Part 1
Nida 130E Test Console

Procedure

Welcome to SkillsUSA. You have just begun a sample project that should help you understand both procedures and interactions required during the real competition. Read all instructions carefully and do not skip any steps. Let's begin the Sample Project!

Observe the display on the Nida 130E Test Console and ensure that it looks like the example shown in Figure 1. Verify that your contestant number replaces the **[--- xx ---]** shown in the example.

WRITTEN TEST
--- xx ---
Question 1 [ ]: ___

Figure 1

During the Written Test and the Customer Service Exam, the codes listed below are the only acceptable entries. Also, if you should identify a discrepancy, press the **"H"** key and then the **"ENTER"** key on the test console, and a Judge will respond. The Judge will assess the situation and determine the appropriate solution.

[S]	Enter "S" to skip question.
[R]	Enter "R" & question number to go to a specific question (example - R26).
[Y]	Enter "Y" to answer a yes question.
[N]	Enter "N" to answer a no question.
[EXIT]	Enter "EXIT" to end the test.
[TIME]	Enter "TIME" to see how much time has elapsed.
[1, 2, 3, 4]	Enter these numbers to identify correct answer.
[A, B, C, D]	Enter these letters to identify correct answer.

1. How many legs does a normal dog have?

   A. 10

   B. 22

   C. 4

   D. 35

2. **READ!!!** Which of the following creatures can fly? **DO NOT** answer this question. Notice that the display indicates question number 2 and that it corresponds to the question you are currently on. **SKIP** this question and we will recall it later. Type "**S**" and press ENTER.

   1. Dog
   2. Frog
   3. Horse
   4. Eagle

3. What is the sum of 150 and 25?

   1. 25
   2. 125
   3. 175
   4. 200

4. **READ!!!** Using the resistor color codes, what value does green represent? Answer (B) to this question ***even though it is not the correct answer***.

   A. 1

   B. 3

   C. 4

   D. 5

5. **READ!!!** Which of the following answers is an equivalent of 10^3?
HINT: Select answer (2) to this question.

1. 3E8
2. $2^3 \times 5^3$
3. 0.25 x 4000
4. 900 + 300 - (200)

At this point, you have completed all five questions and your display should look like the example in Figure 2. The Sample Project told you to skip one question and answer another question incorrectly. In order to recall, review, and modify your answers, you need to respond to the question on the display by answering **"N"**.

WRITTEN TEST
--- XX ---

End of Test
Finished ? (Y / N): ___

Figure 2

When you've answered **No** to the previous question, your display should look like the example in Figure 3. You have returned to Question 1 and your answer to Question 1 is shown in brackets [C].

WRITTEN TEST
--- XX ---

Question 1 [C]: ___

Figure 3

You have a choice to change the answer by entering a new response or skipping to the next question by entering "**S**". In either case, you will automatically sequence to the next question. Enter "**S**" and observe that your display has changed to Question 2. See Figure 4.

WRITTEN TEST
--- XX ---

Question 2 [ ]: ___

Figure 4

The brackets should be empty for Question 2 unless you did not follow the instructions. This is the question that you were told to skip. Refer to Question 2 in the booklet and enter the correct answer (4) to continue. Your display should sequence to Question 3. Type **R4** to recall Question 4 so that you can correct the answer entered incorrectly earlier. Your display should look like Figure 5.

WRITTEN TEST
--- XX ---

Question 4 [B]: ___

Figure 5

READ!!! Notice that the brackets contain the letter B. The correct answer to this question is D. Type the correct answer and press ENTER. The display sequences to Question 5; since we have finished our review, type "**EXIT**" and press ENTER to conclude the test. The display shown in Figure 6 should appear.

WRITTEN TEST
--- XX ---

End of Test
Finished ? (Y / N): ___

Figure 6

READ!!! We are finished with the test and the correct response to this question should be "**Y**". Notice that you are required to confirm your answer. The second confirmation is required so that you do not accidentally exit the test prematurely. You will **<u>NOT</u>** be permitted to restart or continue the test once you have exited. This concludes the Written Test example.

CONTESTANT SCRATCHPAD ANSWER SHEET - WRITTEN TEST

Total Points - 100

CONTESTANT #:

1. A B C D		
2. 1 2 3 4		
3. 1 2 3 4		
4. A B C D		
5. 1 2 3 4		

SAMPLE PROJECT

Part 2

Electronics Technology

SkillsUSA
Champions at Work®

Contestant Handout

2010

Nida Corporation
300 John Rodes Blvd.
Melbourne, Florida 32904

SAMPLE PROJECT

Introduction

This project is worth a maximum of 100 points but does not count as part of the competition. The total time allowed is 60 minutes. You will be scored on your ability to:

1. Read and follow instructions.
2. Answer questions correctly.
3. Perform an Operational Check.

Judges are **NOT** permitted to answer questions during the competition. Should you encounter a technical problem, you may request assistance by pressing the **"H"** key and then the **"ENTER"** key on the test console. All technical problems will be corrected by the Judge and no demerits will be assessed.

Judges **WILL** assess a 2-point demerit for each violation of the following. Demerit points will be used as a discriminating factor in breaking ties.

1. Unwarranted requests for assistance (2 points)
2. Identifying good equipment as faulty (2 points)
3. Failure to follow instructions (2 points)
4. Safety violations (2 points)
   - ✓ Wearing jewelry
   - ✓ Not wearing safety glasses
   - ✓ Improper use of soldering iron

Materials Required

Sample Project Contestant Handout Part 2
Skills07-1 PWM Switching Power Supply I Circuit Card
Skills07-2 PWM Switching Power Supply II Circuit Card
Skills07-3 Load Circuit Card
Oscilloscope
Multimeter
Nida Screwdriver
Nida 130E Test Console
Miscellaneous Tools as Required

Procedure

Welcome to SkillsUSA. You have just begun a sample project that should help you understand both procedures and interactions required during the real competition. Read all instructions carefully and do not skip any steps. Let's begin Sample Project 2!

1. **READ!!!** Observe the display on the Nida 130E Test Console and ensure that it looks like the example shown in Figure 1. Verify that your contestant number replaces the [--- **xx** ---] shown in the example. The troubleshooting section is slightly different from the written test in that you are not allowed to recall or change a previously entered answer. You will, however, still be allowed to skip questions. Notice the word "Proceed" on the display. During the troubleshooting event, no malfunction (problem) is set until you answer "Y" to this question.

   At this point, perform the Operational Check on pages 13-14 in the Technical Manual and verify the operation of the PWM Switching Power Supply. When you have completed the Operational Check, return to Step 2, and finish the remaining parts of this Sample Troubleshooting Project.

TROUBLESHOOTING
--- xx ---

Part 1
Proceed: ___

Figure 1

Procedure, continued

2. If you are satisfied that the PWM Switching Power Supply and Loads are functioning correctly, Enter **"Y"** at the **Proceed:** prompt. Observe the display on the Nida 130E Test Console and ensure that it looks like the example shown in Figure 2.

   Notice that the display is requesting your input regarding the current status of the PWM Power Supply circuitry. The question you must answer is, "Does the circuit Pass or Fail an Operational Check"?

   Observe that the Varying Load LEDs are NOT flashing and the voltage measured at TP15 is zero. Based on this basic information, you can answer the **Pass / Fail:** ___ question by entering an **"F"** for fail, at the prompt.

TROUBLESHOOTING **--- XX ---** **Part 1** **Pass / Fail: ___**

Figure 2

3. Now that you have identified that the circuit has Failed the Ops Check, you need to identify in which Block the fault has occurred. Use the schematics provided in the Technical Manual for this purpose. Monitor the voltage at TP5 (should be 12 volts) and the voltage at TP15 (is zero). Your readings indicate that no RAMP voltage exists between TP5 and TP15. The Block most likely to be the source of the failure is Block 3. Based on this basic information, you can answer the **Block #:** ____ question by entering **"3"** at the prompt.

TROUBLESHOOTING **--- XX ---** **Part 1** **Block #: ___**

Figure 3

Procedure, continued

4. Now that you have identified that the circuit failed and Block 3 is the most likely source of the problem, you need to enter a Reference # from the Malfunction Description table. Using the table provided and the basic information we have observed/measured, look at reference number 7. This malfunction says that R5 is open on Skills07-1. R5 is the only component between TP5 and TP15 and is located in Block 3. This is the most likely cause of the malfunction. You can answer the **Reference #: ____** question by entering "7" at the prompt.

TROUBLESHOOTING
--- XX ---

Part 1
Reference #: ___

Figure 4

**** END OF SAMPLE PROJECT ****

MALFUNCTION DESCRIPTION

Locate the **CIRCUIT CARD #** and associated **MALFUNCTION** that best describes the operation of your circuit. Enter the corresponding **REFERENCE #** on the Nida Test Console keypad. Malfunction descriptions may be used once, more than once, or not at all.

CIRCUIT CARD #	MALFUNCTION	REFERENCE #
Skills07-1	U2	1
Skills07-1	D3 open	2
Skills07-1	R10 open	3
Skills07-1	R8 shorted	4
Skills07-1	R9 open	5
Skills07-1	R8 open	6
Skills07-1	R5 Open	7
Skills07-2	C9 shorted	8
Skills07-2	U3A	9
Skills07-2	D9 shorted	10
Skills07-2	Q1 C-E short	11
Skills07-2	D9 open	12
Skills07-2	L1 open	13
Skills07-2	Q4 C-E short	14
Skills07-2	Q1 or Q2 B-E open	15
Skills07-3	R48 open	16
Skills07-3	U7	17
Skills07-3	C15 shorted	18
Skills07-3	K2 open	19
Skills07-3	IC1	20
Skills07-3	U6A	21
Skills07-3	D12 open	22

SOLDERING PROJECT

Electronics Technology

SkillsUSA

Champions at Work®

Engineering Change Notice

2010

Nida Corporation
300 S. John Rodes Boulevard
Melbourne, Florida 32904

ENGINEERING CHANGE NOTICE

Instructions

During the design process, U3 pin numbers 2 and 3 were inadvertently crossed. This condition affects the performance of the Dice Circuit. Perform the procedure below.

Procedure

1. Locate the small length of 20 gauge wire.
2. Orient the Roll the Dice printed circuit card as shown in Figure 1.
3. Cut the copper LAN connected to U3 pins 2 and 3 where indicated.

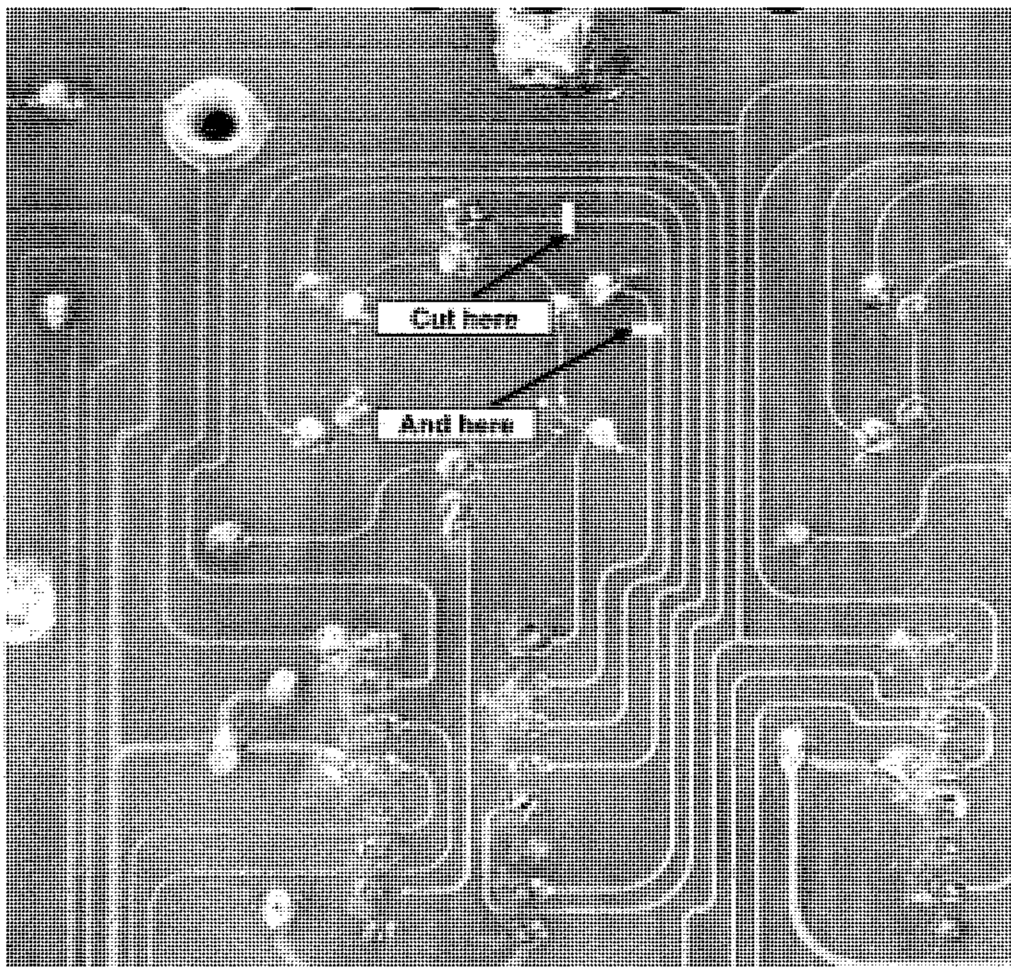

Figure 1

Procedure, continued

4. Install and solder jumper wires as indicated in Figure 2.

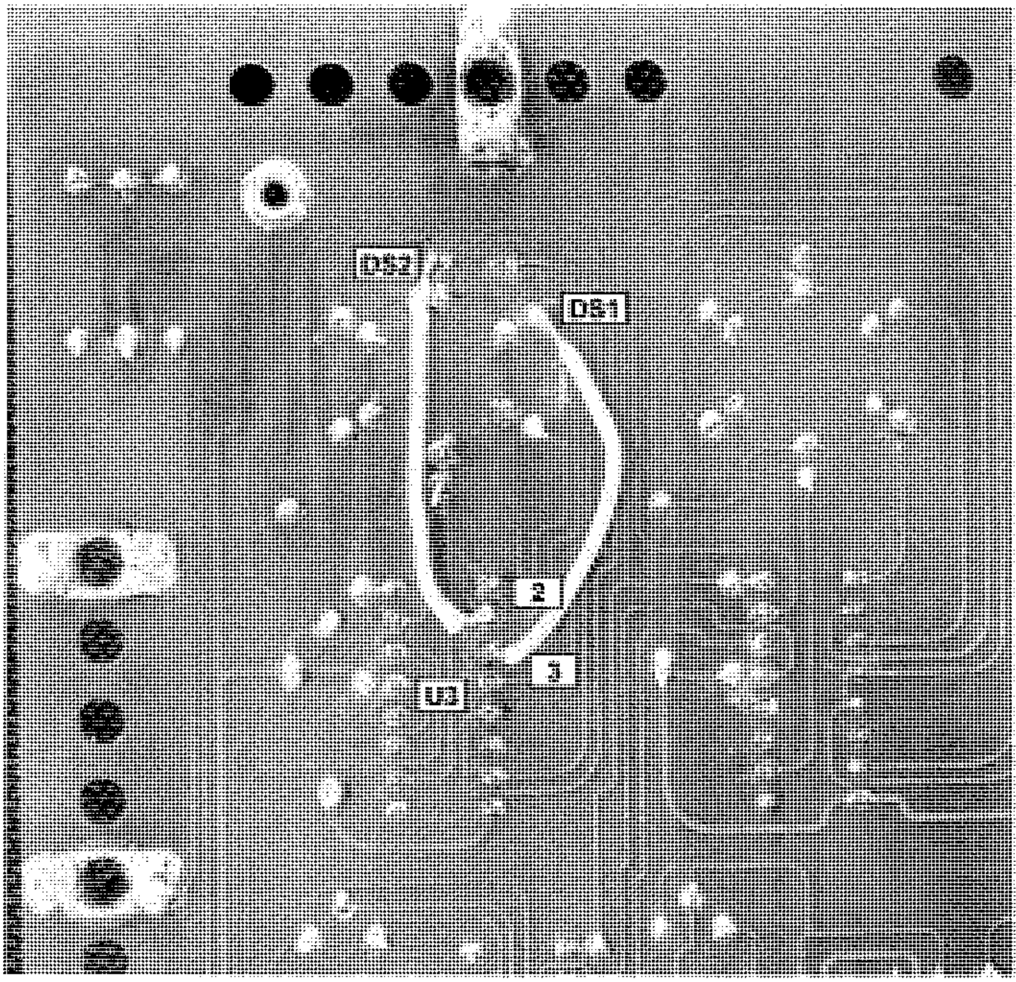

Figure 2

5. Perform the OPERATION CHECK on page 7 of the Soldering Contestant Handout.

6. Perform any necessary troubleshooting and repairs to make the circuit board operational.

7. When you are satisfied that your work is ready for inspection, press the "**H**" key and then the "**ENTER**" key on the keypad to request your final verification check.

