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- Introduction -

Early in the process of selecting items, I decided to base my purchasing decisions toward the goal of stocking an entry-level robotics and industrial automation workbench. Over the course of recent years, hobby-bench level electronics have been focusing on the usage and programming of microcontrollers. These devices have allowed for the increasing simplification in designs that would have taken many more discrete components in the past to implement. Instead, the complexity of hardware is reduced by implementing more functionality in software.

I felt that stocking a general-purpose workbench went against this reality, and so the decision was made to focus my selections around the standard, widely- used PIC 16F84A microcontroller came easily to me. Narrowing the focus even further to robotics applications adds an element of excitement - the student's projects can now move, and he can see the results of his development in a tangible way.

- Tools -

I decided to focus first on the tools. I wanted them to be quality tools that the student could use potentially for a lifetime, if he took care of them. At the same time, I had to be mindful of cost. This necessitated the goal of obtaining as much functionality as I could for the price from each tool in the set I assembled.

A good multimeter was a must. While certainly not a Fluke, I personally own a couple of the low-cost multimeters I selected for this workbench, and I have found them to be very capable and reliable tools for a fraction of the price. The good selection of ranges, transistor/diode testing capabilities, and small size make this multimeter an excellent introductory choice for the workbench.

The soldering iron seemed like a good selection because it is of a low enough wattage to handle some of the more fragile components without overheating, while still having enough power to solder larger components with ease. The grip seemed like it would be comfortable for longer periods of use, and the grounded plug should help with ESD issues.

The soldering iron stand combines both a third-hand with magnifier with a soldering stand complete with sponge, which means less room on the workbench taken up by individual tools, which is always a plus when prototyping and assembling circuits. The magnifier allows for easy visual inspection and correction of solder joints as needed. A small but adequate amount of 60/40 solder rounds out the soldering station supplies.

The 25 piece Velleman toolset is similar to a toolset I own. For the price, it cannot be beat on the necessary selection of tools you get: miniature wire cutters, long nose pliers, tweezers, multi-bit screwdriver, and a selection of precision screwdrivers are all included. All are very handy to have on the workbench. The carrying case is a bonus.

A desoldering tool and alligator clips complete the tool package for entry level usage. While we can strive to never make a soldering mistake, inevitably it creeps in, regardless of skill level, and the desoldering tool can save the day. Alligator clips provide quick hookup of parts that just need temporary connections during prototyping.

- Prototyping -

All electronic workbenches need prototyping tools. The solderless breadboard chosen affords the student plenty of room to develop and test a variety of microcontroller interfacing circuits. Hookup wire can be used for soldered connections or as wire jumpers on the solderless breadboard, at a price point much lower than formed wire jumpers. A battery holder and connectors, with 4 AA batteries, provides a simple and portable DC power source for development. Finally, the prototyping PCB, with parts, can be assembled as a carrier board for the microcontroller, which can then be

easily interfaced to circuitry developed on the solderless breadboard.

- Components -

The standard, easy to use PIC 16F84A was selected as the microcontroller for this workbench. A 20MHz part was chosen, to allow for future upgrades in speed if so desired. The prototyping PCB discussed above was designed to use a 4MHz oscillator crystal/resonator. The PIC selected can run at this lower speed, being rated for DC-20MHz operation.

To allow the user to program the PIC, a programmer is necessary. The following design was selected due to the simplicity of its construction, and the need for only standard and simple parts. Power for programming is derived from the host PC's serial port.

Parts for the programmer are included in the list, while leaving enough parts for the student to prototype and construct other circuitry on the solderless breadboard, or elsewhere. The PIC 16F84A is plugged into a socket on the programmer. The assembled hex file is uploaded to it, then the PIC is moved to the carrier board and interfaced to controlled circuitry as desired. The development software for creating the hex files can easily be found as open source software for most platforms, and is thus free for use by the student.

Various other passive and active components are provided to allow the student the capabilty to construct a variety of control and automation circuits. LED flashers and sequencers, relay and H-bridge motor control of a small DC motor, control of RC servos, and input from buttons and leaf switches, are all capable of being constructed using the components provided, allowing the student to develop a wide set of skills and knowledge of robotics and industrial automation.

Projects utilizing these parts can be easily found on the internet by the student. There is a plethora of designs and code available for the PIC 16F84A; it is easily one of the most utilized microcontrollers in existance, mainly due to its simplicity and low-cost.

- Conclusion -

I was unable to include everything I wanted to in this workbench (in particular, I wanted to add a simple oscilloscope, or at least a logic probe, but neither were in the cards). By careful selection and research, I believe I have managed to include the necessities needed for the introductory student to explore a large swath of territory within the fields of robotics and industrial automation.

