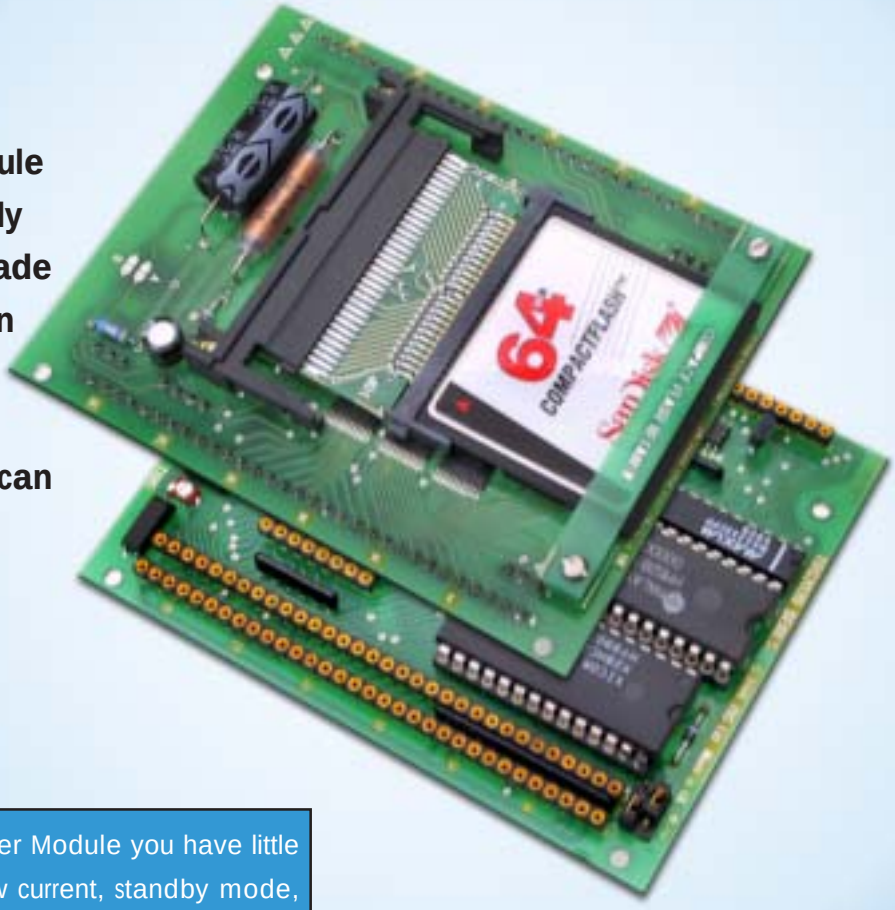
TDS2020*F* & TDS2020CM2

Data Logger Module

With this module you can quickly build tailor-made data collection systems with removable memory that can be read by a personal computer.



As a Data Logger Module you have little to add to its low current, standby mode, over a gigabyte of memory, 10-bit 8-channel A to D and real-time clock. There are keyboard, graphics LCD, CAN and serial port interfaces. Use Industry standard digital camera Compact Flash and PCMCIA-ATA cards. You can also log to a flash chip on the computer.

As a High Performance 16-bit Control Computer its on-board Assembler and high level language make programming and debugging a pleasure. It has the execution speed you need in a real-time system. High software productivity comes from interactive development in a Windows environment. Ready-made library routines mean most of the work is already done.

The ideal way to save TIME and MONEY designing custom loggers.

Straight into Excel

Data collected in this module can be copied as a Windows file to your office hard disk or laptop. You can open the file with your Excel spreadsheet or import the data into an Access database. If you prefer, send the data back using a modem link.

