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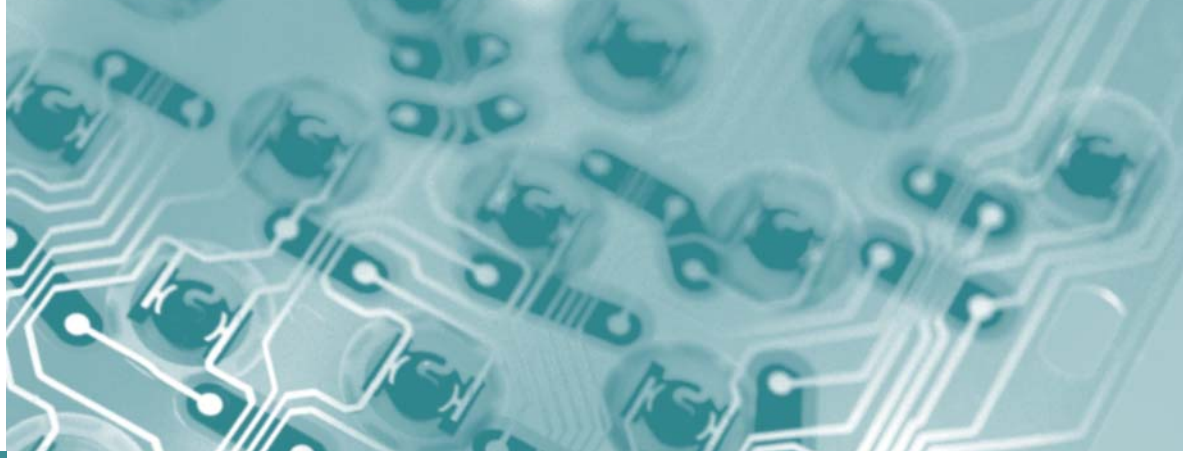

Why Intelligent Fax Boards are the Smart Choice

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white paper

Abstract

A myth exists that all fax boards and fax modems are essentially the same. If they all send and receive at relatively the same speed, then all fax phone bills are the same and what else could matter?

But fax technology can be surprising: for example, intelligent fax boards can send at 2 to 3 times the speed of most Class 1 and 2 modems. To add to this, even by sending at the same speed of 14.4 Kbps, Class 1 and 2 fax modems typically triple page transmission time compared to intelligent fax board throughput!

Three distinct types of fax cards exist: Class 1 fax modems, Class 2 fax modems, and intelligent fax boards, and each provides substantially different levels of performance. In the mid-volume (approximately, 70 four page faxes) scenario presented in this white paper, intelligent fax boards are shown to reduce life-of-system fax phone bills by as much as $5,900 over Class 1 and 2 modems. The reasons why intelligent fax boards provide superior performance may be obscure—including Modified Modified Read compression, signal-to-noise ratios, critical timing issues, call progress capabilities and bit-stuffing, which will be explained later—but they are no less real to the bottom line for being esoteric.

This paper explains how fax boards differ, how those differences play out according to fax phone call elements and installed base capabilities, and why intelligent fax boards are a superior choice for virtually all but the very lowest-volume computer fax applications. The paper also provides a checklist of items to consider when purchasing intelligent fax boards.

Introduction: Why Buy Intelligent Fax Boards?

In the glossy pages of the popular computer trade press, the "fax modem" has been widely regarded as a commodity item, triggering the widely held belief that all fax modems are the same. In fact, however, vast disparities exist between the performance provided by low-cost fax/data modems (e.g., Class 1 and 2 devices) and intelligent fax boards (fax cards with on-board microprocessors). Schooled largely by the trade press, when equipping their LAN fax servers, fax-on-demand systems and fax broadcasting engines with fax cards, businesses all too often choose low-cost fax modems, a choice that typically saddles them with one or more of the following problems:

Dollar Drain: Just about every fax phone call made with low-cost fax modems costs about twice as much as necessary in usage charges paid to one's telephone company (and it can literally be ten times as much!). This is a critical issue because over the life of a fax system, the "pennies" paid for thousands of fax calls tend to add up to far more than the original purchase price.

