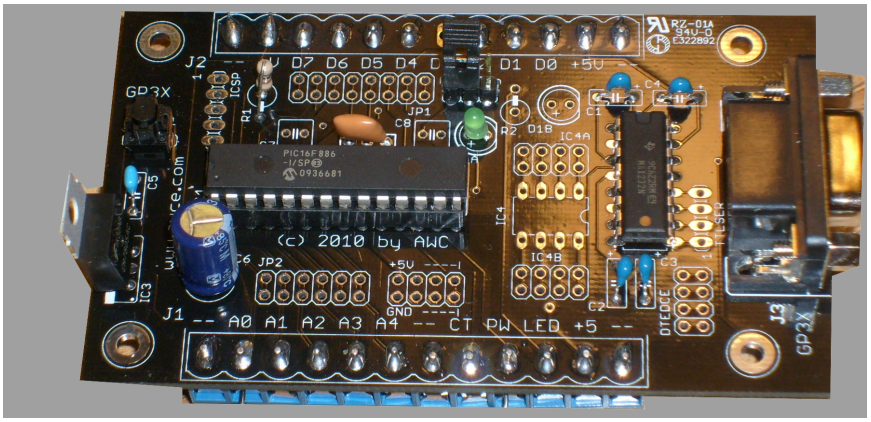
AWC

GP9 PC Analog/PWM I/O Kit



For the latest documentation see http://www.awce.com/doclib.htm#gp9

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Overview

The GP9 is an easy way to produce PWM outputs either with or without computer control. Features include:

- 5 8-bit A/D inputs
- 8 PWM outputs
- Initially, the A/D inputs drive 5 of the PWM outputs
- A computer program can control the GP-9 (via a serial or USB port) to read the A/D inputs and directly control the PWM outputs as desired
- Use the analog inputs to drive the PWM outputs, or read them on the host computer (or both)
- Control the PWM outputs independently or via analog input control

Documentation

To make sure you have the latest documentation, please check online (http://www.awce.com/doclib.htm#GP9) for the latest versions and updates.

If You Need Help

If you require assistance, please feel free to contact us. The best way to get support is via our FAQ system (http://www.awce.com/faqs). Be sure to check out our Web page for updates at www.al-williams.com/awce.

Details

The GP-9 can be used as a chip or on its base board, the GP3X board.

There are 6 sections on any GP9 system:

- CPU – The CPU chip contains the firmware and memory for the system. Note that a jumper input selects if the GP9 determines if the outputs are active by default or not. Using this jumper to disable outputs on start up allows computer control to set the chip up before enabling the outputs.
- Clock – The CPU requires a 20MHz oscillator.
- Communications – By default, the GP9 communicates with 9600 baud serial data over a standard RS-232 port or a built-in USB adapter. No handshaking is used and the serial data is 8 bit, 1 stop bit, and no parity.
- Power – The GP9 requires a 5 volt regulated supply. You can connect an external regulated supply or use the onboard power system of the GP3X board. If using certain USB daughter boards, the GP9 can obtain power from the USB port.
- Reset – The CPU requires a pull up resistor on the reset pin. In addition, a jumper or switch can be used to manually reset.
- Interface – The whole point to the GP9 is to interface to the outside world. The GP3X board can accommodate terminal blocks or other connectors to connect your analog inputs and PWM outputs.