Triangle Digital Support

Technical Data

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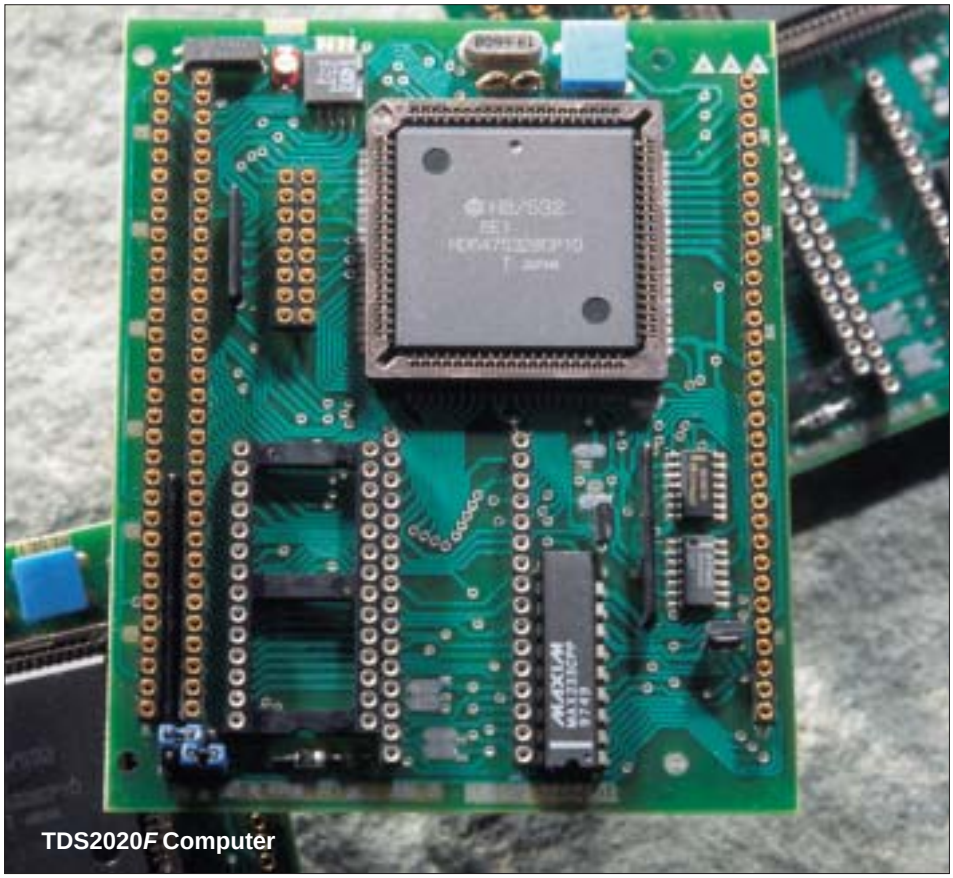
Technical Data
TDS2020F & TDS2020CM2
Data Logger Module


TDS2020*F* Computer

TDS2020*F* COMPUTER

Full details of the computer board are given in the TDS2020*F* data sheet, available free on request. You can also download it in PDF format from www.TriangleDigital.com

The TDS2020*F* is a powerful 16-bit control computer. Despite the small size and low power consumption, it is packed with important features that make it easy to use in solving control and data collection problems.

Rapid application development is assured by the interactive nature of development and debugging. A library of software provides instant solutions to many application problems. Source code, written in the high level language Forth, is directly compiled into Flash-EEPROM non-volatile memory. Coupled with the ready-made software modules, designs can be completed very quickly, even without a prior knowledge of Forth.

WHY FLASH?

Direct compilation to Flash-EEPROM is convenient and avoids the cost and development cycle of a PROM programmer. There is a further advantage—you can zap the program remotely over a modem and recompile. Suppose the TDS2020*F* were embedded in a vehicle or a pressurised vessel, you could update the program without even removing the computer.

WHY FORTH?

The reason for programming card computers in Forth is productivity—you get results faster with less cost. It is closer to the machine than 'C' but is a higher-level language than assembler. Unlike either, it is interactive, giving quicker development. The multitasking Forth specially written for the board gives easy access to all its features and allows software to be written quickly. You write programs in high-level language, mixing it with assembler as required.

WHAT HARDWARE?

The TDS2020*F* is based on the Hitachi 16-bit H8/532 microprocessor. There are 45k bytes of space for your compiled program and up to 512k bytes of Flash memory or battery-backed RAM to keep vital data while the board is not working. This can be expanded to over a gigabyte with plug-in PCMCIA or Compact Flash cards.

The Analog to Digital converter has eight channels of 10-bit resolution (better than 1 in 1000) and there are three channels of 8-bit Digital to Analog (1 in 250). Both can readily be expanded with off-card chips.

Driver software is available for 12 and 16-bit A to D converters connected in parallel, or remotely through a serial SPI or I^2C interface.

The board has between 26 and 41 Parallel I/Os depending on the other options selected and there are two RS232 Serial Ports.

Additional features include four hardware Counter-Timers (three are 16-bit), two separate Watchdog Timers and Multitasking. An on-board clock provides date and time to be kept alongside your data.

The single power supply draws 32mA with only 155µA in a low power operational mode for datalogging. Regular automatic wakeup assures sub-milliamp power consumption and long battery life.