Hassle: Headaches arise from unnecessarily high percentages of fax phone calls never being completed by low-cost fax modems, particularly with Class 1 devices.

Disinterest: A fall-off occurs in computer fax system usage by workers due to the unreliability of the low-cost fax modems on which the system is based.

Quick System Max-Out: Low-cost modems fail to support adequate system scalability because they require general-purpose PCs to struggle to muster enough power, quickly enough, to manage the multi-channel faxing that intelligent fax boards support with ease. When businesses commit to systems using fax cards that don't scale up well, one result can be the needless expense of an extra PC for every couple of ports (instead, for example, of one PC supporting 24 or 48 ports).

Intelligence Report: Differentiating Fax Cards

The three types of fax cards are Class 1 modems, Class 2 modems, and intelligent fax boards:

Class 1 fax modems (EIA 578) comprise the lowest-cost category for a very simple reason: they rely totally on the power of PC microprocessors for tasks critical to sending faxes, including the conversion of PC files to fax format, support for bit-stuffing (bit-stuffing is explained below), and management of the fax phone call itself, including all signaling to set up and maintain a fax call. They support 14.4 Kbps transmission speed, not 33.6 Kbps, and only the slowest form of standard fax compression.

Class 2 fax modems, like their Class 1 cousins, rely on the power of PC microprocessors to convert PC files to fax format, but handle all signaling to set up and maintain fax calls via on-board circuitry. They may handle bit stuffing on-board or via the PC microprocessor, but support only low-level fax compression.

Intelligent fax boards differentiate themselves via on-board microprocessors which, in addition to sending faxes at 14.4 Kbps and 33.6 Kbps speed, also can support advanced fax compression methods, convert documents to fax format and bit-stuff on-the-fly on the board (not on the PC), and can manage fax phone calls via on-board processing power.

Intelligent fax boards carry the highest price tags, which is why buyers naturally flock to the lower-cost "class" modems. But they save far more than the differential in cost by more reliably completing calls *(see Table 1)*, sending faxes in less time to reduce fax phone bills *(see Table 2)*, by minimizing maintenance issues, by providing strong enough performance that people actually use the computer fax systems based on them, and by cost-effectively exploiting server resources.

Assuming that only 10% to 25% of the worldwide fax installed base actually requires bit-stuffing, then pre-storing unnecessarily extends 75% to 90% of calls, typically by about 40%, give or take.

Are You Bit-Stuffing Your Fax Phone Bill?

Bit stuffing is required because, with many older non-memory fax machines, the code sent to describe a fax scan line transmits faster than the time it takes the printhead to move across the page. The solution is to stuff extra bits into the code to keep the mechanical parts synchronized. The receive-end fax machine invokes the need for bit stuffing and, if the sending device cannot bit stuff, the fax call aborts. The best way to bit-stuff is dynamically, on-the-fly, via an on-board microprocessor. This way, fax phone call time is extended for bit-stuffing only when called for and only to the extent necessary. The alternative is to pre-stuff every file to be computer faxed, but this means that every fax phone call lasts longer and that more bits than necessary must be stuffed.

