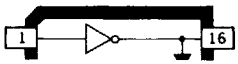
T-43-25

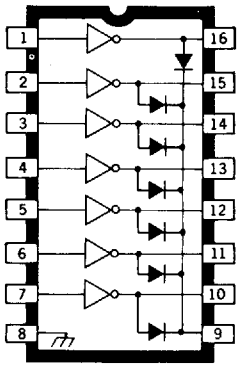
# 2001 THRU 2024

# HIGH-VOLTAGE, HIGH-CURRENT DARLINGTON ARRAYS

**ULN20XXL**




**ULN20XXA**




Dwg. No. A-9594

## ABSOLUTE MAXIMUM RATINGS

Output Voltage, $V_{CE}$
(ULN200X*, ULN2013A) . . . . . **50 V**
(ULN202X*) . . . . . **95 V**
Input Voltage, $V_{IN}$ . . . . . **30 V**
Continuous Output Current, $I_C$
(ULN200X*, ULN202X*) . . . . . **500 mA**
(ULN2013A) . . . . . **600 mA**
Continuous Input Current, $I_{IN}$ . . . . . **25 mA**
Power Dissipation, $P_D$
(one Darlington pair) . . . . . **1.0 W**
(total package) . . . . . **See Graph**
Operating Temperature Range,
$T_A$ . . . . . **-20°C to +85°C**
Storage Temperature Range,
$T_S$ . . . . . **-55°C to +150°C**

Note that the ULN2000A series (dual in-line package) and ULN2000L series (small-outline IC package) are electrically identical and share a common pin number assignment.

Ideally suited for interfacing between low-level logic circuitry and multiple peripheral power loads, the Series ULN2000A/L high-voltage, high-current Darlington arrays feature continuous load current ratings to 600 mA for each of the seven drivers. At an appropriate duty cycle depending on ambient temperature and number of drivers turned ON simultaneously, typical power loads totaling over 260 W (400 mA x 7, 95 V) can be controlled. Typical loads include relays, solenoids, stepping motors, magnetic print hammers, multiplexed LED and incandescent displays, and heaters. All devices feature open collector outputs with integral clamp diodes.

The ULN2001A device is a general-purpose array that may be used with external input current limiting, or with most PMOS or CMOS logic directly.

The Series ULN20x3A/L has series input resistors selected for operation directly with 5 V TTL or CMOS. These devices will handle numerous interface needs—particularly those beyond the capabilities of standard logic buffers.

The Series ULN20x4A/L features series input resistors for operation directly from 6 to 15 V CMOS or PMOS logic outputs.

The Series ULN200xA/L is the standard Darlington array. The outputs are capable of sinking 500 mA and will withstand at least 50 V in the OFF state. Outputs may be paralleled for higher load current capability. The ULN2013A device is similar except that it will sink 600 mA. The Series ULN202xA/L will withstand 95 V in the OFF state.

These Darlington arrays are furnished in 16-pin dual in-line plastic packages (suffix A) and 16-lead surface-mountable SOICs (suffix L). All devices are pinned with outputs opposite inputs to facilitate ease of circuit board layout.

## FEATURES

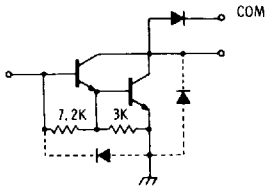
- TTL, DTL, PMOS, or CMOS Compatible Inputs
- Output Current to 600 mA
- Output Voltage to 95 V
- Transient-Protected Outputs
- Dual In-Line Plastic Package or Small-Outline IC Package

x = digit to identify specific device. Characteristic shown applies to family of devices with remaining digits as shown. See matrix on next page.

