

# Fax

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**Fax** (short for **facsimile**), sometimes called **telecopying** or **telefax**, is the telephonic transmission of scanned printed material (both text and images), normally to a telephone number connected to a printer or other output device. The original document is scanned with a **fax machine** (or a **telecopier**), which processes the contents (text or images) as a single fixed graphic image, converting it into a bitmap, and then transmitting it through the telephone system in the form of audio-frequency tones. The receiving fax machine interprets the tones and reconstructs the image, printing a paper copy.<sup>[1]</sup> Early systems used direct conversions of image darkness to audio tone in a continuous or analog manner. Since the 1980s, most machines modulate the transmitted audio frequencies using a digital representation of the page which is compressed to quickly transmit areas which are all-white or all-black.



A fax machine from the late 1990s

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E-Watch, Inc.  
Exh. 2013

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## Fax in the 21st century

Although businesses usually maintain some kind of fax capability, the technology has faced increasing competition from Internet-based alternatives. In some countries, because electronic signatures on contracts are not yet recognized by law, while faxed contracts with copies of signatures are, fax machines enjoy continuing support in business.<sup>[2]</sup> In Japan, faxes are still used extensively for cultural and graphemic reasons and are available for sending to both domestic and international recipients from over 81% of all convenience stores nationwide. Convenience-store fax machines commonly print the slightly re-sized content of the sent fax in the electronic confirmation-slip, in A4 paper size.<sup>[3][4][5]</sup>

In many corporate environments, freestanding fax machines have been replaced by fax servers and other computerized systems capable of receiving and storing incoming faxes electronically, and then routing them to users on paper or via an email (which may be secured). Such systems have the advantage of reducing costs by eliminating unnecessary printouts and reducing the number of inbound analog phone lines needed by an office.

The once ubiquitous fax machine has also begun to disappear from the small office and home office environments. Remotely hosted fax-server services are widely available from VoIP and e-mail providers allowing users to send and receive faxes using their existing e-mail accounts without the need for any hardware or dedicated fax lines. Personal computers have also long been able to handle incoming and outgoing faxes using analogue modems or ISDN, eliminating the need for a stand-alone fax machine. These solutions are often ideally suited for users who only very occasionally need to use fax services.

## History

### Wire transmission

Scottish inventor Alexander Bain worked on chemical mechanical fax type devices and in 1846 was able to reproduce graphic signs in laboratory experiments. He received patent 9745 on May 27, 1843 for his "Electric Printing Telegraph."<sup>[6]</sup> Frederick Bakewell made several improvements on Bain's design and demonstrated a telefax machine. The Pantelegraph was invented by the Italian physicist Giovanni Caselli. He introduced the first commercial telefax service between Paris and Lyon in 1865, some 11 years before the invention of telephones.<sup>[7][8]</sup>

In 1881, English inventor Shelford Bidwell constructed the *scanning phototelegraph* that was the first telefax machine to scan any two-dimensional original, not requiring manual plotting or drawing. Around 1900, German physicist Arthur Korn invented the *Bildtelegraph*, widespread in continental Europe

especially, since a widely noticed transmission of a wanted-person photograph from Paris to London in 1908, used until the wider distribution of the radiofax. Its main competitors were the *Bélinographe* by Édouard Belin first, then since the 1930s the *Hellschreiber*, invented in 1929 by German inventor Rudolf Hell, a pioneer in mechanical image scanning and transmission.

The 1888 invention of the telautograph by Elisha Grey marked a further development in fax technology, allowing users to send signatures over long distances, thus allowing the verification of identification or ownership over long distances.<sup>[9]</sup>

On May 19, 1924, scientists of the AT&T Corporation "by a new process of transmitting pictures by electricity" sent 15 photographs by telephone from Cleveland to New York City, such photos suitable for newspaper reproduction. Previously, photographs had been sent over the radio using this process.<sup>[10]</sup>

## **Wireless transmission**

As a designer for the Radio Corporation of America (RCA), in 1924, Richard H. Ranger invented the wireless photoradiogram, or transoceanic radio facsimile, the forerunner of today's "fax" machines. A photograph of President Calvin Coolidge sent from New York to London on November 29, 1924 became the first photo picture reproduced by transoceanic radio facsimile. Commercial use of Ranger's product began two years later. Radio fax is still in common use today for transmitting weather charts and information to ships at sea. Also in 1924, Herbert E. Ives of AT&T Corporation transmitted and reconstructed the first color facsimile, using color separations. Around 1952 or so, Finch Facsimile, a highly developed machine, was described in detail in a book; it was never manufactured in quantity.

In the 1960s, the United States Army transmitted the first photograph via satellite facsimile to Puerto Rico from the Deal Test Site using the Courier satellite.