Table 1: Why Fax Phone Calls Fail Unnecessarily

Factor	Explanation	Impact
Poor T.30 Implementation	When fax/data modems first emerged, it was makers of data modems that captured the low-cost high-volume business (data-comm works fine without on-board microprocessors, fax does not). Many data-comm oriented vendors were not fax experts; as a result, many data/fax modems handshake incorrectly, causing calls to abort more or less frequently.	Businesses pay for failed calls and retries that fail. They also pay the labor to identify the failed call and to fax it by fax machine.
Time-Outs	Because Class 1 fax modems rely on general-purpose PC architectures and processing power—subjecting them to PC-caused latencies—they will always be subject to high percentages of fax calls aborting due to time-outs.	Businesses pay for failed calls and retries—and when a 20-page fax fails at the 19th page, they pay to send both a 19-page and 20-page fax.
Poor Call Progress	Call progress involves the intelligent detection of telephone network signals, such as busy signals, special instruction tones (SITs), and even human voices. Busy signal tones and cadences vary, for one, from country to country and, when fax devices provide poor call progress monitoring, the results include (1) instead of terminating the problem call immediately and moving onto the next, the call continues on until the fax handshake process finally times out, and (2) the incorrect information relayed back to the fax server typically results in bad fax numbers being redialed time and again.	The amount of traffic a fax server can handle is diminished as doomed calls linger and then are retried—and linger again. Also, system administrators aren't alerted to change or delete bad numbers, typically resulting in broadcast lists with substantial amounts of bad fax numbers, in turn institutionalizing inefficiencies and unnecessarily failing to deliver faxes to intended recipients.
Signal-to-Noise Ratio (SNR)	When phone line noise is too high, causing intolerable error rates, fax calls abort. The higher the signal-to-noise ratio of a fax device, the more noise it can tolerate (i.e., fewer calls abort). The signal-to-noise ratios of intelligent fax boards are significantly stronger than for Class 1 and 2 fax modems.	SNR modems are estimated to cause 5% to 20% of overseas fax calls to fail.

Source: Davidson Consulting, 2003

Anatomy of a Fax Phone Call

A great deal of the difference in modem types can be illustrated by examining the elements of a fax phone call:

Document conversion: computer files must be converted from original formats to the G/3 fax format (e.g., a TIFF file). Document conversion is about 10 to 20 times more processing-intensive than managing the actual fax phone call. Both Class 1 and 2 fax modems place the document conversion burden—which is the primary bottleneck area in a computer fax system—on the PC, not on them. This either substantially reduces the volume of traffic that any fax server can support or interferes with the ability of individual users to use their fax-enabled PCs while documents are being converted.

Intelligent fax boards can handle document conversion on-board, on-the-fly, freeing PC resources so a fax server can support greater volume or so end users need not sit idly at their PCs during fax phone call preparation time. They may also support on-the-fly enhancements to images, such as automatically superimposing business-form designs onto raw data (called business-form overlay) and scaling document sizes to fit the need of receive-end fax machines (e.g., from the letter size used in the US to the B4 paper size used in Japan).

Call progress (or lack thereof): Call progress involves the intelligent detection of telephony signals, such as busy signals, special instruction tones (SITs) and even signals from phone-line sharing devices and the sounds of human voices. Busy signal tones and cadences vary depending on whether they are generated by subscriber equipment (e.g., a fax machine) or within a phone network (e.g., all ports on a telephone company switch are temporarily busy)—as well as from country to country.

An example of special instruction tones (SITs) are the ever more frequent messages, on long-distance calls, informing callers that area code numbers have changed. High-quality call progress means that a fax device can detect all these different tones accurately. For example, if a fax device misreads an SIT tone as a busy tone, it will continue to re-try the transmission to the same fax number, even though the call cannot connect and the only result is inefficient use of fax server resources. Moreover, if the fax system then reports back to the system administrator that non-delivery of the fax was merely due to busy signals rather than the need to change the phone number, the number typically will be left intact and the fax system will end up trying and failing to connect to the same destination over and over again.

The best intelligent fax boards support call progress for the full range of signals for all countries in which they are sold. In contrast, virtually all Class 1 and 2 fax modems and even some intelligent fax boards support more or less limited call progress. With low-end fax cards, the extent of call progress often comes down to recognizing US-based busy signals some of the time—and defaulting to error reports like "busy signal" or "non-fax device" when they fail to detect the actual response signal.

