SEXTA Construction Notes

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Preamble:-

SEXTA is a system (hardware device, firmware, and application software) to create and analyse optical timestamps as observed by a camera and recorder. The paper provides more information about the properties (accuracy, resolution, etc). This document is intended to provide information to allow the researcher to build their own device.

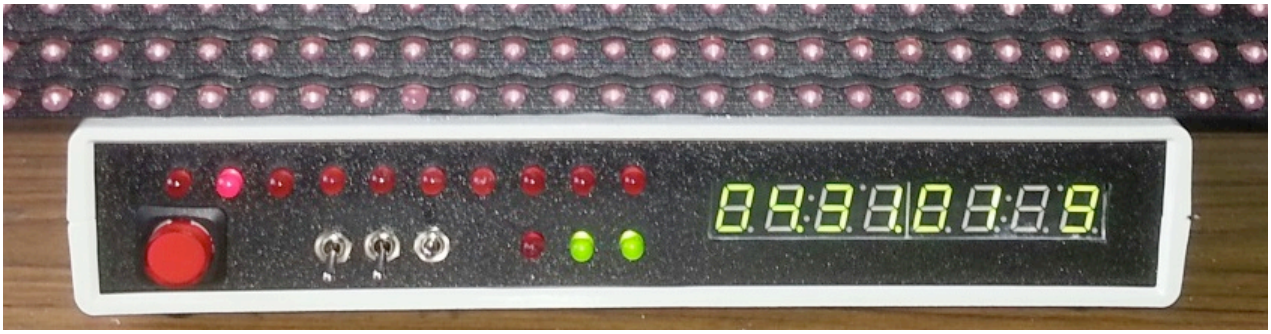
Bill Of Materials:- See Appendix - A

a) The Bill of Materials (BoM) lists the parts required to make a SEXTA and lists suggested suppliers for the Major components. Other suppliers may well have equivalent products. Minor components can be sourced from any hobby electronics supplier.
b) Arduino Compatibles: Many firms offer Arduino compatible microcontroller boards and most of these will be suitable as long as they use a crystal oscillator rather than a ceralock resonator.
c) GPS Receivers: SEXTA will operate with almost any GPS receiver as long it can output just one NMEA sentence (GGA) at 57600 baud as well as a 1 pulse per second (1pps) signal. The prototypes have been built using the GPS receivers listed in the BoM. However to use a receiver other than that listed will require some tinkering with the MEGA code. Use of an internal or external GPS or an internal GPS with an external antenna depends on reception available at the site where SEXTA will be used.
d) Dot-Matrix-Display: Available in blue and red
e) 7-Segment Array: Available in many colours. blue or green will limit overexposure to some extent.
f) Plastic Case: Two prototypes were built using a case available at a local electronics hobby shop, however almost any case would be suitable to house the SEXTA electronics.

Layout:-

a) The DMD panel, the 7-segment displays, the lock and almanac LEDs and the 10 unit seconds LEDs need to be coplanar, so that the camera can take a picture of the whole panel and have them all in reasonable focus.

b) The reader application can take care of some mild keystoning of the panel due to tilt, but ideally the panel will be face-on to the camera system and the camera system will have minimal optical distortions.
c) The two Arduino units are mounted in the case of on standoffs of some kind.
d) The 10 unit seconds LEDs need to be co-linear and equally spaced, because the reader application interpolates ten equidistant "sample zones" between the 0 and the 9 LED click points. If the spacing is not regular, the reader will not reliably read the unit seconds.



