

# THE *fido*™ NEWSLETTER

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## I. OUTPERFORMING A 133MHz RISC

How can a 66MHz *fido*™ outperform a 133MHz ARM9? Well, at Innovasic we designed *fido* to be able to do so and now, thanks to the efforts of our partner Schneider Electric in Grenoble, France, we demonstrate this capability in an industry research project. It proves the strength of *fido's* architecture in the areas of: real time performance and flexible I/O.

But, before we discuss the results, let us tell the full story.

Schneider Electric, as many other leading players in the industrial automation market today, is working on projects to replace their traditional fieldbus communication systems with protocols based on Ethernet.

The problem they must overcome, however, is: Ethernet was never designed to be a hard realtime communication platform, but realtime is an absolute *must* in the automation industry.

One way to overcome this Ethernet limitation is to modify the Ethernet protocol itself. ProfiNET-IRT(not ProfiNET-RT!) and EtherCAT, for example, have solved the problem that way. Such a

modification, however, requires custom silicon solutions.

This approach works very well, but the downside is “standard Ethernet products” can no longer be integrated into those networks. In some applications that may work fine, in others it will not.

Another approach, used by protocols like Modbus/TCP or Ethernet/IP (promoted by the ODVA), is to leave the Ethernet protocol unchanged. To improve realtime capabilities of those protocols, standard Ethernet or IP extensions can be used – like QoS (Quality Of Service). QoS gives Ethernet or IP (Internet Protocol) traffic a higher priority that will make sure any further processing will be prioritized with respect to the QoS level. There are different layers where QoS can be implemented. One is the Ethernet Protocol itself, using a so called *VLAN Tag*. The other is using the *Type-Of-Service* field of std. IPv4 for the same purpose. The solution demonstrated at Schneider uses the second approach but is in no way limited to it.

QoS is also used in major Internet Applications, like *Voice-Over-IP*. So its really a standard feature with importance far beyond industrial solutions.

When talking with our partner Schneider Electric, we learned that they were working on a research project (follow this link to read the full report: “[Improving Determinism of Real-Time Applications Over Ethernet](#)”) to evaluate QoS. In this project, there were two std. Modbus/TCP servers running on a single node. The idea was to run those servers at different

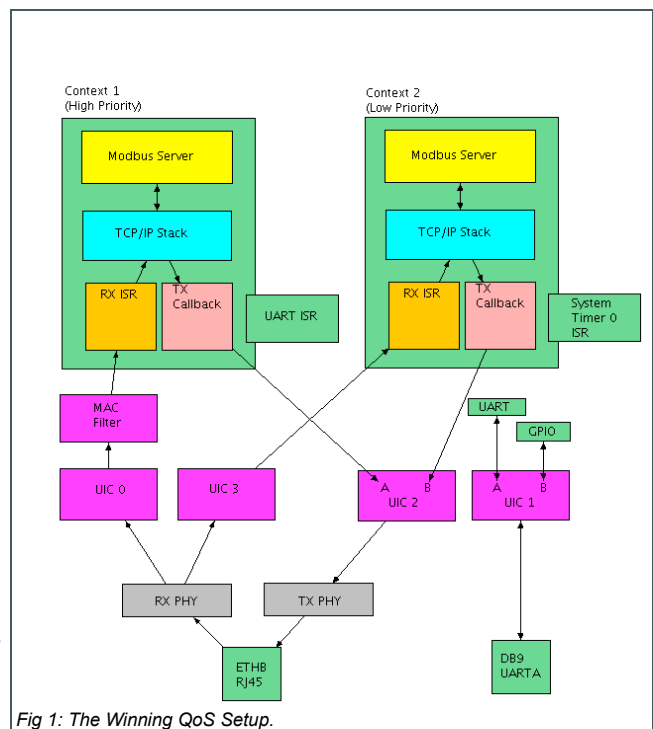


Fig 1: The Winning QoS Setup.

priorities using QoS. Because both ran on the same machine, the high priority server is expected to be influenced by the lower priority Servers activities. This fluctuation of the high priority response time is called jitter. To make a real-time application work reliably and predictably, this jitter must be as small as possible. It's important to understand that a low average jitter is not enough, its important to have a low and repeatable worst case jitter.

