ADAPTIVE®
Adaptive Micro Systems LLC

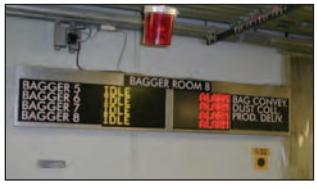
White Paper

The "Ideal" Real-time LED Production Display Board

For many years, there has been an interest in communicating production, quality and safety information to the factory worker. Even so, the limitations of older display and annunciation technology prevented widespread deployment. Limitations consisted of:

- Brightness
- Viewing Cone i.e. angle of viewability
- Contrast Ratio
- Outdoor Ratings
- Working Temperature
- EMI Immunity
- EMI Emissions
- Shock and Vibration
- Viewing Distance
- Cost per Sq. Ft of Viewing Area
- Image Retention
- Power Consumption
- Life
- Heat Output per Sq. Ft. of Viewing Area
- Serviceability

Stack lights, strobes, white boards, are reactive…problem or event has already occurred



Even after the introduction of LED display technology users were still dissatisfied with older style line matrix display boards. Users stated that these displays, on average, required replacement every four years due to their inability to easily and efficiently accommodate new process line configurations. Still others were reluctant to install proprietary protocols required by these displays, forcing their production management systems to communicate utilizing special gateways. They felt that substantial resources had already been invested developing human machine interface (HMI) screens using commercially available software packages like RSView®, GE Cimplicity®, Wonderware®, etc. and that display board ROIs did not justify one-of modifications to these systems.

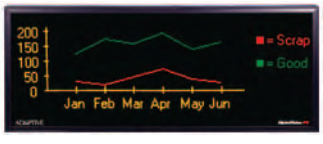
Armed with this information, Adaptive concluded that for LED display boards to be embraced and broadly deployed in the manufacturing setting the design must accept any Microsoft® 2000 compatible open data communication platform like ODBC, OPC, and DDE. The display would have to easily interface to existing HMI's and not require customers to redefine their data tag structures or communication architectures and that higher resolution displays were preferred if they could be made cost comparable to current technology.

As a world leader in the design and manufacturing of LED display boards, Adaptive was confident it could design and commercialize the "ideal" real-time production display board. The successful product would not only have to overcome those known limitations of scalability and connectivity but also offer customers compelling performance and cost benefits.

Adaptive AlphaVision™ PC

I. Performance

Adaptive AlphaVision PC - full matrix, tricolor LED display board with embedded PC technology



Power Utilization – Adaptive utilizes a special current driver algorithm that limits the unusable current produced when switching on a LED. Although the current limit algorithm removes these otherwise unusable spikes at milli-amp levels, the net sum for a display that utilizes over 10,000 LED's is somewhat significant. This also allows the LED to operate with less heat and increased LED life.

LED Brightness – Adaptive rigorously evaluates LED chips produced by dozens of manufacturers for color purity, color intensity, and degradation characteristics. Adaptive utilizes special lab grade spectrophotometers, which provide optical measurements that far exceed anything the human eye can detect. Only the best of these LED suppliers are then chosen as Adaptive's LED suppliers.

LED Flickering – One of the most visible performance indicators relating to LED displays is display flicker. Display flicker is caused when LED display refresh rates occur at the same frequency as fluorescent lights. This is typically at 60Hz. Harmonics of 90Hz and 120Hz can also cause flicker. The AVPC refreshes at 80Hz. This frequency was confirmed to be the most stable to reduce flicker.

Viewing Angle – Adaptive has invested significant resources investigating and designing special LED lens and light channels for its LED Cubes. These designs maximize the balance between viewing angle and brightness.

Parabolic mirror equations are used to determine the optimum viewing angle and brightness. Adaptive's AVPC characters can produce 120-degree viewing cones at no less than 50% brightness degradation.