SOLDERING PROJECT

Electronics Technology

SkillsUSA
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Contestant Handout

2010

Nida Corporation
300 S. John Rodes Boulevard
Melbourne, Florida 32904

SOLDERING PROJECT

Instructions

The total time allowed is 90 minutes. You will be scored on your ability to:

1. Read and follow instructions.
2. Interpret a component layout diagram.
3. Prepare components for soldering.
4. Solder and de-solder components to a printed circuit board.

Judges are NOT permitted to answer questions during the competition. Should you encounter a technical problem, you may request assistance by pressing the "**H**" key and then the "**ENTER**" key on the Nida Model 130E Test Console. All technical problems will be corrected by the Judge and no demerits will be assessed.

Judges **WILL** assess a 2 point demerit for each violation of the following. Demerit points will be used as a discriminating factor in breaking ties.

1. Unwarranted requests for assistance (2 points)
2. Identifying good equipment as faulty (2 points)
3. Failure to follow instructions (2 points)
4. Safety violations (2 points)
   - ✓ Wearing jewelry
   - ✓ Not wearing safety glasses
   - ✓ Improper use of soldering iron

Materials Required

Soldering Project Contestant Handout
Reference Manual (Data Sheets)
Blank Roll the Dice Circuit Board
Soldering Project Pre-Packaged Parts Kit
Nida Screwdriver
Multimeter
Oscilloscope
Solder Equipment
Miscellaneous Tools as Required

Procedure

1. **Log On.** Observe the display on the Nida Model 130E Test Console. Ensure that it looks like the example shown in Figure 1. Verify that your contestant number replaces the **[--- xx ---]** shown in the example.

SOLDERING PROJECT
--- XX ---

Part 1
Judge's Code: ____

Figure 1

2. **Verification.** Locate the pre-packaged parts kit (blue dot) provided for this project. Verify that it is complete and visibly serviceable using the "**Soldering Parts List**" information provided in the "Reference Section" of this handout. If you determine that a component is missing or you have a surplus of components, press the "**H**" key and then the "**ENTER**" key, and a Judge will respond.

3. This project tests your ability to solder. The circuitry on the Nida Solder Project circuit board is a game that simulates the rolling of two dice. Upon completing the soldering portion of this project, you must demonstrate proper operation to one of the judges. **Read the Project Overview portion of the Reference Section before performing the final test.**

4. The separate Reference Manual and the Reference Section on the following pages are your only guides while you are constructing the soldering project. You will be scored on your ability to read and follow instructions, interpret a schematic and component layout diagram, prepare components for soldering, solder components to a printed circuit board, and de-solder components.

>>> Proceed to the "Reference Section" and Continue <<<

REFERENCE SECTION

PROJECT OVERVIEW

The soldering project is a pair of identical one-of-six random number generator circuits disguised as a Roll the Dice game. Your task is to construct the circuit from commonly used electronic components while following the Soldering Procedure and schematic diagrams provided. The operation of the circuit will be judged functional when all components have been properly soldered and the circuit functions in accordance with the Operational Check. The schematic is at the end of this manual.

As mentioned, the two circuits are identical and share no common parts except for portions of integrated circuit U1, a hex buffer IC. Each circuit uses three of the six inverting buffers contained in U1. Two of the inverting buffers and a Junction Field Effect Transistor (JFET) make up the oscillator circuit for each random generator circuit, and the third inverting buffer is used in the decade counter circuit of U2 or U3.

Other than power and ground, U2 and U3 require just two inputs to operate: a clock input at pin 14, and an active low enabling input at pin 13. When enabled, the counter in U2/U3 advances at the leading edge of each clock input pulse, causing the IC to advance the count by one from Q0 to Q5, illuminating the single corresponding LED for each output. Since just six of the ten counting positions are used, the counter resets to zero whenever the counter enables position seven (Q6), with the high output state at pin 5 coupled to pin 15, the IC Reset input.

Each random generator circuit operates at a fast speed whenever the Roll button S1 or S2 is depressed. The circuit can be powered using the +12 volt power supply internal to the Nida 130E trainer, or externally by a 9-volt battery.

>>> Begin Part 1 when ready <<<

SOLDERING PROCEDURE

Part 1

a. Locate the Roll the Dice circuit board.

b. Solder the six flanges and two turrets at the back of the circuit board as shown in Figure 2.

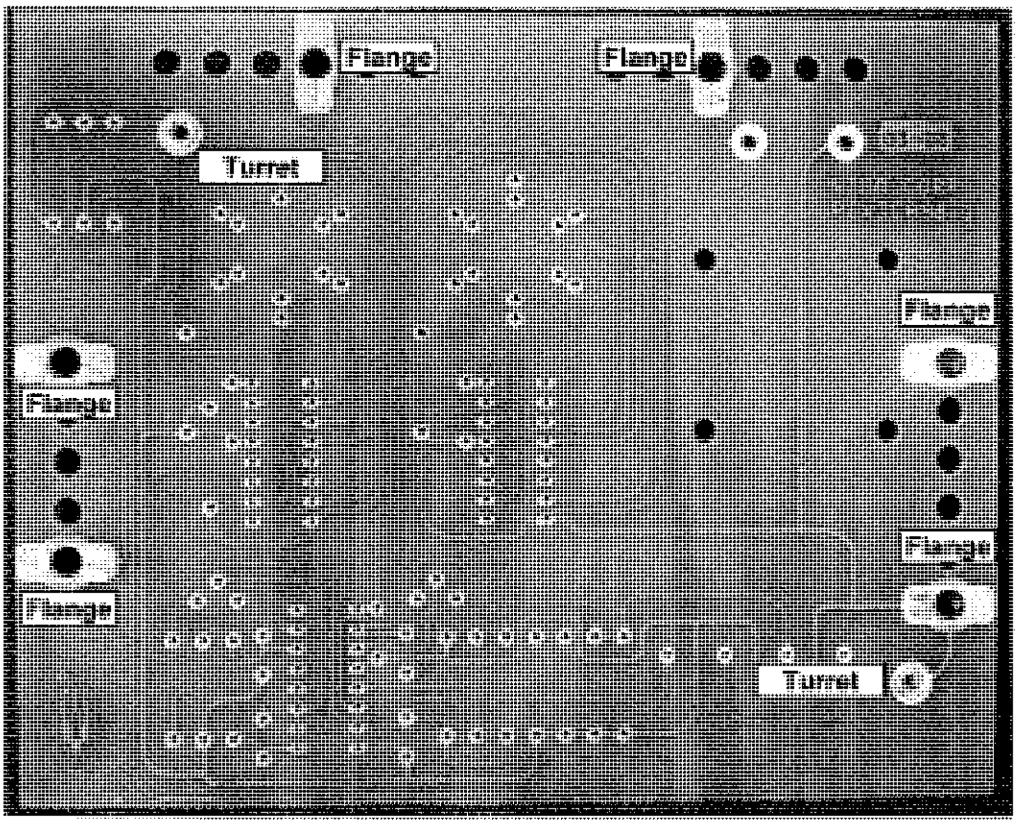


Figure 2

SOLDERING PROCEDURE

Part 1, continued

c. Install and solder the ½" precut jumper, the nine resistors, and the three diodes as shown in Figure 3. Observe polarity on the diodes and install the resistors so the color codes can be read from top to bottom when installed on the circuit board.

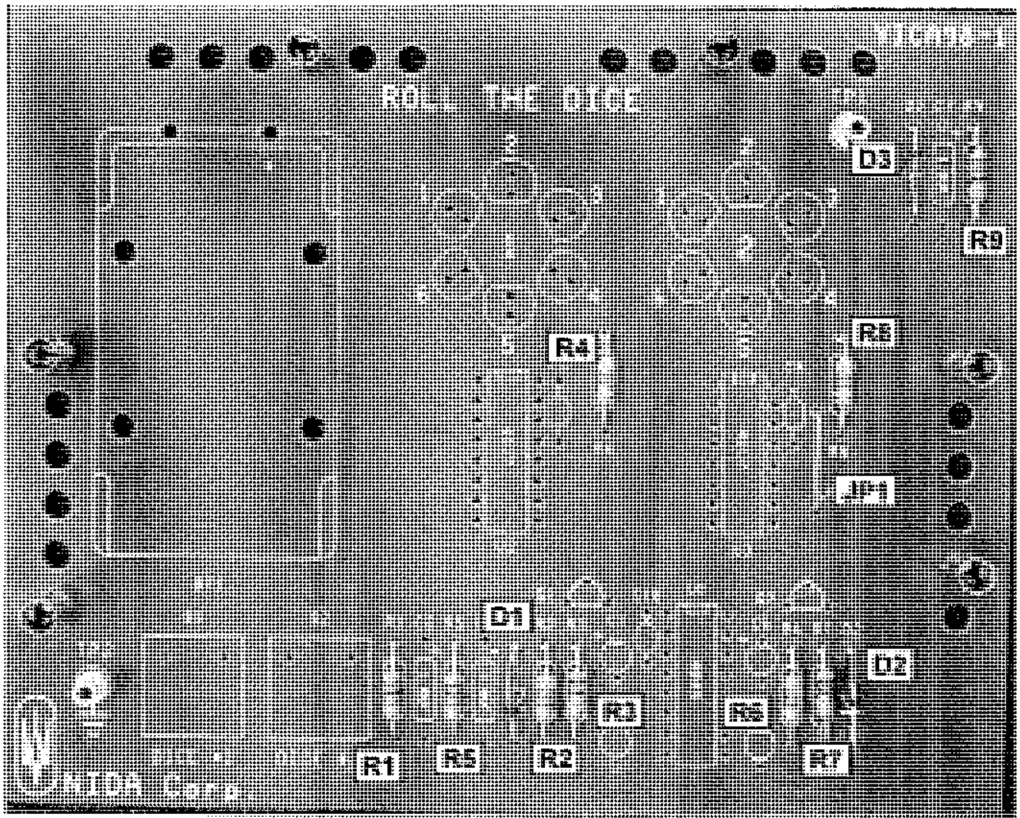


Figure 3

d. When you are satisfied with the solder connections and are ready for inspection, press the "**H**" key and then the "**ENTER**" key on the keypad to request your first verification check.

SOLDERING PROCEDURE

Part 2

a. Locate the necessary components from the parts kit, and solder the ten capacitors and the twelve LEDs to the printed circuit board. Capacitors should be installed with the label in a position so the value can be seen from the top of the circuit board if mounted horizontally or the left side of the circuit board if mounted vertically. Make sure to observe polarity as needed and trim the component leads to the proper length. Use Figure 4 for reference.

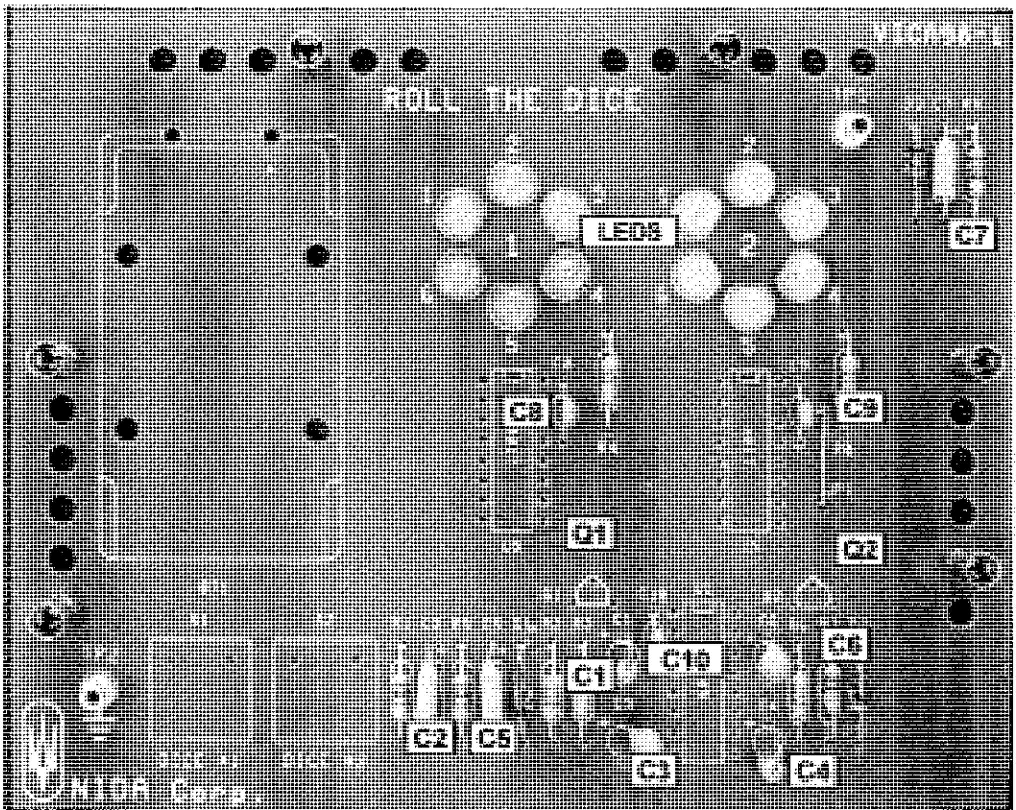


Figure 4

b. Locate and solder Q1 and Q2 to the printed circuit board. Q1 and Q2 should be approximately ¼ inch above the circuit board when completed. Make sure to observe polarity as needed and trim the component leads to the proper length.

c. When you are satisfied that your soldering thus far is ready for inspection, press the "**H**" key and then the "**ENTER**" key on the keypad to request your second verification check.

SOLDERING PROCEDURE

Part 3

a. Solder to the circuit board the integrated circuit sockets for U1, U2, and U3. When completed, install the ICs. Observe proper pin alignment when soldering and installing.

b. Install and solder switches S1 and S2. Make sure each switch is in alignment and flush with the circuit board after soldering.

c. Solder the 9-volt battery holder to the circuit board. Cut the excess leads from the back of the printed circuit board after installation.

d. Test your soldering circuit board according to the OPERATION CHECK procedure below.

e. Perform any necessary troubleshooting and repairs to make the circuit board operational.

f. When you are satisfied that your work is ready for inspection, press the "**H**" key and then the "**ENTER**" key on the keypad to request your third verification check.

OPERATIONAL CHECK

1. Carefully install the Roll the Dice board on the test console in the PC2 location.

2. Set the 130E test console DC power supply to +12 VDC.

3. Press the DC Power switch  on the PC2 position. Verify the DC LED at the PC2 position is illuminated.

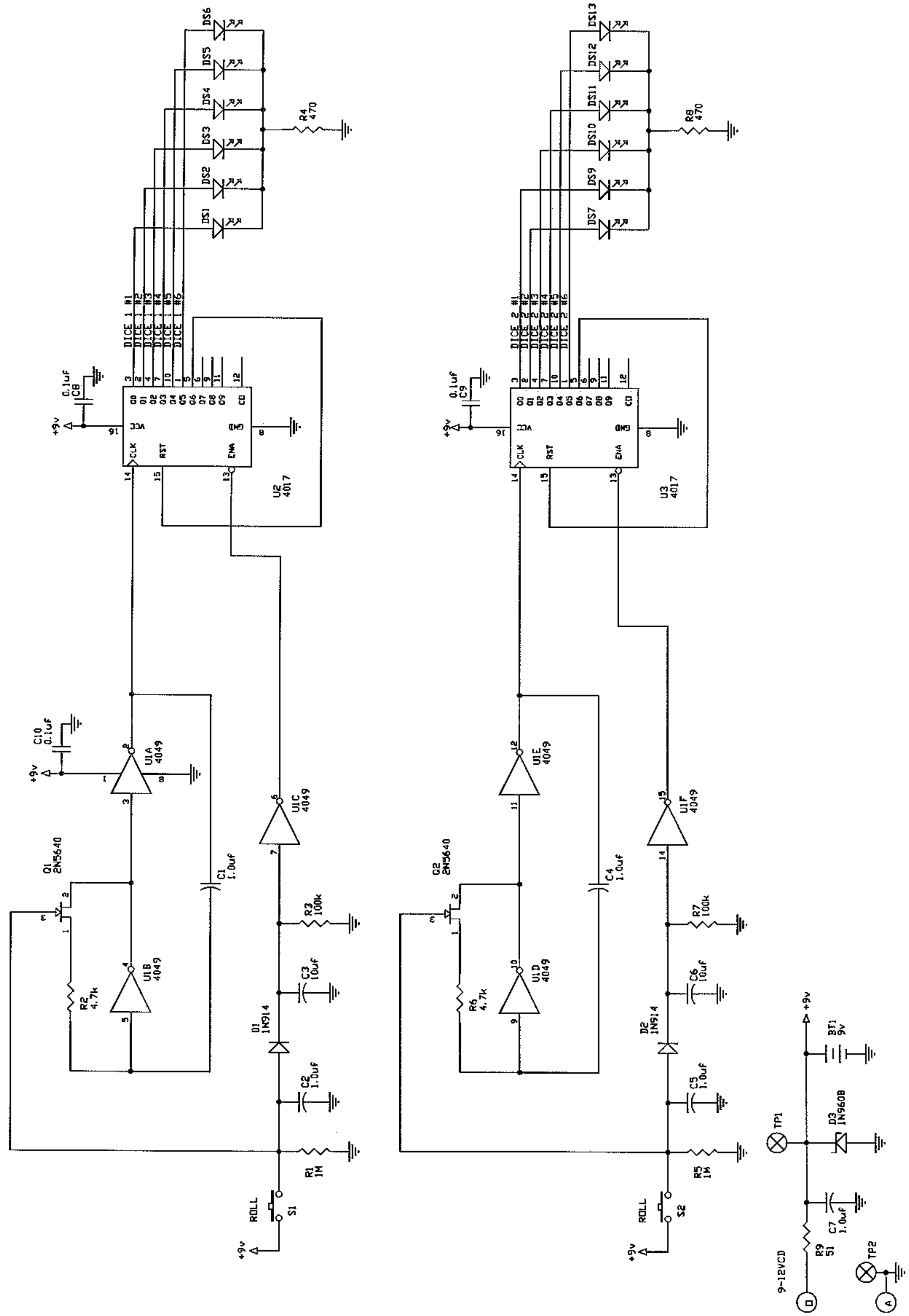
4. Test the circuit by depressing S1 and S2 and observing the LED outputs. Each press of a roll input button will cause the corresponding LED display to "spin" and then stop at a single LED.