The real world background to this project is a model of a node, where one high priority server is responsible for any real-time traffic and a lower priority server is in charge for configuration and maintenance of the node. This traffic has no real-time constraints.

After reviewing *fido* Schneider decided to include it as an alternative platform in the ongoing research project. The other system under evaluation at that time was a 133MHz ARM9 with integrated Ethernet Switch. This switch was able to queue traffic based on QoS in independent queues, helping the software to handle the priorities correctly.

How did *fido* perform? Very well. Typical response time was equivalent to the ARM, while under heavy Ethernet traffic the response time was significantly better. In addition *fido* showed a much lower Jitter (almost 6 times lower.) All this was made possible by the [RTOS-Kernel-in-a-Chip](#) design of *fido* and as a result it made the nasty and costly RTOS layer obsolete.

But the *RTOS-Kernel-in-a-Chip* was not the only *fido* feature that had an important role in this project.

The other winning feature is [flexible I/O](#). To overcome the fact that the current *fido* 1100 does not include a QoS aware switch out-of-the-box, Innovasic's engineering came up with the design shown in Fig 1. They used 2 UICs, *fido's* programmable peripherals, to receive the same incoming Ethernet frames with two independent channels simultaneously. A minor Modification in the Ethernet MAC firmware of these UIC's gave them the ability to filter out frames that do not match the channels QoS requirements. Doing it this way, we had independent data paths for both priorities and could assign one of *fido's* real-time contexts to each priority. Doing so, the low priority context could not interrupt the high one, but the high priority context could always interrupt the low priority traffic – one key to the excellent performance and a proof of *fido's* flexible design.

It's important to understand that the features that have been so important in this project, the *RTOS-Kernel-in-a-Chip* and the *flexible I/O*, could do their good work not only for Schneider and for Ethernet QoS applications. Similar problems are *everywhere!* Think of other protocols. Think of having a high performance control loop and a HMI (Human Machine Interface) on the same machine. Think of having a ProfiNET-RT node running a higher priority control loop while communicating. Think of QoS based Internet applications like *Voice-Over-IP*. *Fido* is designed for hard real-time applications – across all markets!

We are pleased to invite you to learn more about *fido* and this project is the free Web-Seminar. The box below gives you all the information you need to attend.

## RELATED WEB-SEMINAR

### *Minimizing Packet Timing Uncertainties in Embedded Ethernet Systems*

It will be September 6th at 12:00 Eastern time in the US and 17:00 in the UK and 18:00 for most of mainland Europe.

For Free registration, go <http://www.techonline.com/learning/webinar/201203233>

#### Presenters:



#### **Jordan Woods, Chief Technical Officer**

Jordan Woods is a co-founder of the company and leads the R&D activities at Innovasic. Mr. Woods has 20 years of experience in the industry, most of which has been in the semiconductor design business. His engineering experience includes employment at Honeywell where he developed semiconductor solutions for various markets including optical disk, digital mapping and graphics. He holds a BSEE from the University of New Mexico.



#### **Harold Wilson, Applications Manager**

Harold Wilson is an Applications Manager at Innovasic for the *fido* family of microcontrollers. Mr. Wilson has 20 years of experience in technical applications, ranging from radio transmitters to firewalls. His research has been widely published and he has served as the Chair of Publications for the International Symposium on Software Reliability Engineering. In addition, Mr. Wilson is an IEEE Section Board member and holds an Adjunction Faculty position at The College of Santa Fe.