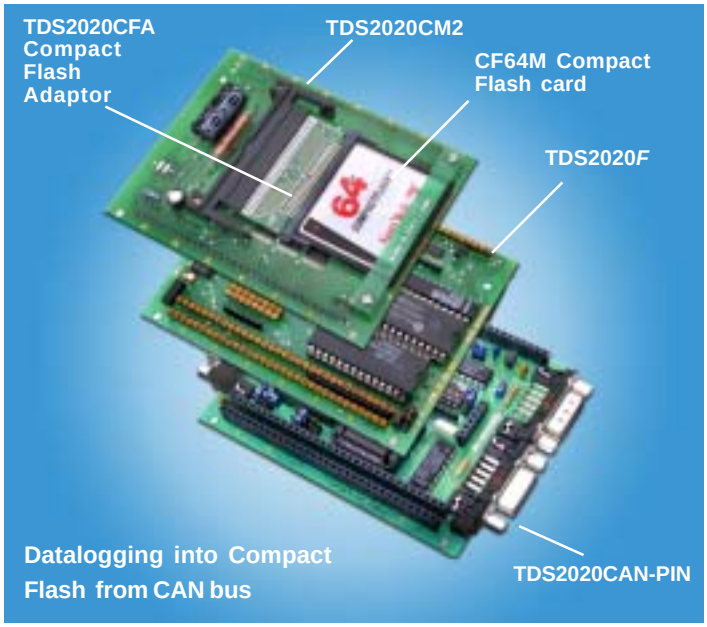
The TDS2020*F* measures 100 x 80mm. It has pin headers for connection by ribbon cable, or simply use it as a component inserted on a larger board. Another version has a DIN41612 connector for use in a rack.

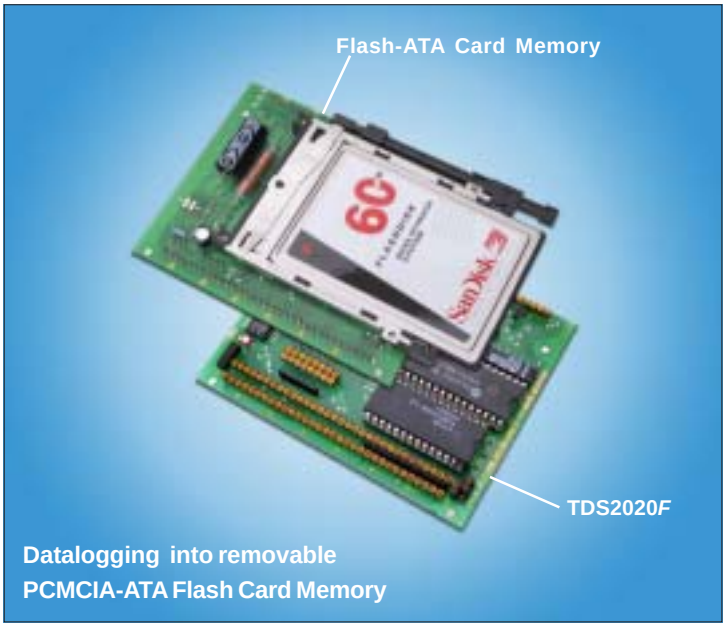
CAN ADAPTER

A Controller Area Network adapter (CAN bus) allows fast interconnection of TDS2020*F* computers, with a PC in the network if required. Both low level and high-level industrial and automotive J1939 CAN protocols are provided. CAN bus uses an RS485 physical connection in a secure peer-to-peer network. It is widely used in cars, boats and industry.

Technical Data
TDS2020F & TDS2020CM2

Data Logger Module





TDS2020CM2 COMPACT FLASH & PCMCIA ADAPTER

The TDS2020*F* computer card carries a TDS2020CM2 PCMCIA piggyback adapter. Add removable Flash-ATA, Compact Flash, RAM or hard disk memory cards as appropriate to the application. The amount of data you can collect is limited only by card capacity.

Data collected can be copied as a Windows file. Alternatively recover data by connecting the module to a parallel printer, or send the information through a serial port, perhaps to a modem or over a telephone or radio link.

Unlike PC solutions, the emphasis is on low power. The Flash or hard disk card is electrically disconnected most of the time. It is not even in standby—it consumes nothing. The software is written so that the storage card powers up as infrequently as possible. Between data readings the system itself may be put into standby so the whole Data Logger Module will consume less than 200µA most of the time.

