The Pentek PIPELINE

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Pentek Helps AT&T Labs Improve Cellular Communications

AT&T Labs is the research and development organization of AT&T. Its mission is to create new services, systems and the technology needed to achieve AT&T's vision of being the service provider of choice in voice and data communications in the home, on the road and in the office. This vision provides universal communications of any form, over any distance, to any person or place in the world.

AT&T Labs was formed in 1996 when Bell Laboratories was split in two, following the divestiture of Lucent Technologies and NCR by the new AT&T. The new R&D organization kept its AT&T Bell Labs heritage including about 2,000 people.

Among its many inventions and innovations, Bell Labs developed the car telephone back in the 1940s and has continued to make improvements. Until a dozen years ago though, mobile phones were rare because they were limited due to lack of available channels. The breakthrough came when Bell Labs divided wireless communications into a series of cells, then automatically switched callers as they moved from one to the next, so that each cell could be reused. This led to the development of cellular phones and made today's mobile communications possible.

There are seven major AT&T Labs locations, four in New Jersey, two in California and one in the UK. We visited with the one in Red Bank, NJ and spent a good deal of time with Bruce McNair, Principal Technical Staff Member of the Wireless Systems Research Department.

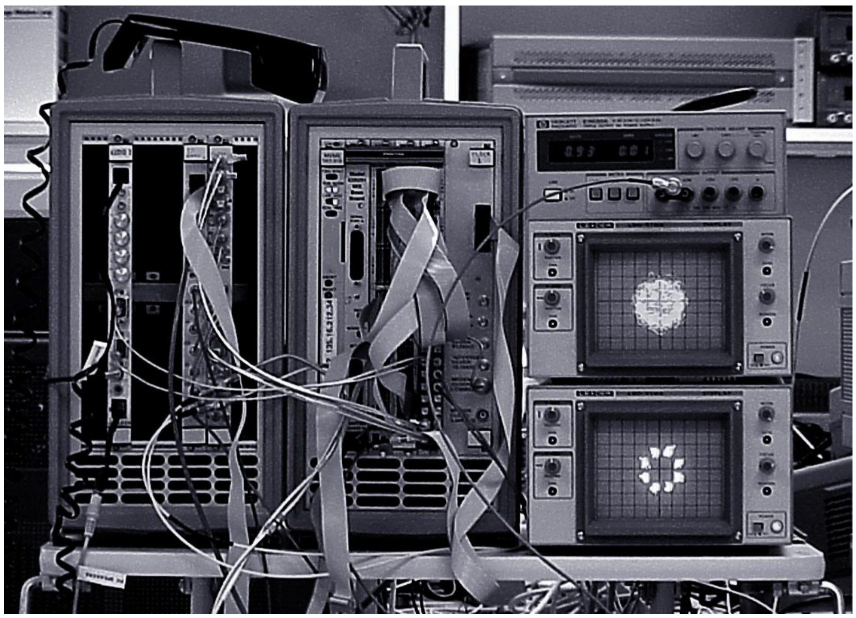

Figure 1. Signal Processing System (Courtesy of AT&T Labs)

Bruce has done a lot of work on improving the quality and performance of cellular phones. We'll cover some of it in this and future issues of the Pipeline. Not only has he made extensive use of Pentek products for the last five years, he has conducted many different investigations using essentially the same Pentek system configuration.

Indoor Wireless Systems

One of the investigations centered around techniques to improve communications of IS-136 compatible TDMA systems in an indoor personal base station environment. This is in line with AT&T's vision of the office building of the future, where cellular telephones are as common as the present copper wire connected phones.

Indoor cellular communications present challenging problems that are quite different in nature from the wide outdoors. For instance, indoor reception is more susceptible to fading due to multiple signal reflections from metallic structures and objects. These problems can become even more pronounced as the caller remains stationary at a desk, rather than moving around the office.

To improve reception in this type of environment, Bruce McNair's group investigated preselection antenna diversity.