Handshaking: the sending fax device calls the receive-end device and they exchange signals (handshake) to determine which speed and compression methods the fax phone call will use (note that handshaking takes place at 300 Kbps, regardless of how fast any modem can transmit). When fax designers built millisecond tolerances into the timing of fax machine and fax phone call operations back in the 1970s, they never guessed that computer fax systems would have to meet those timing requirements via modems operating through serial interfaces that had to relay interrupt signals to PC microprocessors that, as often as not, would already be busy handling computer-centric operations. Fax machines are hardwired to meet the very strict "millisecond" timing requirements of fax, so they virtually never have "time-out" problems. Class 1 fax modems, however, rely on general-purpose PC architectures and processing power to manage handshaking routines that can time-out if various sub-second timing requirements are not met. As a result, Class 1 devices will always be subject to high percentages of fax calls aborting due to time-out conditions. The microprocessors on intelligent fax boards make certain that time-outs are eliminated as a problem.

Page transmission: after handshaking, each page is transmitted at the highest compatible and achievable speed (i.e., from 2.4 to 33.6 Kbps) that both fax modems in a session can support. While products exist among all three types of fax cards that can transmit at 14.4 Kbps, today only intelligent fax boards support 33.6 Kbps (known as the V.34 fax standard).

Take the three levels of standardized fax compression. At 9.6 Kbps with a benchmark page, the Modified Huffman (MH) compression that is the best that Class 1 and 2 modems offer supports 45-second/page throughput speed. In contrast, the Modified Read (MR) and Modified Modified Read (MMR) compression methods that intelligent fax boards and fax machines can offer support 30 and 10 second-per-page throughput speed, respectively.

Retraining: after each page is transmitted, the two fax devices resynchronize with each other (retrain) and, upon successfully doing so, transmit another page (then retrain, then transmit another page, and so on, until the call is completed). Notably, largely

because of their relative cost structures and the resulting quality of components used on the cards, intelligent fax boards employ modems that send out stronger signals than Class 1 and 2 modems. The stronger signals handle phone line noise more effectively (i.e., support a higher signal-to-noise ratio). Relative to retraining, the real-world result is that, whereas failures to retrain are rare among intelligent fax boards, they occur with significantly greater frequency with lower-cost fax modems.

In summary, intelligent fax boards save money in a number of ways: better compression cuts throughput time on most calls, efficient bit-stuffing eliminates unnecessary extensions to transmission time, stronger signals and higher quality call setup mean more calls are completed the first time and need not be retransmitted.

Table 2: Factors Impacting Fax Throughput Speed

Factor	Explanation	Impact
Transmission Speed	The fastest current intelligent fax boards send at 33.6 Kbps, more than 3 times faster than 9.6 Kbps Class 1 and 2 modems.	Save up to 350% on the page-transmission portion of fax calls.
Compression	On average at 9.6 Kbps, MH supports 45-second/page speed, MR 30-second, and MMR 10-second. Class 1 and 2 fax modems support MH only. Intelligent fax boards also support MR and MMR. About 85% of fax traffic uses MR or MMR.	Faster compression speeds means reduced transmission time, which results in, reduced fax phone bill costs.
Bit-Stuffing	Between 10% and 25% of installed fax machines require bit-stuffing. When fax devices can bit-stuff on-the-fly, they do so only when necessary and to the extent necessary. When they must pre-store fill bits (all Class 1 modems and some Class 2), then they bit stuff on every call and more than necessary.	Pre-bit-stuffing can increase call duration by about 40% on 75% to 90% of all calls.
Signal-to-Noise Ratio (SNR)	The faster modems transmit, the less tolerance they have to phone line noise. When phone line noise is too high for full speed, fax devices step down to slower speeds, enabling the calls to happen but extending their duration by 10% to 400%. The higher the SNR, the less likely that step-downs need occur. Intelligent fax board SNRs tend to be significantly higher than those of Class 1 and 2 fax modems.	Low SNR modems can increase fax phone bills by 10% to 40% (worse if there is a high percentage of overseas calls).
Handshaking & Retraining	Poor handshaking and retraining can cause fax phone calls to last longer than necessary by causing handshaking and retraining time to be extended because certain sub processes need to be repeated.	Poor handshaking and retraining can increase fax phone bills by 5% to 15%.