Color Consistency –The human eye can typically begin detecting a color variance of 25-30nm for red and 5nm for green. Adaptive utilizes state of the art automatic visual inspection equipment in the manufacturing of its LED cubes. These cubes are then sorted into several bins with no more than 5nm variances for superior color matching. When a display is being manufactured, LED cubes are all selected from the same bin insuring color consistency.

Data Throughput – Since the AVPC utilizes an embedded PC, the need to process data off-line is greatly reduced. Any Windows® 2000 compatible HMI can be run directly on the AVPC and receive data at speeds equivalent to the HMI. In other words, the bandwidth is based on the native application and network topology.

II. Cost

Initial Purchase Price – The AVPC has achieved a price position comparable to previous generation boards that offered lower resolution (.3" pixel pitch versus .57" pixel pitch). As a wholly vertically integrated manufacturer, Adaptive consumes over 1,000,000 LED chips per day and purchases over ¼ billion LED components per year, providing substantial costs savings to the end-user.

Pneumatic shocks assure safe and secure front door access to all components

Training – AVPC installation is straightforward; locate the unit, wire power and communications. Ethernet TCP/IP addressing can be done in less than 10 minutes or preprogrammed in the factory at no additional charge. The AVPC Windows 2000 desktop viewer software training takes less than 15 minutes. Training can be performed over the phone, via CD, or locally through Adaptive's authorized AVPC distributors. No special code is required as your development screens are created in your existing HMI's.

Spare Parts – Adaptive utilizes the same driver boards, processor card, fans, thermostats, power supplies, and LED cubes across multiple AVPC sizes. This significantly decreases the costs associated with on-site spare parts. In fact, the parts used in the AVPC are so common, they can be ordered and shipped anywhere across the USA in less than one day. For this reason, most end users maintain a minimum quantity of spare parts on site.

Installation – Whether wall or ceiling mounted, the AVPC can be installed in less than 1 hour. Easy to access power wiring and communications terminals further reduce installation costs. Once mounted, the AVPC can be quickly accessed for parts replacement via quarter turn cam screws. Safety features, like pneumatic door shocks, hold the AVPC front accessible door open to facilitate power and communications wiring.

Mean Time Between Failure (MTBF) – The estimated MTBF for the AVPC is 100,000 based on past LED display designs and Adaptive's Accelerated Life Testing, (ALT) program. The current limiting algorithms utilized by the AVPC further increases the life of the AVPC by reducing heat, a common enemy of LED's. This equates to 11.4 years of 24 X 7 X 52 usage.

Flexibility / Compatibility – Since the AVPC does not require special HMI software or proprietary protocols, it can be used with any Windows 2000 or Windows CE compatible software. This significantly reduces the costs associated with not only initial integration within existing system networks, but also decreases the costs associated with integrating the AVPC into future systems. Some automotive companies have estimated this savings to exceed thousands of dollars per facility.
**OS is compatible with standard virus protection software such as Norton Anti-Virus™ and McAfee® VirusScan®.*

Maintenance – Aside from checking the cooling fans once a year, (or commensurate with level of environmental contamination), there are no other routine maintenance activities required. If a part replacement is required, a twenty-minute mean time to repair is typical.

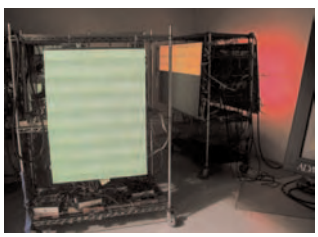
III. Reliability Factors

Reliability Design Testing – Adaptive employs a full time staff of test engineers dedicated to testing new designs employing environmental test chambers. Temperature and humidity chambers are programmed to replicate tropical and arctic environments, where suspectible components are quickly identified. Adaptive's salt spray tests simulate outdoor coastal environments. And, Adaptive even utilizes UV and IR light simulators to determine material degradation levels.

