# Emulators for TMS320 series DSPs: Technical Comparison

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## Contents:

## 1. Introduction

Kane Computing Limited have over 8 years experience of supplying and supporting a wide range of JTAG and MPSD emulators for the Texas Instruments TMS320 range of Digital Signal Processors.  This Technical Comparison document is the result of that experience and is based on in-house testing, evaluation and benchmarking of the various emulation options. By answering such questions as:

- Which emulators support my target DSP?
- Which emulators are suitable for portable or remote debugging?
- Which emulators are fastest?

It is hoped that DSP users will be able to make an informed decision as to which is the best emulator for their application.

The report also includes a quick reference section which lists all the emulators available from Kane Computing along with a brief technical description.

Finally the report includes some information on the JTAG and MPSD specifications as used on the TMS320 range of DSPs along with suggestions for further reading.

## 2. Compatibility

The first consideration when choosing an emulator, is does it support the required DSP family? Once DSP support has been established then another major consideration is the way the emulator interfaces to the host PC. This information is summarized in Figure 1.

| Mfr | Model | Interface | C2x | C24x | C27xx | C28xx | C30-32 | C33 | C4x / C5x | C54xx | C55xx | C62 / C67 | C64xx | OMAP | ARM7 / 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KCL | Predator | PCMCIA | | ✔ | ✔ | ✔ | | ✔ | | ✔ | ✔ | ✔ | ✔ | ✔ | |
| | Predator 560 | Ethernet | | 5 | 5 | 5 | | | | ✔ | ✔ 3 | ✔ 4 | ✔ 3 | ✔ | ✔ |
| Spectrum Digital | XDS510PP Plus | Parallel | ✔ | ✔ | ✔ | ✔ | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | |
| | XDS510PP MPSD | Parallel | | | | | ✔ | | | | | | | | |
| | XDS510 USB | USB2.0 | | | | ✔ | | | | ✔ | ✔ | | ✔ | | |
| | SPI510 | ISA | ✔ | ✔ | ✔ | ✔ | ✔ 1 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | |
| | SPI515 | Parallel | ✔ | ✔ | ✔ | ✔ | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | |
| | SPI520 | Parallel | | | ✔ | ✔ | | | | | | | | | |
| | SPI525 | PCI | ✔ | ✔ | ✔ | ✔ | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | |
| | SPI530 | Parallel | | | | | ✔ | | | | | | | | |
| DSP Research | FleXDS | PCI | | ✔ | ✔ | ✔ | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| | FleXDS - USB | USB2.0 | | ✔ | ✔ | ✔ | | ✔ | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| | FleXDS - 560 | PCI | | 5 | 5 | 5 | | | | ✔ | ✔ 3 | ✔ 4 | ✔ 3 | ✔ | ✔ |
| Softronics | Ice*Pack | ISA | ✔ | ✔ | ✔ | ✔ | ✔ 1 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ 2 |
| | DspIceLV | PCI | ✔ | ✔ | ✔ | ✔ | ✔ 1 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ 2 |
| | DspIceLVx | PCI | | ✔ | ✔ | ✔ | | | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ 2 |
| | nIce | Ethernet | | ✔ | ✔ | ✔ | ✔ 1 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ 2 |
| | ACE | USB2.0 | | | | | | | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ 2 |
| T.I. | XDS510 | ISA | ✔ | ✔ | ✔ | ✔ | ✔ 1 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ 2 |
| | XDS560 | PCI | | 5 | 5 | 5 | | | | ✔ | ✔ 3 | ✔ 4 | ✔ 3 | ✔ | ✔ |

**Figure 1: Emulator Support by DSP Family**

(Any representation made with respect to processor support here is intended as a guide only. While every effort has been made to ensure that this table is up-to-date, for the very latest information or confirmation of support for a particular processor visit our web site www.kanecomputing.com or call one of our sales engineers on 01606 351006

1. Requires special 12-pin MPSD Cable and Pod
2. Requires special 20-pin JTAG Cable and Pod
3. Includes high-speed RTDX support (v2 silicon and higher)
4. Includes high-speed RTDX support on C6x1x silicon only
5. Support for basic emulation planned)

The vast majority of the TMS320 families use the JTAG standard for emulation. However, three devices, the C30, C31 and C32, use the MPSD standard. The most visible difference between these standards is that the JTAG connector has 14 pins, whereas the MPSD connector has 12 pins. This means that you need either a completely different emulator or at least a different cable and pod for each standard. For further information on the differences between JTAG and MPSD see Section 5.