# 2001 THRU 2024
# *HIGH-VOLTAGE, HIGH-CURRENT DARLINGTON ARRAYS*

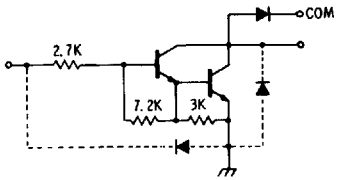
## PARTIAL SCHEMATICS

**ULN2001A (Each Driver)**



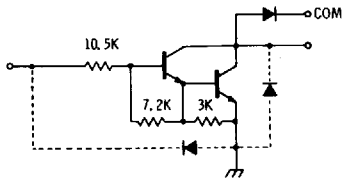

Dwg. No. A-9595

**ULN20X3A/L (Each Driver)**




Dwg. No. A-9651

**ULN20X4A/L (Each Driver)**

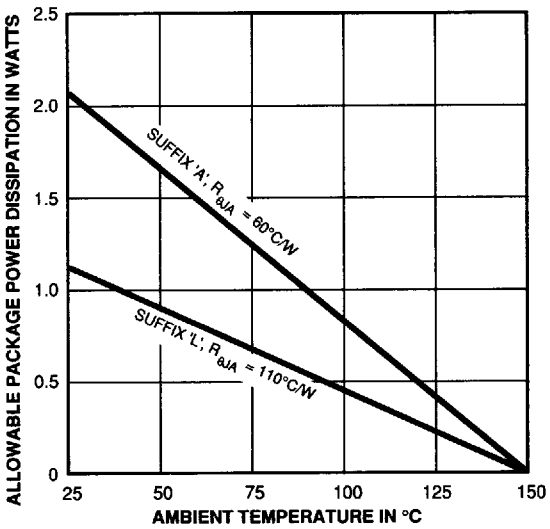



Dwg. No. A-9898A

## DEVICE NUMBER DESIGNATION

| $V_{CE(MAX)}$ | 50V | 50V | 95V |
|---|---|---|---|
| $I_{C(MAX)}$ | 500 mA | 600 mA | 500 mA |
| **Logic** | **Part Number** | | |
| General Purpose PMOS, CMOS | ULN2001A* | — | — |
| 5 V TTL, CMOS | ULN2003A* ULN2003L* | ULN2013A* | ULN2023A* ULN2023L |
| 6-15 V CMOS, PMOS | ULN2004A* ULN2004L* | — | ULN2024A |

*Also available for operation between -40°C and +85°C. To order, change prefix from 'ULN' to 'ULQ'.




Dwg. No. GP-006

X = Digit to identify specific device. Specification shown applies to family of devices with remaining digits as shown. See matrix above.

# 2001 THRU 2024
# *HIGH-VOLTAGE, HIGH-CURRENT DARLINGTON ARRAYS*

**SERIES ULN2000A/L**

## ELECTRICAL CHARACTERISTICS at +25°C (unless otherwise noted).

| Characteristic | Symbol | Test Fig. | Applicable Devices | Test Conditions | Limits Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|---|
| Output Leakage Current | $I_{CEX}$ | 1A | All | $V_{CE}$ = 50 V, $T_A$ = 25°C | — | < 1 | 50 | µA |
| | | | | $V_{CE}$ = 50 V, $T_A$ = 70°C | — | < 1 | 100 | µA |
| | | 1B | ULN2004* | $V_{CE}$ = 50 V, $T_A$ = 70°C, $V_{IN}$ = 1.0 V | — | < 5 | 500 | µA |
| Collector-Emitter Saturation Voltage | $V_{CE(SAT)}$ | 2 | All | $I_C$ = 100 mA, $I_B$ = 250 µA | — | 0.9 | 1.1 | V |
| | | | | $I_C$ = 200 mA, $I_B$ = 350 µA | — | 1.1 | 1.3 | V |
| | | | | $I_C$ = 350 mA, $I_B$ = 500 µA | — | 1.3 | 1.6 | V |
| Input Current | $I_{IN(ON)}$ | 3 | ULN2003* | $V_{IN}$ = 3.85 V | — | 0.93 | 1.35 | mA |
| | | | ULN2004* | $V_{IN}$ = 5.0 V | — | 0.35 | 0.5 | mA |
| | | | | $V_{IN}$ = 12 V | — | 1.0 | 1.45 | mA |
| | $I_{IN(OFF)}$ | 4 | All | $I_C$ = 500 µA, $T_A$ = 70°C | 50 | 65 | — | µA |
| Input Voltage | $V_{IN(ON)}$ | 5 | ULN2003* | $V_{CE}$ = 2.0 V, $I_C$ = 200 mA | — | — | 2.4 | V |
| | | | | $V_{CE}$ = 2.0 V, $I_C$ = 250 mA | — | — | 2.7 | V |
| | | | | $V_{CE}$ = 2.0 V, $I_C$ = 300 mA | — | — | 3.0 | V |
| | | | ULN2004* | $V_{CE}$ = 2.0 V, $I_C$ = 125 mA | — | — | 5.0 | V |
| | | | | $V_{CE}$ = 2.0 V, $I_C$ = 200 mA | — | — | 6.0 | V |
| | | | | $V_{CE}$ = 2.0 V, $I_C$ = 275 mA | — | — | 7.0 | V |
| | | | | $V_{CE}$ = 2.0 V, $I_C$ = 350 mA | — | — | 8.0 | V |
| D-C Forward Current Transfer Ratio | $h_{FE}$ | 2 | ULN2001A | $V_{CE}$ = 2.0 V, $I_C$ = 350 mA | 1000 | — | — | — |
| Input Capacitance | $C_{IN}$ | — | All | | — | 15 | 25 | pF |
| Turn-On Delay | $t_{PLH}$ | 8 | All | 0.5 $E_{IN}$ to 0.5 $E_{OUT}$ | — | 0.25 | 1.0 | µs |
| Turn-Off Delay | $t_{PHL}$ | 8 | All | 0.5 $E_{IN}$ to 0.5 $E_{OUT}$ | — | 0.25 | 1.0 | µs |
| Clamp Diode Leakage Current | $I_R$ | 6 | All | $V_R$ = 50 V, $T_A$ = 25°C | — | — | 50 | µA |
| | | | | $V_R$ = 50 V, $T_A$ = 70°C | — | — | 100 | µA |
| Clamp Diode Forward Voltage | $V_F$ | 7 | All | $I_F$ = 350 mA | — | 1.7 | 2.0 | V |