Part 4

One of the judges will advise you of the Part 4 instructions when this point in the assembly is reached.

SOLDERING PARTS LIST

PART ID	DESCRIPTION	QUANTITY
VICA98-1	NIDA ROLL THE DICE CIRCUIT BOARD	1
51010005	HOLDER, 9 VOLT BATTERY	1
21053350	CAPACITOR, TANTALUM, 1 MFD 35V (105K)	5
21063160	CAPACITOR, 10 MFD 16V (106)	2
21042500	CAPACITOR, 0.1 MFD 50V (104)	3
51020006	LED, GREEN SHORT, ROUND	6
51020007	LED, YELLOW SHORT, ROUND	6
00510073	SILICONE DIODE, 1N914	2
00550029	ZENER DIODE, 1N960B 9.1V	1
81150031	JUMPER, 0.500 X 0.250	1
04100004	J-FET, 2N5640	2
11053030	RESISTOR, CARBON FILM, 1M 1/4W	2
14723030	RESISTOR, CARBON FILM, 4.7K 1/4W	2
11043030	RESISTOR, CARBON FILM, 100K 1/4W	2
14713030	RESISTOR, CARBON FILM, 470Ω 1/4W	2
15103030	RESISTOR, CARBON FILM, 51Ω 1/4W	1
41020030	PUSH BUTTON SWITCH, SPST MOMENTARY	2
05040047	4049 INVERTING HEX IC	1
05040143	4017 DECADE COUNTER IC	2
61000013	IC SOCKET, 16-PIN	3



Roll the Dice Schematic

REFERENCE MANUAL

Electronics Technology

SkillsUSA

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Data Sheets

2010

REFERENCE MANUAL

DATA SHEETS

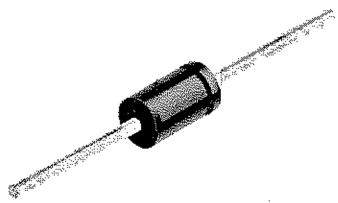
Table Of Contents

FAIRCHILD
SEMICONDUCTOR™

1N4001 - 1N4007

Features

- Low forward voltage drop.
- High surge current capability.



DO-41
COLOR BAND DENOTES CATHODE

1.0 Ampere General Purpose Rectifiers

Absolute Maximum Ratings*

T_A = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
$I_{F(AV)}$	Average Rectified Current .375 " lead length @ T_A = 75°C	1.0	A
I_{FSM}	Non-repetitive Peak Forward Surge Current 8.3 ms single half-sine-wave Superimposed on rated load (JEDEC method)	30	A
P_D	Total Device Dissipation Derate above 25°C	2.5 20	W mW/°C
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	50	°C/W
T_{stg}	Storage Temperature Range	-55 to +175	°C
T_J	Operating Junction Temperature	-55 to +150	°C

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

Electrical Characteristics

T_A = 25°C unless otherwise noted

Symbol	Parameter	Device							Units
		4001	4002	4003	400	400	4006	4007	
V_{RRM}	Peak Repetitive Reverse Voltage	50	100	200	400	600	800	1000	V
V_{RMS}	Maximum RMS Voltage	35	70	140	280	420	560	700	V
V_R	DC Reverse Voltage (Rated V_R)	50	100	200	400	600	800	1000	V
I_{RM}	Maximum Instantaneous Reverse Current @ rated V_R T_A = 25°C T_A = 100°C	5.0 500							µA µA
V_{FM}	Maximum Instantaneous Forward Voltage @ 1.0 A	1.1							V
I_{rr}	Maximum Full Load Reverse Current, Full Cycle T_A = 75°C	30							µA
C	Typical Junction Capacitance V_R = 4.0 V, f = 1.0 MHz	15							pF

High-speed diodes 1N4148; 1N4448

FEATURES

- Hermetically sealed leaded glass SOD27 (DO-35) package
- High switching speed: max. 4 ns
- General application
- Continuous reverse voltage: max. 100 V
- Repetitive peak reverse voltage: max. 100 V
- Repetitive peak forward current: max. 450 mA.

APPLICATIONS

- High-speed switching.

DESCRIPTION

The 1N4148 and 1N4448 are high-speed switching diodes fabricated in planar technology, and encapsulated in hermetically sealed leaded glass SOD27 (DO-35) packages.

The diodes are type branded.

Fig.1 Simplified outline (SOD27; DO-35) and symbol.

MARKING

TYPE NUMBER	MARKING CODE
1N4148	1N4148PH or 4148PH
1N4448	1N4448

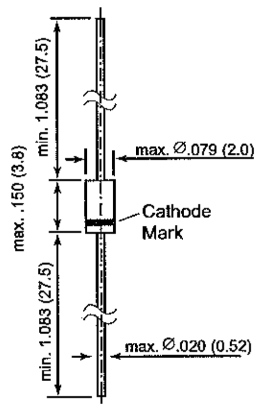
ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
1N4148	–	hermetically sealed glass package; axial leaded; 2 leads	SOD27
1N4448			

1N914

SMALL SIGNAL DIODE

DO-35



Dimensions in inches and (millimeters)

FEATURES

- Silicon Epitaxial Planar Diode
- For general purpose and switching.

MECHANICAL DATA

Case: DO-35 Glass Case
Weight: approx. 0.13 g

MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS

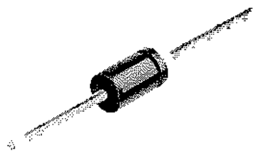
Ratings at 25°C ambient temperature unless otherwise specified.

	SYMBOL	*VALUE*	*UNIT*
Peak Reverse Voltage	V_{RM}	100	V
Maximum Average Rectified Current	I_o	75	mA
Maximum Power Dissipation at T_{amb} = 25 °C	P_{tot}	500	mW
Maximum Junction Temperature	T_j	200	°C
Maximum Forward Voltage Drop at I_F = 10 mA	V_F	1.0	V
Maximum Reverse Current at V_R = 20 V V_R = 75 V	I_R	25 5.0	nA µA
Max. Reverse Recovery Time at I_F = I_R = 10 mA, V_R = 6 V, R_L = 100 Ω, to I_{rr} = 1 mA	t_{rr}	4.0	ns
Maximum Capacitance at V_R=0, f=1.0 MHz	C_{tot}	4.0	pF

FAIRCHILD
SEMICONDUCTOR®

January 2005

1N4728A - 1N4764A
Zeners



DO-41 Glass case
COLOR BAND DENOTES CATHODE

Absolute Maximum Ratings * $T_a = 25°C$ unless otherwise noted

Symbol	Parameter	Value	Units
P_D	Power Dissipation @ TL ≤ 50°C, Lead Length = 3/8"	1.0	W
	Derate above 50°C	6.67	mW/°C
T_J, T_{STG}	Operating and Storage Temperature Range	-65 to +200	°C

* These ratings are limiting values above which the serviceability of the diode may be impaired.

Electrical Characteristics $T_a = 25°C$ unless otherwise noted

Device	V_Z (V) @ I_Z (Note 1)			Test Current	Max. Zener Impedance			Leakage Current	
	Min.	Typ.	Max.	I_Z (mA)	Z_Z @ I_Z (Ω)	Z_{ZK} @ I_{ZK} (Ω)	I_{ZK} (mA)	I_R (µA)	V_R (V)
1N4728A	3.315	3.3	3.465	76	10	400	1	100	1
1N4729A	3.42	3.6	3.78	69	10	400	1	100	1
1N4730A	3.705	3.9	4.095	64	9	400	1	50	1
1N4731A	4.085	4.3	4.515	58	9	400	1	10	1
1N4732A	4.465	4.7	4.935	53	8	500	1	10	1
1N4733A	4.845	5.1	5.355	49	7	550	1	10	1
1N4734A	5.32	5.6	5.88	45	5	600	1	10	2
1N4735A	5.89	6.2	6.51	41	2	700	1	10	3
1N4736A	6.46	6.8	7.14	37	3.5	700	1	10	4
1N4737A	7.125	7.5	7.875	34	4	700	0.5	10	5
1N4738A	7.79	8.2	8.61	31	4.5	700	0.5	10	6
1N4739A	8.645	9.1	9.555	28	5	700	0.5	10	7
1N4740A	9.5	10	10.5	25	7	700	0.25	10	7.6
1N4741A	10.45	11	11.55	23	8	700	0.25	5	8.4
1N4742A	11.4	12	12.6	21	9	700	0.25	5	9.1
1N4743A	12.35	13	13.65	19	10	700	0.25	5	9.9
1N4744A	14.25	15	15.75	17	14	700	0.25	5	11.4
1N4745A	15.2	16	16.8	15.5	16	700	0.25	5	12.2
1N4746A	17.1	18	18.9	14	20	750	0.25	5	13.7
1N4747A	19	20	21	12.5	22	750	0.25	5	15.2

FAIRCHILD
SEMICONDUCTOR®

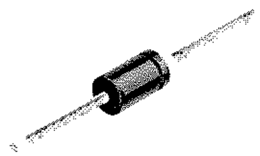
Zeners
1N957B - 1N991B

Absolute Maximum Ratings * T_A = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
P_D	Power Dissipation @ TL ≤ 75°C, Lead Length = 3/8"	500	mW
	Derate above 75°C	4.0	mW/°C
T_J, T_{STG}	Operating and Storage Temperature Range	-65 to +200	°C

* These ratings are limiting values above which the serviceability of the diode may be impaired.

Tolerance = 5%



DO-35 Glass case
COLOR BAND DENOTES CATHODE

Electrical Characteristics T_A=25°C unless otherwise noted

Device	V_Z (Volts) (Note 1)				Z_Z (Ω) (Note 2)			I_R @ V_R		I_{ZM} (mA) (Note 3)
	Min.	Typ.	Max.	@ I_Z (mA)	Z_Z @ I_Z	Z_{ZK} @ I_{ZK} Ω	mA	µA	Volts	
1N957B	6.46	6.8	7.14	18.5	4.5	700	1.0	150	5.2	47
1N958B	7.125	7.5	7.875	16.5	5.5	700	0.5	75	5.7	42
1N959B	7.79	8.2	8.61	15	6.5	700	0.5	50	6.2	38
1N960B	8.645	9.1	9.555	14	7.5	700	0.5	25	6.9	35
1N961B	9.5	10	10.5	12.5	8.5	700	0.25	10	7.6	32
1N962B	10.45	11	11.55	11.5	9.5	700	0.25	5	8.4	28
1N963B	11.4	12	12.6	10.5	11.5	700	0.25	5	9.1	26
1N964B	12.35	13	13.65	9.5	13	700	0.25	5	9.9	24
1N965B	14.25	15	15.75	8.5	16	700	0.25	5	11.4	21
1N966B	15.2	16	16.8	7.8	17	700	0.25	5	12.2	19
1N967B	17.1	18	18.9	7.0	21	750	0.25	5	13.7	17
1N968B	19	20	21	6.2	25	750	0.25	5	15.2	15
1N969B	20.9	22	23.1	5.6	29	750	0.25	5	16.7	14
1N970B	22.8	24	25.2	5.2	33	750	0.25	5	18.2	13
1N971B	25.652	27	28.35	4.6	41	750	0.25	5	20.6	11
1N972B	8.5	30	31.5	4.2	49	1000	0.25	5	22.8	10
1N973B	31.35	33	34.65	3.8	58	1000	0.25	5	25.1	9.2
1N974B	34.2	36	37.8	3.4	70	1000	0.25	5	27.4	8.5
1N975B	37.05	39	40.95	3.2	80	1000	0.25	5	29.7	7.8
1N976B	40.85	43	45.15	3.0	93	1500	0.25	5	32.7	7.0
1N977B	44.65	47	49.35	2.7	105	1500	0.25	5	35.8	6.4
1N978B	48.45	51	53.55	2.5	125	1500	0.25	5	38.8	5.9
1N979B	53.2	56	58.8	2.2	150	2000	0.25	5	42.6	5.4
1N980B	58.9	62	65.1	2.0	185	2000	0.25	5	47.1	4.9
1N981B	64.6	68	71.4	1.8	230	2000	0.25	5	51.7	4.5

FAIRCHILD
SEMICONDUCTOR™

October 1987
Revised January 2004

CD4017BC • CD4022BC
Decade Counter/Divider with 10 Decoded Outputs • Divide-by-8 Counter/Divider with 8 Decoded Outputs

General Description

The CD4017BC is a 5-stage divide-by-10 Johnson counter with 10 decoded outputs and a carry out bit.

The CD4022BC is a 4-stage divide-by-8 Johnson counter with 8 decoded outputs and a carry-out bit.

These counters are cleared to their zero count by a logical "1" on their reset line. These counters are advanced on the positive edge of the clock signal when the clock enable signal is in the logical "0" state.

The configuration of the CD4017BC and CD4022BC permits medium speed operation and assures a hazard free counting sequence. The 10/8 decoded outputs are normally in the logical "0" state and go to the logical "1" state only at their respective time slot. Each decoded output remains high for 1 full clock cycle. The carry-out signal completes a full cycle for every 10/8 clock input cycles and is used as a ripple carry signal to any succeeding stages.

Features

- Wide supply voltage range: 3.0V to 15V
- High noise immunity: 0.45 V_{DD} (typ.)
- Low power TTL compatibility: Fan out of 2 driving 74L or 1 driving 74LS
- Medium speed operation: 5.0 MHz (typ.) with 10V V_{DD}
- Low power: 10 µW (typ.)
- Fully static operation

Applications

- Automotive
- Instrumentation
- Medical electronics
- Alarm systems
- Industrial electronics
- Remote metering

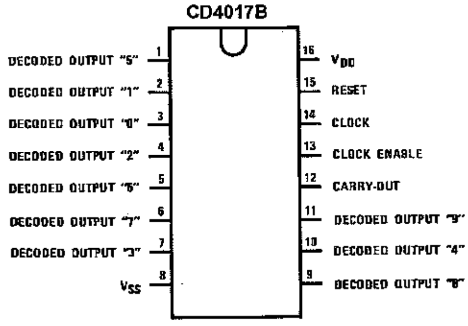
Ordering Code:

Order Number	Package Number	Package Description
CD4017BCM	M16A	16-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150" Narrow
CD4017BCN	N16E	16-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide
CD4022BCM	M16A	16-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150" Narrow
CD4022BCN	N16E	16-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide

Devices also available in Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.