For portable, laptop or notebook based, applications it is normally not possible to use an ISA or PCI based emulator. For such applications a PCMCIA, Parallel Port or USB based emulator is the best solution. For a dedicated notebook solution then a PCMCIA emulator is perhaps the best solution as it is hot plugable, easy to configure and much

faster than the other two options. The new USB based emulators are also hot plugable and easy to configure but tend to be rather slow on many targets.  Parallel Port emulators are a low-cost flexible solution but users have experienced problems as some laptops do not fully implement the parallel port specification with the result that the emulator is unable to establish bi-directional communication with the PC.

Parallel port and USB based emulators are very flexible because they are also suitable for use with desktop PC systems, but here ISA and PCI cards are also an option. As the ISA standard is rapidly becoming obsolete then for a fast, future proof, internal board based emulator the best solution is to choose one of the new PCI based boards.

For users who want the ability to debug a remote target then there are dedicated Ethernet emulators available as well as software which will allow a PCI emulator to be used over a LAN.

The final compatibility issue is: Will the emulator work with ones preferred Operating System?  All the major Microsoft OS's are supported, although one restriction is that currently the TI Debuggers only work with Windows 2000 / XP from Code Composer Studio v2.0 onwards. Currently the latest versions of all the other debuggers are limited to Win9x and NT.  The only emulator that supports UNIX workstations is the XDS510, but this must be ordered as a different part than the Windows version. Currently Kane Computing do not supply an emulator that supports Linux.  Further details of support for the various Microsoft OS's is detailed in Figure 2.

| Mfr | Model | TMS320 Debugger | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | | C2000 Code Composer v4.1x | C2000 Code Composer Studio v2.x | C3x/4x Code Composer v4.10 | C5000/6000/OMAP Code Composer Studio v1.xx | C5000/6000/OMAP Code Composer Studio v2.x |
| Kane | Predator | 95, 98, NT | 9x, NT, 2K, XP | 95, 98, NT | 95, 98, NT | 9x, NT, 2K, XP |
| | Predator 560 | | | | | |
| Spectrum Digital | XDS510PP Plus | 95, 98, NT | 9x, NT, 2K, XP | 95, 98, NT | 95, 98, NT | 9x, NT, 2K, XP |
| | XDS510PP MPSD | | | 95, 98, NT | | |
| | XDS510 USB | | 98SE, 2K, XP | | | 98SE, 2K, XP |
| | SPI510 | 95, 98, NT | 9x, NT, 2K, XP | 95, 98, NT | 95, 98, NT | 9x, NT, 2K, XP |
| | SPI515 | 95, 98, NT | 9x, NT, 2K, XP | 95, 98, NT | 95, 98, NT | 9x, NT, 2K, XP |
| | SPI520 | | | | | |
| | SPI525 | 95, 98, NT | 9x, NT, 2K, XP | 95, 98, NT | 95, 98, NT | 9x, NT, 2K, XP |
| | SPI530 | | | 95, 98, NT | | |
| DSP Research | FleXDS | 95, 98, NT | 9x, NT, 2K, XP | 95, 98, NT | 95, 98, NT | 9x, NT, 2K, XP |
| | FleXDS-USB | | 9x, NT, 2K, XP | | | 9x, NT, 2K, XP |
| | FleXDS-560+ | | 98 2K XP | | | 98 2K XP |
| Softronics | Ice*Pack | 95, 98, NT | 9x, NT, 2K, XP | 95, 98, NT | 98, NT | 98 NT 2K XP |
| | DspIceLV | 95, 98, NT | 9x, NT, 2K, XP | 95, 98, NT | 95, 98, NT | 98 NT 2K XP |
| | DspIceLVx | 95, 98, NT | 9x, NT, 2K, XP | | 98, NT | 98 NT 2K XP |
| | nIce | 95, 98, NT | 9x, NT, 2K, XP | | 95, 98, NT | 98 NT 2K XP |
| | ACE USB | | 98 2K XP | | | 98 2K XP |
| T.I. | XDS510 | 95, 98, NT | 9x, NT, 2K, XP | 95, 98, NT | 95, 98, NT | 9x, NT, 2K, XP |
| | XDS560 | | 98 2K XP | | | 98 2K XP |

**Figure 2:  Available Drivers & OS Support**
(Any representation made with respect to OS support here is intended as a guide only. While every effort has been made to ensure that this table is up-to-date, for the very latest information or confirmation of support for a particular operating system visit our web site www.kanecomputing.com or call one of our sales engineers on 01606 351006)

# 3. Other Considerations

Once the choice has been narrowed down to a few compatible emulators what are the features that distinguish them?