IS-136 Standard

IS-136 is the prevailing North American standard for cellular communications. It uses a 6-slot TDMA (Time Division

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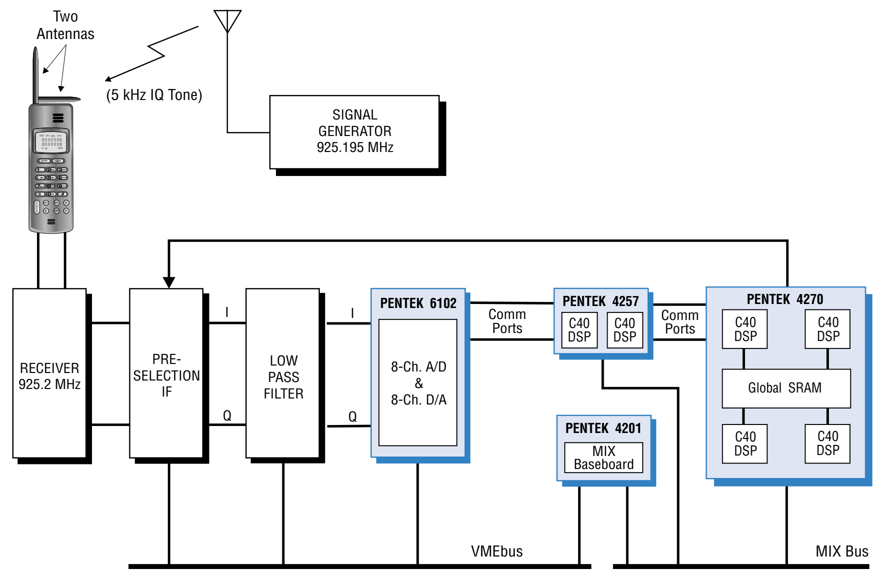
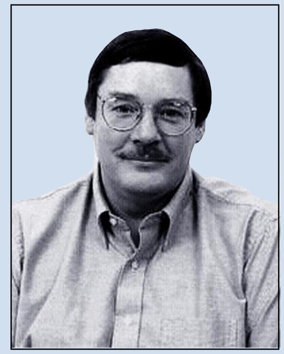


Figure 2. Signal Processing System Block Diagram



"We looked at many DSPs and concluded that the 'C40 had the best mix of performance, availability and development tools when we began these investigations. We elected to go with Pentek because they had the broadest signal processing product line in an industry-standard bus, such as VME. The fact that SwiftNet and SwiftTools were UNIX-based also added to the flexibility of Pentek's line."

Bruce McNair, AT&T Labs

Multiple Access) protocol with 40 msec frames. The base station transmits continuously and interleaves transmissions to each portable station in a fixed pattern. Each portable station is assigned two 6.7 msec time slots, evenly spaced in the 40 msec frame. The portable station listens during its assigned time slot and transmits during a corresponding offset time slot on a different frequency.

Preselection Diversity

Preselection Diversity takes advantage of the fact that the base station is continuously transmitting a signal. By making simple power measurements before an assigned time slot in these experiments, the portable receiver switches between two or more antennas directly at RF or IF and chooses the "better signal" for use during the assigned time slot. This selection can be made without disrupting the time slot.

Experimental System

The general-purpose VME-based signal processing platform shown in Figure 1 was implemented and used to make performance measurements with two-antenna preselection diversity.

The major hardware components were:

- RF unit to convert between baseband/IF signals and 900 MHz signals
- Custom designed interface hardware
- A/D Converters and 'C40 DSP processors from Pentek

A commercially available cellular handset was modified to include a second antenna by utilizing the stub antenna that is usually sold with a handset. This second antenna was orthogonally mounted at the mobile antenna connector in the base of the main antenna. By mounting the two antennas in this fashion, a dual diversity antenna system operates in a RF environment quite similar to what one would expect in a commercial product.

