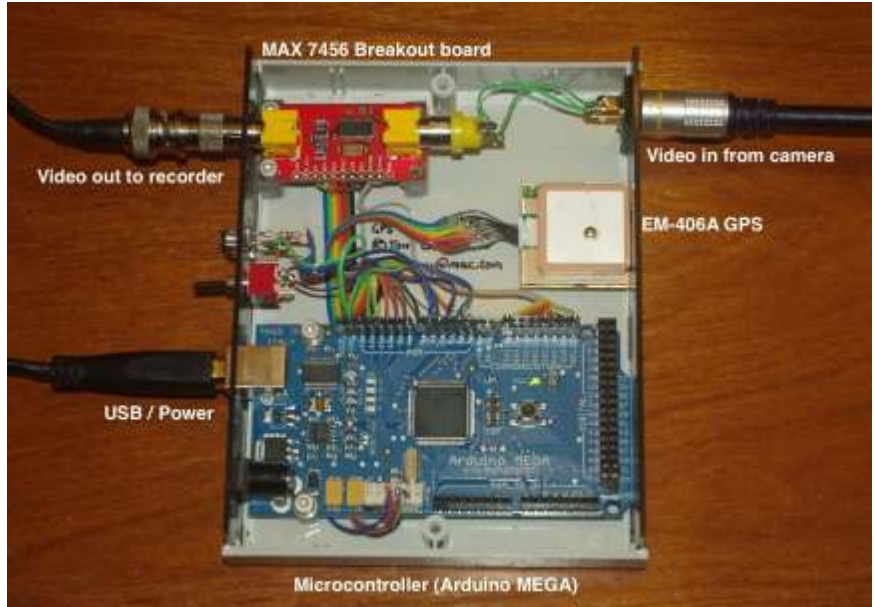# How it was built - the IOTA-VTI

Tony Barry, WSAAG

Thursday, 6 October 2011

In late 2009, I began getting interested in occultation observing after a presentation by Dave Gault at the local astronomy club (the Western Sydney Amateur Astronomy Group). I quickly realised that to do effective observing I needed a time source that was considerably more precise than anything I had to hand. Dave used a device called KIWI-OSD, however I quickly found that these devices were no longer available and anything else was at ruinous cost, and so for an amateur astronomer on a budget, occultation observing was not really a field I could get into.

This irritated me somewhat and I began looking at ways to make my own GPS based time source. From Dave's presentation I knew it had to be able to write to a video stream, and perform sub-second timing on video fields.

I spoke with Dave in the weeks following his presentation, and he offered to help the project along. And his input into the way IOTA-VTI functioned was essential to getting it up to speed in a manner suitable for occultation observers. As an engineer, my interests did not always match with those of the end user, and Dave was able to steer the results towards a more sensible arrangement for the rest of us.

My first lucky break with IOTA-VTI was the method of writing text to a video stream in a timely manner. I had previous experience with a Maxim chip, the MAX7456, for an unrelated project, and I revisited this IC to see if it could be persuaded to do the task. I found it was quite able

Shown here is IOTA-VTI Prototype number 1

to do the job, but my routines to display on the screen were not optimised and they required a serious rewrite to get them up to speed.

The microcontroller chip I had previously used was seriously underpowered for this project and I upgraded it to an Atmel Mega 1280 AVR. This chip had some excellent features that were essential for the smooth working of IOTA-VTI - the most important was an extra hardware serial port to allow the GPS to communicate with the microcontroller on a different channel to the programmer and the user.
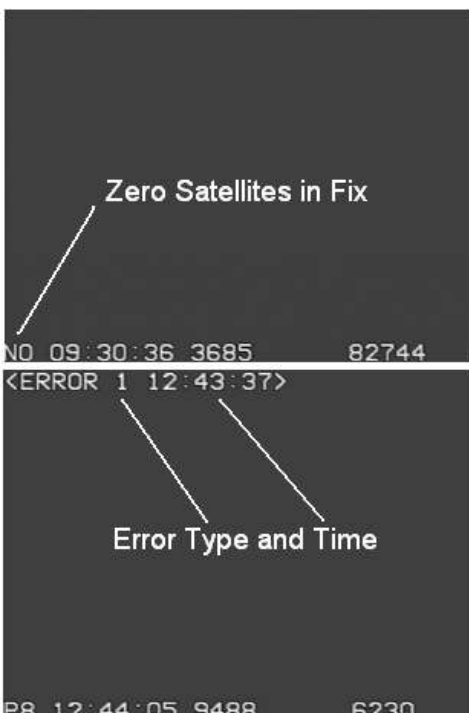
Two examples of the IOTA-VTI Time screen

My second lucky break did not seem at all lucky at the start. I picked the GPS unit for the IOTA-VTI on the basis of on-line reviews, which praised the USGlobalSat EM406A for its excellent sensitivity and rapid time to first fix. But my first experiences with this first unit were anything but praiseworthy. It would sometimes start up a second ahead of true UTC… and then five to ten minutes after a fix, would repeat a time stamp for two seconds. Other times it was fine. I ended up putting in a good deal of code to test the time stamp integrity every second while the unit was operational, with the idea that it would noisily advertise any failure and we could look at the GPS sentences and try to work out what was going on.