Hardware

GP9X

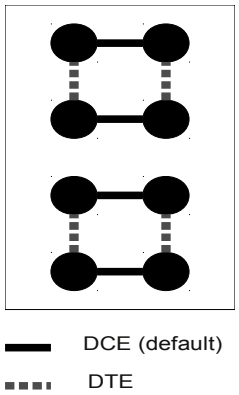
GP9X Parts List

Designator	*Description*
C1-C4	1 uF capacitor (not included with USB kit)
C5	0.1 uF capacitor
C6	330 uF capacitor (not included with USB kit)
C7, C8	Optional. Capacitors matched to X1 if needed.
D1A	5V LED (not used)
D1B	5V or regular LED (not used; see options)
IC1	GP9 CPU and 28 pin narrow socket
IC2	MAX232 (not included with USB kit)
IC3	7805 (not included with USB kit)
IC4	USB daughter board (UB232R); If used, includes two 4 pin socket strips and is usually mounted on bottom side of board. If not used, IC4 can be used for other purposes (see options)
J1, J2	Connectors on .2” centers; usually installed on bottom of board, but may be installed on top if preferred (see options). Standard kit comes with pin headers (which may be on .1” centers; remove extra pins with pliers) or optional screw terminals which interlock to make 12 position connectors.
J3	DB9 (actually DE9) female (right angle, short reach; not included with USB kit)
JP1, JP2	Normally nothing is connected here. You can cut traces between the centers and rewire the digital and analog I/O to your liking (see options)
R1	10K resistor
R2	Dropping resistor for D1B, if required
X1	20Mhz ceramic resonator (three terminal) or 20Mhz crystal (outer pins only) with matching C7 and C8 installed
Reset	(optional) 5mm tact switch (pins 1 and 3) or 2 pin header (pins 1 and 2)
Pgm Run	3 pin header and jumper used to select initial mode
+V	Coaxial power jack (optional; see text)
Empty	By default ICSP, JP1, JP2, R2 D1A, D1B, C7, C8, IC4, IC4A, IC4B, TTLSER, DTEDCE, and +5V/GND header (to the right of JP2) are empty. See customization for more information on how these parts of the board may be used.

The GP3X board is highly flexible. Each of the sections has several options for customization. You should plan the options that will meet your needs before starting construction.

- CPU – The CPU should be socketed, although this is not strictly necessary. The 3 pin header marked Pgm Run (near JP1) allows you to install a header to switch the board between the mode where it accepts commands from the PC (Pgm) or starts working right away without waiting for PC commands (Run). Normally you will install a 3 pin header in this location and a jumper will select between the two options. However, if you are certain you only want to operate the board in one mode, you can hard wire the jumper.
- Clock – By default, kits based on the GP9X board use a 20MHz ceramic resonator that includes capacitors. However, the same socket can accept a regular resonator or a crystal in which case you'll need to install C7 and C8 with the capacitors required. In addition, an 8 pin DIP oscillator (20MHz) could be installed at IC4 and its output fed into pin 9 of IC1.
- Communications – By default, the GP9 communicates via a DCE RS232 port formed by J3, IC2, and C1-C4. A DCE port mates via a straight cable to DTE ports such as those commonly found on a PC. However, there are several options available.

First, you can rewire the port so it selectable between DTE and DCE. Near J3 there is a 2x4 pin header marked DTEDCE. The PC board has traces running across the pins. You can carefully remove the traces between each of the four pairs of pins using a hobby knife or razor (the traces are on the top side of the board – the side with the silk screen markings). Then you can install a 2x4 pin header into the holes. If you place 4 jumpers across the pins (making the same connections as the traces did) the port will be DCE. However, if you place the jumpers at right angles, the port will be DTE suitable for connection to, for example, a modem. However, if wired as DTE, you'll need a cross cable (sometimes called a null modem cable) to connect to a PC for programming. The figure below shows how the DTEDCE jumpers can be connected.



If you are connecting the GP9 to a non-RS232 device like a microcontroller, you can use the TTLSER pins and remove IC2. The pins are:

1 – Handshaking in to GP9 (RTS; not used)
2 – Handshaking out from GP9 (CTS; not used, but asserted)
3 – Transmit from PIC (TX)
4 – Receive from PIC (RX)

In addition, if you don't plan on using the board with a PC at all, you can remove the following parts: J3, IC2, and C1-C4.

The IC4 socket can accept a USB daughter board (part number UB232R). Normally this board is fitted under the board using the socket strips supplied with the daughter board. The pins are soldered on the top side of the board (the side of the board with the silk screen markings). Because of the unusual pin spacing of the daughter board, one row of pins goes into IC4's pins 1-4. The other row goes into the row of holes marked IC4B that are nearest to IC4. The USB port should face the edge of the board that holds J1.

Note that because the daughter board is installed under the board, the pin numbers are reversed. That is, pin 1 of the module corresponds to IC4 pin 8 and the module's pin 8 will connect to IC4 pin 1. With the USB port on the underside of the board, it is usually a good idea to use spacers or bolts in the four corner mounting holes to form “feet” for the board so it does not rest on the USB interface.