Source: Davidson Consulting, 2003

Money Changes Everything

Although the preceding information should make it clear that intelligent fax boards provide much better overall performance than Class 1 and 2 fax/data modems, that may not matter unless the superior performance translates into real-world cost-justification. In other words, since Class 1 and 2 modems tend to cost between $100 and $300 per port, while intelligent fax boards cost between $500 and $1,000 per port, the $400 to $900 extra for intelligent fax boards must be offset by reduced operating costs.
To illustrate, we have created a return-on-investment model based on the following assumptions:

- The extra cost per port for an intelligent fax board compared to a Class 1 & 2 fax modem (with on-the-fly bit-stuffing) is the highest-possible $900.
- That a port is used to send 70 four page faxes per day, 260 days per year.

- That a weighted average of $.07 per minute phone charge is used based upon the assumption that 25% of faxes are local (free), 62.5% are long distance ($.07 per minute) and 12.5% are overseas ($.20 per minute).
- That traffic patterns are more conservatively stated than estimates made above, by which we mean that assumptions of the percentages of faxes transmitted at various speeds and with various compression methods are quantified as follows: (1) 40% 9.6 Kbps, 45% 14.4 Kbps and 15% 33.6 Kbps relative to transmission and (2) 18% MH, 39% MR, 42% MMR and 1% JBIG relative to compression support.

Using this model, intelligent fax boards pay off in less than a year, as shown in Table 3, and over the five-year life of a system save $4,089 with a 14.4 Kbps intelligent fax board and $5,945 with a 33.6 Kbps intelligent fax board versus Class 1 and 2 modems. Such savings are mid-volume, per port, and do not include the following:

Server savings: Class 1 fax modems support merely one port per PC, period. If you need two ports, you must buy a second PC. Class 2 modems, because of the overhead associated with document conversion, can push the limit of PC server processing power with as few as two to four ports. In contrast, intelligent fax boards can support up to 96 ports per server. The upshot: past two to four ports, *an additional hidden cost of Class 2 ports can be the purchase of additional PCs.*

Table 3: Intelligent Fax Board Return On Investment

	1st Year Phone Bill	1st Year Savings per port with 14.4 Kbps IFB*	1st Year Savings per port with 33.6 Kbps IFB*	5 Year Fax Phone Bill	5 Year Savings per port with 14.4 Kbps IFB*	5 Year Savings per port with 33.6 Kbps IFB*
Class 1 & 2	$3,057.60	$97.97	$469.13	$15,288	$4,089.83	$5,945.63
14.4 Intelligent Fax Board	$2,059.63			$10,298.17		
33.6 Intelligent Fax Board	$1,688.47			$8,442.37		

** Savings after purchase price differential subtracted*

Source: Davidson Consulting, 2003

More 33.6 Kbps faxing: Where a fax system sends faxes to many 14.4 Kbps fax machines or intelligent fax boards, greater savings will accrue to a system based on intelligent fax boards because it can send at up to 33.6 Kbps coupled with MMR compression (about 5 seconds per page), where Class 1 and 2 modems can only send at 14.4 Kbps with MH compression (about 30 seconds per page). Even at 14.4 Kbps, Class 1 and 2 fax modems are 6 times slower in transmission time!

More overseas faxing: Because overseas phone rates are higher, if one sends more than 1 of every 8 faxes overseas, greater savings will result from intelligent fax board use than is shown in Table 3 above. Of course, due to time-zone differences, fax accounts for greater percentages of overseas than domestic calls.

Intangibles: With intelligent fax boards, less labor is exerted to track down and handle failed call attempts. Productivity increases are greater because more people use intelligent fax board-based fax systems more often. Crises don't occur when workers arrive at the office in the morning to find that 70 faxes out of a 400-site fax broadcast were never actually sent.

How to Buy Intelligent Fax Boards

Considerations in the purchase of intelligent fax boards include:

Compatibility: Boards must be compatible with server operating systems, fax application software (e.g., LAN fax, fax-on-demand), print-to-fax conversion methods and telephone network facilities (e.g., analog loop start, T1, ISDN). Broad operating system

support can be important to avoiding premature obsolescence. Support for T1 lines (and ISDN lines, particularly in Europe and Japan) can be crucial to generating the substantial savings that such bulk volume phone lines offer.