## 3.1 Speed

This is particularly important for the C5000, C6000 and OMAP families of DSPs. One reason for this is that their complexity and power leads to larger code sizes and hence, longer download times. The main reason however is that these families are supported by Code Composer Studio which includes two new features, DSP/BIOS and RTDX (Real-Time Data eXchange). Both of these features communicate data back to the debugging PC while the DSP target is running in real-time. For this to work well it demands a high speed emulator. The following graph shows known emulator speeds compared to the industry standard XDS510 emulator.

**Relative Emulator Speeds (CCS2 Win2K - C6711 target)**
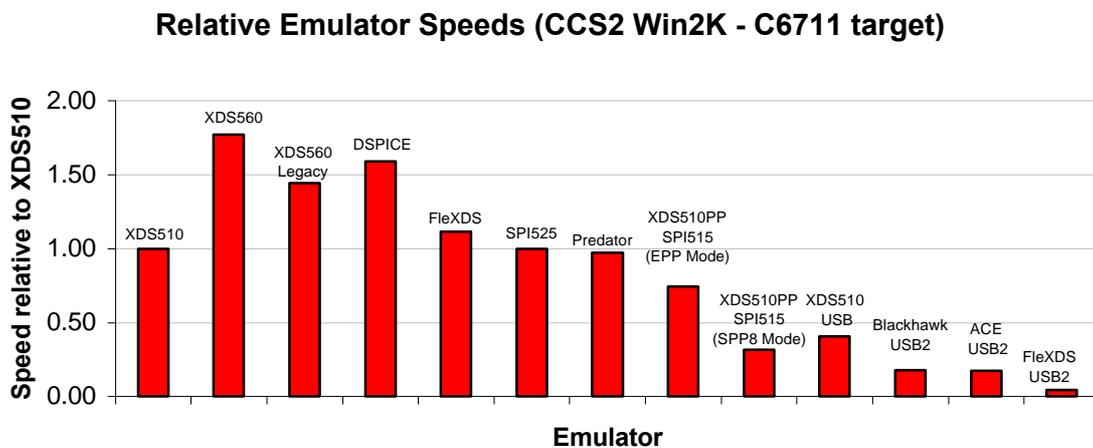


**Figure 3: Relative Emulator Speeds**

(Based on benchmarks performed by KCL, higher values indicate faster speeds. The relative speeds are based on time taken to download a 6MB COFF file onto an ATEME C6711 IEK using Code Composer Studio v2.10 under Win2K. These benchmarks are intended as a guide only, actual speeds may vary from system to system and target to target.)
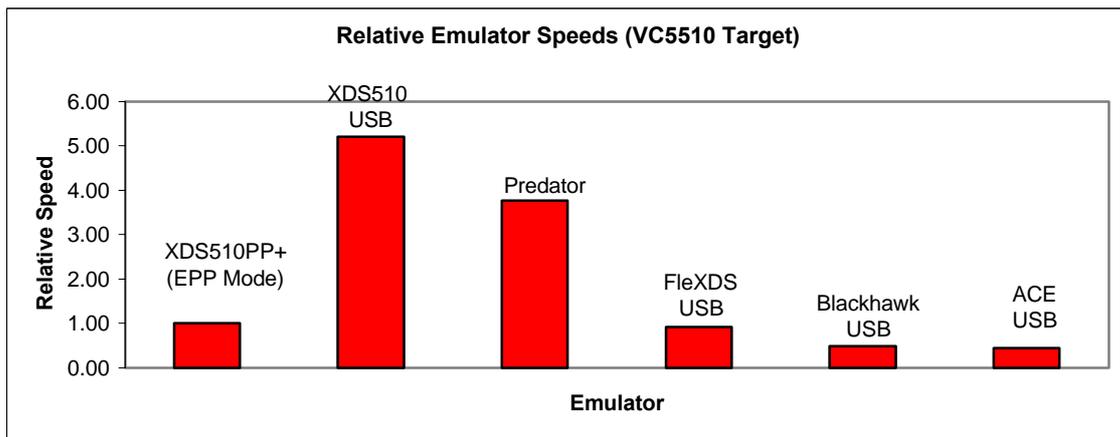