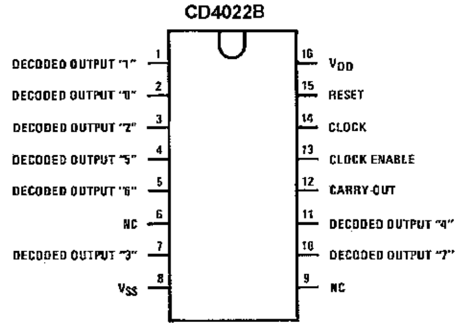
Connection Diagrams

CD4017B



Top View

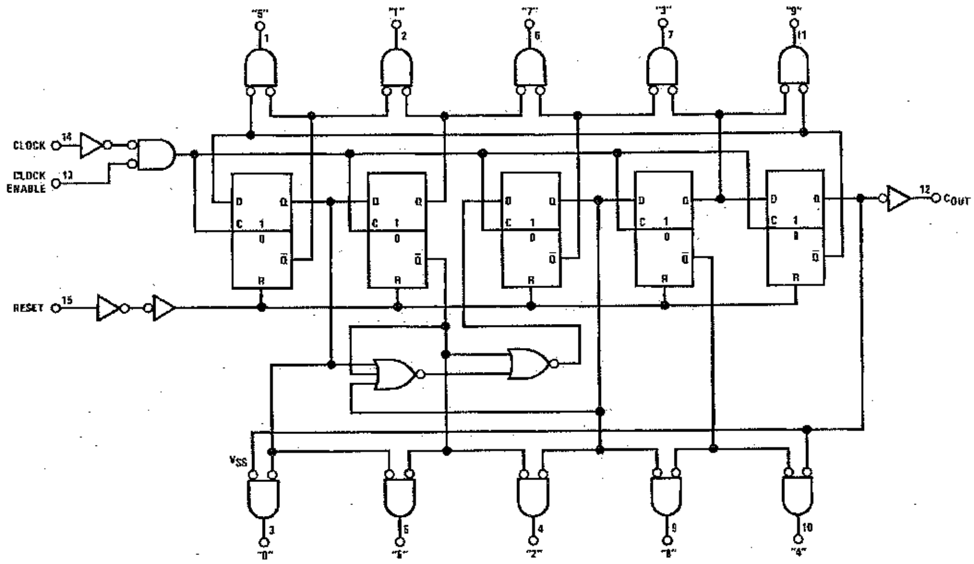
CD4022B



Top View

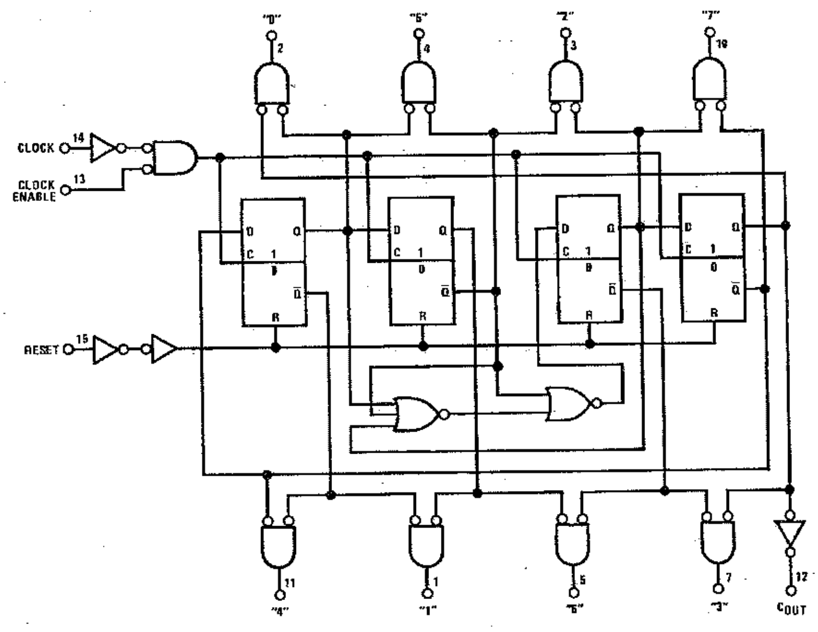
Logic Diagrams

CD4017B



Terminal No. 8 = GND
Terminal No. 16 = V_{DD}

CD4022B



Terminal No. 16 = V_{DD}
Terminal No. 8 = GND

Absolute Maximum Ratings (Note 1)

(Note 2)

DC Supply Voltage (V_{DD})	−0.5 V_{DC} to +18 V_{DC}
Input Voltage (V_{IN})	−0.5 V_{DC} to V_{DD} +0.5 V_{DC}
Storage Temperature (T_S)	−65°C to +150°C
Power Dissipation (P_D)	
Dual-In-Line	700 mW
Small Outline	500 mW
Lead Temperature (T_L)	
(Soldering, 10 seconds)	260°C

Recommended Operating Conditions (Note 2)

DC Supply Voltage (V_{DD})	+3 V_{DC} to +15 V_{DC}
Input Voltage (V_{IN})	0 to V_{DD} V_{DC}
Operating Temperature Range (T_A)	−55°C to +125°C

Note 1: "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed, they are not meant to imply that the devices should be operated at these limits. The table of "Recommended Operating Conditions" and "Electrical Characteristics" provides conditions for actual device operation.

Note 2: V_{SS} = 0V unless otherwise specified.

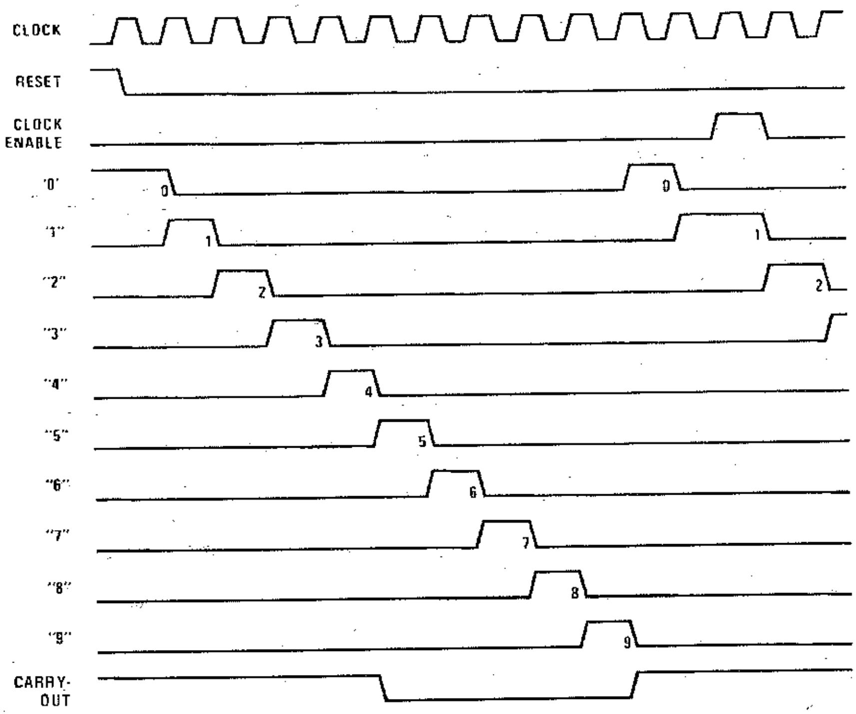
DC Electrical Characteristics (Note 2)

Symbol	Parameter	Conditions	−55°C Min	−55°C Max	+25° Min	+25° Typ	+25° Max	+125°C Min	+125°C Max	Units
I_{DD}	Quiescent Device Current	V_{DD} = 5V		5		0.3	5		150	μA
		V_{DD} = 10V		10		0.5	10		300	
		V_{DD} = 15V		20		1.0	20		600	
V_{OL}	LOW Level Output Voltage	$\|I_O\|$ < 1.0 μA								V
		V_{DD} = 5V		0.05		0	0.05		0.05	
		V_{DD} = 10V		0.05		0	0.05		0.05	
		V_{DD} = 15V		0.05		0	0.05		0.05	
V_{OH}	HIGH Level Output Voltage	$\|I_O\|$ < 1.0 μA								V
		V_{DD} = 5V	4.95		4.95	5		4.95		
		V_{DD} = 10V	9.95		9.95	10		9.95		
		V_{DD} = 15V	14.95		14.95	15		14.95		
V_{IL}	LOW Level Input Voltage	$\|I_O\|$ < 1.0 μA								V
		V_{DD} = 5V, V_O = 0.5V or 4.5V		1.5			1.5		1.5	
		V_{DD} = 10V, V_O = 1.0V or 9.0V		3.0			3.0		3.0	
		V_{DD} = 15V, V_O = 1.5V or 13.5V		4.0			4.0		4.0	
V_{IH}	HIGH Level Input Voltage	$\|I_O\|$ < 1.0 μA								V
		V_{DD} = 5V, V_O = 0.5V or 4.5V	3.5		3.5			3.5		
		V_{DD} = 10V, V_O = 1.0V or 9.0V	7.0		7.0			7.0		
		V_{DD} = 15V, V_O = 1.5V or 13.5V	11.0		11.0			11.0		
I_{OL}	LOW Level Output Current (Note 3)	V_{DD} = 5V, V_O = 0.4V	0.64		0.51	0.88		0.36		mA
		V_{DD} = 10V, V_O = 0.5V	1.6		1.3	2.25		0.9		
		V_{DD} = 15V, V_O = 1.5V	4.2		3.4	8.8		2.4		
I_{OH}	HIGH Level Output Current (Note 3)	V_{DD} = 5V, V_O = 4.6V	−0.25		−0.2	−0.36		−0.14		mA
		V_{DD} = 10V, V_O = 9.5V	−0.62		−0.5	−0.9		−0.35		
		V_{DD} = 15V, V_O = 13.5V	−1.8		−1.5	−3.5		−1.1		
I_{IN}	Input Current	V_{DD} = 15V, V_{IN} = 0V		−0.1		-10^{-5}	−0.1		−1.0	μA
		V_{DD} = 15V, V_{IN} = 15V		0.1		10^{-5}	0.1		1.0	

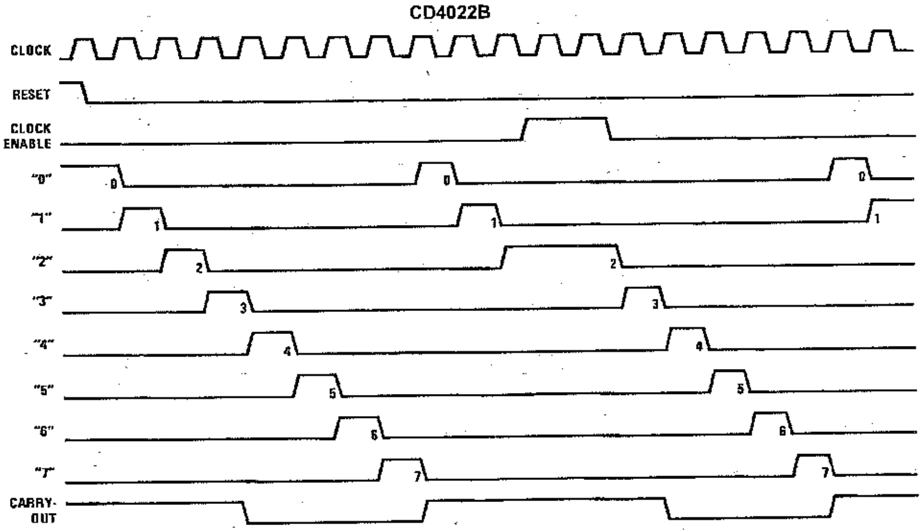
Note 3: I_{OL} and I_{OH} are tested one output at a time.

Timing Diagrams

CD4017B



CD4022B



MC14049B, MC14050B

Hex Buffer

The MC14049B Hex Inverter/Buffer and MC14050B Noninverting Hex Buffer are constructed with MOS P–Channel and N–Channel enhancement mode devices in a single monolithic structure. These complementary MOS devices find primary use where low power dissipation and/or high noise immunity is desired. These devices provide logic level conversion using only one supply voltage, V_{DD}.

The input–signal high level (V_{IH}) can exceed the V_{DD} supply voltage for logic level conversions. Two TTL/DTL loads can be driven when the devices are used as a CMOS–to–TTL/DTL converter (V_{DD} = 5.0 V, $V_{OL} \leq$ 0.4 V, $I_{OL} \geq$ 3.2 mA).

Note that pins 13 and 16 are not connected internally on these devices; consequently connections to these terminals will not affect circuit operation.

Features

- High Source and Sink Currents
- High–to–Low Level Converter
- Supply Voltage Range = 3.0 V to 18 V
- V_{IN} can exceed V_{DD}
- Meets JEDEC B Specifications
- Improved ESD Protection On All Inputs
- Pb–Free Packages are Available*

MAXIMUM RATINGS (Voltages Referenced to V_{SS})

Symbol	Parameter	Value	Unit
V_{DD}	DC Supply Voltage Range	−0.5 to +18.0	V
V_{in}	Input Voltage Range (DC or Transient)	−0.5 to +18.0	V
V_{out}	Output Voltage Range (DC or Transient)	−0.5 to V_{DD} + 0.5	V
I_{in}	Input Current (DC or Transient) per Pin	±10	mA
I_{out}	Output Current (DC or Transient) per Pin	±45	mA
P_D	Power Dissipation, per Package (Note 1) (Plastic) (SOIC)	 825 740	mW
T_A	Ambient Temperature Range	−55 to +125	°C
T_{stg}	Storage Temperature Range	−65 to +150	°C
T_L	Lead Temperature (8–Second Soldering)	260	°C

1. Temperature Derating: See Figure 3.

This device contains protection circuitry to protect the inputs against damage due to high static voltages or electric fields referenced to the V_{SS} pin only. Extra precautions must be taken to avoid applications of any voltage higher than the maximum rated voltages to this high–impedance circuit. For proper operation, the ranges $V_{SS} \leq V_{in} \leq$ 18 V and $V_{SS} \leq V_{out} \leq V_{DD}$ are recommended.

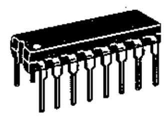
Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V_{SS} or V_{DD}). Unused outputs must be left open.

*For additional information on our Pb–Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

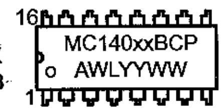
ON Semiconductor®

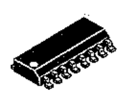
http://onsemi.com

MARKING DIAGRAMS

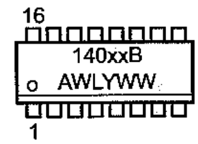


PDIP–16
P SUFFIX
CASE 648

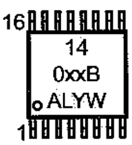


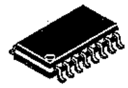


SOIC–16
D SUFFIX
CASE 751B

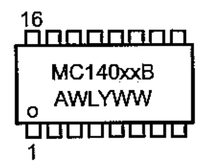


TSSOP–16
DT SUFFIX
CASE 948F





SOEIAJ–16
F SUFFIX
CASE 966



xx	= Specific Device Code
A	= Assembly Location
WL, L	= Wafer Lot
YY, Y	= Year
WW, W	= Work Week

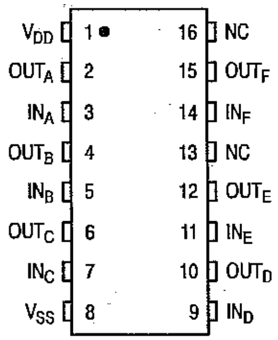
ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.

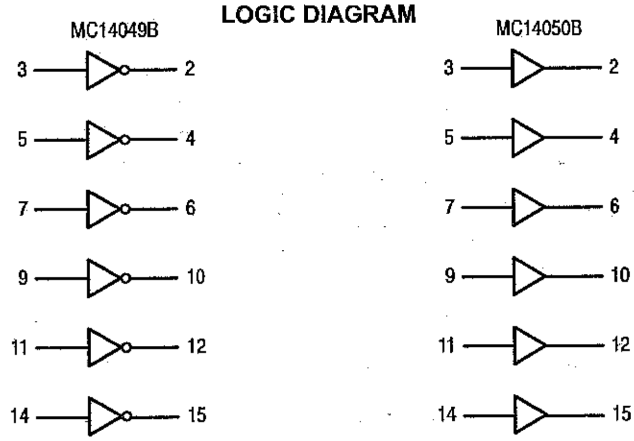
February, 2005 − Rev. 5

Publication Order Number:
MC14049B/D

PIN ASSIGNMENT



LOGIC DIAGRAM



MC14049B: NC = PIN 13, 16; V_{SS} = PIN 8; V_{DD} = PIN 1

MC14050B: NC = PIN 13, 16; V_{SS} = PIN 8; V_{DD} = PIN 1

ORDERING INFORMATION

Device	Package	Shipping†
MC14049BCP	PDIP−16	500 Units / Rail
MC14049BCPG	PDIP−16 (Pb−Free)	500 Units / Rail
MC14049BD	SOIC−16	48 Units / Rail
MC14049BDG	SOIC−16 (Pb−Free)	48 Units / Rail
MC14049BDR2	SOIC−16	2500 Units / Tape & Reel
MC14049BDR2G	SOIC−16 (Pb−Free)	2500 Units / Tape & Reel
MC14049BFEL	SOEIAJ−16	2000 Units / Tape & Reel
MC14050BCP	PDIP−16	500 Units / Rail
MC14050BCPG	PDIP−16 (Pb−Free)	500 Units / Rail
MC14050BD	SOIC−16	48 Units / Rail
MC14050BDR2	SOIC−16	2500 Units / Tape & Reel
MC14050BDR2G	SOIC−16 (Pb−Free)	2500 Units / Tape & Reel
MC14050BDT	TSSOP−16*	96 Units / Rail
MC14050BDTR2	TSSOP−16*	2500 Units / Tape & Reel
MC14050BFEL	SOEIAJ−16	2000 Units / Tape & Reel
MC14050BFELG	SOEIAJ−16 (Pb−Free)	2000 Units / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

*This package is inherently Pb−Free.