*Complete part number includes suffix to identify package style: A = DIP, L = SOIC.

# 2001 THRU 2024
# *HIGH-VOLTAGE, HIGH-CURRENT DARLINGTON ARRAYS*

**TYPE ULN2013A**

## ELECTRICAL CHARACTERISTICS at +25°C (unless otherwise noted).

| Characteristic | Symbol | Test Fig. | Test Conditions | Limits | | | |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | Units |
| Output Leakage Current | $I_{CEX}$ | 1A | $V_{CE}$ = 50 V, $T_A$ = 25°C | — | < 1 | 50 | µA |
| | | | $V_{CE}$ = 50 V, $T_A$ = 70°C | — | < 1 | 100 | µA |
| Collector-Emitter Saturation Voltage | $V_{CE(SAT)}$ | 2 | $I_C$ = 200 mA, $I_B$ = 350 µA | — | 1.1 | 1.3 | V |
| | | | $I_C$ = 350 mA, $I_B$ = 500 µA | — | 1.3 | 1.6 | V |
| | | | $I_C$ = 500 mA, $I_B$ = 600 µA | — | 1.7 | 1.9 | V |
| Input Current | $I_{IN(ON)}$ | 3 | $V_{IN}$ = 3.85 V | — | 0.93 | 1.35 | mA |
| | $I_{IN(OFF)}$ | 4 | $I_C$ = 500 µA, $T_A$ = 70°C | 50 | 65 | — | µA |
| Input Voltage | $V_{IN(ON)}$ | 5 | $V_{CE}$ = 2.0 V, $I_C$ = 250 mA | — | — | 2.7 | V |
| | | | $V_{CE}$ = 2.0 V, $I_C$ = 300 mA | — | — | 3.0 | V |
| | | | $V_{CE}$ = 2.0 V, $I_C$ = 500 mA | — | — | 3.5 | V |
| Input Capacitance | $C_{IN}$ | — | | — | 15 | 25 | pF |
| Turn-On Delay | $t_{ON}$ | 8 | 0.5 $E_{IN}$ to 0.5 $E_{OUT}$ | — | 0.25 | 1.0 | µs |
| Turn-Off Delay | $t_{OFF}$ | 8 | 0.5 $E_{IN}$ to 0.5 $E_{OUT}$ | — | 0.25 | 1.0 | µs |
| Clamp Diode Leakage Current | $I_R$ | 6 | $V_R$ = 50 V, $T_A$ = 25°C | — | — | 50 | µA |
| | | | $V_R$ = 50 V, $T_A$ = 70°C | — | — | 100 | µA |
| Clamp Diode Forward Voltage | $V_F$ | 7 | $I_F$ = 350 mA | — | 1.7 | 2.0 | V |
| | | | $I_F$ = 500 mA | — | 2.1 | 2.5 | V |