**Figure 4: Relative Portable Emulator Speeds**

(Based on benchmarks performed by KCL, higher values indicate faster speeds. The relative speeds are based on time taken to download a 3MB COFF file onto a DSPR VC5510 Module using Code Composer Studio v2.10 under Win2K. These benchmarks are intended as a guide only, actual speeds may vary from system to system and target to target.)

As some of the new generation of USB emulators claimed far better download speeds with C5000 DSP targets we have also included a comparison of these devices with such a target as well as the standard C6711 benchmark.

A major innovation recently has been the introduction of the new XDS560 class of emulator. The XDS560 is available as a PCI card from Texas Instruments and in various other formats from accredited third parties (eg. The Ethernet based Predator 560 emulator).  As well as allowing improved download speeds the XDS560 class of emulator also allows vastly improved RTDX speeds on certain devices (see section 3.10 for more details).

## 3.2 Support for low voltage DSPs
To make its DSPs more power efficient and suitable for portable battery powered applications, Texas Instruments is currently driving down the core and IO voltages of many of the TMS320 DSP families, particularly the C5000 family. Already there are C5000 devices running with IO voltages as low as 1.8V.  TI has introduced a 1.8V - 5.0V JTAG cable for the XDS510 emulator. However newer devices on the C55xx roadmap will have I/O voltages below 1.8V. These newer devices with I/O voltages of 1.0V will require still further lower voltage support.

The XDS510, SPI510 and SPI525 emulators include variable voltage pods which allow the user to select the correct I/O voltage manually.  A better solution however, is provided by the SPI515, DspIceLV, FleXDS-MV and XDS560 emulators which automatically detect the processor's I/O voltage anywhere in a range from 1.0V to 5.0V. The JTAG interface is then auto-trimmed to the processor's I/O voltage using ONB signal. This removes any risk of incorrectly selecting the target voltage. The use of active drive circuitry, rather than open drain circuitry that requires pull-ups reduces the current drain from the emulator on the target power supply.

## 3.3 Flash Programming Support
Certain DSP's, notably the C2000 range, have on-chip flash memory.  For other DSP's flash memory will often be provided as a separate device on the target board. This memory can be programmed by the user and is typically used to store boot code that is executed when the system is powered up. This sort of functionality is often essential in embedded or standalone systems. For users with C2000 Code Composer 4.10 there is a free flash programming plug-in available from the TI website (www.ti.com). For C2000 users without Code Composer, there are a set of command line tools (again available for free download from the TI website). These utilities support the XDS510 and can also be used by all the Softronics emulators and the FleXDS emulator. A version of these command line utilities which supports all the Spectrum Digital emulators is available for free download from their website (www.spectrumdigital.com). Spectrum Digital also have a nice Windows GUI based flash programming utility called SDFlash. This utility supports the full range of Spectrum Digital emulators, and is again freely available from their website. In addition to allowing flash programming of the C2000 series on-chip flash, SDFlash also offers a method by which users can program any on-board flash on C5000 series targets without needing to purchase Code Composer Studio.

### 3.4 Flexibility

One advantage of the FleXDS emulator is its flexibility. It can be used as a base board for a number of daughter modules which then make the FleXDS a PCI based development board. The modules are competitively priced and consist of both DSP modules and IO / Telephony modules. DSP modules are currently available for the following DSP families: VC33, C54xx, C55xx, C62xx, C64xx, C67xx. This provides a neat way for a designer to begin to develop his system on a known good target, before removing the modules and debugging his custom hardware via the JTAG pod. The FleXDS emulator can also be used remotely over a LAN.

### 3.5 Data Logging

Two emulators, the SPI515 and the SPI520 support data logging and also have programmable I/O lines. Data logging is a means whereby the target DSP can act as a Master and send data over the I/O lines where they will be logged at 20kHz by the Slave emulator.