FAIRCHILD
SEMICONDUCTOR™

October 1987
Revised January 1999

CD4020BC • CD4040BC • CD4060BC
14-Stage Ripple Carry Binary Counters • 12-Stage Ripple Carry Binary Counters • 14-Stage Ripple Carry Binary Counters

General Description

The CD4020BC, CD4060BC are 14-stage ripple carry binary counters, and the CD4040BC is a 12-stage ripple carry binary counter. The counters are advanced one count on the negative transition of each clock pulse. The counters are reset to the zero state by a logical "1" at the reset input independent of clock.

Features

- Wide supply voltage range: 1.0V to 15V
- High noise immunity: 0.45 V_{DD} (typ.)
- Low power TTL compatibility: Fan out of 2 driving 74L or 1 driving 74LS
- Medium speed operation: 8 MHz typ. at V_{DD} = 10V
- Schmitt trigger clock input

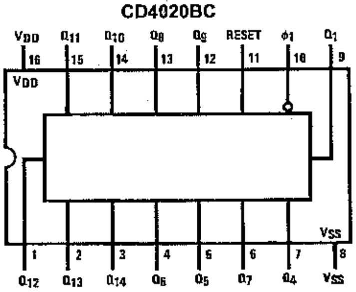
Ordering Code:

Order Number	Package Number	Package Description
CD4020BCM	M16A	16-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150" Narrow
CD4020BCN	N16E	16-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide
CD4040BCM	M16A	16-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150" Narrow
CD4040BCSJ	M16D	16-Lead Small Outline Package (SOP), EIAJ TYPE II, 5.3mm Wide
CD4040BCN	N16E	16-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide
CD4060BCM	M16A	16-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-012, 0.150" Narrow
CD4060BCN	N16E	16-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide

Devices also available in Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.

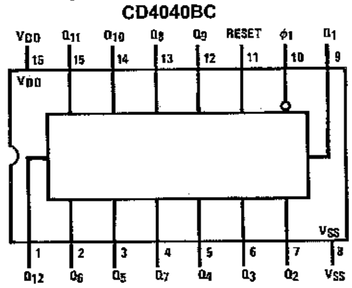
Connection Diagrams

Pin Assignments for DIP and SOIC
CD4020BC



Top View

Pin Assignments for DIP, SOIC and SOP
CD4040BC

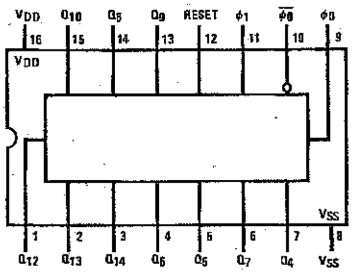


Top View

Connection Diagrams (Continued)

Pin Assignments for DIP and SOIC

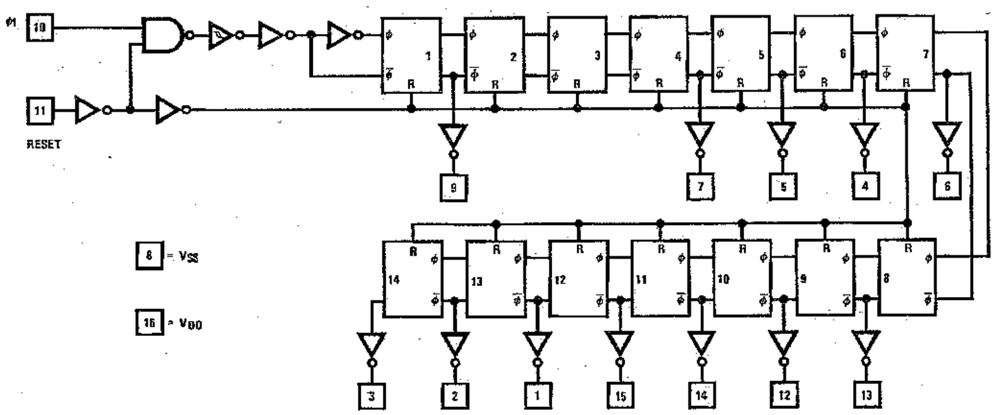
CD4060BC



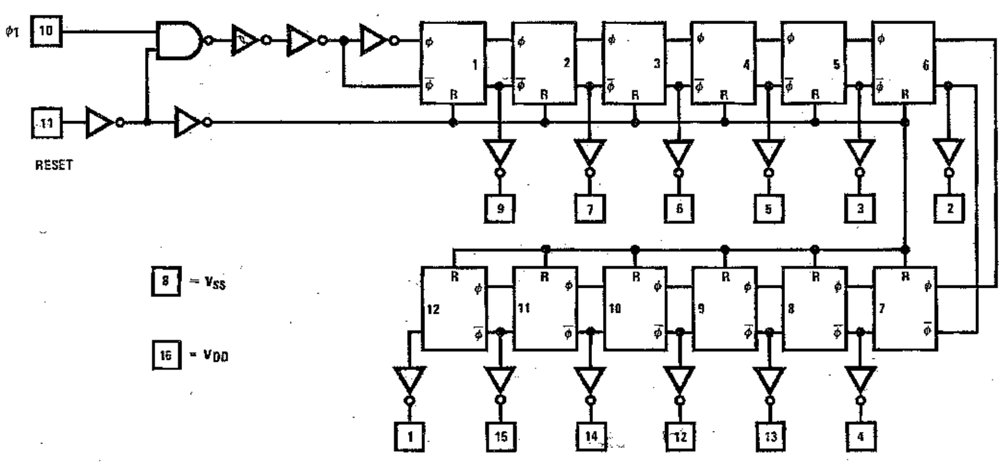
Top View

Schematic Diagrams

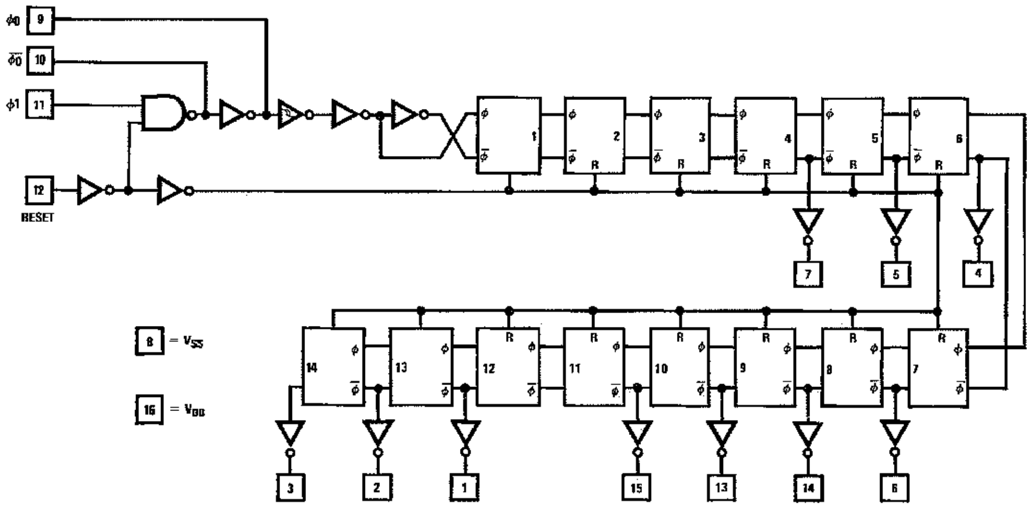
CD4020BC



CD4040BC

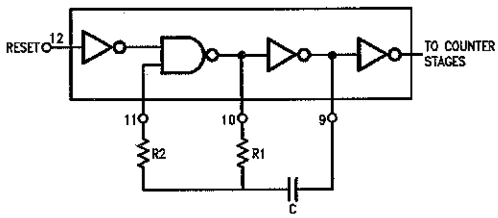


CD4060BC

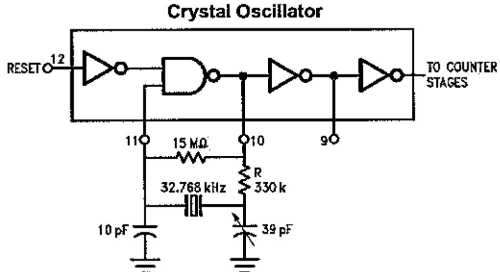


CD4060B Typical Oscillator Connections

RC Oscillator



Crystal Oscillator



August 2002

National Semiconductor

LM193/LM293/LM393/LM2903
Low Power Low Offset Voltage Dual Comparators

General Description

The LM193 series consists of two independent precision voltage comparators with an offset voltage specification as low as 2.0 mV max for two comparators which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. These comparators also have a unique characteristic in that the input common-mode voltage range includes ground, even though operated from a single power supply voltage.

Application areas include limit comparators, simple analog to digital converters; pulse, squarewave and time delay generators; wide range VCO; MOS clock timers; multivibrators and high voltage digital logic gates. The LM193 series was designed to directly interface with TTL and CMOS. When operated from both plus and minus power supplies, the LM193 series will directly interface with MOS logic where their low power drain is a distinct advantage over standard comparators.

The LM393 and LM2903 parts are available in National's innovative thin micro SMD package with 8 (12 mil) large bumps.

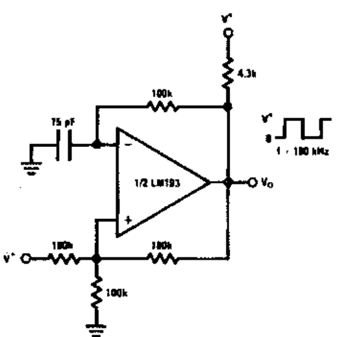
Advantages

- High precision comparators
- Reduced V_{OS} drift over temperature
- Eliminates need for dual supplies
- Allows sensing near ground
- Compatible with all forms of logic
- Power drain suitable for battery operation

Features

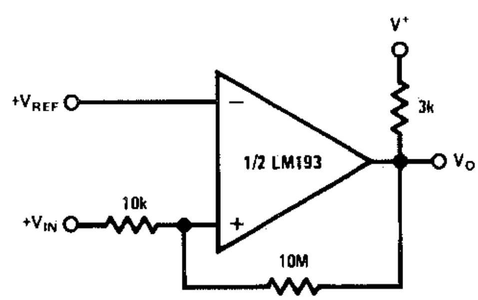
- Wide supply
  - — Voltage range: 2.0V to 36V
  - — Single or dual supplies: ±1.0V to ±18V
- Very low supply current drain (0.4 mA) — independent of supply voltage
- Low input biasing current: 25 nA
- Low input offset current: ±5 nA
- Maximum offset voltage: ±3 mV
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Low output saturation voltage,: 250 mV at 4 mA
- Output voltage compatible with TTL, DTL, ECL, MOS and CMOS logic systems
- Available in the 8-Bump (12 mil) micro SMD package
- See AN-1112 for micro SMD considerations

Squarewave Oscillator



00570938

Non-Inverting Comparator with Hysteresis



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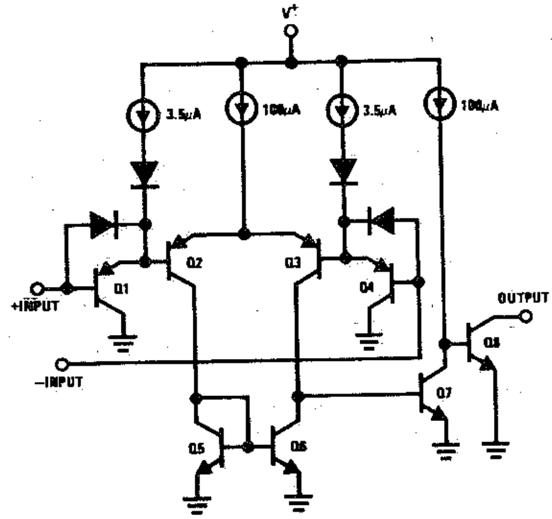
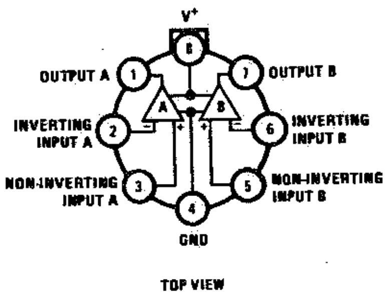
Schematic and Connection Diagrams



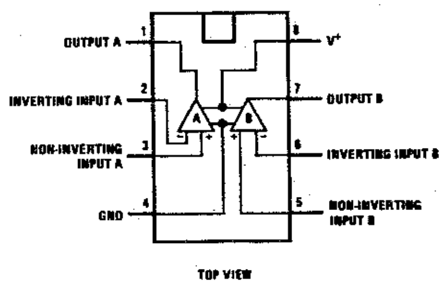
00570902

Metal Can Package



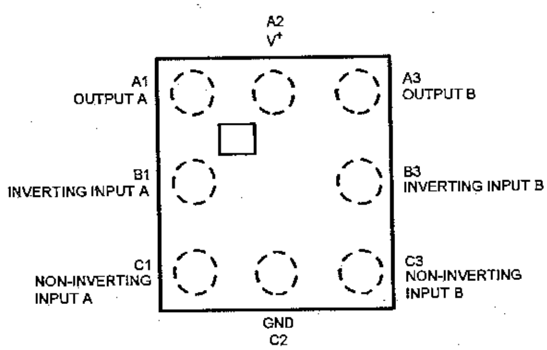
00570903

Dual-In-Line/SOIC Package



00570901

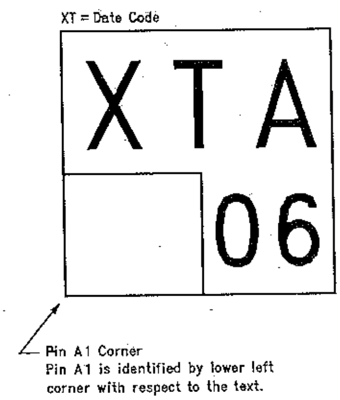
micro SMD



00570945

Top View

micro SMD Marking



00570946

Top View

National Semiconductor

February 2003

LM3914
Dot/Bar Display Driver

General Description

The LM3914 is a monolithic integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display. A single pin changes the display from a moving dot to a bar graph. Current drive to the LEDs is regulated and programmable, eliminating the need for resistors. This feature is one that allows operation of the whole system from less than 3V.

The circuit contains its own adjustable reference and accurate 10-step voltage divider. The low-bias-current input buffer accepts signals down to ground, or V^-, yet needs no protection against inputs of 35V above or below ground. The buffer drives 10 individual comparators referenced to the precision divider. Indication non-linearity can thus be held typically to ½%, even over a wide temperature range.

Versatility was designed into the LM3914 so that controller, visual alarm, and expanded scale functions are easily added on to the display system. The circuit can drive LEDs of many colors, or low-current incandescent lamps. Many LM3914s can be "chained" to form displays of 20 to over 100 segments. Both ends of the voltage divider are externally available so that 2 drivers can be made into a zero-center meter.

The LM3914 is very easy to apply as an analog meter circuit. A 1.2V full-scale meter requires only 1 resistor and a single 3V to 15V supply in addition to the 10 display LEDs. If the 1 resistor is a pot, it becomes the LED brightness control. The simplified block diagram illustrates this extremely simple external circuitry.

When in the dot mode, there is a small amount of overlap or "fade" (about 1 mV) between segments. This assures that at no time will all LEDs be "OFF", and thus any ambiguous display is avoided. Various novel displays are possible.

Much of the display flexibility derives from the fact that all outputs are individual, DC regulated currents. Various effects can be achieved by modulating these currents. The individual outputs can drive a transistor as well as a LED at the same time, so controller functions including "staging" control can be performed. The LM3914 can also act as a programmer, or sequencer.

The LM3914 is rated for operation from 0°C to +70°C. The LM3914N-1 is available in an 18-lead molded (N) package.