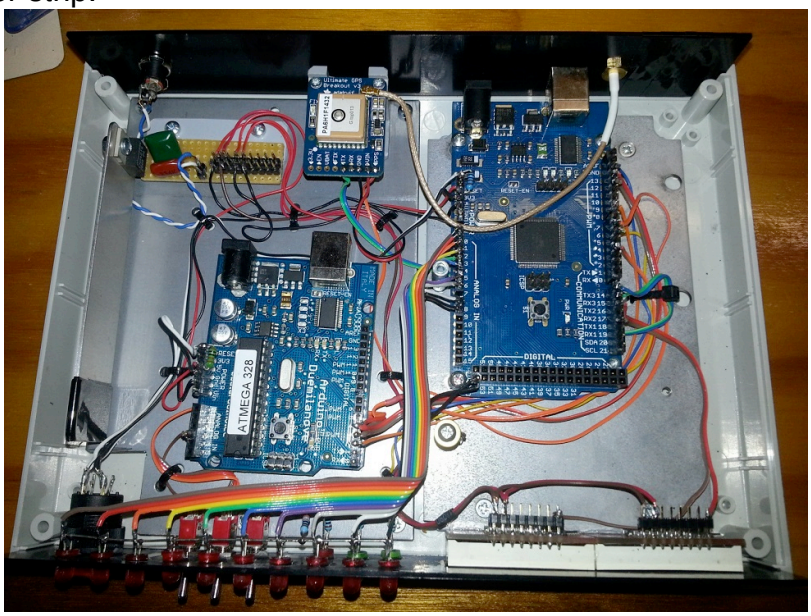
e) The GPS unit is quite sensitive to RF, and so if an internal GPS is used (without an external antenna), it should be mounted a reasonable distance (say 150mm or 6") away and at right angles to the face of the micro-controllers. The GPS unit can be fixed in place with double sided tape or velcro. Most GPS units have rules about how far away metal things must be from their sensitive bits. Follow those rules and you will do well.

Power Supply:-

a) Power may be supplied by either;
b) The USB ports on either of the Arduino boards
c) The DC input port on either of the Arduino boards. This will utilize one of the 5v regulators on the Arduino
d) An external regulator using a LM7805 and two capacitors. A large heatsink can be implemented with this option.

Wiring:-

It is not necessary to etch a board for the task of connecting components. The wiring and connecting can be done in one hour using standard hookup wire (rainbow cable) and 0.1" single row header strip.



Loading the Software:-

a) The two Arduino microcontrollers are programmed using the Arduino environment. This is available for PC, Mac and Linux and is available at http://arduino.cc/en/Main/Software
b) Arduino 0022 in particular is the correct version to utilize for both boards. This is available at http://arduino.cc/en/Main/OldSoftwareReleases
c) The DMD libraries must be installed into the Arduino libraries folder. See the Arduino docs for where the library folder is on your particular system.
d) Do not use the DMD library which is freely available from the supplier. The library we supply has a modification which sets the SPI frequency for optimal use.
e) The modded DMD library is included in the SEXTA files.

Setting the Sweep Rate:-

a) The Sweep Rate is the time the DMD takes to illuminate all the LEDS, left to right.
b) The user sets the rate to suit the camera test exposure setting under examination.
   - The device provides 4 sweep time settings;
   - 1 second
   - 2 seconds
   - 5 seconds
   - 10 seconds.
   - Typically for test exposure durations briefer than a half-second, a sweep time of 1 second should suffice.
c) The Sweep Rate is set using Switch1 and Switch2 on the front panel in the following schema.
   - *Sw1 – off and Sw2 – off, then the rate is 1 sec*
   - *Sw1 – on and Sw2 – off, then the rate is 2 sec*
   - *Sw1 – off and Sw2 – on, then the rate is 5 sec*
   - *Sw1 – on and Sw2 – on, then the rate is 10 sec*
d) Switch3 is to reset after a GPS error. The errors are displayed on the 7 seg LEDs as "E7 45 6" where the E7 is the error number, and the 45 is the UTinteger seconds from the last correctly parsed GGA sentence, and the 6 is the number of satellites registered in the GPS constellation.

Error number	Name	Notes
0	eAlmanacUpdate	GPS downloaded the GPS - UTC offset in the almanac, which was different to the GPS offset stored in firmware, and changed UTC in a non-sequential manner. This is not really an error, but an indication the firmware was programmed before the latest integer second change to UT.
1	eUTCdidNotChangeCorrectly	This is an error 0 which happens outside the expected almanac download time of 15 minutes.