### 3.6 Device Driver Support

Driver support continues to be an issue for emulator manufacturers. Whilst TI continues to provide emulation porting kits (EPKs) to emulator manufacturers, device driver updates often lag behind the introduction of new silicon or revisions to silicon. This often means that emulation support may not be available until TI releases an EPK update and the emulator manufacturer then releases updated drivers for its emulators. Inherent delays occur between the introduction of new silicon and device driver support from Third Party emulator companies. TI has sought to reduce this type of dependency by the introduction of a Sourceless EPK (SEPK), which is no longer dependent on silicon variations and hence introduction of new silicon appears seamlessly without the need for Third Party emulator updates. The Predator, DspIceLV, IcePack, FleXDS and Blackhawk are all based on sourceless EPK drivers and so use the standard TI Code Composer drivers.

### 3.7 XDS510 Legacy Support

With the discontinuation of the Texas Instruments XDS510, there is a need for continued support for older applications such as TI C Source Debuggers, Flash Programming Utilities and older versions of Third Party Software such as Allant Aspex's debug environment. XDS510 legacy support is available via the IcePack and SPI510 ISA bus emulators. Softronics also offers an XDS510 Legacy mode on the PCI bus with the DspIceLV.

### 3.8 DSK Support

Those users with a TI DSK who wish to enjoy the benefits of using an emulator (such as faster download speed) would normally have to also purchase the full version of Code Composer Studio. Softronics offer a free driver, which will allow any of their emulators to be used with the restricted version of Code Composer Studio shipped with the TI VC5402, C6211 or C6711 DSKs. This is a substantial cost reduction entry point, but the user must be aware that the license conditions of the DSK versions of Code Composer explicitly state that it is only for use with the DSK. Anybody wishing to use the emulator to debug any other target board or system will need to purchase the full version of Code Composer Studio.

## 3.9 Multiprocessor Support

Another increasingly important support feature is that of multiprocessor support. Softronics offers the DspIceLVx multi scan path emulator which is capable of providing up to 16 separate JTAG paths. Each emulator is tailored to providing parallel JTAG scan paths each operating independently of the other. This removes the requirement to daisy chain processors and produces huge increases in emulation speed on multiprocessor systems, as shown in Figure 5.

**Relative Emulator Speeds**
**Multiprocessor(16) Target Processors**
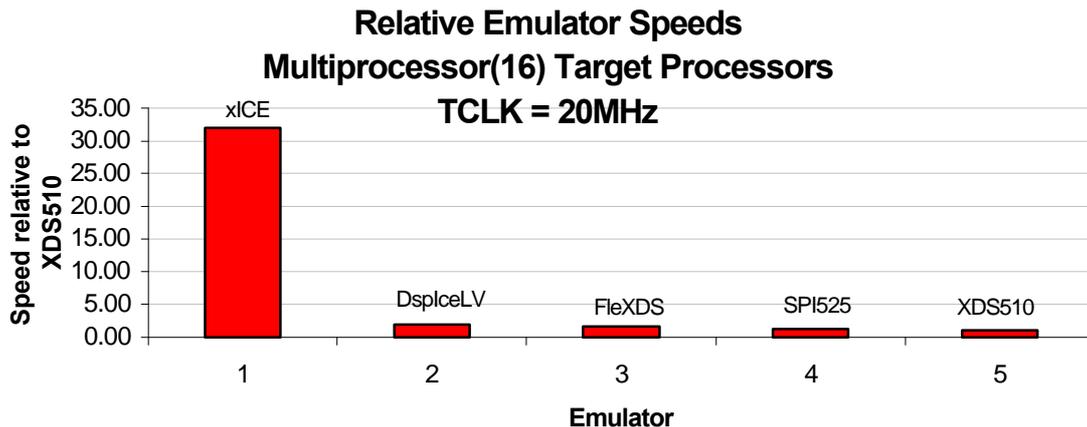
**Figure 5: Multiprocessor Emulation Speeds**
(Figures provided by Softronics Pty and intended as a guide only)

## 3.10 High-Speed RTDX

The new XDS560 class of emulators supports high-speed RTDX on certain devices. RTDX, along with DSP/BIOS was introduced as part of Code Composer Studio and enables application data to be transferred bi-directionally in real-time between the host computer and the target DSP, without stopping the application, and with a minimum of CPU cycle intrusion on the target. It provides critical real-time visibility into the behavior of the application on the target and allows that data to be brought up to the host for analysis and advanced visualization. Standard RTDX however was limited by the download/upload speed of the JTAG emulator, typically < 100KB/s. The new XDS560 class emulators remove this limitation on certain devices as the new high-speed RTDX standard has a bandwidth of over 2 Mbytes per second thus enabling visibility into a whole new range of high-bandwidth applications, and multi-channel or multiprocessing versions of lower bandwidth applications.