The connections between the daughter board and the rest of the board appear in the table using the IC4 pin numbers and the module pin numbers for reference. If you wish to power the board from its own power supply or from an external 5V source, do not connect pin 2 of the USB board. However, if you

wish to operate the board from the USB power supply you can connect pin 2 to one of the holes near JP2 marked +5V and omit IC2 and C6. The jumper on the daughter board should be connected between pins 1 and 2 so that the board operates on 5V instead of 3.3V.

IC4 pin #	*USB232 Pin #*	*GP9X connection*
8	1	Ground
7	2	+5V (if USB power desired; no connection if using separate power supply)
6	3	TTLSER-2
5	4	TTLSER-1
2	7	TTLSER-3
1	8	TTLSER-4

Note that it is possible to socket IC2 and the USB module so that the board can operate in either mode. With the power removed, simply install either IC2 or the USB module as desired. To switch the board to use the other type of communications, remove the power. Then remove either IC2 or the USB module and install the other unit.

A DB9 USB (DB9-USB) adapter is also available that replaces the DB9 connector. However, this adapter does not supply 5V and the board will require another source of power when using this adapter. This option does not lend itself to dual RS232/USB operation.

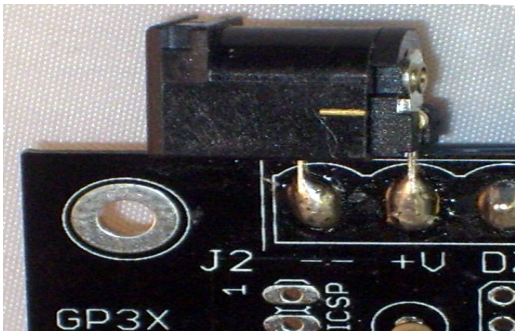
However, the simplest way to obtain a USB connection is to build the board with the RS232 port and then use a standard USB to serial port adapter (available as an option, if you don't have access to these standard cables).

- Power – There are several options to power the GP9. The only actual requirement is a regulated 5 volt (5V) supply. Feeding such a regulated voltage into any of the pins on J1 or J2 marked 5V (and ground on any of the pins marked –) is sufficient to power the board (with all I/O quiescent, the board draws roughly 11 to 15 mA).

  If you prefer, you can install the regulator (IC3) and C6 and feed a higher voltage (usually 8 to 12V) into V+ on J2. Then the board will produce 5V for itself and provide it at the 5V points on J1 and J2. There are also holes where you can tap (or supply) 5V and ground near JP2 marked +5V and GND.

  If you wish to use the optional coaxial power jack, you must modify it slightly. The jack has three pins, two that line up and one that is offset. Using pliers, bend the offset pinup against the body of the jack. This pin is the same as the pin nearest the open end of the connector and it is customary to use this pin for ground. The bent pin can be used as a ground point for testing or it can be clipped. For mechanical stability, you may wish to secure the jack with hot glue.

  The jack can be placed against the – and V+ pins of J2 along the top side of the board. The pins will line up with the holes and you can tack solder the pins (see Figure below). In this configuration, a standard DC “wall wart” with the sleeve grounded (the center pin should have between 8 and 12 volts) will power the onboard regulator.



- Reset – The chip requires a 10K resistor at R1. In addition, the RESET header near IC3 can accommodate a 2 pin header (between pins 1 and 2) so a jumper can reset the board.
- Interface – The primary external access to the board's functions is via J1 and J2. The markings on the board explain what each pin does. The 4 corners (marked with –) are ground points. There is another ground on J1 right after the analog channels. The analog channels are marked A0 to A4. There is a connection to the 5V supply rail (+5). J2 also has a 5V supply rail connection, an input to the voltage regulator (+V), and the PWM output pins (D0 to D7). Other pins are not used with the GP9.