Error number	Name	Notes
2	eNoPPS	No 1PPS signal was received in 1.000 099 seconds. The GPS will fail to emit 1PPS if the number of sats goes below 3.
3	eNoGPSmsg	No GPS message was received between two 1PPS signals.
4		This error is not pertinent for SEXTA.
5	eGPSfail	A fail error not of the other GPS fail types.
6	ePPStooQuick	More than one 1PPS was received in 1 second. Generally due to electrical interference e.g. motor starting, fluoro lights.
7	eTooManyGPSmsg	More than one GPS messages were received in one second.
8	eCouldNotSetGPSforNAV5	Initialisation failure for uBlox GPS. This is fatal, and halts the system. Requires hard reset to restart operations.
9	eCouldNotSetGPSforPowerManagement	Ditto
10	eCouldNotSetGPSfor1Hz	Ditto
11	eCouldNotSetGPSforGGA	Ditto
12	eCouldNotSetGPSfor57600	Init failure for both PA6H and uBlox GPS. Fatal, halts the system.

The beeper and switch attached to pin 10 of the MEGA is optional, but lets you know the unit is working :-)

GPS Units:-

There are two GPS units we have tested, and it is your choice as to which unit you get. The wiring diagrams are essentially identical for each. The SEXTA-MEGA code is specific for the GPS - use the PA6H code for the PA6H unit, and the uBlox code for the uBlox unit.

In use we have found the PA6H to be more sensitive, and with an external antenna option may be best for people who have to use the device in an enclosed area where GPS reception is poor.

Power on:-

When SEXTA is powered on, the Splash screen is displayed for about ten seconds. Then the unit tests out the internals, and establishes comms with the GPS. If this fails, the unit halts with an error number which describes the particular failure. This has to be fixed before you can proceed.

After comms is established, the unit begins by sending the moving dot across the DMD panel, to the last valid LED, and then waits for the GPS to begin outputting 1PPS signals. This may take some time if you are not in a good signal area. Typical times to first fix are under five minutes. While this wait is occurring, it may seem like nothing is happening :-)

Once the GPS begins to emit 1PPS, the unit allows for about 10 seconds for signals to stabilise. In this mode, the text "STAB" and a count down is shown on the seven seg. LEDs. During this time the GPS may stop emitting 1PPS as satellite signals vary. It may take more than 10 seconds to get to a point where the sats are strong enough to keep the unit running.

Then the unit starts its lock in approach to panel operational status. This takes less than a minute in most cases.

Your first run will require you to wait for 15 minutes for the unit to download a current almanac from the GPS constellation. When that is done, the unit will light the A-OK LED.

This 15 minute wait is not optional. We are due for another leap second addition in June 2015, and from that time on, the GPS will have an incorrect default UT-GPS offset. This means that when the device starts up from cold (power off, no battery backup) there will be an integer second offset that will invalidate SEXTA output untila correct almanac is downloaded from the GPS constellation.

The PA6H unit has a battery backup which avoids the necessity to download the almanac on each power up (provided there has **not** been a leap second addition during power-off). The uBlox unit also has a battery backup which we have found to **not** work, requiring you to wait 15 minutes on each power up before the almanac is considered current.

If you lose 1PPS due to the GPS losing satellites, the unit errors by displaying E1 (or another number depending on the error type), and you must clear the error using the front toggle switch. Click on for about one to two seconds and click off. You should **not** have to reset the whole unit. The unit should lock in soon after the error clear.

Note that for SEXTA Reader to give you correct timing, the Lock LED and the Almanac OK LED must be lit.

Appendix
Bill of Materials

The following is Bill of Materials (BoM) for SEXTA : Version: v3

	Item	Quantity	Comments
	Major Components		
	Arduino MEGA-1280 or 2560 Processor		
1)	Board	1	Available from many sources.
2)	Arduino Dumilanove or equ.	1	must have crystal, NOT a ceralock resonator
3)	GPS - uBlox M8-Q or PA6H	1	from HAB supplies or LadyAda
4)	Dot-Matrix-Display (DMD)	1	
5)	7-Segment LED Array	2	Various colours available.
	Minor Components		
	LED Red	11	
	LED Green	2	
	Resistor 330 ohm	4	
	Resistor 1k ohm	2	
	Capacitor ceramic 68pF	1	
	Momentary switch	1	
	Toggle switch SPST	3	
	Header Pins (40)	1	for Arduino modules to connect to.
	Rainbow Cable (1 metre is more than enough)	1	
6)	Plastic Case 225x165x40	1	Or Similar
	Miscellaneous bits and pieces		

Note, if the On Arduino regulators are not used (for whatever reason) then a voltage regulator circuit is required.