Signal Processing

As shown in Figure 2, the experiments utilized a signal generator transmitting at 925.195 MHz to simulate a base station transmitting a 5 kHz modulation tone. This was done to allow power level measurements of the received signal. The outputs of the two antennas of the receiving handset were routed through a RF receiver tuned to a frequency of 925.2 MHz, and then through the IF preselection circuits.

Their output I and Q signals were then sent to a Pentek 6102 8-Channel A/D and D/A Converter through an anti-aliasing low pass filter. Only two of the A/D channels were used to digitize the two analog signals, while two of the D/A channels were used to provide active signal displays on a x-y monitor (not shown in Figure 2 for clarity).

A Pentek 4270 Quad 'C40 DSP processor augmented with a Model 4257 Dual 'C40 Coprocessor and a Pentek 4201 MIX Baseboard completed the system. Only two of the six DSPs were used in this experiment to handle the real-time signal power measurements and provide the switching control to the preselection circuitry based on a diversity algorithm. Measurements were also downloaded to a Sun workstation for statistical analysis.

In a future article, we'll describe how the full system was integrated into a complete IS-136 station.

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RACEway Interfaces and FPDP Adapter Modules Added to the Pentek VIM Line

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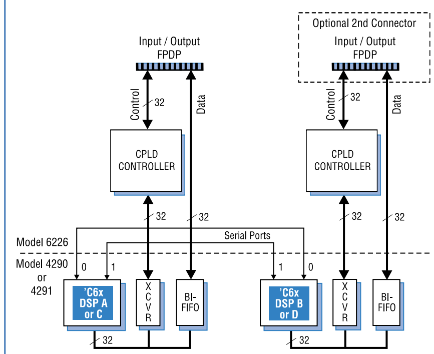
The **Model 6226** Front Panel Data Port (FPDP) Adapter is a VIM-2 module for the Pentek Models 4290 and 4291 Quad ’C6x DSP boards. It brings two bi-directional, 160 MB/sec FPDP ports to the TMS320C6x processors.

Two Model 6226s may be used to provide four FPDP ports, one per processor. Alternately, the Model 6226 may be combined with another VIM-2 module to provide additional I/O functions.

FPDP (Front Panel Data Port) is an industry standard front panel ribbon interface, now defined by an ANSI/VITA specification, providing high speed data transfers between system peripherals at sustained rates of 160 MB/sec using standard flat ribbon cable.

The Model 6226 contains up to two identical sections, each providing a bidirectional FPDP port to its respective ’C6x processor. A CPLD controller provides timing and handshaking to interface through the mezzanine connectors to the 32-bit mezzanine BI-FIFO ports of Models 4290 and 4291. Each FPDP port can be software-configured for either input or output operation.

For more information on these or any other Pentek products call us at 201-818-5900 ext. 609 or visit our website at **www.pentek.com.** ❏



Model 6226 Block Diagram

Congratulations to the Prize Winners

Bill Martinez of Statware is the lucky winner of our $400 Hewlett Packard digital camera drawing. We wish Bill good luck and many hours of fun with his new digital photography hobby.

Hsueh-Yuan Pao of Lawrence Livermore Labs won our $100 dinner for two at Birk’s restaurant, just for stopping by our booth during DSP World Spring conference in Santa Clara, CA. Bon appetit Hsueh-Yuan and guest! ❏

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New Literature and Documentation

A just-printed ’C6x color catalog is now available. It includes up-to-date specifications for our 4290 and 4291 Quad ’C6x DSP processor boards and our continually expanding VIM I/O peripherals product line. More VIM modules are being announced practically every month.

Also available is a product documentation CD-ROM, yours for the asking. Call us at 201-818-5900 for your free copies, or visit our website at **www.pentek.com** and ask for them. ❏

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Experimental Results

Theory predicts that for selection diversity with signals from two uncorrelated antennas, one should observe a 10 dB improvement in average signal level during fades that occur 1% of the time.