  You can install headers in these locations either on the top of the board or the bottom (the bottom is handy for plugging into solderless breadboards). In addition, you can use standard "screw terminals" which come in interlocking blocks of 2 or 3 terminals, or use any other type of 12 pin connector with 0.2" spacing. If you ordered the **screw terminals and install them on the bottom of the board** (soldering them on the same side as the silk screen) they will form "feet" that will hold the board up which is handy and also leave the other components on the board more accessible. However, you can also install them on the top of the board if you prefer. In particular, if you install the USB daughter board (which mounts on the bottom) you may want to keep the pins on the top. The choice between top and bottom is purely one of personal preference – the circuit works either way.

  The analog and digital pins route through JP1 and JP2. If you wish, you can cut the traces between the sections of JP1 (digital) or JP2 (analog) and reroute the signals. For example, you might put a series resistor between the holes to limit current. Or you could route a wire from an analog input to an op-amp in the spare IC4 socket and then back from the op-amp to the GP9's CPU. Note that on JP2, the 5th pin (near J1's A3) is not connected through and only connects to an unused GP9 pin.

  IC4 is available for use with any circuitry you might want to add unless you are using it for the USB daughter board. An op amp, a temperature sensor, a solid state relay, a DIP switch, or anything else you can arrange to fit in an 8 pin DIP factor can be placed at IC4. The IC4A and IC4B holes connect to IC4 to provide places you can connect your circuitry to the board. In addition, there are convenient holes that carry +5V and ground nearby for your use.

  The GP9 does not use either of the LED slots, however a 5V LED is included that you can use for testing. To use this LED, place it into the holes for D1B being careful to observe the polarity marked on the board (the long lead is the + lead). Then you can use the R1 pad with the circle around it as a connection point to the LED. You can use this LED for any purpose. For example, you could connect it to a PWM channel by soldering a wire from the circled pin of R1 to JP1. As an alternative, you could wire the LED to the 5V supply to act as a pilot light.

  Once you have decided on the options you wish to use, you can assemble the board. In general it is best

to start with the “short” components first. IC1's socket and IC2, for example are easiest to install first. Then you can install discrete components like the smaller capacitors, resistors, and LEDs. Tall components like the connectors, C6, and IC3 should be installed last.

Construction Notes

- If your kit is supplied with two 24 pin .1 inch headers simply remove every other pin with pliers so that the headers fit in the J1 and J2 slots.
- C1-C4 have polarity markings but it is not necessary to use electrolytic capacitors. If your kit is supplied with ceramic capacitors for C1-C4 you can ignore the polarity markings on the board.
- C6, the LEDs, and the ICs are the only devices that you have to be careful to observe the orientation marked on the board. C6 should have its + or – lead clearly marked and the + side is marked on the board. The longer lead of LEDs will go in the hole marked with the plus sign.
- IC1 and IC2 should be oriented as shown on the silk screen. The silk screen for IC3 shows a thick bar near the edge which is the back of the package (the side without the part markings).
- Because IC4 is uncommitted you can install something in IC4 any way you like (including on the back side of the board) as long as you do the rest of the wiring to IC4 to match.
- Although it is customary to put the body of the resistors in the hole that has the white circle around it, putting one in backwards will not affect circuit operation.
- Although it is customary to put the ceramic resonator or crystal so that the markings face away from IC1, putting it backwards will not affect circuit operation.
- Don't forget that JP1, JP2, IC4A, IC4B, and DTEDCE all have traces connecting pins “across” from each other. If you are making any modifications that require these holes to be electrically separate you must use a hobby knife or razor to carefully cut through the trace on the top side of the board that connects them. You should check that you have made the cut by using an ohm meter before and after the cut. Of course, be careful not to cut other parts of the board.

You should check your work before installing IC1 in its socket. Power the board up using your choice of methods (9V to the +V pin on J2, 5V regulated to any of the +5V pins, or USB power) and verify that 5V appears on the +5V connector near JP2.

Final Checkout

If you are using a MAX232, you can also perform an echo test to verify the port circuitry before you install IC1. Connect your PC to the DB9 connector using a straight RS232 cable (assuming you did not modify the DTEDCE jumper on the GP3X; otherwise, use a cross cable). Open a terminal program to the correct port and make sure local echo is off as well as hardware handshaking. The baud rate is not important (use 9600 baud if you like since that is the speed you will use later as well). Typing on the terminal should have no effect at this time. If you see what you are typing you don't have local echo turned off in your terminal program. Short pins 17 and 18 on the IC1 socket and apply power to the board. Now when you type, you should see the characters your type appear. Removing the short should stop your terminal program from showing you what you type. This test will show that the RS232 communications is working correctly. You can perform the same test with the USB daughter board using a USB cable and the appropriate COM port.