5volt Regulator LM7805	1	
Capacitor 0.1uF	1	
Capacitor 0.33uF	1	
Ø2.1mm DC Socket	1	

Vendor References

1) https://www.sparkfun.com/products/11061
2) http://www.freetronics.com/products/eleven#.VCi491IcT4Y

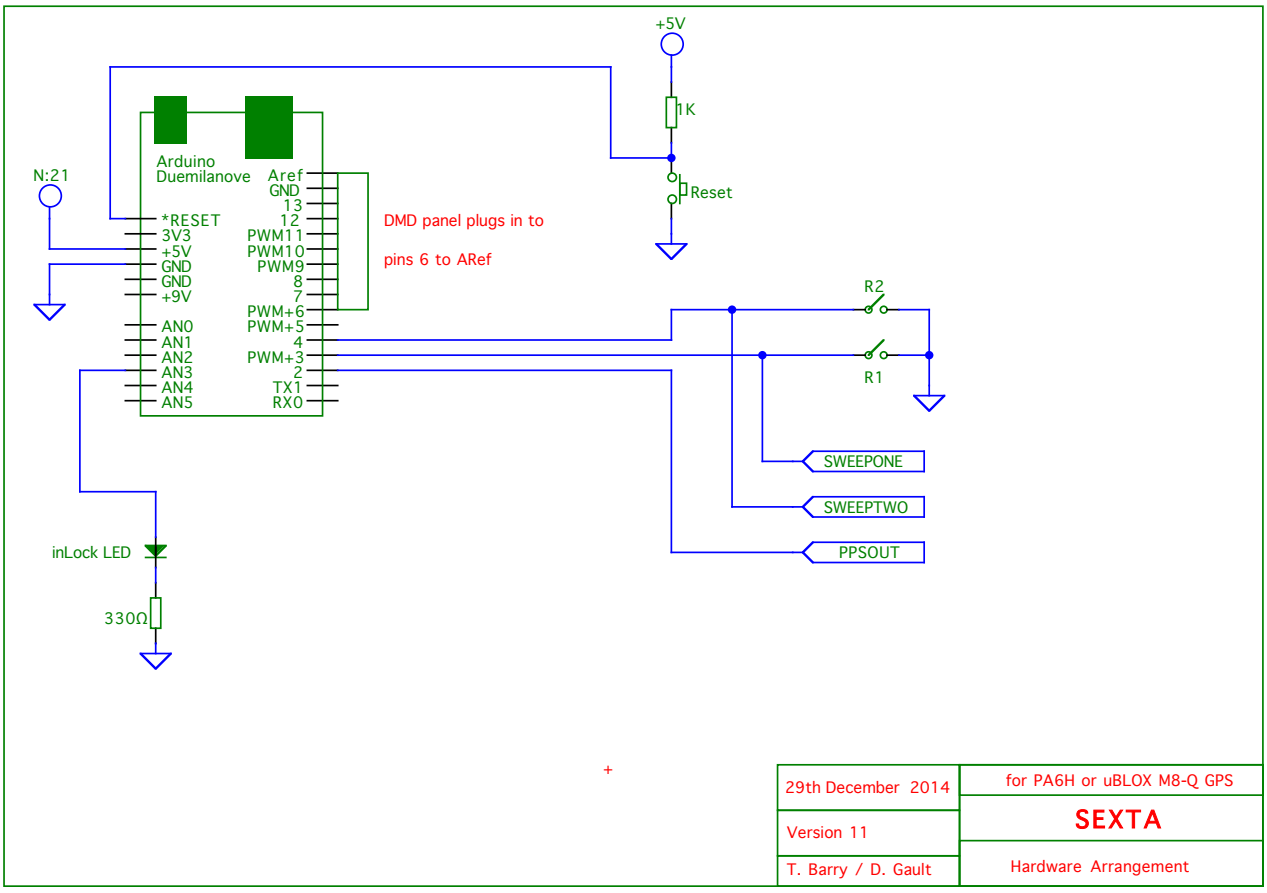
http://ava.upuaut.net/store/index.php?route=product/product&product_id=68

