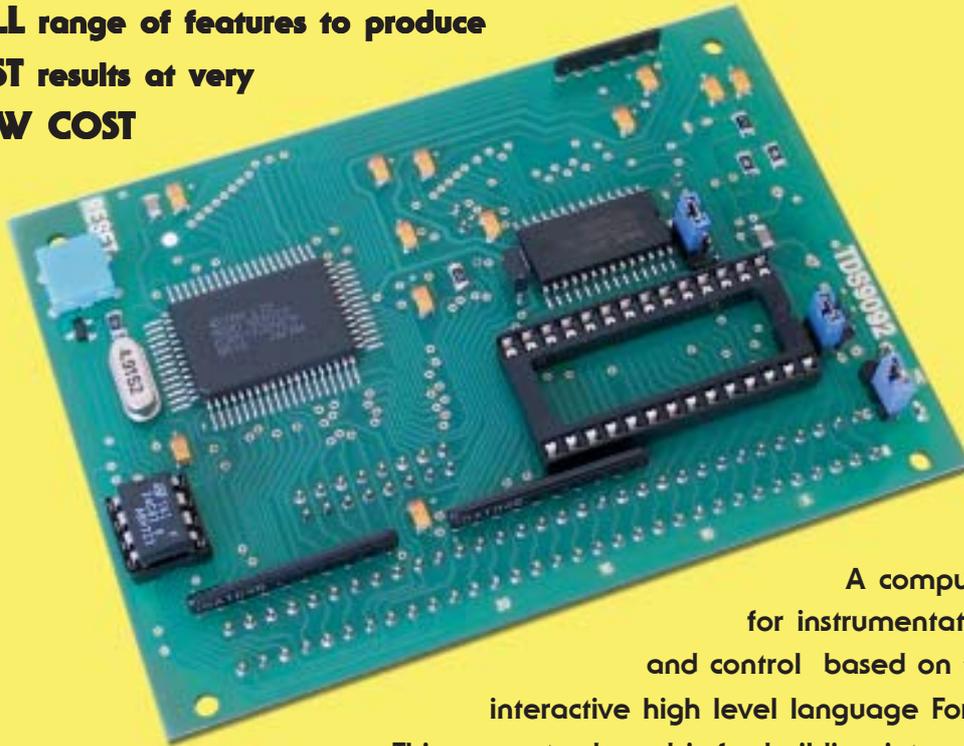# TDS9092

Triangle Digital Support

8-bit Interactive Embedded Computer

Outstanding value for money

A card computer with a
FULL range of features to produce
FAST results at very
LOW COST

A computer
for instrumentation
and control based on the
interactive high level language Forth.
This computer board is for building into your
products. Put software for the application into the
PROM and it starts to run as soon as power is applied.

APPLICATIONS:

Many of these existing uses depend on the low power of the TDS9092, its direct connection to matrix keypads, and output to LCDs:

- Flow measurement and control
- Serial code conversion
- Conveyor weigher
- PABX telephone exchange
- Diesel engine testing
- Mass spectrometry
- Calibration instrumentation
- Intelligent keyboard
- Public address switching

- Crane control
- Paging systems
- Sports timer
- Colour analysis
- Tide measurement
- Geological instrumentation
- Effluent monitoring
- Data buffering

- Agricultural machinery
- Machine-tool control
- Remote robot handling
- Heart rate data collection
- Hand-held data input
- Car-wash control
- Pattern generation
- Electron microscopes
- Security validation

8-bit Interactive Embedded Computer

CONTROL COMPUTER AND DATA COLLECTION MODULE

The TDS9092 is an 8-bit control computer based on a masked Hitachi 6301 microprocessor. Despite the small size and low power requirement it is packed with important features which make it easy to use in solving your control problems.

The interactive Forth specially written for the board gives easy access to all its functions and allows software to be written quickly. The 16k byte Forth includes LCD and keyboard drivers, together with many other utilities and a full symbolic assembler. You write programs in high level language, mixing it with assembler if required.