A cache RAM on the TDS2020*F* ensures that the storage card does not have to power up very often. Eventually it will fill and in only 5 seconds a hard disk will spin-up, the computer will dump half a megabyte of data to the card, and the module will go back to standby. This short operation takes more current but the long-term average remains in microamps. Solid-state Flash solutions are much faster, have lower operational current, and are as rugged as possible.

MEMORY CARD TYPES

Flash-ATA and Compact Flash cards are the solid-state equivalents of hard disks. They present an identical electrical interface. Use a **TDS2020CFA** converter to mount Compact Flash cards on a TDS2020CM2 adapter and a **CF-PCA** adapter to read Compact Flash cards in a notebook PCMCIA slot.

Flash-ATA and Compact Flash cards offer high capacity without the peak current and mechanical operation of a hard disk. They are more expensive per byte than rotating memory, but more rugged. They also nicely fill the gap in size between RAM and disk. Flash technology is known for the limited number of read/write cycles, but these cards claim to give 500,000 typical.

Apart from data collection, Flash cards are useful in read-only applications such as database and speech storage. For example a 4M byte Flash card can speak for over 10 minutes if the data is digitised every 150µs with 8-bit resolution. Alternatively use Flash cards for text or graphics messages, updating the information presented by replacing the flash card.

LIBRARY FILES

Free source code is provided with Starter Packs that supports low level access to the following media for data collection. The software includes optional partial emulation of the Windows file format for when you need compatibility.

- ❑ Flash-ATA PCMCIA cards
- ❑ Compact Flash cards
- ❑ Hard disk PCMCIA cards
- ❑ RAM PCMCIA cards
- ❑ Flash chips

Other ready-to-use software library files implement data logging at a higher level. Some of them are complete data collection programs that often need little modification.

A good strategy is to take one of the standard datalogger programs and steadily modify it towards your requirement.

Alternatively, take low level building blocks and write custom glue software to tie these together to make a data logger that does exactly what you want. Some of the supplied blocks you might need are Flash card access, A to D conversion, timing routines and keypad and LCD drivers.

Technical Data
TDS2020F & TDS2020CM2
Data Logger Module

Technical advice on the best way to write your data logging software is available before purchase and we are well known for the high level of detailed support by email and telephone during development of your equipment. **Send an email now with your outstanding questions.**

REGULAR DATA LOGGING

Data collection usually must be done at regular intervals. Schemes provided fall into five broad categories (see table):

- ***Slowest, least power.*** Low power software standby that is periodically awakened by non-masked interrupts (NMI) from the clock chip.
- ***Intermediate.*** Regular interrupt that stacks the current Forth system and creates a new one for the duration of the interrupt.
- ***Intermediate.*** Regular interrupt that does very little except set a flag that it has happened, ready for a foreground program to do the actual work.
- ***Faster, more power.*** Do the data collection inside the interrupt.
- ***Fastest, no interrupts.*** Abandon everything else for sheer speed.

In the table ***Choosing the library program***, focus on the type that is closest to your required speed of data collection. There are library files near to your needs and you can see if a foreground program will be possible in addition to the data collection operation.

LOW POWER DATA LOGGING

A software framework for data logging when low power is needed is provided. This is suitable when records are taken between 30 times second and once per year. It illustrates the principles behind many data logging programs.

SPREADSHEETS FROM SATELLITES

The Global Positioning System provides position information from a suitable receiver that can be collected with supplied software. The data is in CSV format that can be directly imported to Excel to give the tables and diagrams you need.

LOGGING SERIAL DATA

If you are logging serial input data (with any method of data logging) use a library file that provides an interrupt-driven serial buffer. That way you do not lose input while data is being written to disk. A ready-made complete logging program for RS232 data is provided that will, with very little alteration, fulfil many requirements.

J1939 AUTOMOTIVE BUS

By adding a Controller Area Network (CAN) adapter, supplied software will log the data circulating in buses, trucks, cars and agricultural equipment. It is also hardware compatible with other CAN networks.

CHOOSING THE LIBRARY PROGRAM

Type	Library Files	Samples/sec	Foreground?
Least power (standby)	#TIMED.TDS #DOSHD.TDS #DATALOG.TDS	0-30	No
Forth interrupts, Multiple events	#EVERY.TDS #MT.TDS	0-10 10-2,000	Yes
Assembler signalling	#REGULAR.TDS	20-10,000	No
Assembler interrupts	#DOSDUAL.TDS #FASTLOG.TDS #REGULAR.TDS #FASTAD.TDS	1,000-100,000	Yes
Fastest, no interrupts	#FASTEST.TDS	10,000-364,342	No

TIME SYNCHRONISATION

Suppose you want to log data every quarter of an hour, it is unlikely you will to want record at 10.07, 10.22, 10.37 etc. It would be better to do it at 10.15, 10.30, 10.45 etc. Whatever the method used for data collection, there is software provided for achieving this. For example with a 20 second period, if the program is started at 10.30.07 the first record will be logged at 10.30.20, the next at 10.30.40 and so on. While waiting, the TDS2020*F* will be in low power standby most of the time.