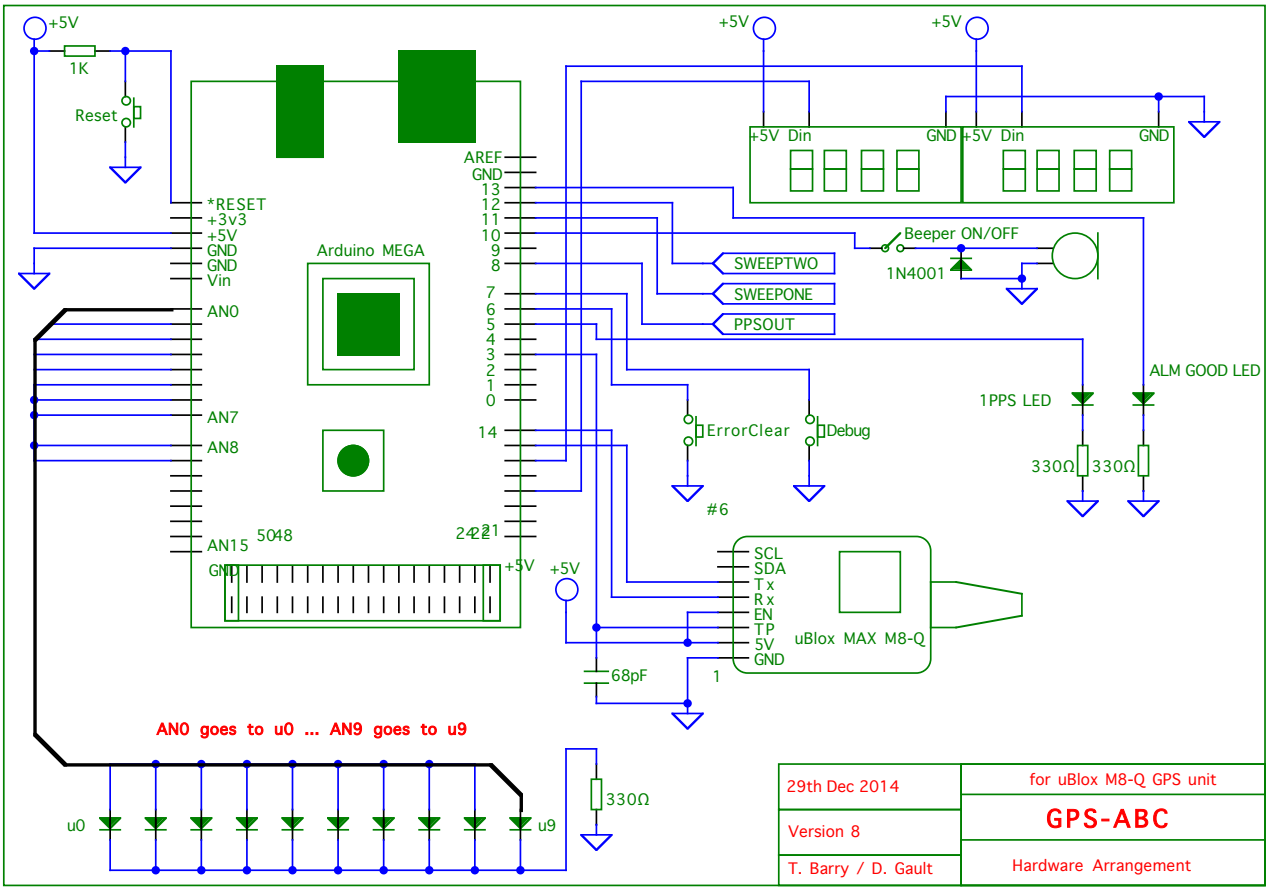
http://www.adafruit.com/product/746

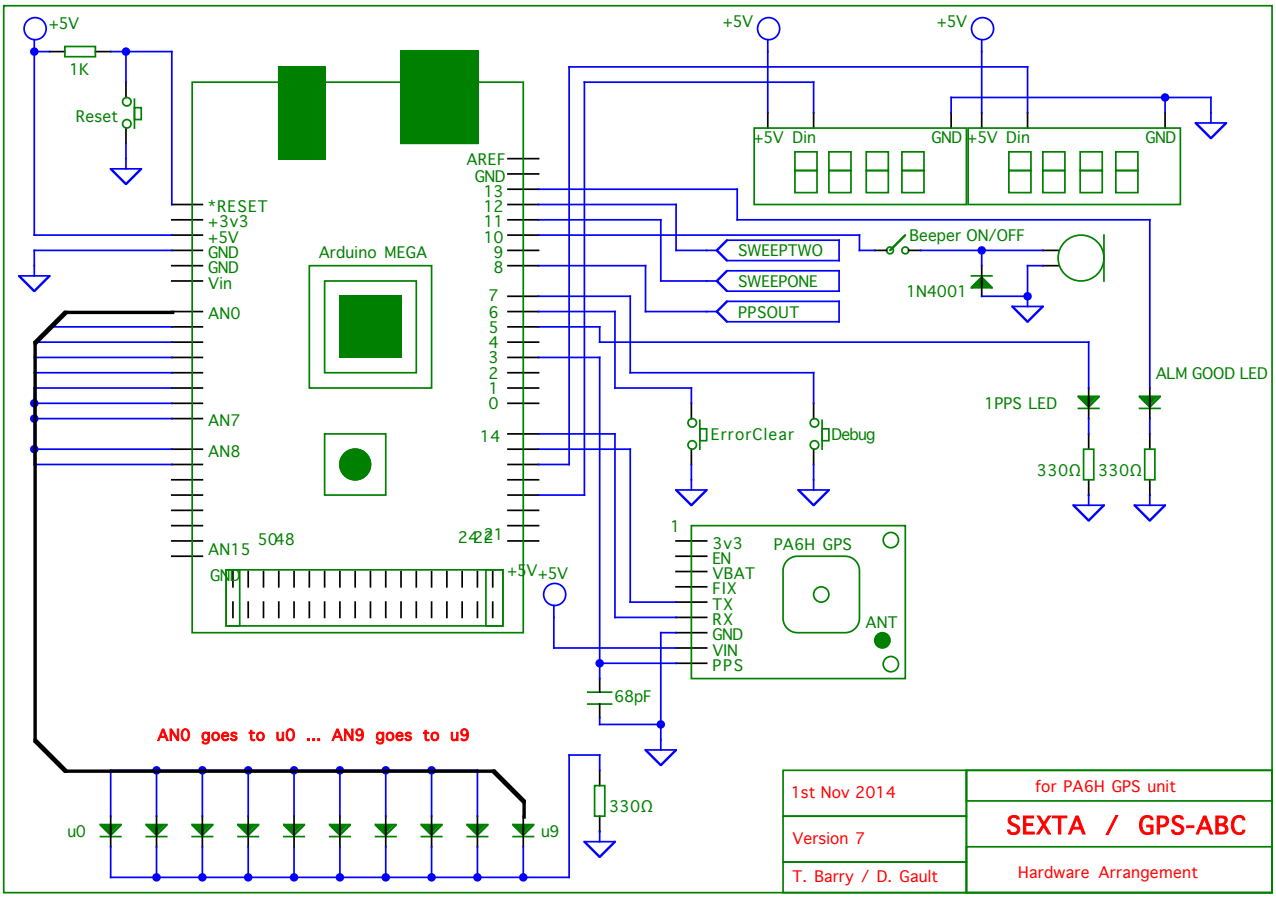
GPS units from HAP supplies (uBlox) or LadyAda (PA6H)

3)
4) http://www.freetronics.com/products/dot-matrix-display-32x16-red#.VCi5tVIcT4Y
5) https://www.sparkfun.com/products/11441
6) http://www.jaycar.com.au/productView.asp?ID=HB5972

Circuit Diagrams






+5V
1K
Reset
*RESET
+3v3
+5V
GND
GND
Vin
AN0
AN7
AN8
AN15
Arduino MEGA
5048
2422
AREF
GND
13
12
11
10
9
8
7
6
5
4
3
2
1
0
14
+5V
+5V
+5V Din
GND
+5V Din
GND
SWEEPTWO
SWEEPONE
PPSOUT
Beeper ON/OFF
1N4001
ALM GOOD LED
1PPS LED
330Ω
330Ω
ErrorClear
Debug
1
3v3
EN
VBAT
FIX
TX
RX
GND
VIN
PPS
PA6H GPS
ANT
68pF
AN0 goes to u0 ... AN9 goes to u9
u0
u9
330Ω
1st Nov 2014
Version 7
T. Barry / D. Gault
for PA6H GPS unit
SEXTA / GPS-ABC
Hardware Arrangement