Once these checks are complete you can install IC1 and power up the board.

Software

The GP9 connects to a PC or other host device via the RS-232 port. The GP9 is a DCE device, so you can use a straight cable to connect directly to a PC. The PC sends commands to the board using 9600 baud serial data (8 bits, no parity, 1 stop bit). The GP9 uses a simple protocol to ensure it stays in sync with the host computer. To send commands to the device you will always send one or two bytes. The first byte will always start with a zero bit (that is, it will be less than 128). Any second byte will always have the first bit set (it will be greater than or equal to 128). This allows the GP9 to stay in sync since it can correctly identify a byte that is out of sync.

The GP9 has a register-based structure that' you'll read about shortly. But as an example, suppose you want to write 71 hex into register 1.The command to write to register 1 is 01 (note this is a byte, not the ASCII characters).

Ideally, you'd like to send 01 71 to the chip, but you can't because the second byte has to have a 1 in the first bit position (80 hex or greater). The GP9 expects you to shift the second byte over one position and include the lowest bit as bit 6 of the command word. Consider the bit patter we want to send:
0000 0001 0111 0001

You have to shift the 2nd byte over one place and set its bit 7. Then you set bit 6 in the first byte if the last bit was a 1 (as it is in this case). So

0100 0001 1011 1000

is the correct encoding. This is 41 B8 hex. If the second byte had been 70 instead of 71, the encoding would have been 01 B8.

Note that bytes sent back from the GP9 are not encoded in any way. You only perform the encoding on bytes you send to the GP9.

Reference

The GP9 has a simple command structure. A command byte normally stores the next byte sent in a GP9 register. However, if the READ bit is set, the GP9 responds with the value of that register. Note that the second byte must be encoded as described above, however, bytes sent by the GP9 are never encoded.

7	6	5	4	3	2	1	0
0	BIT0	READ	REGISTER ADDRESS				

BIT0 – The least significant bit of the next byte (if applicable)
READ – Set to 1 if this is a read command (and thus, the next byte will be sent by the GP9)
REGISTER ADDRESS – The function register to read or write

Register (hex)	*Read/Write*	*Description*
00-07	Yes	PWM Duty cycle (0-255)
08	Yes	Bit-mapped mode; 0 for analog input control, 1 for computer control, default=E0 hex
0A	Yes	Bit-mapped register; any 1 bit will force the corresponding output to a 1 regardless of PWM command (assuming the bit is enabled)
0D	Yes	Bit-mapped register; 0 bits enable outputs (default depends on Run/Pgm jumper)
10-14	Read	Analog values for each input channel
1E	Read	Version byte; reads A0 hex