SPEED

The TDS9092 clock frequency is 4.9152MHz and the microcycle time 814ns.

MEMORY

The memory map for the TDS9092 is shown below. TDS9092 memory includes:

- 16k bytes RAM for data collection applications, arrays and variables.
- 29k bytes user application space. Use with a 32k byte RAM during development. This is copied into a PROM to make the code permanent.
- 256 bytes non-volatile EEPROM (2k, 8k or 32k bytes optional).
- 16k bytes Forth system.

PARALLEL INPUT-OUTPUT

35 lines are available for digital input and output. Two of these may be used as maskable interrupt inputs and another pair can drive I²C bus circuits.
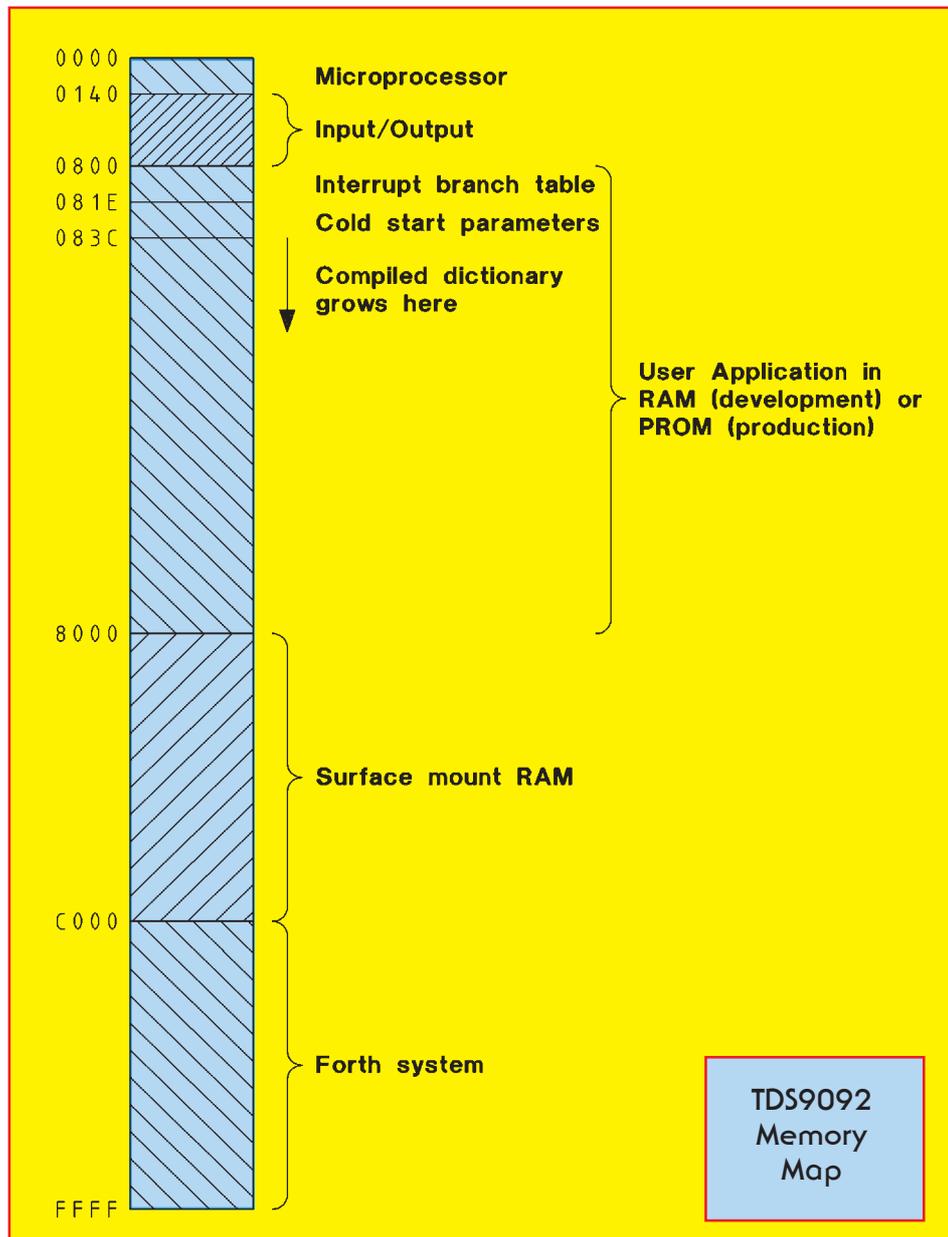
I²C BUS