# 2001 THRU 2024
## *HIGH-VOLTAGE, HIGH-CURRENT DARLINGTON ARRAYS*

**SERIES ULN2020A/L**

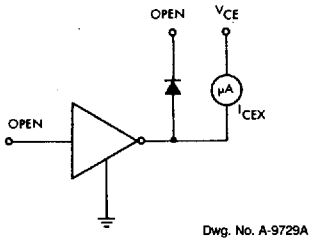
**ELECTRICAL CHARACTERISTICS at +25°C (unless otherwise noted).**

| Characteristic | Symbol | Test Fig. | Applicable Devices | Test Conditions | Limits Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|---|
| Output Leakage Current | $I_{CEX}$ | 1A | All | $V_{CE}$ = 95 V, $T_A$ = 25°C | — | < 1 | 50 | µA |
| | | | | $V_{CE}$ = 95 V, $T_A$ = 70°C | — | < 1 | 100 | µA |
| | | 1B | ULN2024A | $V_{CE}$ = 95 V, $T_A$ = 70°C, $V_{IN}$ = 1.0 V | — | < 5 | 500 | µA |
| Collector-Emitter Saturation Voltage | $V_{CE(SAT)}$ | 2 | All | $I_C$ = 100 mA, $I_B$ = 250 µA | — | 0.9 | 1.1 | V |
| | | | | $I_C$ = 200 mA, $I_B$ = 350 µA | — | 1.1 | 1.3 | V |
| | | | | $I_C$ = 350 mA, $I_B$ = 500 µA | — | 1.3 | 1.6 | V |
| Input Current | $I_{IN(ON)}$ | 3 | ULN2023* | $V_{IN}$ = 3.85 V | — | 0.93 | 1.35 | mA |
| | | | ULN2024A | $V_{IN}$ = 5.0 V | — | 0.35 | 0.5 | mA |
| | | | | $V_{IN}$ = 12 V | — | 1.0 | 1.45 | mA |
| | $I_{IN(OFF)}$ | 4 | All | $I_C$ = 500 µA, $T_A$ = 70°C | 50 | 65 | — | µA |
| Input Voltage | $V_{IN(ON)}$ | 5 | ULN2023* | $V_{CE}$ = 2.0 V, $I_C$ = 200 mA | — | — | 2.4 | V |
| | | | | $V_{CE}$ = 2.0 V, $I_C$ = 250 mA | — | — | 2.7 | V |
| | | | | $V_{CE}$ = 2.0 V, $I_C$ = 300 mA | — | — | 3.0 | V |
| | | | ULN2024A | $V_{CE}$ = 2.0 V, $I_C$ = 125 mA | — | — | 5.0 | V |
| | | | | $V_{CE}$ = 2.0 V, $I_C$ = 200 mA | — | — | 6.0 | V |
| | | | | $V_{CE}$ = 2.0 V, $I_C$ = 275 mA | — | — | 7.0 | V |
| | | | | $V_{CE}$ = 2.0 V, $I_C$ = 350 mA | — | — | 8.0 | V |
| Input Capacitance | $C_{IN}$ | — | All | | — | 15 | 25 | pF |
| Turn-On Delay | $t_{PLH}$ | 8 | All | 0.5 $E_{IN}$ to 0.5 $E_{OUT}$ | — | 0.25 | 1.0 | µs |
| Turn-Off Delay | $t_{PHL}$ | 8 | All | 0.5 $E_{IN}$ to 0.5 $E_{OUT}$ | — | 0.25 | 1.0 | µs |
| Clamp Diode Leakage Current | $I_R$ | 6 | All | $V_R$ = 95 V, $T_A$ = 25°C | — | — | 50 | µA |
| | | | | $V_R$ = 95 V, $T_A$ = 70°C | — | — | 100 | µA |
| Clamp Diode Forward Voltage | $V_F$ | 7 | All | $I_F$ = 350 mA | — | 1.7 | 2.0 | V |

*Complete part number includes suffix to identify package style: A = DIP, L = SOIC.

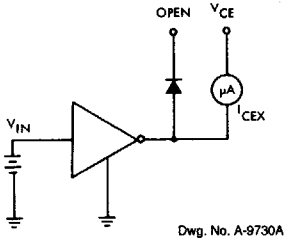
# 2001 THRU 2024
# *HIGH-VOLTAGE, HIGH-CURRENT DARLINGTON ARRAYS*

