Instructions

My Electronics

Nixie Tube Shield for Arduino

V1.1

Safety Notes

This circuit design includes a switch-mode voltage converter which generates 170 VDC. You are responsible for the safety during the assembly and operation of this device. DO NOT USE IF YOU DON'T KNOW HOW TO HANDLE HIGH VOLTAGES. All assembly and safety instructions should be read carefully before the device is operated.

Disclaimer

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Product Description

The Nixie Tube Shield allows you to drive any Nixie tube you want with an Arduino. It is a modular system consisting of a High Voltage (HV) Power Supply and a Socket Module depending on the Nixie tube you want to use. Most of the Arduino pins are available for use with other shields or modules of your project. You can use the kit to getting started with Nixie tubes and to build, e.g., a one-digit clock or a simple counter.

Features

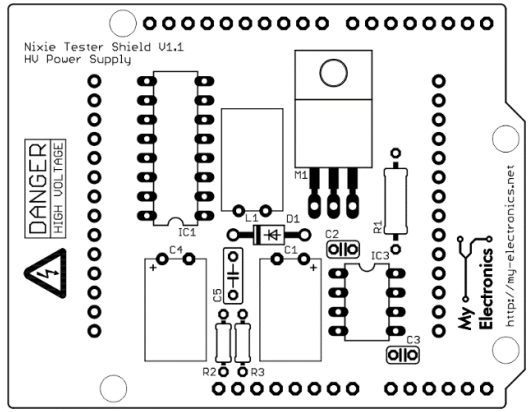
- Compatible with Arduino UNO and MEGA
- Modular system comprising a HV Power Supply and a Socket Module for connecting various types of Nixie tubes
- Very high efficiency using the MAX1771 switch-mode controller
- Customizable using the Arduino IDE
- No SMD parts

Assembly Instructions

To build this kit, you should know how to solder. If you have never soldered before, we recommend to take a look at the Soldering is Easy tutorial.

HV Power Supply

Board Layout



Parts List

Qty.	Part	Value/Description
1	R1	0.1 Ω, 2 W
1	R2	13.3 kΩ
1	R3	1.5 MΩ
1	D1	UF4004
1	M1	IRF630
1	L1	100 µH, 1 A
1	C1	220 µF, 25 V
2	C2, C3	100 nF
1	C4	4.7 µF, 250 V
1	C5	100 nF, 250 V
1	IC1	K155ID1
1	IC2	MAX1771
1		IC Socket DIP 8
1		IC Socket DIP 16
1		Pin Header 1x6
2		Pin Header 1x8
1		Pin Header 1x10
2		Female Header 1x16
1		Pan Head Screw M3 + Lock Nut

First, check if all listed parts are included in your package. We recommend to begin soldering the components with the flattest design. Start with the resistors, followed by the capacitors C2, C3 and the diode D1. Then solder the MOSFET M1 and the IC sockets. Finally, solder the capacitors C1, C4, C5, the inductivity L1 and the headers.

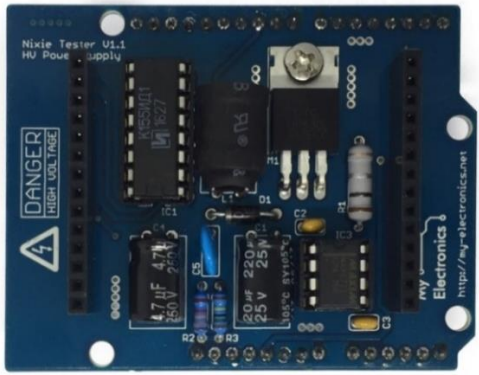
Note that the diode D1, the capacitors C1, C4 and the ICs need to be soldered/mounted in the right direction.

The kit comes with 1x16 female headers instead of the 1x14 headers required for the socket module. We recommend using a utility knife or a side cutter to shorten the headers.

The table below lists the required resistors and their corresponding color codes:

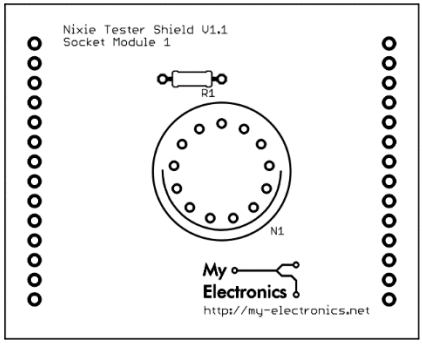
Part	Value	1st Band	2nd Band	3rd Band	4th Band	5th Band
R1	0.1 Ω	Brown	Black	Silver	Gold	-
R2	13.3 kΩ	Brown	Orange	Orange	Red	Brown
R3	1.5 MΩ	Brown	Green	Black	Yellow	Brown

The assembled PCB is shown below:



Socket Module

Board Layout



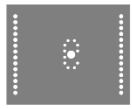
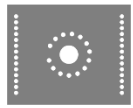
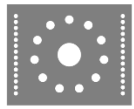
Parts List

Qty.	Part	Value/Description
1	R1	See „List of Socket Modules“ on Page 6
2		Pin Header 1x16

The front side of the Nixie tube is indicated by the semicircle.