This is a two-wire system for use with low-cost peripherals such as A to D converters, clocks, I/O, RAMs, EEPROMs, etc. marketed by Philips, Xicor, Microchip Technology and others. The board has a 256-byte EEPROM connected on this bus but, being socketed, can be replaced by larger capacity devices. Other I²C chips can be added externally.

SERIAL INPUT-OUTPUT

On the board are two serial drivers and receivers using true RS232 format and voltages. They can be used to give a single asynchronous serial link with handshake or as two separate serial links without. All baud rates from 75 to 76.8k are supported on port 1. Port 2 can be used at all rates up to 9600 baud. Although the computer has a single power supply of +6 to +16V the serial ports use ±9V generated on board to give output logic levels which meet RS232 specifications.

MICROPROCESSOR

The microprocessor used is the Hitachi HD63B01Y0 which is an 8-bit device with hardware multiply, 16-bit instructions, direct bit manipulations with memory and input/output. It has much on-chip hardware such


```
0000
0140        Microprocessor
            Input/Output
0800
081E        Interrupt branch table
083C        Cold start parameters

            Compiled dictionary
            grows here

            User Application in
            RAM (development) or
            PROM (production)

8000

            Surface mount RAM

C000

            Forth system

FFFF
```

TDS9092 Memory Map

8-bit Interactive Embedded Computer

TDS9092 Keyboard and Graphics LCD Interface

GRAPHIC DISPLAY USING HD61830 CHIP
EG: HITACHI LMG7400PLFC 240 X 128 PIXELS

8 x Schottky diode

8 x 3K3

10K 3K3 −14V

PERIPHERAL PORT B

PB7 PB6 PB5 PB4 PB3 PB2 PB1 PB0

8 x Schottky diode

TDS9092 Instrumentation Computer

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as two timers, synchronous or asynchronous serial port, and a very versatile interrupt system.

All the capabilities of the microprocessor are available to the TDS9092 user, but through the high-level language Forth, which makes them easier to employ. Access to some of the microprocessor hardware facilities are already built into the Forth system, but the user is free to use them in his own independent way, via Forth or assembler.

TIMEKEEPING

The TDS9092 keeps date and time as standard, even in the 3mA low power mode. When the computer is switched off, date and time can be maintained in either of two ways:

SMARTWATCH: an internal battery powered clock in a socket which plugs into

the TDS9092 below the program PROM. **PCF8583FP:** This is an 8-lead surface mount clock device, and is the clock used on the TDS2020*F*, the TDS9092's more powerful cousin. It can be connected to the TDS9092 by just the two-wire I^{2}C bus.

KEYBOARD SUPPORT

A unique software and hardware system enables up to 64 keys to be connected to the computer and only 8 of the parallel input/ output lines are required. You connect a particular parallel output port to one side of an 8 x 8 key matrix via diodes. The other side is returned via another 8 diodes to the data bus. The Forth system has two functions which scan the keyboard and return 0 if no key is pressed and 1 to 64 otherwise. One gives the key number if it was pressed since the last scan.

LIQUID CRYSTAL DISPLAYS

Most alphanumeric LCDs connect directly to TDS9092, the software to drive them is built into the board. One external chip enables up to 8 LCDs to be connected and the software caters for them all simultaneously.

Graphics LCDs also connect without any extra hardware; driver software is supplied on CD for displays based on the HD61830 graphics chip. The diagram above shows how the TDS9092 is connected to a keyboard and a typical Hitachi graphics display.