## TEST FIGURES



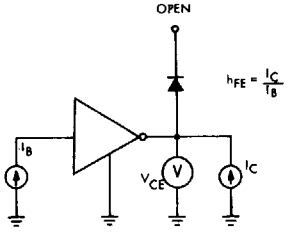

Dwg. No. A-9729A

**FIGURE 1A**



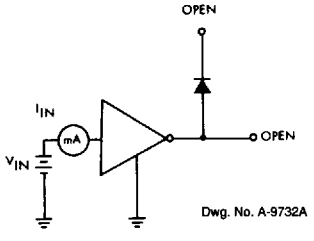

Dwg. No. A-9730A

**FIGURE 1B**



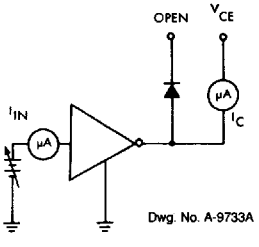

Dwg. No. A-9731A

**FIGURE 2**



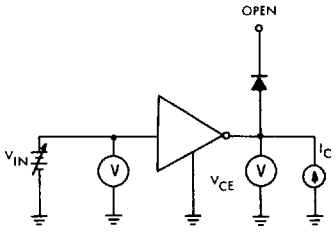

Dwg. No. A-9732A

**FIGURE 3**



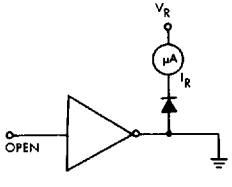

Dwg. No. A-9733A

**FIGURE 4**



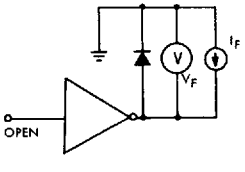

Dwg. No. A-9734A

**FIGURE 5**



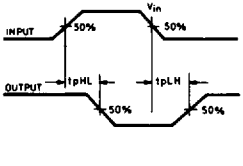

Dwg. No. A-9735A

**FIGURE 6**

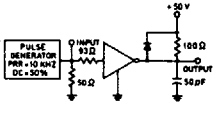



Dwg. No. A-9736A

**FIGURE 7**




| | $V_{in}$ |
|---|---|
| ULN20X1* | 3.5V |
| ULN20X3* | 3.5V |
| ULN20X4* | 12V |



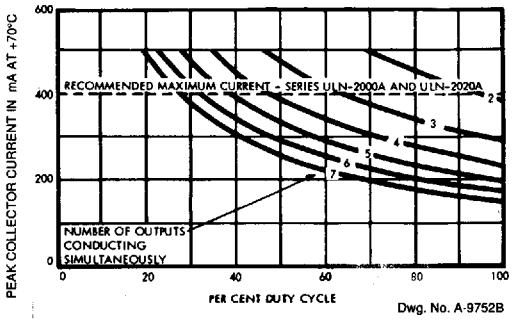

Complete part number includes a final letter to indicate package.

X = Digit to identify specific device. Specification shown applies to family of devices with remaining digits as shown.

**FIGURE 8**

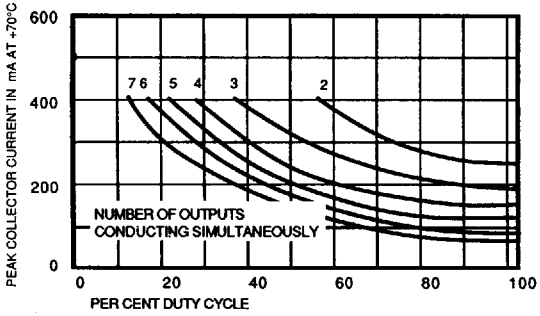
# 2001 THRU 2024
# *HIGH-VOLTAGE, HIGH-CURRENT DARLINGTON ARRAYS*

## PEAK COLLECTOR CURRENT AS A FUNCTION OF DUTY CYCLE
### (DUAL IN-LINE PACKAGED DEVICES)

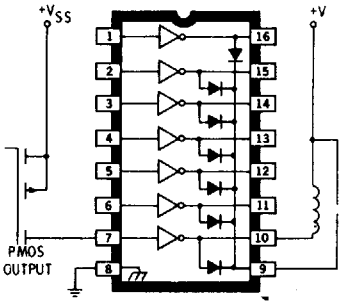



Dwg. No. A-9752B

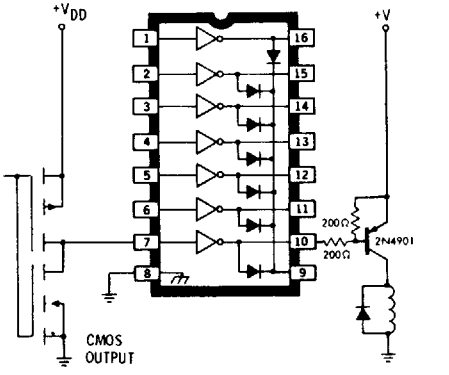
### (SMALL OUTLINE PACKAGED DEVICES)