Throughput speed: Boards preferably should support 33.6 Kbps transmission speed, MR and MMR compression as well as MH, and support both on-board on-the-fly document conversion and bit-stuffing. Whenever possible, buyers should test or otherwise determine the relative throughput speed of competing intelligent fax boards, as actual throughput can vary due to a range of component and software level factors.

Call progress: Boards should provide very efficient call progress for as many signal types and countries as possible. It is worth analyzing how much poor call progress can reduce overall fax server throughput and contaminate fax broadcast lists and address books.

Computer loading: Buyers should test or otherwise determine the relative loading placed on server PCs, with an eye to how loading levels progress as more ports are added to a server.

Image Handling: Can the fax device provide sophisticated and flexible handling of image files? For instance, can it support wide documents and business-form overlays on-the-fly? Does it support transmission of standard TIFF (Type F) files, in particular enabling it not to have to rely on PCX/DCX file formats, which can be much larger than TIFF files and prolong the duration of fax phone calls by a factor of two to ten? When used to receive faxes, can the fax device provide on-the-fly conversion of faxes received in MH or MR formats to the smaller and more efficiently stored and processed MMR format?

Automated Processing of Received Faxes: Particularly in LAN fax environments, buyers should consider the flexibility of using boards that can automatically route received faxes. While it may be significant for the fax device to support a technology like the ITU T.33 standard for sub-addressing (which can automatically route faxes if transmitted from T.33-compatible devices; unfortunately, prior to mid 1996, no fax machines were T.33-compatible), the real issue is direct-inward-dial (DID) support. In North America, DID is the single type of inbound routing system that works with the entire worldwide fax machine installed base and works whether inbound faxes are manually or auto-dialed, doesn't require that the person sending the fax enter some extra code or command, and doesn't require that routing clerks at the receive-end LAN laboriously open every received computer fax file, visually identify the recipient, and then route the fax to that person's fax mailbox. While DID requires special phone lines (sometimes available through one's PBX), by at least having DID implemented on fax devices, it saves the company the cost of buying external DID devices. Overseas, although DID-equivalent services (often abbreviated as DDI) are sometimes available, implementing equally viable and transparent inbound fax routing usually requires ISDN support. Again, having ISDN on the fax card eliminates the need to purchase third-party, external devices.

Programmability: The API furnished with the intelligent fax board should be powerful, reliable, easy to use, and backwards-and forwards-compatible with other boards the vendor offers (and software that runs on the boards). Although there is a de facto standard fax programming interface, CAS, it is out of date and is a factor primarily in terms of supporting legacy applications with leading-edge intelligent fax boards. Because the API is the software "window" into the fax board's hardware functionality, its suitability is critical.

Patch, fix and upgradability: It should be possible to fix and upgrade certain fax board capabilities with relative ease, which preferably means by simply downloading code and using it to update DSP-based functionality.

System integration readiness: How readily can the intelligent fax board be integrated with other, often telephony-based, systems? Can it support voice and fax on the same board? Does it support legacy integration interfaces like PEB and forward-moving architectures like MVIP and SCSA? Does it fully support key computer fax functions like DID and T.33 subaddressing and T.434 binary file transfer?

Overseas Usage Approvals: Where intelligent fax boards are to be used outside their country of manufacture, it is mandatory that manufacturers have received approval from the telecommunications authorities in each country. Moreover, it is not enough that the vendor has just any approval of a fax device in a specific country; it must have approvals for each separate model of fax device for each separate country.

Vendor support: How well can the vendor provide pre- and post-installation support? How effective is the documentation? Can the fax board vendor work closely with your software supplier and other players, like systems integrators?

In the end, the role that intelligent fax boards must fulfill for buyers is to enable the development of flexible and powerful fax applications and, once implemented, to support the fax calling process cost-effectively, reliably, and transparently.

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