EXTERNAL PERIPHERALS

The full data and address buses as well as 5 uncommitted decoded addresses for use as chip selects of peripherals are provided. LCDs, extra parallel I/O and similar devices can be added without a

8-bit Interactive Embedded Computer

single other interface chip. Each decode covers a memory span of 16 locations. Three are not strobed with the E clock signal and are suitable for driving most peripherals such as octal latches or graphics LCDs. The other two are strobed with E. One is negative active, the other positive active. The latter is exactly right for input to alphanumeric LCD displays.

TIMER-COUNTERS

There are two hardware timers; one is 8-bit and the other 16-bit. The 8-bit counter can be clocked internally at any of 3 rates, or externally. The 16-bit counter is clocked internally, has two output capture registers and an input capture mode. Multiple interrupts are associated with the timers to process asynchronous events either in high level Forth or assembler.

WATCHDOG TIMER

If the microprocessor crashes through a power spike or otherwise, the watchdog timer will reset the system and the

USING FORTH IN THE FIELD

When you finally reach the manufacturing stage with a TDS9092 based product it is not the end of Forth. Use it for final test, repair and maintenance because the language is on-board.

Build in a connector that gives serial access to the Forth computer in your instrument. Now, with a PC or hand-held terminal, gain access to the internal language system. You can have available all the functions which make up the application.

On-board Forth is very useful during design, but the ability to access an individual software procedure in a finished product is unique and invaluable.

application software will be re-entered. This is a counter external to the microprocessor. It is reset by many Forth words and normally you will not notice its action, but it will time-out and re-start the system after 106ms have elapsed since a watchdog reset.

POWER SUPPLY

A single supply of +6V to +16V is used, typical current 15mA. A low power operational mode consumes only 3mA and needs no external hardware support. The board has a ±9V generator for use by the serial ports and this can be turned off by software to save power. The negative supply is also useful for some external peripherals. There is a position for a 470µF/16V capacitor to be added on-board to allow power to be taken from a 6V mains transformer.

Other features include a 'battery low' output which indicates when the input is below 5.8V and also provision for a touch switch turn-on, again primarily for battery-powered applications. The on-board regulator can supply up to 180mA so extra current is available to power any circuits particular to the application.

BUS INTERFACE

The TDS9092 bus is compatible with most microprocessor peripherals in logic levels and timing such as many A to D converters. The data bus is not multiplexed. In practice, limit the length of the data and address buses off the board to 300mm.

PHYSICAL

Board size is 100mm x 72mm with mounting holes for 2.5mm screws. Maximum height, excluding pin connectors, is 15mm. The operating temperature is -10 to 70°C. Pin connectors are standard (TDS9092-PIN) with a DIN 41612 type C connector optional (TDS9092-PLUG). The connections all fall on a 0.1 inch matrix so that the TDS9092 can easily be mounted

on a prototyping board with a matrix of holes if required. There is a blue reset button in the corner of the board.

CAN BUS

Controller Area Network (CAN) connects multiple TDS9092, TDS2020F computers and a PC for distributed real-time control applications. The TDS2020CAN board goes under the TDS9092 computer to form a CAN node.

The Controller Area Network data rate can be from 10kbit/s to 1Mbit/s giving recommended distances of 40 to 1000 metres over two twisted pairs, one for the data, the other to carry power and ground. Up to 110 nodes may be connected. It is highly secure and is even used in automotive applications.

FORTH SYSTEM

This is interactive Fig-Forth with many extensions useful to developers of single board systems. For example the number of microseconds taken by any Forth word can be accurately measured in real time. The language has been specifically implemented for the 6301 microprocessor and uses its facilities wherever possible, eg: Forth multiplies are built up from the 8 x 8 hardware multiplier. Its bit manipulation instructions are employed.

The parameter stack is the same as the machine's hardware stack. The application code can be put into PROM to create a stand-alone system.

Apart from Forth, the system ROM has a symbolic assembler enabling you to write machine code directly on the board. No cross-software is necessary, so a defined assembler routine can be tested immediately without any down-loading step. Interactive debugging of assembler is very powerful.