RAM PCMCIA CARDS

RAM cards are only useful when over 512k bytes have to be stored, and it must be done more quickly than Flash cards would allow. The fundamental difference in access is that Flash-ATA cards emulate hard disks but RAM cards do not. They have no 512 byte sector structure and can be written or read at random byte by byte.

Speeds can be much higher. The throughput, using an 8-bit external A-D continuously is up to 364,342 samples per second. Using the on-board internal A-D under interrupt the limit is 41,000 samples per second.

Technical Data
TDS2020F & TDS2020CM2
Data Logger Module

FLASH CHIPS

You can log data to a 512k byte non-volatile Flash-EEPROM chip in the 32-pin socket of the TDS2020*F*. Unlike a RAM, no back-up battery is needed and the stored data is safer from corruption.

The support software provided is for use with **SST28SF040** chip from Silicon Storage Technology Inc. The device can be written byte by byte, but can only be erased (set to hex FF) in sectors of 256 bytes, or by erasing the whole chip. There is protection by software, which prevents accidental erasure. Data retention is quoted by the manufacturer as 100 years minimum and the endurance as 100,000 cycles minimum.

RAM CHIPS

You can put 128k or 512k byte RAM chips in the 32-pin socket with a battery attached to keep stored data and the real-time clock alive even when power is off. Flash chips are generally to be preferred, but there are two situations in which you might want to use RAM chips to collect data:

- ❑ The fastest possible data writing speed is required
- ❑ If you must have RAM in the 32-pin socket for other reasons

A library file is provided as a model for very fast data logging when interrupts and Flash chips impose too big a time penalty.

COLLECTION METHODS

The Flash card can be Windows formatted either on a PC or in the module. Then an empty file is put onto the disk. These are the main strategies for data collection:

- ❑ Extend the data file during data collection.
- ❑ Extend the data file to a fixed size, perhaps the whole card, after formatting. Logging will be faster because the Windows File Allocation Table (FAT) does not have to be updated while data logging.
- ❑ Use a lower-level routine that transfers data between 32-bit addresses in the computer and specified sectors on the storage card. One command transfers from 1 to 255 sectors of 512 bytes each at about 230,000 bytes per second.