100,000-Hour Mean Time Between Failures – These values have been determined based on existing field designs along with Adaptive's ALT testing program discussed earlier. Adaptive assures this level of reliability through specific design features like:

- Built in thermostats with automatic dimming algorithms.
- Input power surge suppressors.
- Special LED current driver circuits
- Vertical manufacturing using surface mount technology.
- Design usability studies.
- Universal power supplies.
- Stringent vendor component selection criteria.
- Industrial grade rugged NEMA 12 enclosure design.

Environmental chambers test the extremes of operating conditions and impact on performance

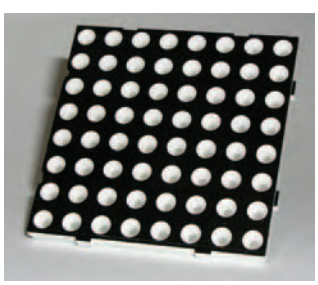


Adaptive utilizes several technologies in the design, test, and manufacturing of the AVPC. New projects are managed using quick response design teams and coordinated using Microsoft Project. This allows for rapid prototyping and customer first-pass evaluations. Products are designed using three-dimensional solid modeling software. This provides our engineers with the ability to evaluate fit and performance before a single PCB or enclosure is manufactured. Additional technologies include:

- Automated digital optical color grading systems using video photometry techniques. This is the marriage of gray scale and chromaticity color imaging. The human eye can detect a 25-30nm variance in red and 5nm variance in green. Adaptive's in-line grading and sorting equipment can detect and sort color hue levels well below these ranges.
- Lab grade spectrophotometers are utilized for optical test and evaluation.
- Materials engineering research focuses on optical diffusent light guide covers. These special covers further add to color consistency, contrast, and brightness, while protecting the light channels from UV and IR light sources.
- Materials engineering research also focuses on optically transparent encapsulates. These materials are designed specifically for opto-electronic components, where light magnification and channeling are key design criteria. These materials also increase LED cube reliability by protecting the LED die from humidity, shock, and vibration. Humidity causes alloy oxidation and LED band gap degradation, which reduces life.
- Surface mount board design and manufacturing along with wave soldering are also critical for the reliability of specific boards.
- Special environmental chamber test fixtures are utilized for both design and manufacturing testing.
- Manufacturing engineering utilizes special lean manufacturing techniques to evaluate new designs for manufacturability. This further streamlines manufacturing costs, while increasing reliability.

IV. General Compatibility

Color matched 8x8 tri-color LED display cube common to all Adaptive products



The AVPC utilizes the identical LED cubes as Adaptive's one, two, three, and four line message marquees products. This insures interchangeability between units and common product platforms. The AVPC can display any size characters from 1.2" to 60 including the popular 4". Utilizing Microsoft Windows 2000 operating system, the AVPC can run any Win 2K application effortlessly, with no application rework required. No special wires or cables are required as the AVPC utilizes common wiring materials and techniques.

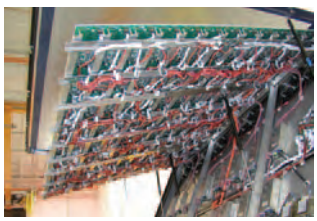
- Microsoft 2000 operating systems are utilized in the AVPC. This allows for OPC, ODBC, and DDE data transfer compatibility's and sound files that can be played using sound blaster. ActiveX control technology is used in the AVPC Windows CE version. Firmware is written using Visual C++, where easy upgrades and flexible engineering practices can be utilized.

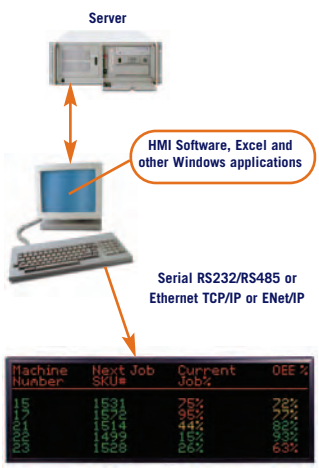
V. Ergonomics

The AVPC is built with several ergonomic features in mind.