List of Socket Modules

Socket Module		Supported Nixie Tubes	Resistor
1		IN-14	10 kΩ
2		Z570/3/4M, Z5700/30/40M, ZM1080/2, ZM1134/5/6/8, B570M, F9080B, TAF1093A, TAF1317A	16 kΩ
3		IN-12, IN-12A/B, IN15A/B, ZM1180/81/82/83/86/88, ZM1162	8.2 kΩ
4		IN-8	8.2 kΩ
5		IN-16	16 kΩ
6		IN-8-2	8.2 kΩ
7		IN-2	12 kΩ
8		IN-4	8.2 kΩ

9		IN-17	39 kΩ
10		IN-18	3.9 kΩ
11		IN-1, LC-516	16 kΩ
12		B6033, B6091, LC513, QS30-1, ZM1022	10 kΩ

Value	1st Band	2nd Band	3rd Band	4th Band	5th Band
3.9 kΩ	Orange	White	Black	Brown	Brown
8.2 kΩ	Gray	Red	Black	Brown	Brown
10 kΩ	Brown	Black	Black	Red	Brown
12 kΩ	Brown	Red	Black	Red	Brown
16 kΩ	Brown	Blue	Black	Red	Brown
39 kΩ	Orange	White	Black	Red	Brown

Operation

To use the shield, mount the HV Power Supply on top of an Arduino board followed by the Socket Module. The Socket Module is supposed to be mounted as shown on the title page.

IMPORTANT: Before operating the shield connect a 9 to 12 V external power supply to the Arduino board.

Then, connect the Arduino to your computer via USB as usual and open the sample sketch using the Arduino IDE. The sample sketch is available on our GitHub repository: Download Sample Sketch

If you are using the Arduino IDE for the first time, we recommend to take a look at the Getting Started with Arduino guide. If the sketch was uploaded without any errors and the kit was assembled properly, you should see your Nixie tube repeatedly counting from 0 to 9 with a 1 s

interval being switch off between 9 and 0. The code is explained in detail in the Functional Description section.

WARNING: The assembled kit generates HIGH VOLTAGES. If you buy the kit, you are fully responsible for the safety during the assembly and operation of this device.

Troubleshooting

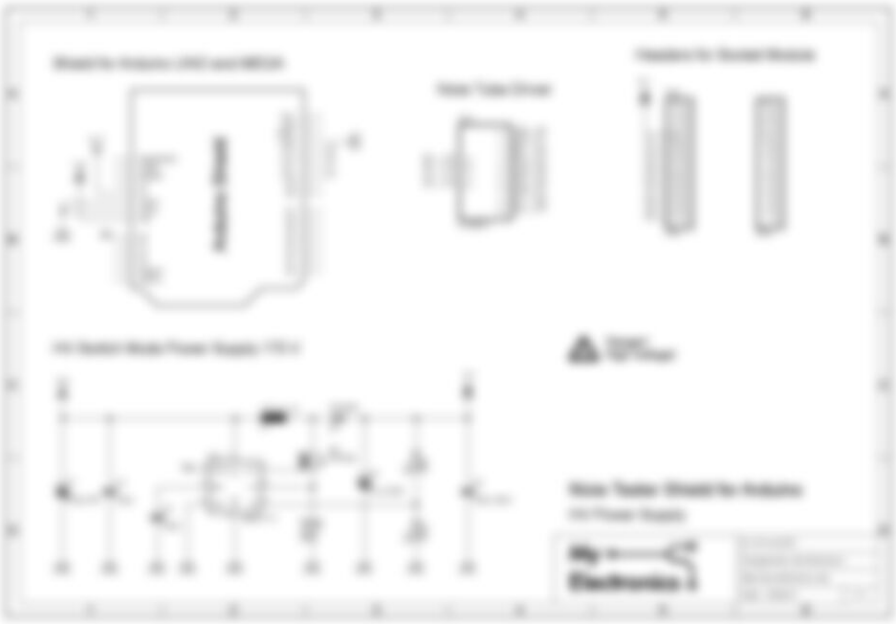
If the kit does not operate, please perform the following tests before sending a support request:

1. Check if all components are soldered properly and installed in the right position and direction
2. Check if the required external power supply is connected to your Arduino.
3. In the Arduino IDE, check if the sketch was uploaded properly.