The Forth system is copyright TDS Ltd and purchase of a TDS9092 conveys a licence to use that copy of it. There are no royalties of any kind.

8-bit Interactive Embedded Computer

BOOKS ON FORTH

These are available from TDS Ltd and elsewhere.

STARTING FORTH
by Leo Brodie

The best book for learning Forth, whether as a beginner or seasoned professional. Although it has a humorous twist there is great depth here. A mastery of its contents will improve not only your Forth applications software expertise, but also give an understanding of how the system works.

If you have not used Forth before, this book is essential.

THINKING FORTH
by Leo Brodie

This takes you from the initial specification of your software project through the analysis and implementation process. Forth style and conventions, decomposition, factoring, handling data, simplifying control structures and more are described.

You can get by without it but your software will be better if you read this book.

FORTH ROM EXTENSIONS

Among the extensions included in the Forth ROM are:

- Keyboard scanning
- Alphanumeric LCD output
- I^2C bus peripheral support
- Interrupts written in assembly code or Forth
- Watchdog timer servicing
- Low power operation
- Complete symbolic assembler
- Vectored serial I/O and other vectored words
- Hex, ASCII & control characters
- Double number (32-bit) arithmetic & stack handling,
- Execution time measurement accurate to 1µs

DEVELOPMENT REQUIREMENTS

Use of a PC is best. *TDS-PC for Windows* offers a 'development environment' including terminal emulation and storage of your source code on disk, although your program is still compiled and debugged on-line in the TDS9092. *TDS-PC for Windows* also runs on Macintosh PC emulators. There is interfacing to your usual word-processor so that writing source code is

TDS-PC for Windows

INSTANT SOLUTIONS

Software modules that easily connect can form the major part of your application program. Ready-made routines are available for:

- **Audio**
- **Battery power**
- **Benchmarks**
- **CAN bus**
- **Control loops**
- **Date & time**
- **Digital in & out**
- **Digital potentiometers**
- **EEPROM memory**
- **Floating point**
- **Forth extensions**
- **Frequency**
- **I^2C bus**
- **IEEE-488 bus**
- **Integer maths**
- **Interrupts**
- **Keypads**
- **LCDs – character**
- **LCDs – graphic**
- **Light input**
- **Memory expansion**
- **Microphone**
- **Modems**
- **Motor control**
- **Multitasking**
- **Networking**
- **Non-volatile memory**
- **Operator input**
- **Opto-isolation**
- **Portable use**
- **Printers**
- **Protocol conversion**
- **PROM programming**
- **Regular events**
- **Serial communications**
- **Speech**
- **Strings**
- **System security**
- **Timekeeping**
- **Timer-counters**
- **Trigonometry**
- **Video**
- **Watchdogs**
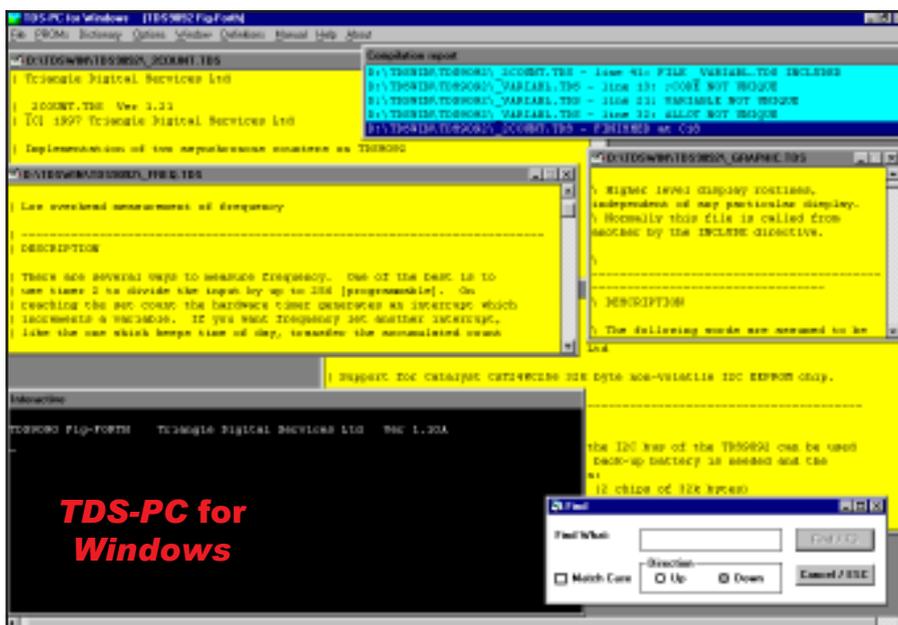
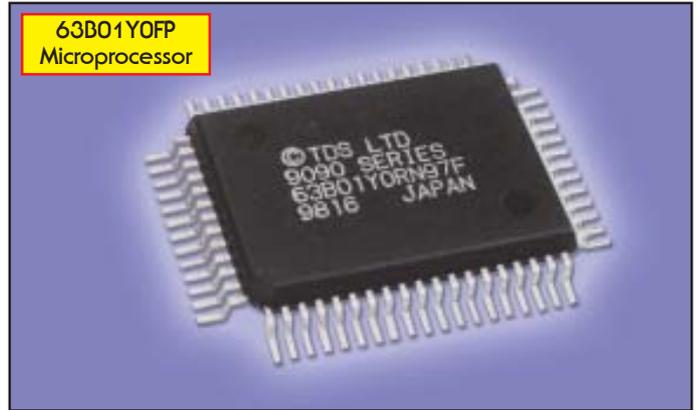## 8-bit Interactive Embedded Computer