- Double-sided units are built with a 5-degree viewing tilt included. This reduces ambient light glare and increases viewing ease at close distances.
- For larger size AVPC's, door mounted air shocks require less than 10 lbs of lifting pressure to open and close the front access door. This increases maintenance safety when accessing units installed in elevated locations.
- Half-turn door fastening cams make opening the AVPC enclosure very simple. Closing the door does not require screw holes to be aligned using this fastening method.
- Wiring termination blocks simplifies AVPC wiring. Double-sided display boards are all prewired from the

Easy access to power wiring and communications terminals speeds repair and installation





AlphaVision PC Display

factory. Ethernet connections utilize standard RJ45 connectors.

- Although the human eye can detect many shades of red, green and amber, the cones located behind the retina can easily focus on certain color bandwidths. Adaptive utilizes LED's that illuminate at a color frequency compatible with the human eye.
- .3" dot pitch is also considered to be more ergonomically appealing to the human eye than larger .57" dot pitch. Since tighter pitch displays do not force the human eye to differentiate pixels into shapes like letters or numbers, this can reduce operator fatigue.

As stated earlier, the AVPC screen refreshes at 80hz. This eliminates flicker as perceived by the human eye. Fluorescent lightflicker has been known to cause tension headaches in office environments

VI. Connectivity

The AVPC was designed to connect to virtually any network. Windows 2000 offers data communication via OPC, ODBC, and DDE through hundreds of commercially available software packages. Windows CE allows communication via ActiveX controls, another Microsoft standard. The AVPC utilizes Transmission Control Protocol /Internet Protocol or TCP/IP, the most common physical network in use today. Together, these systems allow millions of communication configurations.

Internet / Intranet / Extranet – Using Microsoft Explorer, the AVPC can be configured as a client and communicate to a host server. This server can be configured using Enterprise Information Portal, (EIP); technology to send data from multiple departments to the AVPC at predetermined scheduled times. Many industrial manufacturers are funding displays via time-share through multiple departments. Security can be obtained by using a customer's existing virtual private network as one would use with any other computer.

Client / Server Networks – The AVPC can be configured as either a client or server based on however a customer prefers to set up their local area network. As a client, the AVPC can poll production data from an HMI workstation. As a server, the AVPC can be used to share data to other AVPC's or Adaptive displays. Remote configuration can be easily performed through AT&T's Virtual Network Software, (standard on all Windows 2000 AVPC's).

Industrial Networks – The AVPC comes standard with a PCI slot for use with any PCI compatible industrial gateway card. Cards that communicate on ControlNet, DeviceNet, Profibus, Modbus Plus, DH+, and Remote I/O are all common. Polling data directly from a PLC that utilizes any of these protocols, in addition to many others, can communicate directly to the AVPC. Data can be displayed using any Windows 2000 compatible HMI, like RSView, Cimplicity, Wonderware, Iconics, Intellution, Activplant™ (formerly Visual Plant), and many others.

Wireless Networks – The AVPC can communicate over wireless networks by utilizing wireless transponders and receivers. In fact, companies like Plantwatch, located in London, Ontario Canada, have developed special network configuration software specifically for this task. This software also acts as a communications gateway configurator that can communicate on several open and proprietary pager and manufacturing protocols. All Adaptive standard marquees in addition to the AVPC are available within Plantwatch's network configurator.

SCC Protocol Emulator – The AVPC can even communicate to existing system configurations that utilize SCC protocol. A simple screen configurator that runs on the AVPC allows fast integration into existing systems. There is no need to replace old infrastructures for simple one and two order quantities. Note: Many automotive facilities are deploying more flexible, higher performing open networks, where special protocols are not required.

VII. Scalability

Processor Board Upgrades – The AVPC currently utilizes less than 15% CPU processor bandwidth. Even with HMI runtime packages utilized, the CPU utilization rarely exceeds 25%. If future applications require additional CPU processing capabilities, the AVPC's main control board is easily upgraded.