Need help with the DIY Kit? Please send a support request with your order number or eBay ID: support@my-electronics.net

Schematics

HV Power Supply



Socket Module

Functional Description

The shield is based on a step-up switch-mode power supply which generates the 170 V required to drive Nixie tubes. There are a few ICs that can be used for step-up converters including the MC34063, MAX1771 and others. Here, the MAX1771 is used (IC2) because of its high efficiency. The IC is a step-up switching controller that uses a unique pulse-width modulation (PWM) scheme to get a high efficiency in a variety of configurations. The employed circuit is mainly adapted from the MAX1771 Datasheet. However, for a configuration like this, where the step-up is large, the component choice and board layout becomes important.

The key points are:

- M1 should be selected for low R_{DS} and Q_g
- D1 should be ultrafast recovery (t_r < 50 ns) and rated 1 A, > 170 V
- L1 should be rated 1 A
- C1 should be low ESR and close to IC2 as it must provide a high current for L1 and M1 very quickly.
- The trace between the M1 and EXT pin needs to be short to allow the gate of M1 to be charged very quickly, directly effecting the efficiency.
- The connection to the FB pin should be as short as possible as it is very sensitive to EMI interference.
- R1 must be capable of handling at least 1 A.
- C5 must be rated > 170 V.
- C4, the output capacitor, should be low ESR (< 3 Ω) and rated > 170 V.

From the MAX1771 Datasheet we get:

$$R3 = R2 \left(\frac{V_{OUT}}{1.5\ V} - 1 \right).$$

requiring R2 = 10 to 500 kΩ. To get V_{OUT} = 170 V the resistors are selected as R2 = 13.0 kΩ and R3 = 1.5 MΩ:

$$V_{OUT} = 1.5\ V \left(1 + \frac{R3}{R2} \right) = 1.5\ V \left(1 + \frac{1.5\ M\Omega}{13.3\ k\Omega} \right) = 170.7\ V.$$

The specification for, e.g., a IN-14 tube are as follows:

Supply Voltage	170 V
Operating Voltage	140 V
Cathode Current	2.5 mA

Therefore, using Ohm's law, the anode resistor should be:

$$R = \frac{170\ V - 140\ V}{2.5\ mA} = 10\ k\Omega.$$

See the "List of Socket Modules" for comparison.

To drive the Nixie tube a K155ID1 Nixie driver is used (IC1). The IC is a binary to decimal decoder with build in high voltage transistors. It takes a 5 V logic level input on D, C, B, A and outputs the corresponding digit on the Nixie tube.

The shield takes a binary input on the pins 10, 11, 12, 13, connected to D, C, B, A, and outputs the corresponding digit of the Nixie tube. So, e.g., L, L, L, H on the pins 13, 12, 11, 10 will display "1" on the Nixie tube. Here, L stands for "LOW" (0 V) and H for "HIGH" (5 V). The entire logic table is shown in below.

Logic Table for Nixie Driver

EN	D	C	B	A	[illegible]
L	L	L	L	L	[illegible]
L	L	L	L	H	[illegible]
L	L	L	H	L	[illegible]
L	L	L	H	H	[illegible]
L	L	H	L	L	[illegible]
L	L	H	L	H	[illegible]
L	L	H	H	L	[illegible]
L	L	H	H	H	[illegible]
L	H	L	L	L	[illegible]
L	H	L	L	H	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

With the A0 pin, defined as EN in the sample sketch, the HV Power Supply can be turned On and Off.

The sample sketch for the Nixie Tube Shield is shown below.

```
// NixieTubeShield.ino

const int EN = A0;

const int A = 13;
const int B = 12;
const int C = 11;
const int D = 10;

int nixieTable[10][4] = {
  [illegible]
  [illegible]
  [illegible]
  [illegible]
  [illegible]
```

```
  {0, 1, 0, 1}, // 5
  {0, 1, 1, 0}, // 6
  {0, 1, 1, 1}, // 7
  {1, 0, 0, 0}, // 8
  {1, 0, 0, 1}  // 9
};

void nixieWrite(int a, int b, int c, int d, int digit) {
      digitalWrite(a, nixieTable[digit][3]);
      digitalWrite(b, nixieTable[digit][2]);
      digitalWrite(c, nixieTable[digit][1]);
      digitalWrite(d, nixieTable[digit][0]);
}

void setup() {
  pinMode(10, OUTPUT);
  pinMode(6, OUTPUT);
  pinMode(8, OUTPUT);
  pinMode(7, OUTPUT);
  pinMode(9, OUTPUT);
}

void loop() {

   delay (1000);
   digitalWrite(10, LOW); // Turn the tube OFF

   for (int i = 0; i < 10; i++) {
      nixieWrite(6, 8, 7, 9, i);
      delay (1000);
   }

   digitalWrite(10, HIGH); // Turn the tube On
}
```

The array `nixieTable` resembles the logic table for the Nixie driver. The function `nixieWrite` takes the input pins of the Nixie driver and the digit to be displayed as input and writes the corresponding logic levels.