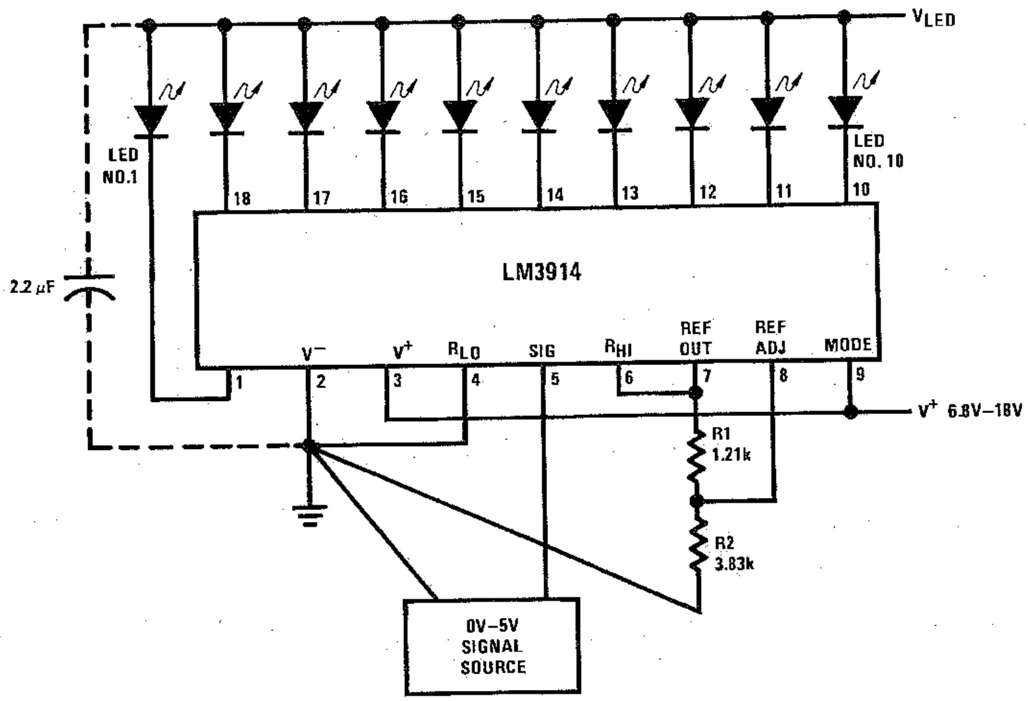
The following typical application illustrates adjusting of the reference to a desired value, and proper grounding for accurate operation, and avoiding oscillations.

Features

- Drives LEDs, LCDs or vacuum fluorescents
- Bar or dot display mode externally selectable by user
- Expandable to displays of 100 steps
- Internal voltage reference from 1.2V to 12V
- Operates with single supply of less than 3V
- Inputs operate down to ground
- Output current programmable from 2 mA to 30 mA
- No multiplex switching or interaction between outputs
- Input withstands ±35V without damage or false outputs
- LED driver outputs are current regulated, open-collectors
- Outputs can interface with TTL or CMOS logic
- The internal 10-step divider is floating and can be referenced to a wide range of voltages

Typical Applications

0V to 5V Bar Graph Meter



00797001

$$\text{Ref Out V} = 1.25\left(1 + \frac{R2}{R1}\right)$$

$$I_{LED} \cong \frac{12.5}{R1}$$

Note: Grounding method is typical of *all* uses. The 2.2µF tantalum or 10 µF aluminum electrolytic capacitor is needed if leads to the LED supply are 6" or longer.

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Power Dissipation (Note 6)	
Molded DIP (N)	1365 mW
Supply Voltage	25V
Voltage on Output Drivers	25V
Input Signal Overvoltage (Note 4)	±35V
Divider Voltage	−100 mV to V^+
Reference Load Current	10 mA
Storage Temperature Range	−55°C to +150°C
Soldering Information	
Dual-In-Line Package	
Soldering (10 seconds)	260°C
Plastic Chip Carrier Package	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

Electrical Characteristics (Notes 2, 4)

Parameter	Conditions (Note 2)	Min	Typ	Max	Units
COMPARATOR					
Offset Voltage, Buffer and First Comparator	$0V \le V_{RLO} = V_{RHI} \le 12V$, $I_{LED} = 1$ mA		3	10	mV
Offset Voltage, Buffer and Any Other Comparator	$0V \le V_{RLO} = V_{RHI} \le 12V$, $I_{LED} = 1$ mA		3	15	mV
Gain ($\Delta I_{LED}/\Delta V_{IN}$)	$I_{L(REF)} = 2$ mA, $I_{LED} = 10$ mA	3	8		mA/mV
Input Bias Current (at Pin 5)	$0V \le V_{IN} \le V^+ - 1.5V$		25	100	nA
Input Signal Overvoltage	No Change in Display	−35		35	V
VOLTAGE-DIVIDER					
Divider Resistance	Total, Pin 6 to 4	8	12	17	kΩ
Accuracy	(Note 3)		0.5	2	%
VOLTAGE REFERENCE					
Output Voltage	$0.1 \text{ mA} \le I_{L(REF)} \le 4$ mA, $V^+ = V_{LED} = 5V$	1.2	1.28	1.34	V
Line Regulation	$3V \le V^+ \le 18V$		0.01	0.03	%/V
Load Regulation	$0.1 \text{ mA} \le I_{L(REF)} \le 4$ mA, $V^+ = V_{LED} = 5V$		0.4	2	%
Output Voltage Change with Temperature	$0°C \le T_A \le +70°C$, $I_{L(REF)} = 1$ mA, $V^+ = 5V$		1		%
Adjust Pin Current			75	120	µA
OUTPUT DRIVERS					
LED Current	$V^+ = V_{LED} = 5V$, $I_{L(REF)} = 1$ mA	7	10	13	mA
LED Current Difference (Between Largest and Smallest LED Currents)	$V_{LED} = 5V$, $I_{LED} = 2$ mA		0.12	0.4	mA
	$V_{LED} = 5V$, $I_{LED} = 20$ mA		1.2	3	mA
LED Current Regulation	$2V \le V_{LED} \le 17V$, $I_{LED} = 2$ mA		0.1	0.25	mA
	$2V \le V_{LED} \le 17V$, $I_{LED} = 20$ mA		1	3	mA
Dropout Voltage	$I_{LED(ON)} = 20$ mA, $V_{LED} = 5V$, $\Delta I_{LED} = 2$ mA			1.5	V
Saturation Voltage	$I_{LED} = 2.0$ mA, $I_{L(REF)} = 0.4$ mA		0.15	0.4	V
Output Leakage, Each Collector	(Bar Mode) (Note 5)		0.1	10	µA
Output Leakage	(Dot Mode) (Note 5), Pins 10–18		0.1	10	µA
	(Dot Mode) (Note 5), Pin 1	60	150	450	µA
SUPPLY CURRENT					
Standby Supply Current (All Outputs Off)	$V^+ = 5V$, $I_{L(REF)} = 0.2$ mA		2.4	4.2	mA
	$V^+ = 20V$, $I_{L(REF)} = 1.0$ mA		6.1	9.2	mA

WP103HDT BRIGHT RED

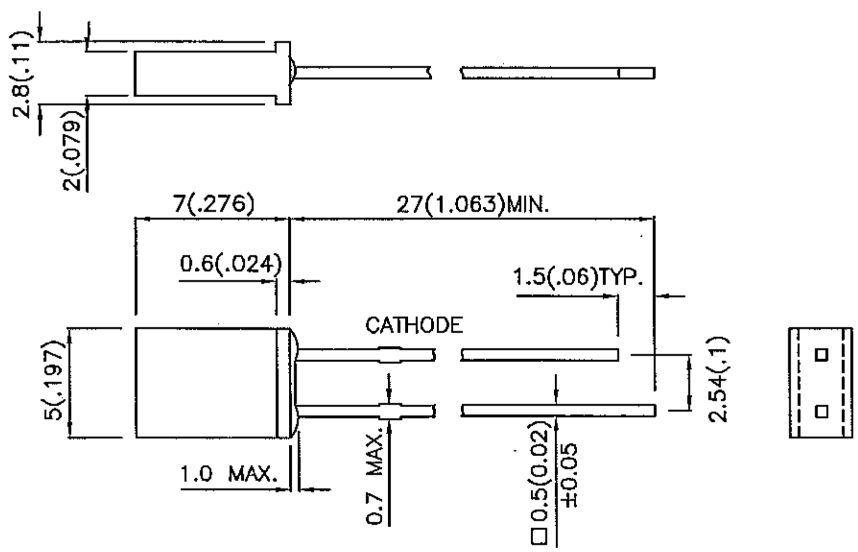
Features

- LOW POWER CONSUMPTION.
- RELIABLE AND RUGGED.
- EXCELLENT UNIFORMITY OF LIGHT OUTPUT.
- SUITABLE FOR LEVEL INDICATOR.
- LONG LIFE - SOLID STATE RELIABILITY.
- RoHS COMPLIANT.

Description

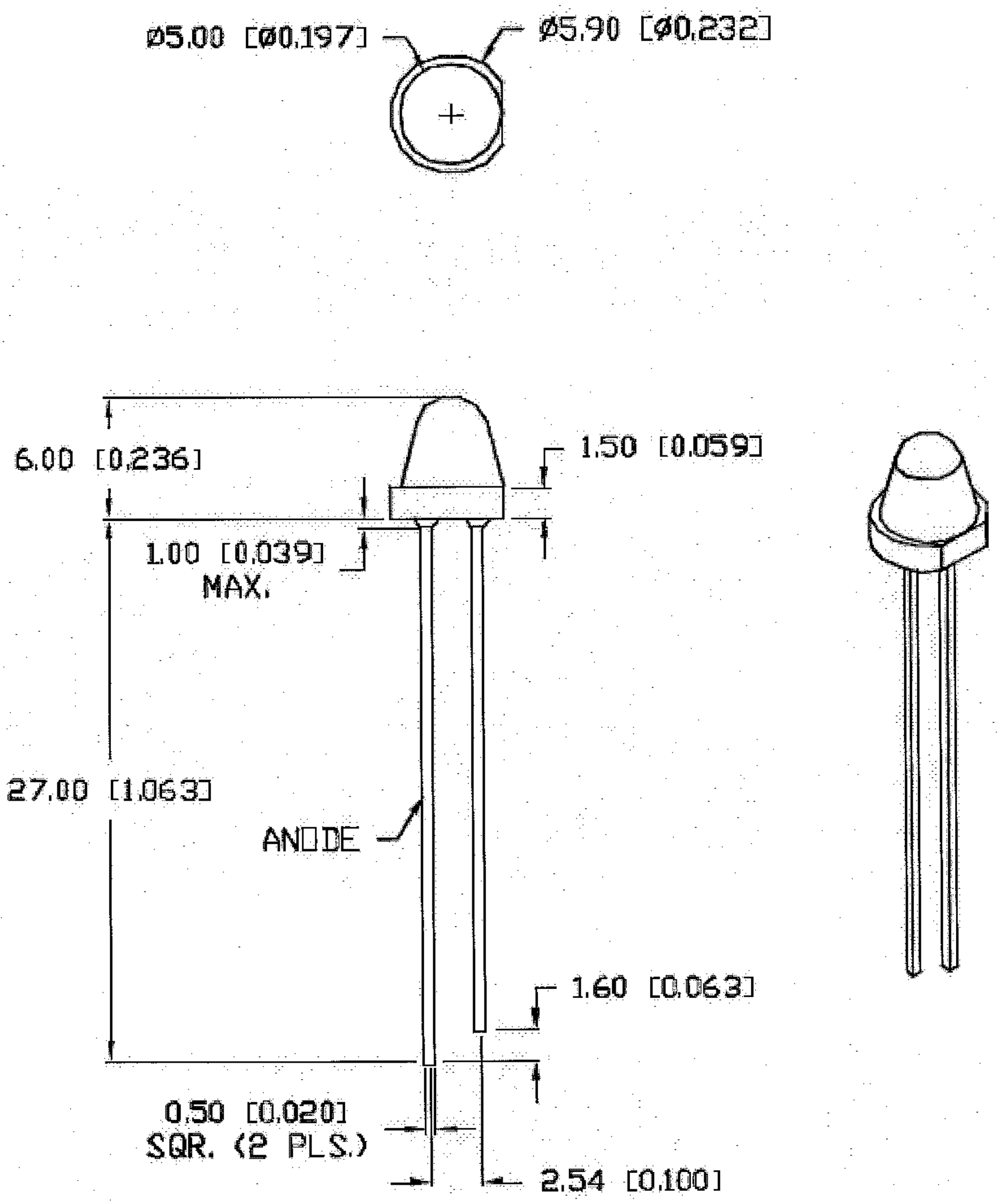
The Bright Red source color devices are made with Gallium Phosphide Red Light Emitting Diode.

Package Dimensions



Notes:
1. All dimensions are in millimeters (inches).
2. Tolerance is ±0.25(0.01") unless otherwise noted.
3. Lead spacing is measured where the leads emerge from the package.
4. Specifications are subject to change without notice.

LEDs



ø5.00 [ø0.197]
ø5.90 [ø0.232]
6.00 [0.236]
1.50 [0.059]
1.00 [0.039]
MAX.
27.00 [1.063]
ANODE
1.60 [0.063]
0.50 [0.020]
SQR. (2 PLS.)
2.54 [0.100]

National Semiconductor

August 2000

LM741
Operational Amplifier

General Description

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439 and 748 in most applications.

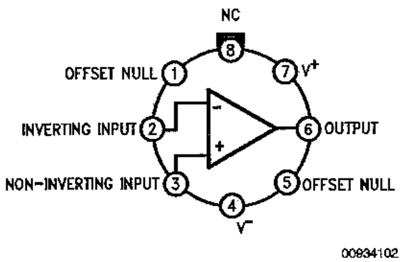
The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

The LM741C is identical to the LM741/LM741A except that the LM741C has their performance guaranteed over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

Features

Connection Diagrams

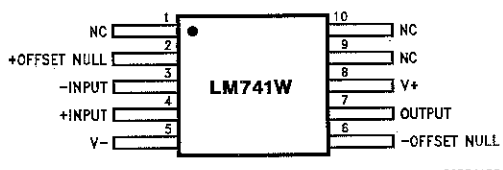
Metal Can Package



Note 1: LM741H is available per JM38510/10101

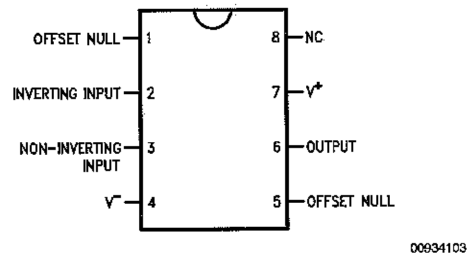
Order Number LM741H, LM741H/883 (Note 1), LM741AH/883 or LM741CH
See NS Package Number H08C

Ceramic Flatpak



Order Number LM741W/883
See NS Package Number W10A

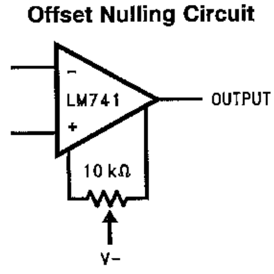
Dual-In-Line or S.O. Package



Order Number LM741J, LM741J/883, LM741CN
See NS Package Number J08A, M08A or N08E

Typical Application

Offset Nulling Circuit



Electrical Characteristics (Note 5) (Continued)

Note 3: For operation at elevated tamperatures, these devices must be derated based on thermal resistance, and T_j max. (listed under "Absolute Maximum Ratings"). $T_j = T_A + (\theta_{jA} P_D)$.