## 2. INNOVASIC JOINED ODVA

After joining the ProfiNet and EtherCAT User Organizations in 2006, Innovasic become a member of the Open DeviceNet Vendors Association (ODVA), whose principal members include Cisco Systems, Eaton Electrical, Omron Corp, Rockwell Automation and Schneider Electric. This guarantees Innovasic a first hand, in depth insight into the major Industrial/Realtime Ethernet technologies.

“Industrial Ethernet is a key defining protocol for the *fido* family roadmap,” said Keith Prettyjohns, CEO of Innovasic Semiconductor. “Industrial control I/O modules represent an important application area for the *fido* family. We have designed *fido* to address both the deterministic control tasks and the communications tasks required for these modules. Going forward, we plan to introduce new features that we believe will help further the adoption of Industrial Ethernet and bring competitive advantage to our customers, while still maintaining compatibility with standard Ethernet.”

## 3. A LOOK INSIDE

*fido* is not about contexts, UICs and debugging only. There are a number of features included that do not make it to prominence. These less prominent features are valuable in every day work and can be a major key to some applications. In the “A Look Inside” we want to present those hidden features to a wider audience.

*IN THIS ISSUE:*

### THE TIMER/COUNTER UNIT (TCU)

The *fido* I100 device includes two Timer/Counter Units (TCU).

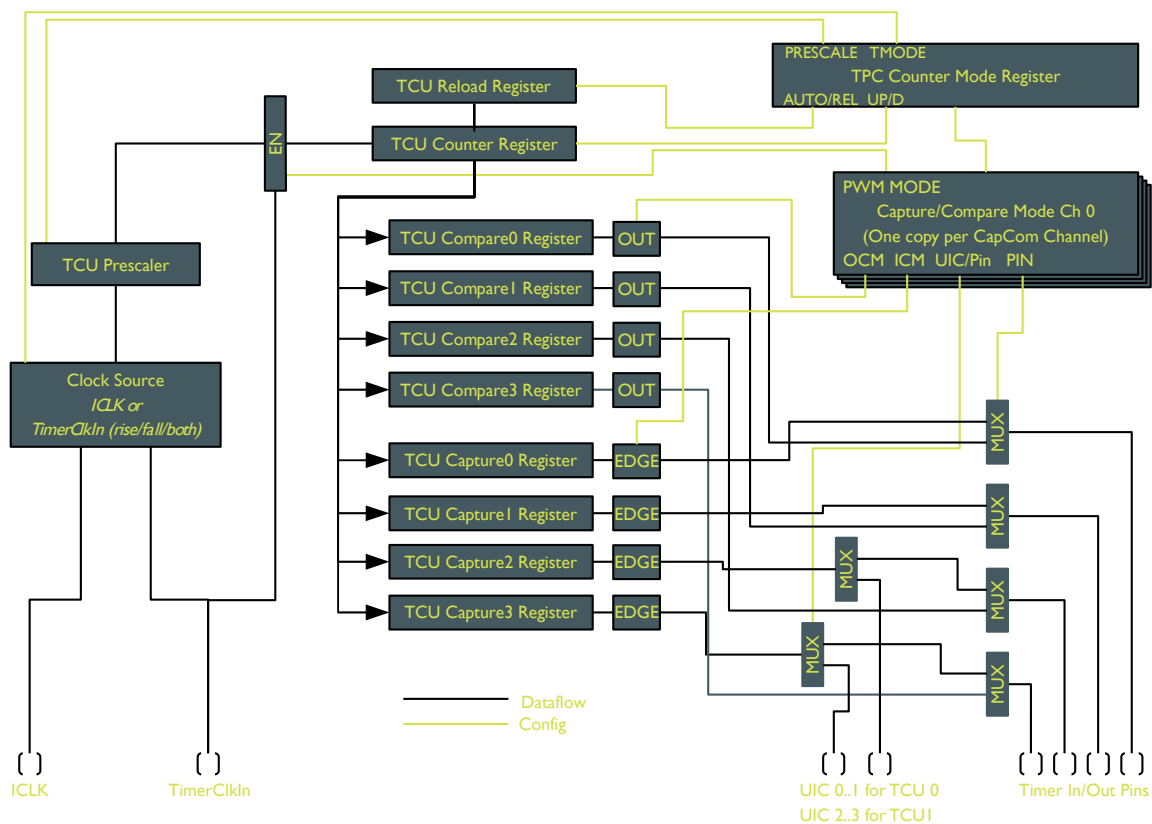


Fig 2: Block Diagram, *fido* TCU single channel

They are completely independent and can be used for a wide range of timer / counter applications, including:

- Pulse Width Modulation
- Pulse Width Measurement
- Pulse Generation
- Timing Capturing

and others. Its flexible design can also be used to implement more complex applications.

A complete application note on how to use the TCU as a 4 channel PWM output is available at [http://innovasic.com/media/docs/App\\_Note\\_PWM.pdf](http://innovasic.com/media/docs/App_Note_PWM.pdf).

The workhorse of the TCU is a 16-Bit Up/Down Counter. This counter can be programmed to reload a given value from the Reload Register of either underrun or overrun condition. Its also possible to Reload the Counter on a input capture event.

The Timer can be driven by either the Internal Clock (typ. 66Mhz) or an external clock provided through the external clock input Pin (Input clock on this pin can be ¼ of ICLK max). No matter what clock source is used, a prescaler is available to scale the input clock down, allowing divide factors from 1 (no change) to 32768.

Fig 2 shows the complete block diagram of one TCU unit. The most notable features of the TCU is its flexible capture /compare unit that allows to select (rising, falling, both) edge detection for the capture inputs and set/reset/toggle selection for the output compare registers.

Fig 2 Also shows, that an input capture can be caused by the UICs. Using this feature, its possible to implement a IEEE1588 device solution for *fid*o.

IEEE1588 is a standard to synchronize clocks in an Ethernet network with high precision. The standard is a major part of some Industrial communication protocols, including ProfiNet and Ethernet/IP.