This contest proved quite an eye-opener for me. I had thought it was going to be simple; a virtual walk in the park. Instead, I found myself neck deep quite quickly, making decisions on parts and vendors based on costs, quantities available, and quality. I ended up with a new respect for individuals who have to do this on a regular basis - for their job, their students, or otherwise. My totals and breakdowns are below:

Grand Total	
Toolset Subtotal:	$32.43
Prototyping Subtotal:	$23.78
Components Subtotal:	$43.15
Project Total:	**$99.36**

Enough left over for some bubblegum (well, maybe not at today's prices!)... If there are any questions about my entry, please feel free to contact me at my email address or via my website.

Thank you for the opportunity to enter this contest, and a huge thank you to all the vendors of Nuts and Volts who have helped to support this magazine over the years. Without their help and support, this hobby would have withered away a long time ago.

Note: Priced during the period of 5/31/2008 thru 6/5/2008

Catagory: Tools					
Qty	Item	Vendor	Part#	Price	Cost
1	Multimeter	jaycar.com	QM1500	$4.00	$4.00
1	Soldering Iron	circuitspecialists.com	200PHG-25WATT	$6.95	$6.95
1	Soldering Stand	oldmine-elec-products.com	G12810	$4.98	$4.98
1	Solder	allelectronics.com	TS-110	$1.25	$1.25
1	Toolset	designnotes.com	VTTS	$9.85	$9.85
1	Desoldering Pump	electronics123.com	VTD1	$2.91	$2.91
1	Alligator Leads	circuitspecialists.com	M000F0003	$2.49	$2.49
				SubTotal:	**$32.43**

Low Cost Digital Multimeter (DMM) - QM1500 - $4.00
25 Watt High Performance Soldering Iron - 200PHG-25WATT - $6.95
Soldering Helping Hands - Soldering 3rd Hand + Magnifying Glass + Soldering Stand G12810 - 4.98
18 ga. 60/40 rosin core.Solder in a convenient tube. 110” TS-110 - $1.25
Velleman 25-PC TOOLSET VTTS - $9.85
POWERFUL DESOLDERING PUMP VTD1 - $2.91
Alligator Test Clips (10 pcs) M000F0003 - $2.49

2. Prototyping

Catagory: Prototyping					
Qty	Item	Vendor	Part#	Price	Cost
1	Breadboard	pololu.com	352	$4.95	$4.95
1	Hookup Wire	jaycar.com	WH3025	$2.25	$2.25
1	Battery Holder 4AA	electronics123.com	H341B	$0.53	$0.53
1	Battery Clip 9V	electronics123.com	SNAP9V	$0.21	$0.21
1	Batteries 4AA	electronics123.com	BB099	$0.89	$0.89
1	Prototyping PCB	imagesco.com	PCB-27WP	$14.95	$14.95
				SubTotal:	**$23.78**

- 830-point Breadboard 352 - $4.95
- Hook-Up Wire Pack - (2 metres of 8 different colours of 13 x 0.12mm hook- up wire) WH3025 - $2.25
- BATTERY HOLDER FOR 4 x AA-CELL (WITH SNAP TERMINALS) H341B - $0.53
- Battery clip for 9V PP3 Battery SNAP9V - $0.21
- SAMSUNG ALKALINE BATTERY BLISTER PACK (AA 4-PK) BB099 - $0.89
- 18 Pin Prototyping PC Board - Overall Dimesnions 1.25" x 2.5" PCB-27WP $14.95
  - High Quality double sided PC board
  - Solder mask both sides
  - 9 volt battery terminals
  - On-off switch
  - Overall Dimesnions 1.25" x 2.5"
  - Compatible with the following microcontrollers:
    U1--PIC 16C52, 54, 56, 58, 554, 558, 61, 620, 621, 622, 71, 710, 711, 712, 715, 716, 717, 84, 16CE623, 624, 625, 16F54, 627, 628, 648A, 716, 818, 819, 83, 84, 87, 88, 16hv540, 18f1220, 1230, 1320, or 1330.
  - Included Parts:
    - 1 4.0 MHz Crystal (X-TAL 4.0)
    - 2 22pf Capacitors (CAP-22pf)
    - 2 22uf Capacitors
    - 1 Voltage Regulator 7805
    - 1 4.7K Resistor (RES-4.7K)
    - 1 470 Ohm Resistor (RES-470 Ohm)
    - 1 Sub Min LED