Currently the following device families support high-speed RTDX:
- C6x1x
- C64xx (new revisions)
- VC55xx (rev. 2 and later)

# 4. Emulator Information

### 4.1   Texas Instruments XDS510
This ISA based board was the industry standard emulator but is now outdated and overpriced. A user wanting a direct replacement for the XDS510 would be better off choosing the SPI510 or IcePack instead.  Approximate Price: £3000.

### 4.2   Texas Instruments XDS560
The new industry standard. The new PCI based successor to the XDS510. It features faster download speeds and revolutionary high-speed RTDX with compatible DSP targets. Approximate Price: £3000.

### 4.3   Kane Computing Predator PCMCIA
PCMCIA based JTAG emulator based on the sourceless EPK (see 3.6) and hence using the standard TI drivers for C2000, VC33, C5000, C6000 and OMAP devices. The emulator is faster (see 3.1) and more reliable than parallel port emulators for portable notebook based applications. The Predator can also be supplied with a PCI adaptor card which allows it to be used on a desktop PC. Approximate Price: £1200.

### 4.4   Kane Computing Predator 560
An Ethernet based version of the XDS560 boasting all the improvements in download speed, advanced event triggering and RTDX support. Approximate Price: £3500

### 4.5   Spectrum Digital XDS510PP MPSD
Industry standard parallel port emulator for MPSD (C30, C31, C32) devices.  For new designs the C33 JTAG based processor should be considered. Approximate Price: £1000.

### 4.6   Spectrum Digital XDS510PP Plus
Industry standard parallel port JTAG emulator, it is the follow on product to the XDS510PP JTAG. The new version has integrated the parallel port logic and JTAG test bus controller logic into an FPGA providing a twofold improvement in download speeds. Approximate Price: £1000.

### 4.7   Spectrum Digital XDS510USB
The long-term replacement for the XDS510PP?  Hot-pluggable USB solution which delivers download speeds at least comparable with a parallel port emulator, much better in some cases. Currently only supports C28x, C5000 and C6000 devices. Approximate Price: £1300

### 4.8   Spectrum Digital SPI510
A straight replacement for the TI XDS510 (see 3.7), it is ISA based board offers; NT support and a variable voltage pod (see 3.2).  It is available with either an MPSD or JTAG pod. Approximate Price: £1700.

### 4.9   Spectrum Digital SPI515
An improved version of the XDS510PP Plus, which offers a number of advantages over the XDS510PP. These include an automatically adjusting variable voltage pod (see 3.2) and data logging (see 3.5). Approximate Price: £1500.

### 4.10   Spectrum Digital SPI520
A parallel port based JTAG emulator specifically for the C27xx family of DSP's for which it supports data logging via an optional 32MB logging buffer (see 3.5).   Approximate Price: £2700

### 4.11   Spectrum Digital SPI525
A PCI based replacement for the SPI510, it features a variable voltage JTAG pod (see 3.2). Approximate Price: £2300.

### 4.12   Spectrum Digital SPI530
An improved version of the XDS510PP MPSD, that offers better performance because it has a processor in the emulator pod itself and can handle the hand shaking with the DSP better.  Approximate Price £2000.

### 4.13   DSP Research FleXDS
Fast PCI based JTAG emulator (see 3.1). It is also very flexible and can be converted into a PCI based development board by adding competitively priced daughter modules (see 3.4).  The FleXDS is now available with an automatically adjusting variable voltage pod (see 3.2).  In addition the FleXDS now supports use in a client-server mode allowing remote debugging over a network. Other useful features include an optional 30 ft JTAG cable and separate reset line from the emulator. Approximate Price: £2100.  with MV Pod £2300.  DSP Modules: £500-£1000 Remote Emulation Software £900

### 4.14   DSP Research FleXDS-USB
A USB based hot-pluggable emulator based around the sourceless EPK. Supports all the current DSP familes (C2000, C5000, C6000 and OMAP).  Quickload technology gives similar performance to parallel port emulators on certain DSP targets. Approximate Price: £1500

### 4.15   DSP Research FleXDS-560+
All the advantages of the FleXDS-MV but with the addition of XDS560 class download speeds, advanced event triggering and high-speed RTDX. Approximate Price: £2500

### 4.16   Softronics IcePack
A straight replacement for the TI XDS510 (see 3.7), it is ISA based board offers; NT support and a variable voltage pod (see 3.2).  It is available with either an MPSD or JTAG pod. Approximate Price: £1100.