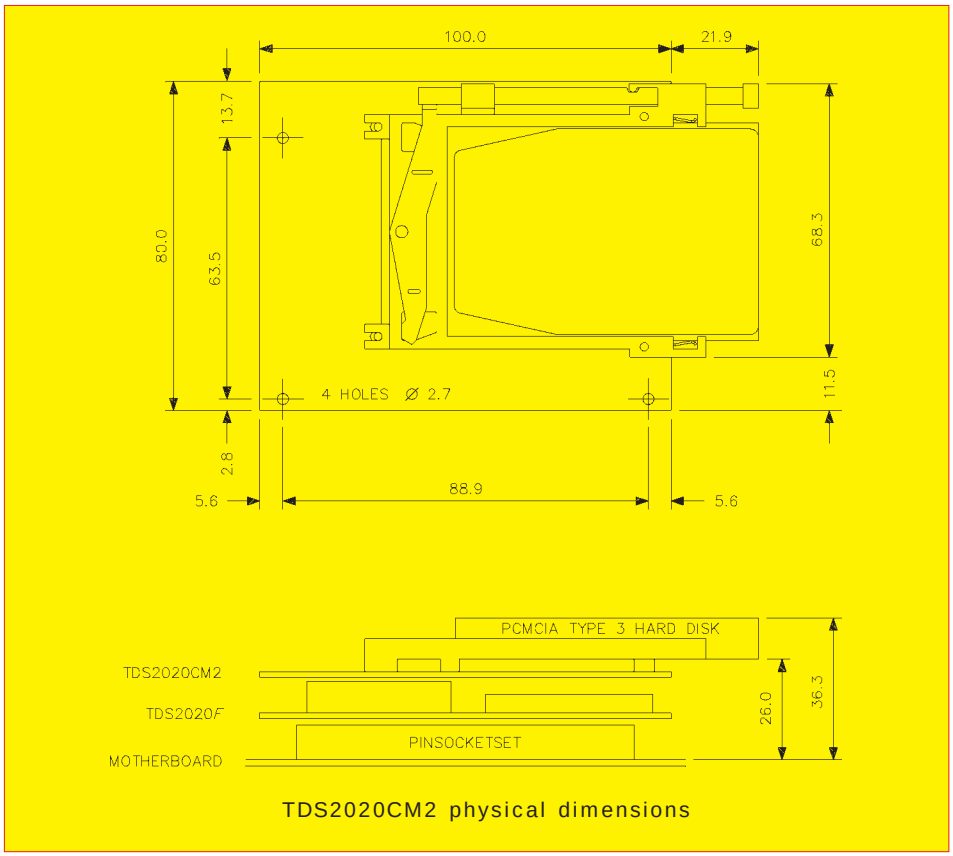
PRINCIPAL OPERATIONS

The following list summarises the key operations you will need, and provided by library routines when working with Compact Flash or Flash-ATA cards:

- ❑ **Windows format a card in a TDS2020*F***. This also partitions the disk and writes an empty file for collecting your data.
- ❑ **Windows format a card in a PC** and add an empty file
- ❑ **Pre-allocate** a data collection file to a fixed size to make logging faster
- ❑ **To log data** the alternatives are as follows:
  1. Repeatedly call a special function provided that stores away one byte at a time
  2. Redirect serial output to the storage medium
  3. Transfer data as a data block from anywhere in memory to anywhere on the storage card.
- ❑ **Update the date and time** of the logged data file
- ❑ **Read collected data** into a PC
- ❑ **Serially output** the collected data

TYPICAL TIMINGS

Solid state Flash-ATA and Compact Flash do not have the spin-up and spin-down times of hard disks. The timings below are for the standard software provided. In many cases they can be shorter than the times



TDS2020CM2 physical dimensions

shown because you will tailor the software to meet your exact need, rather than a general requirement.

- **Awake from standby and read a sector** typically 3.24s (hard disk) and 0.19s (Flash-ATA or Compact Flash).
- **Write per 512 byte sector** typically 2.09 ms (hard disk, Flash-ATA or Compact Flash).
- **Awake disk, dump 496k bytes of data to Windows formatted disk and go back to standby** typically 5.7s (hard disk) and 2.6s (Flash-ATA or Compact Flash) plus 75ms for every megabyte already written on the card. This FAT extension time is not applicable if pre-allocated.
- **Record sectors without Windows emulation.** Throughput with standby between dumps typically 95,000 bytes/sec (hard disk) and 207,000 bytes/s (Flash-ATA or Compact Flash). Maximum sustainable throughput typically 230,000 bytes/s (disk, Flash-ATA or Compact Flash)
- **Time to write one byte** using redirected serial output typically 56µs.
- **Worst case maximum throughput** using redirection typically 11,500 bytes/s on a 130Mb hard disk (without the time for data input), 7,000 bytes/s on a 512Mb hard disk and 15,600 bytes/s on a 20Mb Flash-ATA or Compact Flash card.

HARDWARE

PHYSICAL

The double-board module is 100 x 80mm. When mounted on a motherboard the bottom of the PCMCIA or Compact Flash card is 26mm above the base plane. The thick type III card (e.g. a hard disk) can take the overall height to 36.3mm. See the dimensional drawing on page 5.

CACHE RAM

A 128k or 512k byte RAM is necessary in the 32-pin socket to buffer the data. Memory cards emulate hard disks and cannot be written byte-by-byte. The RAM acts as a disk cache to avoid unnecessary accesses, saving time and reducing power consumption. Data is put into this buffer and the disk is only powered up for the write operation when it is full.

POWER SUPPLY

A single power supply of +6 to 16V is needed—there is an on-board switching converter to +5V. A small rechargeable 12V battery will last for months in most circumstances. A small external 3V lithium battery is needed if you want to keep the clock alive when the unit is not powered. TDS2020BYD (not TDS2020BYN) provides a suitable board and battery holder.

The TDS2020CM2 needs less than 50µA power itself. The overall consumption of a module is typically the 32mA of the TDS2020*F* itself while collecting new data to the storage medium, but only 155µA in standby when not taking readings. The standby mode can be invoked 30 times second or more slowly, down to once per year.

The standby mode also disconnects the PCMCIA card electrically from the rest of the circuit so that it can be safely changed while the unit is in operation ('hot-swapping'). At the same time the switching converter is turned off. The data-sheet standby mode of a Flash-ATA card needs about 4mA, but in this data logger module the card is completely turned off, eliminating this power drain completely.