Thermal Resistance	Cerdip (J)	DIP (N)	HO8 (H)	SO-8 (M)
θ_{jA} (Junction to Ambient)	100°C/W	100°C/W	170°C/W	195°C/W
θ_{jC} (Junction to Case)	N/A	N/A	25°C/W	N/A

Note 4: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

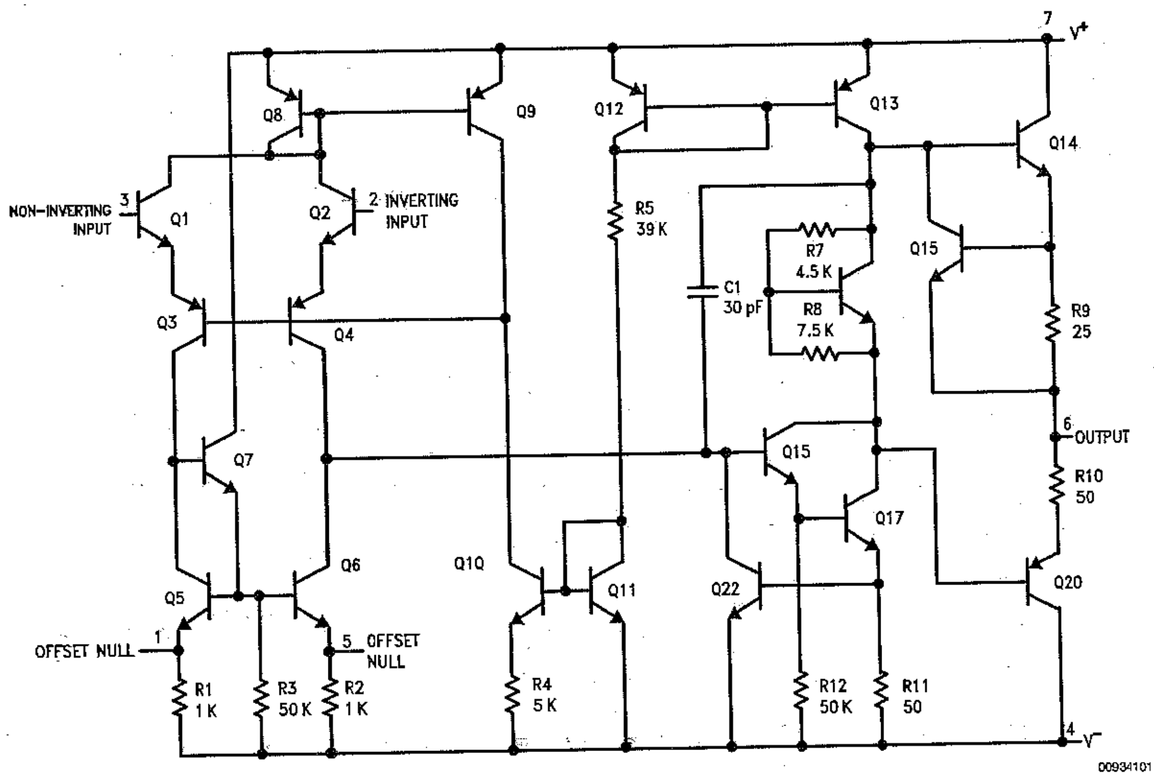
Note 5: Unless otherwise specified, these specifications apply for V_S = ±15V, −55°C ≤ T_A ≤ +125°C (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to 0°C ≤ T_A ≤ +70°C.

Note 6: Calculated value from: BW (MHz) = 0.35/Rise Time(µs).

Note 7: For military specifications see RETS741X for LM741 and RETS741AX for LM741A.

Note 8: Human body model, 1.5 kΩ in series with 100 pF.

Schematic Diagram



NPN high-voltage transistors BF458; BF459

FEATURES

- Low current (max. 100 mA)
- High voltage (max. 300 V).

APPLICATIONS

- Intended for video output stages in black-and-white and in colour television receivers.

DESCRIPTION

NPN transistors in a TO-126; SOT32 plastic package.

PINNING

PIN	DESCRIPTION
1	emitter
2	collector, connected to mounting base
3	base

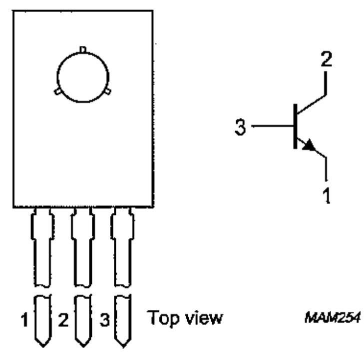


Fig.1 Simplified outline (TO-126; SOT32) and symbol.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

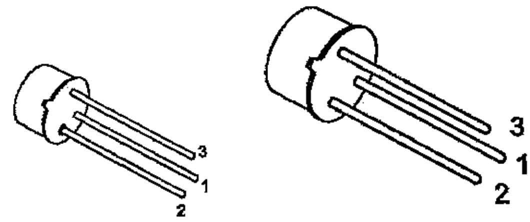
SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	BF458		–	250	V
	BF459		–	300	V
V_{CEO}	collector-emitter voltage	open base			
	BF458		–	250	V
	BF459		–	300	V
V_{EBO}	emitter-base voltage	open collector	–	5	V
I_C	collector current (DC)		–	100	mA
I_{CM}	peak collector current		–	300	mA
I_{BM}	peak base current		–	100	mA
P_{tot}	total power dissipation	$T_{mb} \leq 90$ °C	–	6	W
T_{stg}	storage temperature		–65	+150	°C
T_j	junction temperature		–	150	°C
T_{amb}	operating ambient temperature		–65	+150	°C

HIGH SPEED SWITCHES

DESCRIPTION

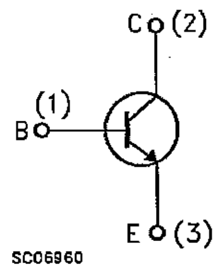
The 2N2219A and 2N2222A are silicon planar epitaxial NPN transistors in Jedec TO-39 (for 2N2219A) and in Jedec TO-18 (for 2N2222A) metal case. They are designed for high speed switching application at collector current up to 500mA, and feature useful current gain over a wide range of collector current, low leakage currents and low saturation voltage.

2N2219A approved to CECC 50002-100, 2N2222A approved to CECC 50002-101 available on request.



TO-18 TO-39

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

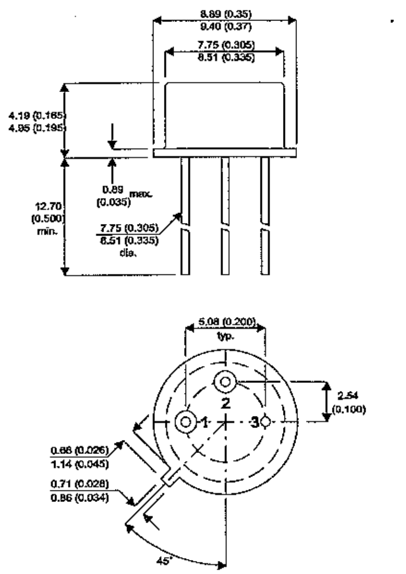
Symbol	Parameter	Value	Unit
V_{CBO}	Collector-Base Voltage ($I_E = 0$)	75	V
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)	40	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)	6	V
I_C	Collector Current	0.8	A
P_{tot}	Total Dissipation at $T_{amb} \leq 25\ ^oC$		
	for **2N2219A**	0.8	W
	for **2N2222A**	0.5	W
	at $T_{case} \leq 25\ ^oC$		
	for **2N2219A**	3	W
	for **2N2222A**	1.8	W
T_{stg}	Storage Temperature	-65 to 200	^oC
T_j	Max. Operating Junction Temperature	175	^oC

SEME LAB

2N3053

MECHANICAL DATA
Dimensions in mm (inches)

MEDIUM POWER SILICON NPN PLANAR TRANSISTOR



TO39 PACKAGE

Underside View

Pin 1 = Emitter   Pin 2 = Base   Pin 3 = Collector

FEATURES

- V_{CEO} = 40V
- I_C = 0.7A
- P_{tot} = 5W

ABSOLUTE MAXIMUM RATINGS (T_{case} = 25°C unless otherwise stated)

V_{CBO}	Collector – Base Voltage	60V
V_{CEO}	Collector – Emitter Voltage	40V
V_{CER}	Collector – Emitter Sustaining Voltage	50V
V_{CEX}	Collector - Emiiter Voltage	60V
V_{EBO}	Emitter-Base Voltage	5V
I_C	Collector Current	0.7A
P_{TOT}	Power Dissipation T_{amb} = 25°C	1W
	T_{case} = 25°C	5W
T_j	Junction Temperature	200°C
T_{stg}	Storage Temperature	–65 to 200°C
$R_{th(jc)}$	Thermal Resistance Junction to Case	35°C / W
$R_{th(ja)}$	Thermal Resistance Junction to Ambient	175°C / W

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Manufacturers of World Class Discrete Semiconductors

Data Sheet

2N4248
2N4249
2N4250
2N4250A

SILICON PNP TRANSISTOR

JEDEC TO-106 CASE

DESCRIPTION

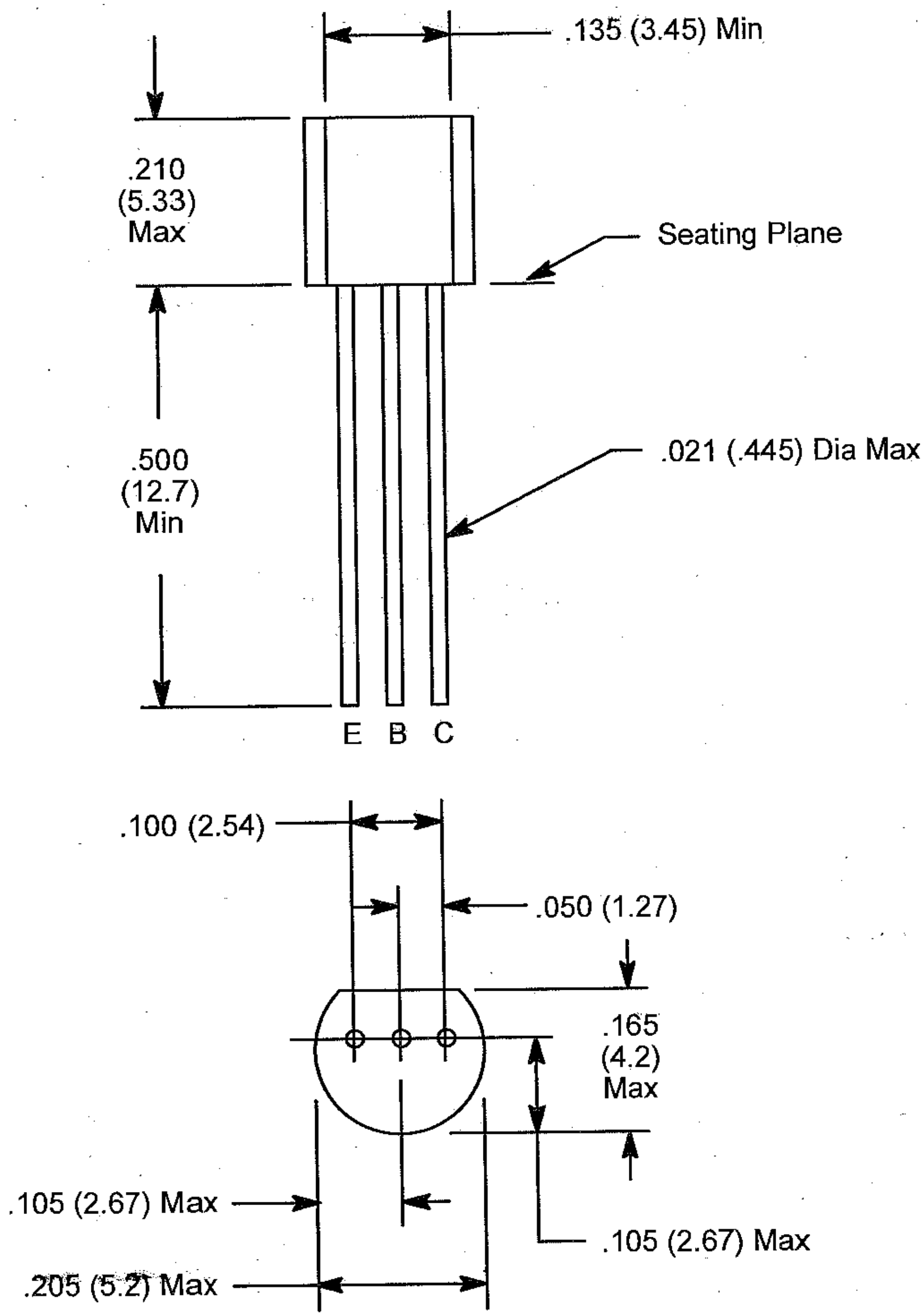
The CENTRAL SEMICONDUCTOR 2N4248 Series Types are Silicon PNP Transistors designed for low level - low noise amplifier applications.

MAXIMUM RATINGS (T_A=25°C)

	SYMBOL	2N4248 2N4250	2N4249 2N4250A	UNIT
Collector-Base Voltage	V_{CBO}	40	60	V
Collector-Emitter Voltage	V_{CES}	40	60	V
Collector-Emitter Voltage	V_{CEO}	40	60	V
Emitter-Base Voltage	V_{EBO}	5.0	5.0	V
Power Dissipation	P_D	200	200	mW
Operating and Storage Junction Temperature	T_J, T_{stg}	-55 TO +150		°C

ELECTRICAL CHARACTERISTICS (T_A=25°C)

SYMBOL		2N4248 MIN	2N4248 MAX	2N4249 MIN	2N4249 MAX	2N4250 MIN	2N4250 MAX	2N4250A MIN	2N4250A MAX	UNIT
I_{CBO}	V_{CB}=40V (2N4250A V_{CB}=50V)		10		10		10		10	ηA
I_{EBO}	V_{EB}=3.0V		20		20		20		20	ηA
BV_{CBO}	I_C=10μA	40		60		40		60		V
BV_{CES}	I_C=10μA	40		60		40		60		V
BV_{CEO}	I_C=5.0mA	40		60		40		60		V
BV_{EBO}	I_E=10μA	5.0		5.0		5.0		5.0		V
$V_{CE(s)}$	I_C=10mA, I_B=0.5mA		0.25		0.25		0.25		0.25	V
$V_{BE(s)}$	I_C=10mA, I_B=0.5mA		0.9		0.9		0.9		0.9	V
h_{FE}	V_{CE}=5.0V, I_C=100μA	50		100	300	250	700	250	700	
h_{FE}	V_{CE}=5.0V, I_C=1.0mA	50		100		250		---		
h_{FE}	V_{CE}=5.0V, I_C=10mA	50		100		250		---		
f_T	V_{CE}=5.0V, I_C=0.5mA, f=20MHz	40		40		50		---		MHz
C_{ob}	V_{CB}=5.0V, f=1.0MHz		6.0		6.0		6.0		6.0	pF
C_{IB}	V_{EB}=0.5V, f=1.0MHz		16		16		16		---	pF
NF	Wide Band, V_{CE}=5.0V, I_C=20μA, R_S=100KΩ PBW=15.7kHz, f=10Hz TO 10kHz		---		3.0		2.0		2.0	dB
NF	Narrow Band, V_{CE}=5.0V, I_C=20μA, R_S=10KΩ PBW=150Hz, f=1.0kHz		---		3.0		2.0		2.0	dB


.135 (3.45) Min
.210
(5.33)
Max
Seating Plane
.500
(12.7)
Min
.021 (.445) Dia Max
E B C
.100 (2.54)
.050 (1.27)
.165
(4.2)
Max
.105 (2.67) Max
.105 (2.67) Max
.205 (5.2) Max

n-channel JFETs designed for . . .