### 4.17   Softronics DspIceLV
Fast PCI based emulator, the user can control the clock speed in order to optimise download speed for their system, making the fastest emulator we have ever tested (see 3.1) The emulator has an automatically adjusting variable voltage pod (see 3.2). Approximate Price: £1500.

### 4.18   Softronics DspIceLVx
Multi scan path emulator which allows up to 16 JTAG scan paths from a single PCI slot (see 3.9). The emulator uses the same pod as the DSPIceLV and hence shares all those advantages too (see 4.12). Approximate Price: £2500 (one pod). Additional LV Pod £1500.

### 4.19 Softtronics nICE

Ethernet based. It is available in both JTAG and MPSD options. It supports Win95/98 and NT. Downloads are fast but single stepping performance is not yet as fast as the XDS510. Recommended for applications requiring remote debugging and is a replacement for the White Mountain TREK510. Approximate Price: £2900.

### 4.20 Softtronics ACE USB

USB based JTAG emulator which uses standard TI drivers (see 3.6). Powered from the USB port it requires no external power supply. Rugged and small aluminium pod but somewhat let down by slow download speeds. Approximate Price: £1100.

## 5 Further Reading

For further information on emulation in general and also specifics of the JTAG and MPSD specifications as used by Texas Instruments; see the following TI documents:

JTAG: Design Considerations - Discussion of the benefits of JTAG testability as well as design considerations.
JTAG/MPSD Technical Reference - TI document detailing their implementation of the JTAG and MPSD emulation specifications.
Emulation Fundamentals for TI DSP Solutions – An introduction to JTAG emulation on TI DSPs.
Real Time Data Exchange – An introduction to RTDX
XDS560 Emulation Technology White Paper – An introduction to XDS560 class emulation

# 6   Glossary of Terms Used in this Report

**CPU**
Central Processing Unit – in this case the core processor of the digital signal processor
**DSP**
Digital Signal Processor - A special-purpose microprocessor designed to handle signal-processing applications very quickly.
**DSP/BIOS**
Developed as a result of TI acquiring SPOX. This is a real-time scaleable kernel with multi-threaded configurations which allows designers to develop time critical applications more effectively.
**EPK**
Emulation Porting Kit – code supplied by TI to third party emulator manufacturers around which they base their emulator drivers
**EPP**
Enhanced Parallel Port – parallel port mode which gives best performance when using Spectrum Digital parallel port emulators
**JTAG**
Joint Test Action Group - IEEE-1149 TI emulation interface standard, used to debug most TI DSPs
**ISA**
Industry Standard Architecture - Common PC bus, with slots to connect internal peripheral cards to a PC. Superceded by PCI and now obsolete)
**LAN**
Local Area Network – needs to be 100Mbits/sec for remote emulation.
**MPSD**
Modular Port Scan Device - TI emulation interface for C30/C31/C32 devices, requires a different emulation pod to JTAG
**OS**
Operating System – in the remit of his report it generally refers to the operating system being run by the host PC. i.e. Windows 98 etc.
**PCI**
Peripheral Component Interconnect – current PC bus standard, replaced the ISA standard
**PCMCIA**
Personal Computer Memory Card International Association – international standards body which maintains the PC Card standard of credit-card sized portable PC plug-in cards.
**PP**
Parallel Port – external PC connection used by a number of emulators, currently being phased out, particularly on notebook PCs.
**RTDX**
Real-time Data exchange - enables real-time, asynchronous exchange of data between the target and the host, without stopping the target application.
**SPP8**
Standard Parallel Port – basic Parallel Port mode, should be available on all PC parallel ports but is significantly slower than EPP.
**USB**
Universal Serial Bus – new external connection standard for PCs. Higher speeds supported by Revision 2.0 of this standard have lead to a number of USB emulators being developed.