Typical currents taken by a PCMCIA hard disk (not including the TDS2020*F*) are:

Power source	9V	12V	15V
Peak current	350mA	255mA	213mA
Idle (spinning)	114mA	85mA	69mA
Sleeping	31mA	25mA	21mA
Standby	<50µA	<50µA	<50µA

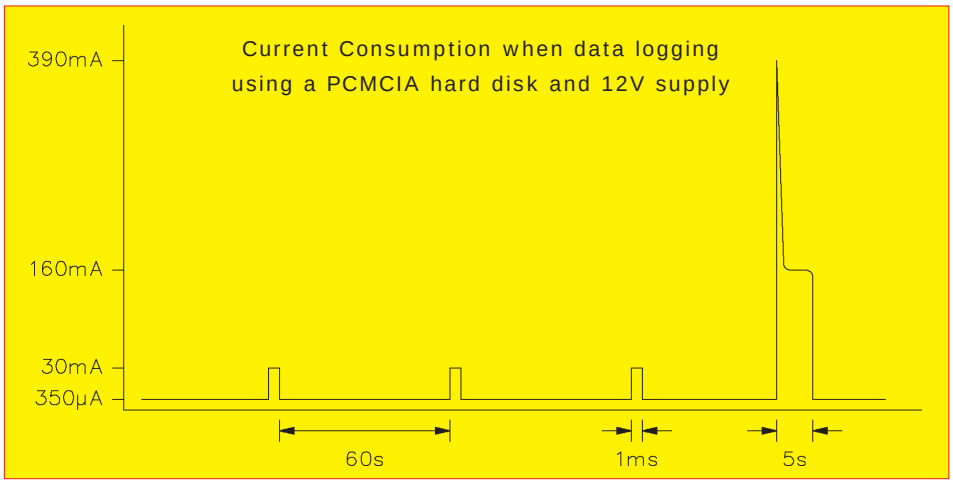
The diagram below shows current consumption when data logging using a one gigabyte hard disk and a +12V supply. Both scales are exaggerated in order to emphasise the detail.

In this example the module is mostly in standby, with the TDS2020*F* powering up every minute to collect data. Assuming that 24 bytes are logged each time, the hard disk will turn on only every 15 days to take the data from the buffer RAM.

DEVELOPMENT REQUIREMENTS

TDS-PC for Windows runs on your PC and provides a development environment including terminal emulation and storage of source code in standard text files on disk. Your program is compiled and debugged on-line in the TDS2020*F*, not in the PC; the interactive operation gives high programmer productivity.

You edit source code in one or more source code windows with full cut-and-paste between them. You may compile a whole file or just a highlighted section.



Source code can be laid out with lots of comments and correctly indented structures. Single keys invoke the word-processor, compilation and other features. Source files may include other source files, which in turn may call others. This gives your program another level of structure.

The *TDS-PC for Windows* CD also contains a set of library routines to add to those already pre-compiled in the Forth ROM. Update Service customers receive a more extensive suite.

You can test the program from RAM before electrically closing the Flash-EEPROM on board the TDS2020*F* to make a stand-alone system. No PROM programmer is necessary.