I was highly embarrassed by these failures, but Dave thought it was great. As a seasoned user of the previous VTI device, he was aware that GPS errors did occur, and in the previous device they were not advertised till the end of the session. IOTA-VTI would (by contrast) check everything it could every second, and keep the user informed of issues as they might occur.

The IOTA-VTI reports on the number of satellites in the GPS fix and will also report the type of error detected and the time of the error detection, within one second of detecting the error.

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The main error we found was the (in)famous GPS leap second additions, which are put out every so often to keep GPS time in synchrony with UTC. The GPS I had purchased was from an old batch, and it had two lucky limitations in it. One was that its firmware was put in before the last leap second was added. The other was that it had a really short retention span for the updated almanac which contains the correct number of leap seconds to add. This almanac is downloaded from the GPS satellites every time the unit is turned on, and most GPS units will remember the almanac for months.

These two shortcomings of the GPS irritated me enough to write quite a lot of code to check the state of the almanac, and keep the user informed till it was up to date from the satellite. If this was a rare occurrence it might have gone un-noticed, and it would only bite users some time down the track, perhaps after a period of months of inactivity. It would also not come to light except via a careful analysis of the data, as it would be buried along with all the other time stamps on a video tape. So these lucky breaks at the time did not seem anything but irritations, but looking back, they helped to make the device much more robust and trustworthy.
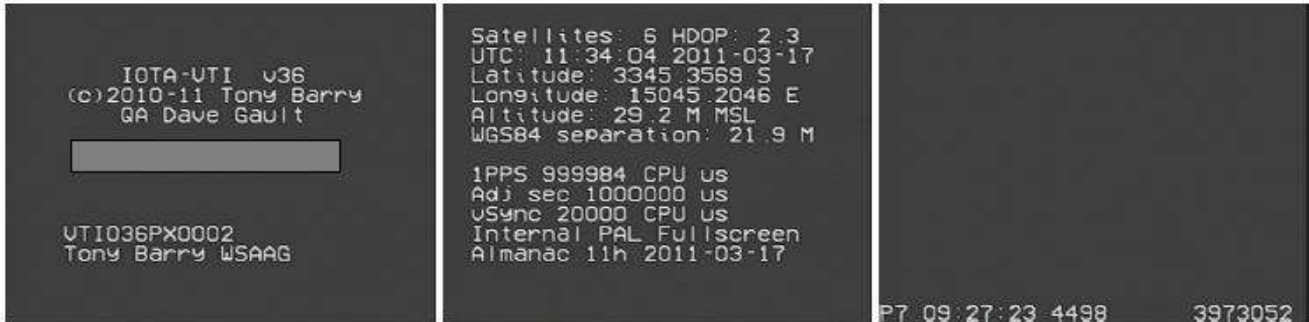
Splash screen   Position screen   Time screen

About the time I started getting ready to consider production of the device, Dave Gault had a conversation with me about how it should be presented to the occultation observing community. He rightly pointed out that most folk do not build their own devices; and the number of people in the community who would be OK with building and programming a microcontroller was pretty limited. He also ewminded me of the unfortunate demise of the previous KIWI-OSD, which had left a lot of people with nowhere to go for spares or new devices. We felt that the best thing we could do would be to provide IOTA, the governing body for occultation timing, with the source code, design, and a permanent gratuitous licence to make the device. Here in Australia, there aren't a lot of people doing occultations. In the US and Europe, there are a lot more people and a lot better infrastructure to make such devices quickly and cheaply.

Dave Gault approached Dave Herald (the creator of the Occult program), and he crafted the licence which IOTA uses today to arrange the production of IOTA-VTI by VideoTimers in San Jose, California.

The proprietor of VideoTimers, Walt Morgan, is also an experienced occultation observer, and he and Sandy Bumgarner asked for one further thing to be added to IOTA-VTI which improves the reliability of the device. Most mission-critical computer programs will check their internal program for errors (principally radiation induced memory changes) and make a big scene if they find any errors. Sandy and Walt were very keen to ensure that radiation changes did not escape notice, and I added the code to check the memory. Because there is a lot of memory to check, and the VTI is doing a lot of other work, I broke the task down into small bites, and the VTI cycles through one complete scan of memory every hour.

I'm pleased to say that IOTA-VTI is now in production, and in the hands of the people who matter - the quiet, unassuming people who set up many observing stations in a twenty mile line to obtain profiles of occulting asteroids that could never be obtained by any other method. I consider it to have been a privilege to help these good folk to keep on doing good science.

Regards,
Tony Barry

For more info. See… http://videotimers.com/home.html