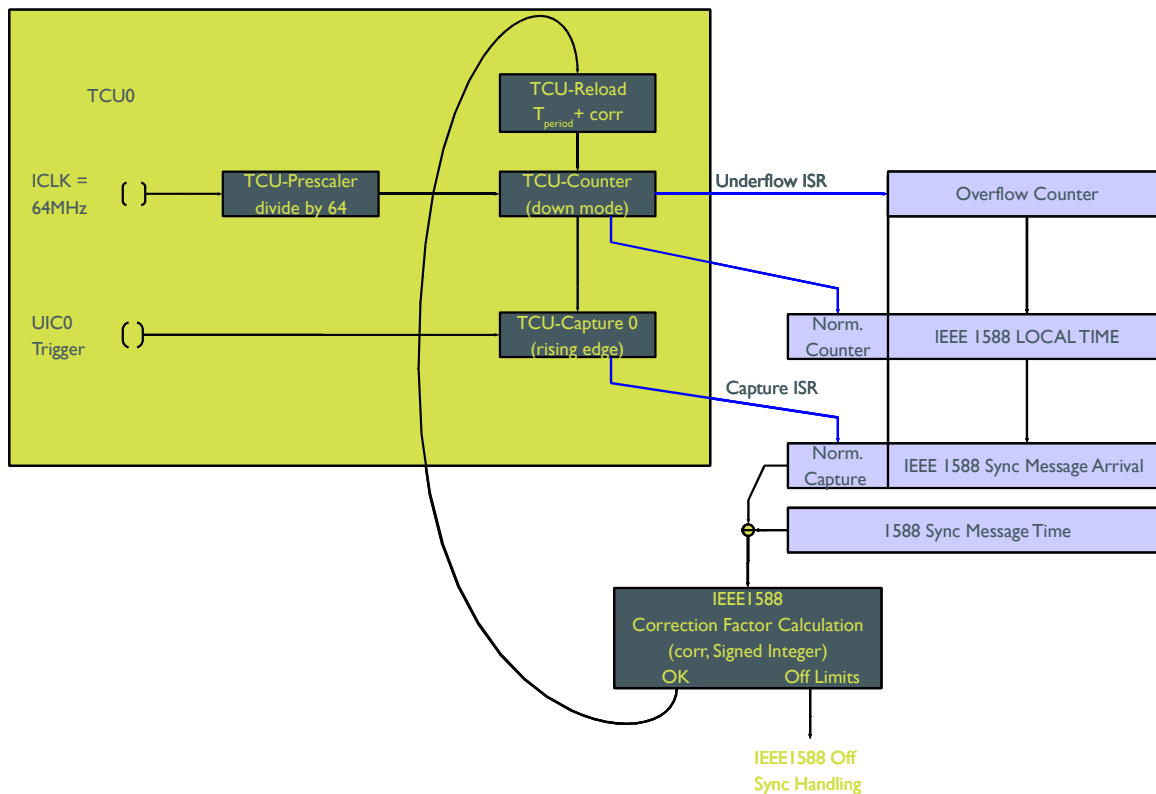


Fig 3: A IEEE1588 Implementation, Operation in Synchronized State

What would be required for such a solution?

Fig 3. shows a potential IEEE1588 architecture using the a TCU. The time correction is calculated from the time of arrival of the IEEE1588 sync message we measured and the time the sync message reports (well, reality its not that simple, but the general concept is). Our captured time is constructed from the timer overflow value and the captured register value. It must be assured, that the captured value is normalized as the counter is operated in down counter mode.

This normalization is calculated as follows,

$$T_{norm} = \frac{(T_{reload} - T_{cap}) * T_{period}}{T_{reload}}$$

where  $T_{cap}$  is the captured value,  $T_{reload}$  is the current corrected reload value and  $T_{norm}$  is the normalized value.  $T_{period}$  is the basic counter period, for which 32768 may be an excellent choice. The normalization can be implemented with *fido's* fast integer shift and divide instructions.

Because the timer period is prolonged or shortened by changing the reload value in a minimal way (+/- maybe 10 ticks or less), the correction is very smooth and the quality of the IEEE1588 local time is high. However, the Fig 3 shows only the synchronized state. Setup and bootstrap phase are not shown.

This architecture may be no high end solution but very suitable for most industrial applications.

For more information on I588, see <http://ieee1588.nist.gov/>.

## 4. UPDATES

### DOCUMENTATION UPDATES

Latest documentation:

Document	Version	Available from
Datasheet	9.4	<a href="http://www.innovasic.com/media/docs/datasheet.pdf">http://www.innovasic.com/media/docs/datasheet.pdf</a>
Users Manual	5	<a href="http://www.innovasic.com/media/docs/usersguide.pdf">http://www.innovasic.com/media/docs/usersguide.pdf</a>
Instruction Set Manual		On request
Embedded Speech	-	<a href="http://www.innovasic.com/pdfs/Speech_EmbeddedWorld2007-1.pdf">http://www.innovasic.com/pdfs/Speech_EmbeddedWorld2007-1.pdf</a>
Whitepaper: Remove the RISC from your Embedded Design	-	<a href="http://www.innovasic.com/media/docs/fido_whitepaper_remove_the_risc.pdf">http://www.innovasic.com/media/docs/fido_whitepaper_remove_the_risc.pdf</a>
Whitepaper: Reliability Starts at the Core	-	<a href="http://www.innovasic.com/media/docs/fido_whitepaper_turley.pdf">http://www.innovasic.com/media/docs/fido_whitepaper_turley.pdf</a>
Whitepaper: Improving Determinism of Real-Time Applications Over Ethernet	-	<a href="http://innovasic.de/QoSfidoWhitePaperFinal.pdf">http://innovasic.de/QoSfidoWhitePaperFinal.pdf</a>
Errata		On request

### SOFTWARE UPDATES

Package	Version	Available from
EDK Toolset	1.2	Call your Distributor or Sales Rep.

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