TDS9 Gate Array

63B01Y0FP Microprocessor

made easier and can be laid out with lots of comments and correctly indented structures. Single keys invoke the word-processor, compilation and other features. There is an INCLUDE facility so that source files can be nested.

Once your program is developed and working correctly a PROM programmer is needed. It should be capable of programming 27C128 and 27C256 PROMs. The TDS961 add-on board gives the TDS9092 PROM programming capability if you are not already equipped.

TDS9092 FORTH CHIPS

The integrated circuits are manufactured as custom chips for Triangle Digital Services Ltd. They are the basis of the TDS9092 computer but are also available to systems integrators for use in other

embedded systems. Ask for a separate data sheet.

63B01Y0FP Microprocessor featuring masked Forth, symbolic assembler, event-driven, multitasking, time of day clock, full-screen editor and interrupt support in Forth or assembler. There are drivers for I^2C bus, alphanumeric LCDs, parallel ports, two serial ports, watchdog timer, keyboard and low power modes. The Forth is an extended version with extensive 32-bit arithmetic, trigonometry and real-time speed measurement functions.

TDS9 Gate Array providing 16 extra parallel ports (35 in total). There is hardware support for the keyboard scanning routines and LCD drivers in the microprocessor. A watchdog timer brings the system back into the application program in case of a crash. Chip selects are provided for external RAM

and PROM. In addition there are spare decoded address lines for directly adding other peripherals such as A to D converters.

TDS2020F EMBEDDED COMPUTER

The TDS2020F is a powerful 16-bit control computer based on the Hitachi H8/532 microprocessor and features direct compilation to Flash-EEPROM. This 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. In addition to the features of the TDS9092 it has on-board A to D and D to A converters and full pre-emptive multitasking capability. There are two RS232 ports, two watchdog timers, four hardware timer-counters and up to 41 parallel Input/Outputs, depending on which other facilities are being used. Typical current drain is 32mA, and just 155µA in a low-power operational mode. Up to 512k bytes of RAM, EEPROM or Flash memory can be used to store vital data, while optional PCMCIA Card Memory and digital camera Compact Flash adapters offer unlimited memory capacity for portable data logging applications. The TDS2020F is very similar to the TDS9092 and you can easily migrate between the two. Ask for the separate data sheet.