Siliconix

Performance Curves NC
See Section 5

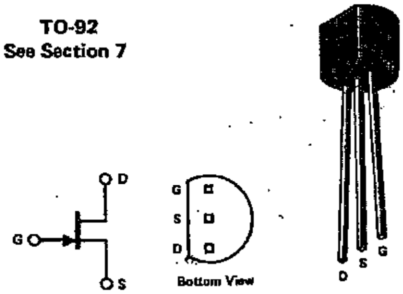
- ■ **Analog Switches**
- ■ **Commutators**
- ■ **Choppers**

BENEFITS

- Low Cost
- Industry Standard Package
- Automatic Insertion Package
- Fast Switching
  $t_{rise} < 5$ ns (2N5638)
- Low Insertion Loss
  $R_{DS(on)} < 30\ \Omega$ (2N5638)
- Short Sample and Hold Aperture Time
  $C_{rss} < 4$ pF

2N5638 2N5639 2N5640

TO-92
See Section 7



*ABSOLUTE MAXIMUM RATINGS (25°C)

Drain-Source Breakdown Voltage . . . . 30 V
Drain-Gate Breakdown Voltage . . . . 30 V
Source-Gate Breakdown Voltage . . . . 30 V
Forward Gate Current . . . . 10 mA
Total Device Dissipation at T_{LEAD} = 25°C . . . . . . 625 mW
  Derate above 25°C . . . . 5.68 mW/°C
Operating Junction Temperature Range . . . . . -65 to +135°C
Storage Temperature Range . . . . -65 to +150°C
Lead Temperature
  (1/16" from case for 10 seconds) . . . . 300°C

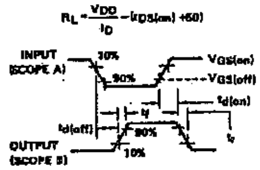
*ELECTRICAL CHARACTERISTICS (25°C unless otherwise noted)

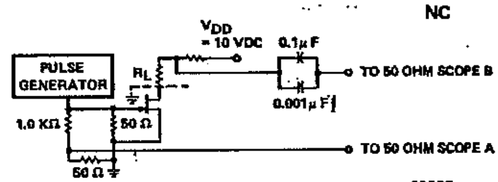
#		Symbol	Characteristic	2N5638 Min	2N5638 Max	2N5639 Min	2N5639 Max	2N5640 Min	2N5640 Max	Unit	Test Conditions	
1	STATIC	BV_{GSS}	Gate-Source Breakdown Voltage	-30		-30		-30		V	$I_G = -10\ \mu A$, $V_{DS} = 0$	
2		I_{GSS}	Gate Reverse Current		-1.0		-1.0		-1.0	nA	$V_{GS} = -15$ V, $V_{DS} = 0$	
3					-1.0		-1.0		-1.0	μA		$T_A = +100°C$
4		$I_{D(off)}$	Drain Cutoff Current		1.0		1.0		1.0	nA	$V_{DS} = 15$ V, $V_{GS} = -12$ V (2N5638) $V_{GS} = -8$ V (2N5639), $V_{GS} = -6$ V (2N5640)	
5					1.0		1.0		1.0	μA		$T_A = +100°C$
6		I_{DSS}	Saturation Drain Current	50		25		5.0		mA	$V_{DS} = 20$ V, $V_{GS} = 0$ (Note 1)	
7		$V_{DS(on)}$	Drain-Source ON Voltage		0.5		0.5		0.5	V	$V_{GS} = 0$, $I_D = 12$ mA (2N5638), $I_D = 6$ mA (2N5639), $I_D = 3$ mA (2N5640)	
8		$r_{DS(on)}$	Static Drain-Source ON Resistance		30		60		100	Ω	$I_D = 1$ mA, $V_{GS} = 0$	
9	DYN	$r_{ds(on)}$	Drain-Source ON Resistance		30		60		100	Ω	$V_{GS} = 0$, $I_D = 0$	f = 1 kHz
10		C_{iss}	Common-Source Input Capacitance		10		10		10	pF	$V_{GS} = -12$ V, $V_{DS} = 0$	f = 1 MHz
11		C_{rss}	Common-Source Reverse Transfer Capacitance		4.0		4.0		4.0	pF		
12	SW	$t_{d(on)}$	Turn-On Delay Time		4.0		6.0		8.0	nsec	$V_{DD} = 10$ V, $I_{D(on)} = 12$ mA (2N5638) $R_L = 800\ \Omega$ (2N5638)	
13		t_r	Rise Time		5.0		8.0		10	nsec	$V_{GS(on)} = 0$, $I_{D(on)} = 6$ mA (2N5639) $R_L = 1.6k\ \Omega$ (2N5639)	
14		$t_{d(off)}$	Turn-OFF Delay Time		5.0		10		15	nsec	$V_{GS(off)} = -10$ V, $I_{D(on)} = 3$ mA (2N5640) $R_L = 3.2k\ \Omega$ (2N5640)	
15		t_f	Fall Time		10		20		30	nsec		

* JEDEC registered data

NOTE:

1 Pulse test PW ≤ 300 μsec, duty cycle ≤ 3.0%





NC

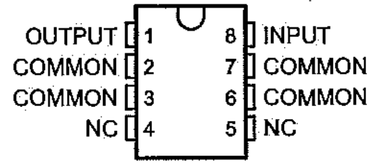
SCOPE TEKTRONIX 567A OR EQUIVALENT

$R_L = \frac{V_{DD}}{I_D} - (r_{DS(on)} + 50)$

Siliconix

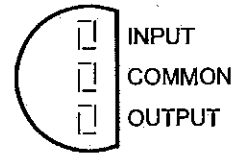
- **3-Terminal Regulators**
- **Output Current up to 100 mA**
- **No External Components**
- **Internal Thermal-Overload Protection**
- **Internal Short-Circuit Current Limiting**
- **Direct Replacements for Fairchild μA78L00 Series**

**D PACKAGE
(TOP VIEW)**



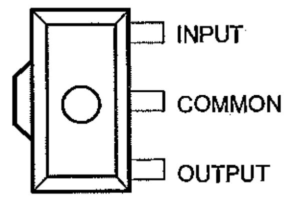
NC – No internal connection

**LP PACKAGE
(TOP VIEW)**



TO–226AA

**PK PACKAGE
(TOP VIEW)**



The center lead is in electrical contact with the tab.

description

This series of fixed-voltage integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. In addition, they can be used with power-pass elements to make high-current voltage regulators. One of these regulators can deliver up to 100 mA of output current. The internal limiting and thermal-shutdown features of these regulators essentially make them immune to overload. When used as a replacement for a zener diode-resistor combination, an effective improvement in output impedance can be obtained, together with lower bias current.

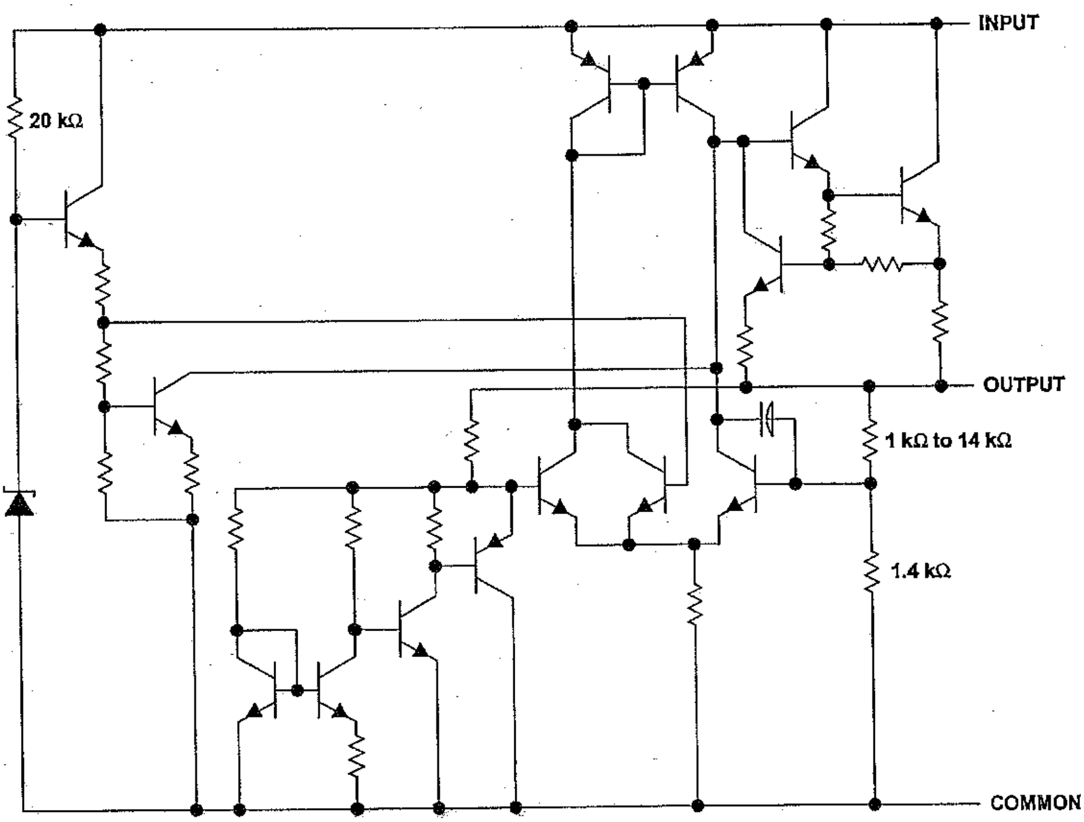
The μA78L00C and μA78L00AC series are characterized for operation over the virtual junction temperature range of 0°C to 125°C. The μA78L05AI is characterized for operation over the virtual junction temperature range of –40°C to 125°C.

AVAILABLE OPTIONS

T_J	$V_{O(NOM)}$ (V)	PACKAGE					
		SMALL OUTLINE (D)		PLASTIC CYLINDRICAL (LP)		SOT-89 (PK)	
		OUTPUT VOLTAGE TOLERANCE					
		5%	10%	5%	10%	5%	10%
0°C to 125°C	2.6	µA78L02ACD	–	µA78L02ACLP	–	–	–
	5	µA78L05ACD	µA78L05CD	µA78L05ACLP	µA78L05CLP	µA78L05ACPK	µA78L05CPK
	6.2	–	–	µA78L06ACLP	–	µA78L06ACPK	–
	8	µA78L08ACD	µA78L08CD	µA78L08ACLP	–	µA78L08ACPK	µA78L08CPK
	9	µA78L09ACD	–	µA78L09ACLP	µA78L09CLP	µA78L09ACPK	–
	10	µA78L10ACD	–	µA78L10ACLP	–	µA78L10ACPK	–
	12	µA78L12ACD	–	µA78L12ACLP	–	µA78L12ACPK	–
	15	µA78L15ACD	–	µA78L15ACLP	–	µA78L15ACPK	–
–40°C to 125°C	5	–	–	µA78L05AILP	–	–	–

D and LP packages are available taped and reeled. Add the suffix R to the device type (e.g., µA78L05ACDR). The PK package is only available taped and reeled (do not add the suffix R to the device type).

schematic



NOTE A: Resistor values shown are nominal.

absolute maximum ratings over virtual junction temperature range (unless otherwise noted)†

Input voltage, V_I: μA78L02AC, μA78L05C–μA78L09C, μA78L10AC .... 30 V
μA78L12C, μA78L12AC, μA78L15C, μA78L15AC .... 35 V
Package thermal impedance, θ_{JA} (see Notes 1 and 2): D package .... 97°C/W
LP package .... 156°C/W
PK package .... 52°C/W
Virtual junction temperature, T_J .... 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds .... 260°C
Storage temperature range, T_{stg} .... –65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal-overload protection may be activated at power levels slightly above or below the rated dissipation.
2. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions

			MIN	MAX	UNIT
V_I	Input voltage	μA78L02AC	4.75	20	V
		μA78L05C, μA78L05AC	7	20	
		μA78L06C, μA78L06AC	8.5	20	
		μA78L08C, μA78L08AC	10.5	23	
		μA78L09C, μA78L09AC	11.5	24	
		μA78L10AC	12.5	25	
		μA78L12C, μA78L12AC	14.5	27	
		μA78L15C, μA78L15AC	17.5	30	
I_O	Output current			100	mA
T_J	Operating virtual junction temperature range	μA78LxxC and μA78LxxAC series	0	125	°C
		μA78L05AI	–40	125	

LM350

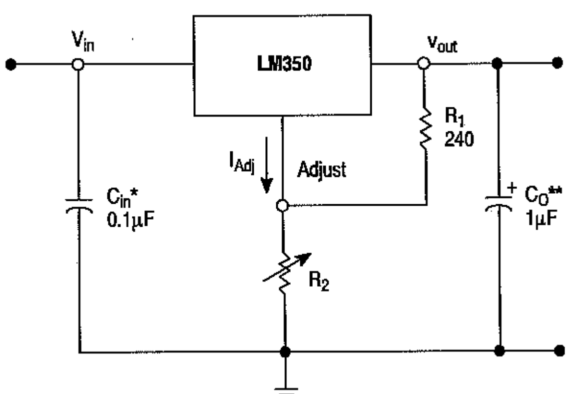
3.0 A, Adjustable Output, Positive Voltage Regulator

The LM350 is an adjustable three–terminal positive voltage regulator capable of supplying in excess of 3.0 A over an output voltage range of 1.2 V to 33 V. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, it employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow–out proof.

The LM350 serves a wide variety of applications including local, on card regulation. This device also makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the LM350 can be used as a precision current regulator.

Features

- Guaranteed 3.0 A Output Current
- Output Adjustable between 1.2 V and 33 V
- Load Regulation Typically 0.1%
- Line Regulation Typically 0.005%/V
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting Constant with Temperature
- Output Transistor Safe Area Compensation
- Floating Operation for High Voltage Applications
- Standard 3–lead Transistor Package
- Eliminates Stocking Many Fixed Voltages
- Pb–Free Packages are Available*



* = C_{in} is required if regulator is located an appreciable distance from power supply filter.
** = C_O is not needed for stability, however, it does improve transient response.

$$V_{out} = 1.25\ V\left(1 \le \frac{R_2}{R_1}\right) \le I_{Adj} R_2$$

ince I_{Adj} is controlled to less than 100 μA, the error associated with this term is negligible in most application

Figure 1. Simplified Application

*For additional information on our Pb–Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

ON Semiconductor®

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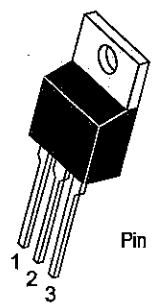
THREE–TERMINAL ADJUSTABLE POSITIVE VOLTAGE REGULATOR

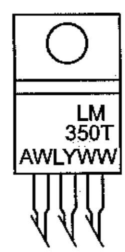


TO–220
T SUFFIX
PLASTIC PACKAGE
CASE 221A

Pin 1. Adjust
2. V_{out}
3. V_{in}

Heatsink surface is connected to Pin 2.

MARKING DIAGRAM



A = Assembly Location
WL = Wafer Lot
Y = Year
WW = Work Week

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 3 of this data sheet.

December, 2004 – Rev. 3

Publication Order Number:
LM350/D

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input–Output Voltage Differential	$V_I–V_O$	35	Vdc
Power Dissipation	P_D	Internally Limited	W
Operating Junction Temperature Range	T_J	−40 to +125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Soldering Lead Temperature (10 seconds)	T_{solder}	300	°C

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

ELECTRICAL CHARACTERISTICS ($V_I–V_O$ = 5.0 V; I_L = 1.5 A; T_J = T_{low} to T_{high}; P_{max} [Note 1], unless otherwise noted.)

Characteristics	Figure	Symbol	Min	Typ	Max	Unit
Line Regulation (Note 2) T_A = 25°C, 3.0 V ≤ $V_I–V_O$ ≤ 35 V	1	Reg_{line}	–	0.0005	0.03	%/V
Load Regulation (Note 2) T_A = 25°C, 10 mA ≤ I_l ≤ 3.0 A V_O ≤ 5.0 V V_O ≥ 5.0 V	2	Reg_{load}	 – –	 5.0 0.1	 25 0.5	 mV % V_O
Thermal Regulation, Pulse = 20 ms, (T_A = +25°C)		Reg_{therm}	–	0.002	–	% V_O/W
Adjustment Pin Current	3	I_{Adj}	–	50	100	μA
Adjustment Pin Current Change 3.0 V ≤ $V_I–V_O$ ≤ 35 V 10 mA ≤ I_L ≤ 3.0 A, P_D ≤ P_{max}	1,2	ΔI_{Adj}	–	0.2	5.0	μA
Reference Voltage 3.0 V ≤ $V_I–V_O$ ≤ 35 V 10 mA ≤ I_O ≤ 3.0 A, P_D ≤ P_{max}	3	V_{ref}	1.20	1.25	1.30	V
Line Regulation (Note 2) 3.0 V ≤ $V_I–V_O$ ≤ 35 V	1	Reg_{line}	–	0.02	0.07	%/V
Load Regulation (Note 2) 10 mA ≤ I_L ≤ 3.0 A V_O ≤ 5.0 V V_O ≥ 5.0 V	2	Reg_{load}	 – –	 20 0.3	 70 1.5	 mV % V_O
Temperature Stability (T_{low} ≤ T_J ≤ T_{high})	3	T_S	–	1.0	–	% V_O
Minimum Load Current to Maintain Regulation ($V_I–V_O$ = 35 V)	3	I_{Lmin}	–	3.5	10	mA
Maximum Output Current $V_I–V_O$ ≤ 10 V, P_D ≤ P_{max} $V_I–V_O$ = 30 V, P_D ≤ P_{max}, T_A = 25°C	3	I_{max}	 3.0 0.25	 4.5 1.0	 – –	A
RMS Noise, % of V_O T_A= 25°C, 10 Hz ≤ f ≤ 10 kHz		N	–	0.003	–	% V_O
Ripple Rejection, V_O = 10 V, f = 120 Hz (Note 3) Without C_{Adj} C_{Adj} = 10 μF	4	RR	 – 66	 65 80	 – –	dB
Long Term Stability, T_J = T_{high} (Note 4) T_A= 25°C for Endpoint Measurements	3	S	–	0.3	1.0	%/1.0 k Hrs.
Thermal Resistance, Junction–to–Case Peak (Note 5) Average (Note 6)		$R_{\theta JC}$	 – –	 2.3 –	 – 1.5	°C/W

1. T_{low} to T_{high} = 0° to +125°C; P_{max} = 25 W for LM350T; T_{low} to T_{high} = −40° to +125°C; P_{max} = 25 W for LM350BT
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.
3. C_{Adj}, when used, is connected between the adjustment pin and ground.
4. Since Long–Term Stability cannot be measured on each device before shipment, this specification is an engineering estimate of average stability from lot to lot.
5. Thermal Resistance evaluated measuring the hottest temperature on the die using an infrared scanner. This method of evaluation yields very accurate thermal resistance values which are conservative when compared to the other measurement techniques.
6. The average die temperature is used to derive the value of thermal resistance junction to case (average).