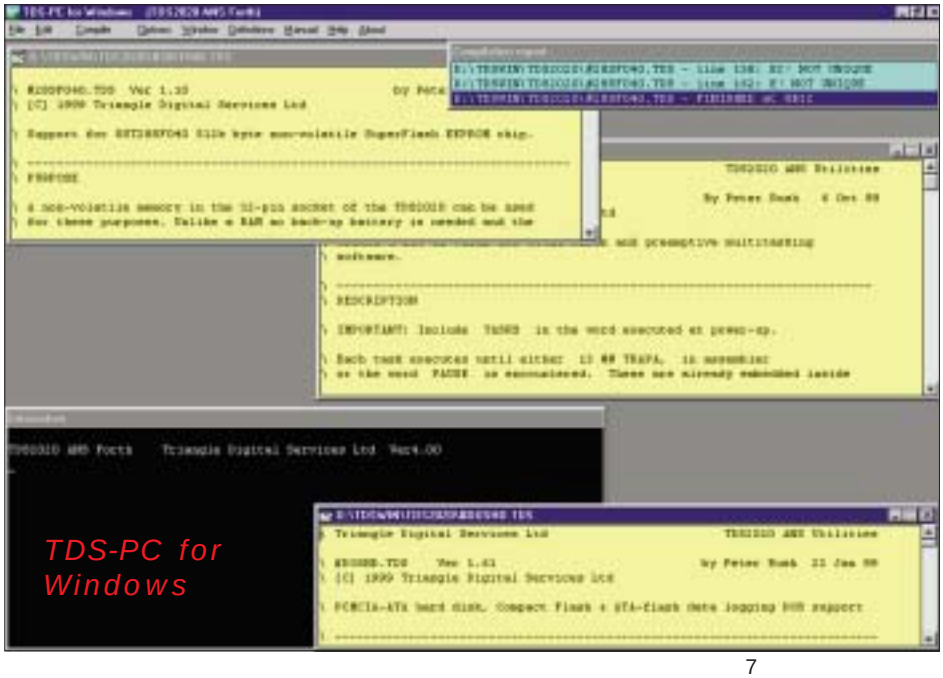
ORDERING INFORMATION

SUGGESTED FIRST ORDER

For data-logging applications to Flash-ATA or Compact Flash cards you need to order the following items. If you are in doubt, send us an email detailing your application and we will be pleased to advise.

- ❑ **TDS2020*F*-SP** Starter Pack containing:
  —**TDS2020*F*** card computer with Forth in the microprocessor
  —**RAM32K** RAM for holding program during development
  —**EEPROM32K** Flash-EEPROM for compilation in the latter stages
  —**PINSOCKETSET** set of sockets for the prototype application
  —**TDS2020TM** TDS2020*F* Technical Manual
  —**TDS2020HM** microprocessor Hardware Manual
  —**TDS2020PM** microprocessor assembler Programming Manual
  —***TDS-PC for Windows*** CD with development system, software library, website and other useful material.

- ❑ Select just one of these adapters to fit on top of the TDS2020*F*:
  —**TDS2020CM2** PCMCIA adapter (standard part—right-handed ejector)
  —**TDS2020CM2LH** PCMCIA adapter (left-handed ejector)
  —**TDS2020CM2NE** PCMCIA adapter (no ejector mechanism). This is the usual choice when using Compact Flash and the TDS2020CFA converter.



- ❑ **RAM512K** or **RAM128K** to act as cache memory in the 32-pin socket. The larger RAM gives better performance because the time between Flash or disk card use is greater.

- ❑ An appropriate Flash or hard disk card. Order codes are as follows, the xxx indicates the size:
  —**CMxxxMFLASHATA** for PCMCIA-ATA Flash cards
  —**CFxxxM** for Compact Flash as used in some digital cameras
  —**HDxxxM** or **HDxxxG** for PCMCIA hard disks

- ❑ **TDS2020CFA** Compact Flash converter if using CF cards

- ❑ **CF-PCA** adapter to read Compact Flash cards in a PC or external attachment.

- ❑ **TDS2020BYD** lithium battery and holder if you want to log dates and times alongside your data.

Order on-line from our website
www.TriangleDigital.com

Contact us if you would like a copy of any other datasheets

TDS2020*F* 16-Bit Embedded Computer

At last - the embedded computer that doesn't need a PROM programmer. An ideal way to develop instruments and data loggers. The datasheet is available in PDF format from our website: www.TriangleDigital.com.

TDS9092 8-Bit Embedded Computer

For simpler applicaitons in control or data logging the TDS9092 has many similar features to TDS2020*F* but at a lower price. The datasheet is available in PDF format from our website: www.TriangleDigital.com.

Components for Embedded Computer

For quantity usage, a Chip Set solution for the commercial manufacturing of systems developed with either Embedded Computer.

Can Bus Adapter

Communicate over secure Controller Area Network to control dispersed systems. Use re-programmable intelligent nodes and a PC link. For TDS2020*F* or TDS9092.

Application Software Library

Descriptions of source code available to customers and Update Service subscribers - continuously being updated.

Text to Speech

If you can display it, you can speak it. Converters for text to speech in PC, card and boxed formats from RC Systems Inc.

A Promotional CD is also available containing prices, specifications, circuit diagrams, web site, *TDS-PC for Windows* development environment, full technical manuals and most of the applications software library.

UPDATE SERVICE

For a yearly subscription you can receive the latest releases of TDS library routines plus the following:

- Latest updates to *TDS-PC for Windows*
- Source code for *TDS-PC for Windows*
- Forth words database and indexing utility
- Source code optimisation utility
- Extended software library routines
- New additions to the library
- New Forth kernel if and when there is an update
- Co-operative traditional Forth multitasker for TDS2020*F*

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