TDS2020F Embedded Computer

8-bit Interactive Embedded Computer

ORDERING INFORMATION

SUGGESTED FIRST ORDER

TDS9092SP Starter Pack contains most of what you need for TDS9092 developments. Also required are **STARTING FORTH** (if Forth is new to you), a PC and (eventually) a PROM programmer. The contents of the Starter Pack are shown on this page.

TDS9092-PIN &TDS9092-PLUG

These are for manufacturing once development is complete.

The 28-pin socket is vacant. RAMs and EPROMs are available separately.
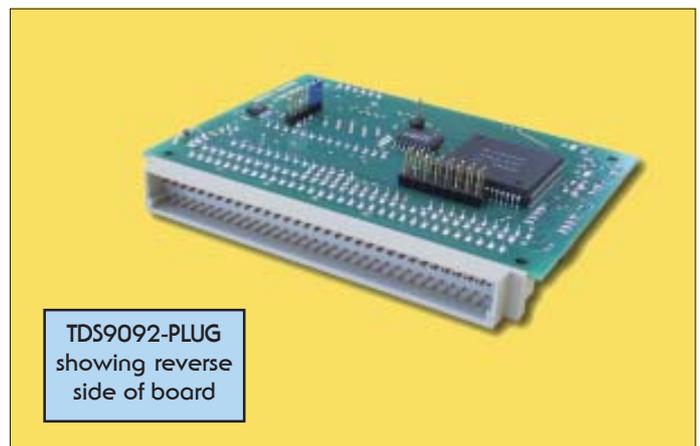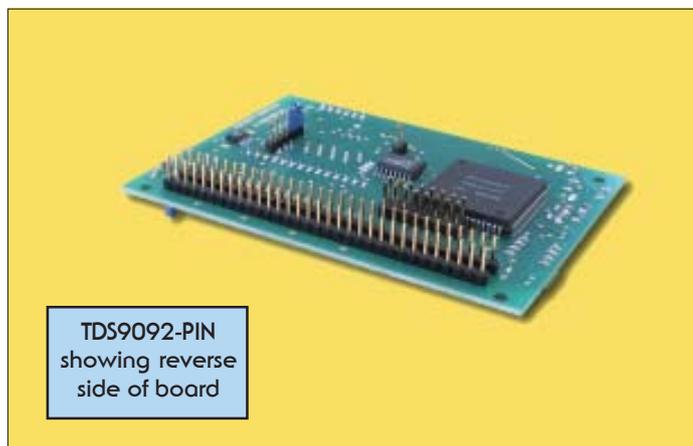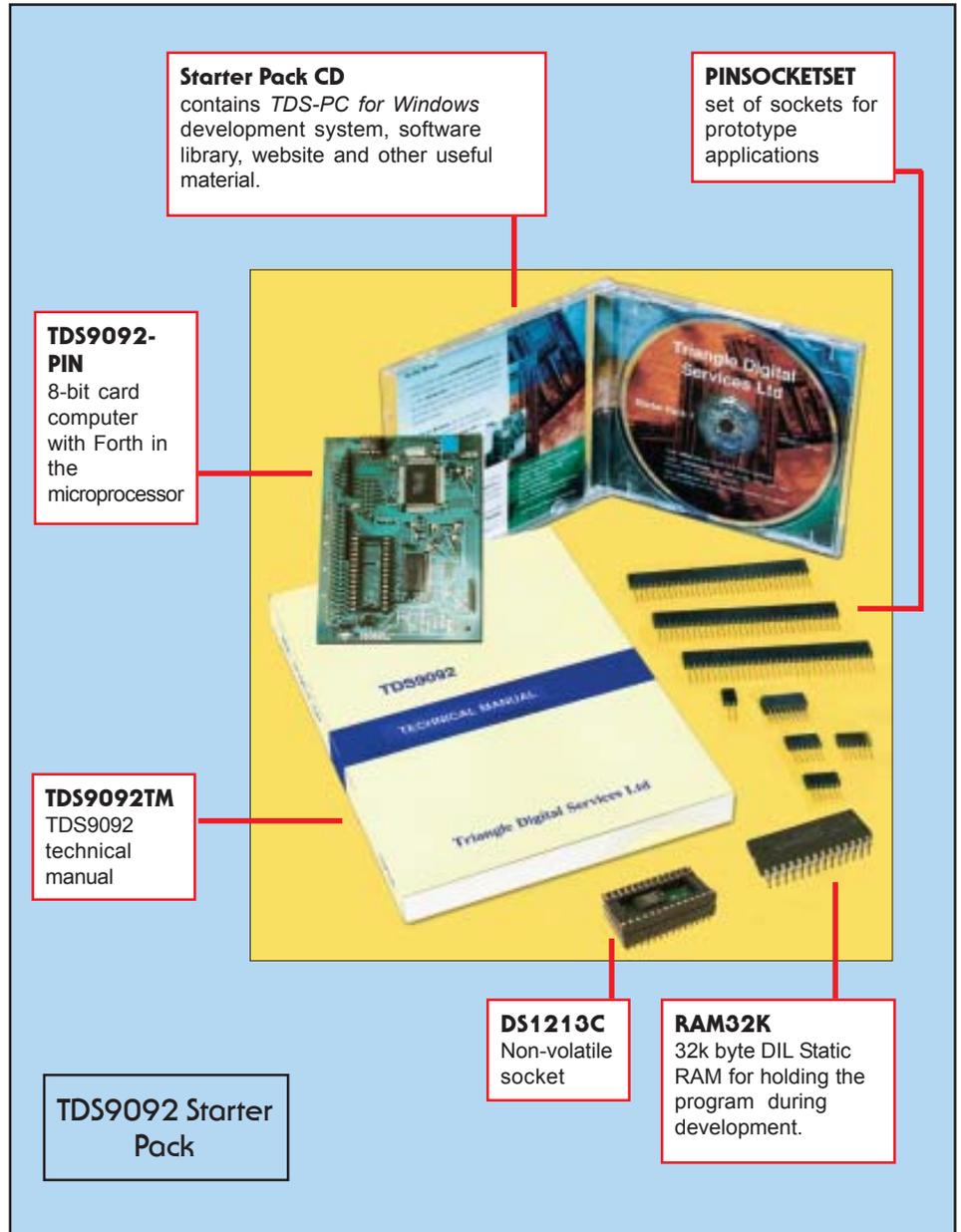
- RAM order code: **RAM32K** (62256 or equivalent)
- EPROM order code: **27C256**