## TYPICAL APPLICATIONS

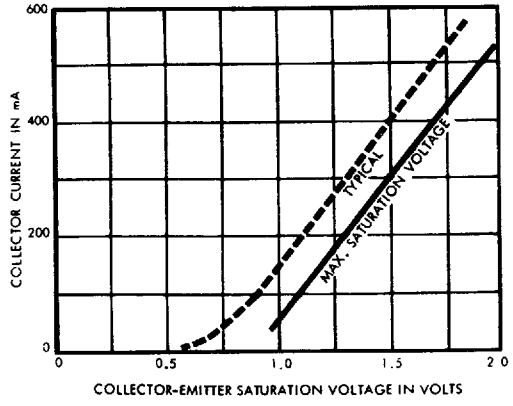



Dwg. No. A-9652



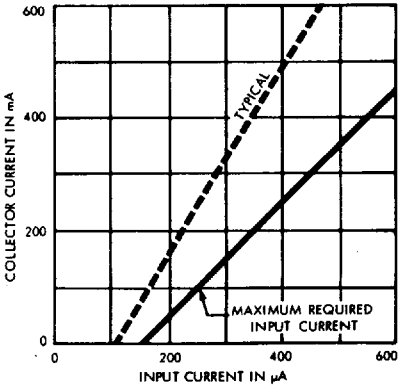

Dwg. No. A-9654A

## COLLECTOR CURRENT AS A FUNCTION OF SATURATION VOLTAGE




Dwg. No. A-9754C

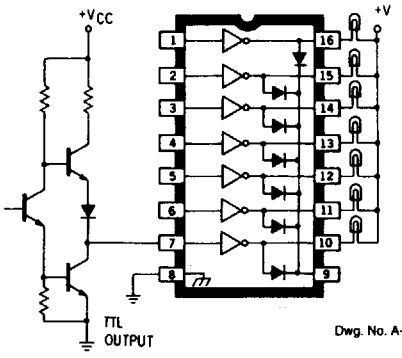
## COLLECTOR CURRENT AS A FUNCTION OF INPUT CURRENT



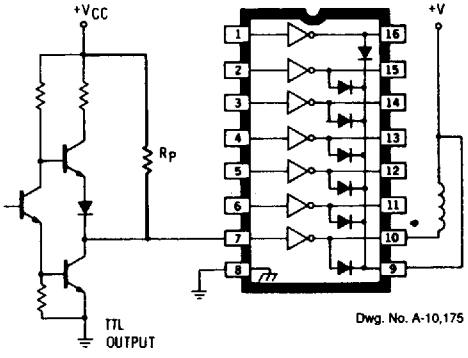

Dwg. No. A-10,872B

# 2001 THRU 2024
# *HIGH-VOLTAGE, HIGH-CURRENT DARLINGTON ARRAYS*

## TYPICAL APPLICATIONS



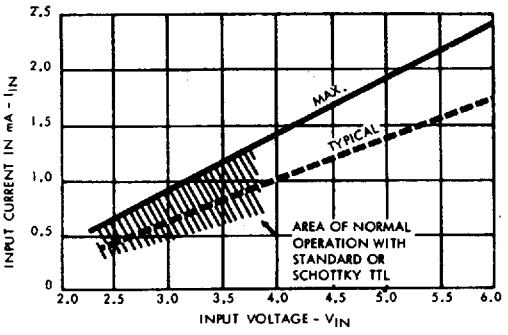

Dwg. No. A-9653A




Dwg. No. A-10,175

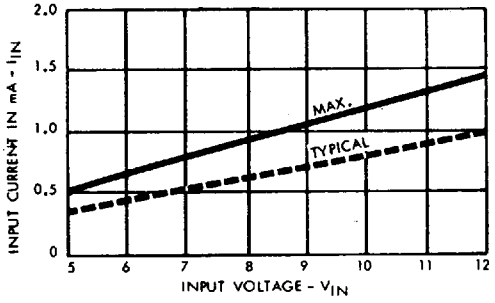
## INPUT CURRENT AS A FUNCTION OF INPUT VOLTAGE

### SERIES ULN20X3A/L




Dwg. No. A-9750B

### SERIES ULN20X4A/L




Dwg. No. A-9899A