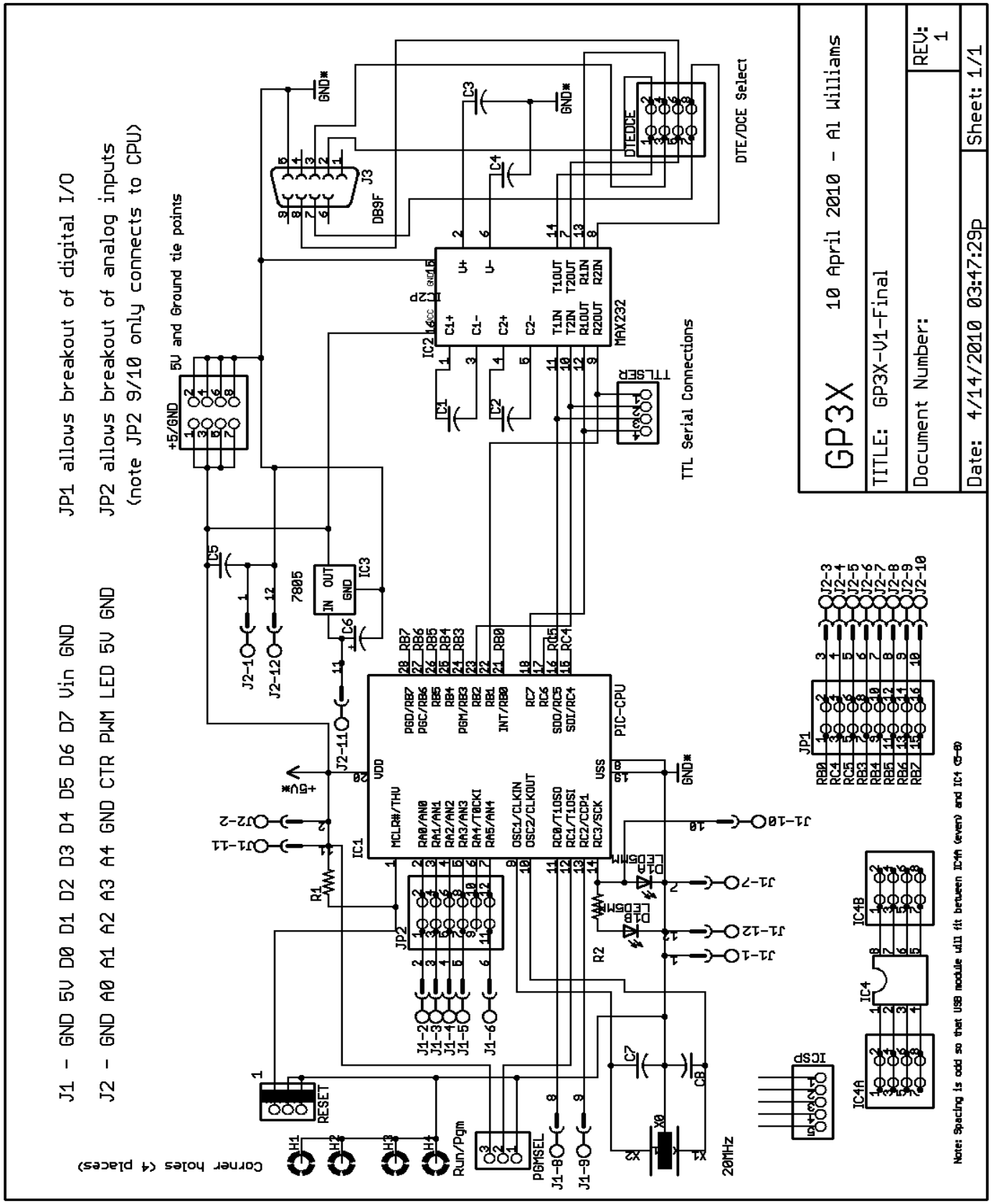
Do not attempt to write to addresses other than the ones specified above. By default, the first five PWM outputs are tied to the analog inputs. However, if the analog inputs are not connected to anything they will produce unpredictable outputs. If you connect a voltage to one analog input and leave others disconnected the disconnected inputs will tend to pick up values close to the connected pin.

The jumper determines if the outputs start in enabled mode (Run) or not (Pgm). If they are not enabled, nothing will happen until a host computer sets up the chip and enables the outputs. However, in the Run position, the chip will operate on its own, converting 5 analog inputs into 5 PWM outputs. Of course, a host computer can still command the device as it sees fit.

Note that commanding a PWM channel will not work as you expect unless the channel is set to take computer control (register 8) and the output is enabled (register D). In addition, the corresponding bit in register A must be zero.

For a complete example for Linux or Windows see http://www.awce.com/gp9demo.htm.

Specifications

Maximum total current sunk or sourced by all I/O pins	90mA
Supply voltage	4.5 to 5.5V
Supply current (with regulator, no output)	12mA nominal (RS232 installed, no IC4 installed)
Input low voltage (maximum)	0.8V
Input high voltage (minimum) 2.0V	
Input leakage current (maximum)	+/- 1uA
Output low voltage (maximum)	0.6V
Output High voltage (minimum)	Vdd-0.7V
A/D resolution	8 bits
A/D Integral error	+/- 1LSB
A/D Differential error	+/- 1LSB
Recommended analog input impedance	10k ohm

Schematic (GP9X)