TDS9092-PIN

has a 64-way pin-header connector, use this version if the module will be put on a motherboard or connected by ribbon cable.

TDS9092-PLUG

has a DIN 41612 connector type C for use in a rack system.

Starter Pack CD
contains *TDS-PC for Windows* development system, software library, website and other useful material.

PINSOCKETSET
set of sockets for prototype applications

TDS9092-PIN
8-bit card computer with Forth in the microprocessor

TDS9092TM
TDS9092 technical manual

DS1213C
Non-volatile socket

RAM32K
32k byte DIL Static RAM for holding the program during development.

TDS9092 Starter Pack

TDS9092-PIN
showing reverse side of board

TDS9092-PLUG
showing reverse side of board

8-bit Interactive Embedded Computer

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

TDS2020F 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.

Data Logger Module

A PCMCIA and Compact Flash solution for TDS2020F to hold large quantites of data in removable or transmittable forms. 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 TDS2020F 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 TDS2020F
- Pre-emptive multitasking for TDS2020F

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

Triangle Digital Support Ltd

VISA   **MasterCard**

64A Market Place
Thirsk
North Yorkshire
UK
YO7 1LW

Tel   **+44 1845 527437**
Fax   **+44 870 705 9860**
E-mail   **Business@TriangleDigital.com**
Web   **www.TriangleDigital.com**

USA & Canada

Triangle Digital Support
Suite #1630, 14781 Memorial Drive, Houston, TX 77079

Tel **(360) 812 2316**   Fax **(206) 202 0402**   E-mail **Business@Triangle Digital.com**