Most of the experiments were conducted with a transmitter-receiver separation of about 20 to 40 feet. Given the short path length, this was considered a worse-case scenario in providing uncorrelated fading.

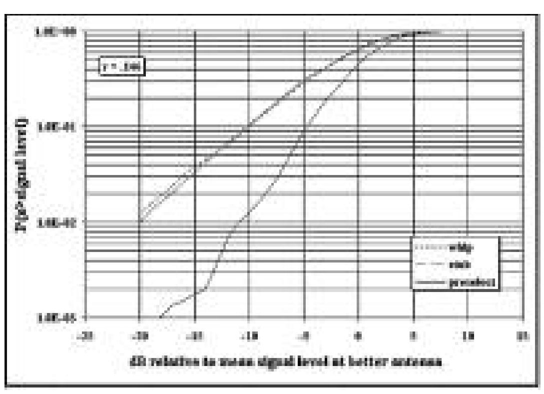

Figure 3. Typical distribution of signal level with and without diversity (Courtesy AT&T Labs)

Measured antenna correlation coefficients were between 0.05 and 0.2 with an improvement in signal level of 9 dB.

Figure 3 shows the results of a representative run. Signal power levels were measured for each antenna in 1 msec intervals. The mean for each antenna was calculated over the 2 minute experiment and the greater of the two mean signal levels was chosen as the reference. The abscissa indicates the signal level on each antenna and the preselected signal in dB relative to this reference. The ordinate indicates the probability that the abscissa exceeds the signal level. ❏

Product Focus:
Models 6219, 6220, 6226

RACEway Interfaces and FPDP Adapter VIM Modules

Newest Additions to Pentek's VIM Lineup Offer 160 MB/sec Data Transfer Rate

The**Model 6219** is a high-performance RACEway interface VIM-2R module which attaches directly to the Pentek Models 4290 and 4291 Quad 'C6x DSP processor boards. The 4290 and 4291 can hold two VIM-2 modules, or one VIM-2 plus a VIM-2R module in one VMEbus slot.

The Model 6219 attaches to the lower VIM position and utilizes two processors, while the upper position may be used for additional I/O functions. The flexible configurations of the VIM standard provide customizable system solutions with a 160 MB/sec RACEway interface.

Likewise, **Model 6220** offers the high performance RACEway interface. This VIM-4R module attaches to the Pentek Models 4290 and 4291 Quad 'C6x DSP processor boards and utilizes all four processors of the DSP board.

The Model 6220 provides a RACEway interface while occupying the same slot as the processor board. No other VIM modules may be attached to the processor board at the same time.

Both models allow master and slave access to the RACEway bus on P2 and route RACEway data packets to and from the 'C6x processors. The mezzanine BI-FIFOs of the processors are used to buffer the data for efficient block transfers. Interrupt inputs can be enabled for each processor to signal the presence of input or output data in the FIFOs for easy implementation of 'C6x DMA transfers. Peak data rates of 160 MB/sec are supported by hardware routing of RACEway data packets to and from the processors.

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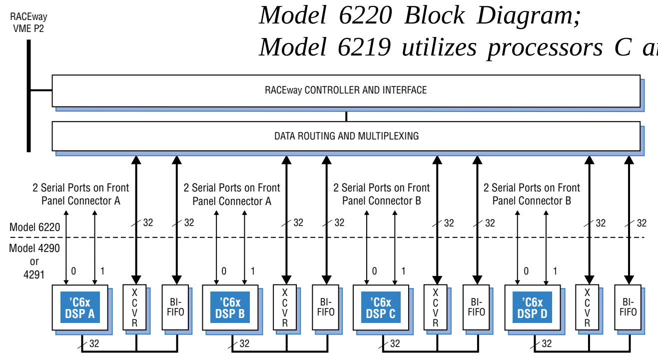
Model 6220 Block Diagram;
Model 6219 utilizes processors C and D only.



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