- 1 1N4007 Diode
- 1 9 Volt Battery Terminal (BAT-05)
- 1 9 Volt Battery Terminal (BAT-06)
- 1 On-Off PC Mount Switch (SW-06)
- 1 18 Pin Socket (ISC-18)

3. Components

Catagory: Components					
Qty	**Item**	**Vendor**	**Part#**	**Ea**	**Cost**
1	PIC16F84A-20/P MCU	microchip.com	PIC16F84A-20/P	$3.85	$3.85
1	9-pin Female D-Sub	circuitspecialists.com	DE-09S	$0.46	$0.46
1	18-pin IC Socket	allelectronics.com	ICS-18	$0.30	$0.30
1	Solderable Perf Bd	circuitspecialists.com	64-8933	$0.94	$0.94
1	6' Serial Cable	allelectronics.com	CB-397	$4.00	$4.00
10	330 Ohm Resistors	allelectronics.com	530200	$0.05	$0.50
10	1K Ohm Resistors	allelectronics.com	530200	$0.05	$0.50
10	3.3k Ohm Resistors	allelectronics.com	530200	$0.05	$0.50
10	4.7K Ohm Resistors	allelectronics.com	530200	$0.05	$0.50
10	10K Ohm Resistors	allelectronics.com	530200	$0.05	$0.50
10	15K Ohm Resisters	allelectronics.com	530200	$0.05	$0.50
3	100uf 16v Radial Caps	allelectronics.com	140400	$0.15	$0.45
10	MPSA06 NPN Trans	allelectronics.com	MPSA06-HM	$0.06	$0.60
10	MPSA56 PNP Trans	allelectronics.com	MPSA56-HM	$0.06	$0.60
10	T 1¾ RED LEDs	allelectronics.com	LED-1	$0.10	$1.00
10	T 1¾ GREEN LEDs	allelectronics.com	LED-2	$0.15	$1.50
6	1AMP/600PIV Diodes	allelectronics.com	1N4005	$0.17	$1.00
4	5.1V Zener Diode	allelectronics.com	1N4733	$0.25	$1.00
2	7805 5V Pos Reg	allelectronics.com	7805T	$0.50	$1.00
4	Mini Tact Button	allelectronics.com	MPB-132	$0.25	$1.00
2	SPDT Lever Switch	allelectronics.com	SMS-220	$0.90	$1.80
1	5VDC DPDT Relay	allelectronics.com	RLY-625	$1.50	$1.50
1	3VDC Motor	allelectronics.com	DCM-322	$1.25	$1.25
2	2pk Economy Servos	imagesco.com	HS-311	$8.95	$17.90
				SubTotal:	$43.15

PIC16F84A-20/P PIC16F84A-20/P - $3.85

Programmer:
http://www.semis.demon.co.uk/uJDM/uJDMmain.htm

- 9 Pin Female D-Sub Connector DE-09S - $0.46
- 18 PIN IC SOCKET ICS-18 - $0.30
- Solderable Perf Board, 2-1/2 x 3-1/8" (64-8933) 64-8933 - $0.94
- 6' SERIAL CABLE DB-9M TO DB-09F CB-397 - $4.00
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  - 330 x 10pcs - $0.50
  - 1K x 10pcs - $0.50
  - 3.3K x 10pcs - $0.50
  - 4.7K x 10pcs - $0.50
  - 10K x 10pcs - $0.50
  - 15K x 10pcs - $0.50
- Radial Electrolytic Capacitors - 100uF/16V 3 x $0.15ea
- MPSA06 NPN TRANSISTOR HOUSE MARKED – 10pcs MPSA06-HM - $0.60
- MPSA56 PNP TRANSISTOR HOUSE-MARKED – 10pcs MPSA56-HM - $0.60

- T 1 3/4 RED LED – 10pcs LED-1 - $1.00
- GREEN 5MM T1 3/4 LED – 10pcs LED-2 - $1.50
- RECT DIODE 1AMP/600PIV – 6pcs 1N4005 - $1.00
- 5.1V 1 WATT ZENER DIODE - 4pcs 1N4733 - $1.00
- 5V POS REG 1 AMP 7805T - $0.50
- MINI TACTILE PUSHBUTTON x 4 MPB-132 - $1.00
- SPDT MINI-SNAP-ACTION SWITCH W/ LEVER SMS-220 - $0.90
- 5VDC DPDT DIP RELAY RLY-625 - $1.50
- 3 VDC MOTOR DCM-322 - $1.25
- HS-311 Economical Standard Servo HS-311 - $8.95ea