Display Array Configurations – The AVPC was designed to allow for .3" pitch using modular driver board configurations. A single driver board can represent one line of 3.5 qty. 4" high characters. Previously board manufacturers designed their driver boards in a manner that force their customers to purchase either 3, 6, or 9 line displays based on the larger fixed .57" pixel resolution. Adaptive offers dozens of possible combinations of AVPC's in both single and double-sided configurations. Since Adaptive manufacturers the AVPC from start to finish, any size is possible.

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Font Size – The Automotive Industry has selected 4" high letter font sizes as the default standard in part due to the .57" pixel pitch line matrix displays offered years ago. Today's .3" pitch affords customers the ability to utilize font sizes that range from 1.5", 2.1", 3", 4.2", 9.6" and even larger. More importantly, the AVPC now allows customers to mix their font sizes to meet their needs as easily as setting font size in any Microsoft 2000 program.

Hard Drive Storage – The AVPC comes standard with a 20-Gigabyte hard drive. Like any other PC based system, this can be easily upgraded.

PCI Slots – As previously stated, the AVPC's main control board comes standard with a PCI slot. This slot can accept any PCI compatible gateway communications card. These cards can communicate PLC data over ControlNet, DeviceNet, Profibus, Modbus Plus, DH+, and Remote I/O.

Mechanical & Electrical Specifications

Enclosure:	-NEMA 12 heavy duty enclosure -Front door with non-glare, scratch resistant polycarbonate lens -Door is hinged on top for easy access -5 Degree downward tilt on double-sided models to reduce glare
Display Boards:	-Modular 32x16 pixel design -High resolution 0.3" (7.6mm) pitch tricolor pixels -High intensity LED displays -LED drive designed to insure long life and maximum display brightness
Power Circuit:	-Auto-ranging universal input power (100-132VAC, 200-252VAC, 50/60Hz) -Built-in surge suppressors and EMI filters
Environment Characteristics:	-Operating temperature: 0 to 50 degrees C -Humidity: 0% to 95% non-condensing -Built-in temperature sensing circuits to insure long, dependable operation

Agency Approvals:	**North America** -US Emissions: FCC Part 15 Class A -US Safety – ANSI/UL 1950, Third Edition -Canadian Emissions: Industry Canada ICES-003, Class A -Canadian Safety: CAN/CSA C22.2 No. 950-95, Third Edition **Europe** -Emissions: EN55022 (CISPR 22), Class A -Immunity: EN55024 -Harmonics/Flicker: IEC 61000-3-2, IEC 6100-3-3 -Safety: IEC60950: 1991 (plus amendment) -EN60950: 1992 + A1, A2, A3, A4 and A11 -CE marking on all models **Australia/New Zealand** -Safety: AS/NZS 3260: 1996

Processor Specifications

Processor:	Pentium class National Semiconductor® Geode™ GX1 300Mhz
Memory:	-Flash: Intel Strata, 16MB maximum -SDRAM: 144-pin SODIMM socket, 256MB maximum -Cache 16k L1 write-back cache
Video:	TFT flat panel and CRT XVGA, 1-4MB SDRAM video memory
Drive Support:	FDD, HDD, Silicon Disk in Flash, CompactFlash
Network Support:	10/100BaseT Ethernet via RJ-45
Serial & I/O Ports:	4 x 16550 fast serial ports; 3 x RS232, 1 x RS232/422/485, 2 x USB

PC Peripheral Ports:	Keyboard, mouse, LPT, GPIO
Expansion:	CompactFlash socket, PC/104 bus, PCI slot
Sound:	16-bit Soundblaster/Pro compatible interface
BIOS:	Award BIOS (Millennium compliant)
MTBF:	90,000 Hours
LED Interface:	PC104 High speed LED turbo interface card
Hard Drive:	20GB Ruggedized laptop hard drive
Operating System:	-Microsoft® Windows® 2000 -WinVNC remote network control -AVPC power-up utility -AVPC screen mapping utility