## **Telephone transmission**

In 1964, Xerox Corporation introduced (and patented) what many consider to be the first commercialized version of the modern fax machine, under the name (LDX) or Long Distance Xerography. This model was superseded two years later with a unit that would truly set the standard for fax machines for years to come. Up until this point facsimile machines were very expensive and hard to operate. In 1966, Xerox released the Magnafax Telecopier, a smaller, 46-pound facsimile machine. This unit was far easier to operate and could be connected to any standard telephone line. This machine was capable of transmitting a letter-sized document in about six minutes. The first sub-minute, digital fax machine was developed by Dacom, which built on digital data compression technology originally developed at Lockheed for satellite communication.<sup>[11][12]</sup>

By the late 1970s, many companies around the world (especially Japan), entered the fax market. Very shortly after a new wave of more compact, faster and efficient fax machines would hit the market. Xerox continued to refine the fax machine for years after their ground-breaking first machine. In later years it would be combined with copier equipment to create the hybrid machines we have today that copy, scan and fax. Some of the lesser known capabilities of the Xerox fax technologies included their Ethernet enabled Fax Services on their 8000 workstations in the early 1980s.

Prior to the introduction of the ubiquitous fax machine, one of the first being the Exxon Qwip<sup>[13]</sup> in the mid-1970s, facsimile machines worked by optical scanning of a document or drawing spinning on a drum. The reflected light, varying in intensity according to the light and dark areas of the document, was focused on a photocell so that the current in a circuit varied with the amount of light. This current was used to control a tone generator (a modulator), the current determining the frequency of the tone produced. This audio tone was then transmitted using an acoustic coupler (a speaker, in this case) attached to the microphone of a common telephone handset. At the receiving end, a handset's speaker was attached to an acoustic coupler (a microphone), and a demodulator converted the varying tone into a variable current that controlled the mechanical movement of a pen or pencil to reproduce the image on a blank sheet of paper on an identical drum rotating at the same rate.

## Computer facsimile interface

In 1985, Dr. Hank Magnuski, founder of GammaLink, produced the first computer fax board, called GammaFax.

## Capabilities

There are several indicators of fax capabilities: Group, class, data transmission rate, and conformance with ITU-T (formerly CCITT) recommendations.

Fax machines utilize standard PSTN lines and telephone numbers.

### Group

#### Analog

Group 1 and 2 faxes are sent in the same manner as a frame of analog television, with each scanned line transmitted as a continuous analog signal. Horizontal resolution depended upon the quality of the scanner, transmission line, and the printer. Analog fax machines are obsolete and no longer manufactured. ITU-T Recommendations T.2 and T.3 were withdrawn as obsolete in July 1996.

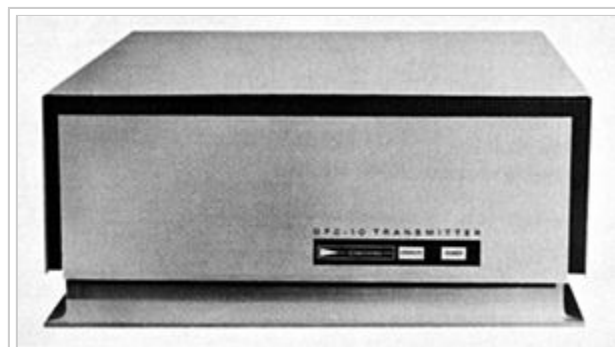
- Group 1 faxes conform to the ITU-T Recommendation T.2. Group 1 faxes take six minutes to transmit a single page, with a vertical resolution of 96 scan lines per inch. Group 1 fax machines are obsolete and no longer manufactured.
- Group 2 faxes conform to the ITU-T Recommendations T.30 and T.3. Group 2 faxes take three minutes to transmit a single page, with a vertical resolution of 96 scan lines per inch. Group 2 fax machines are almost obsolete, and are no longer manufactured. Group 2 fax machines can interoperate with Group 3 fax machines.

#### Digital

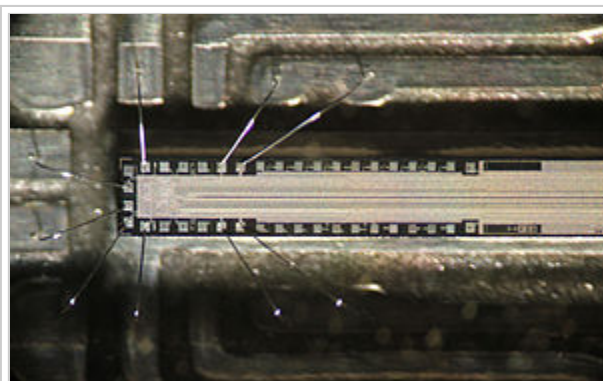
A major breakthrough in the development of the modern facsimile system was the result of digital technology, where the analog signal from scanners was digitized and then compressed, resulting in the ability to transmit high rates of data across standard phone lines. The first digital fax machine was the Dacom Rapidfax first sold in late 1960s, which incorporated digital data compression technology developed by Lockheed for transmission of images from satellites.<sup>[11][12]</sup>

Group 3 and 4 faxes are digital formats, and take advantage of digital compression methods to greatly reduce transmission times.

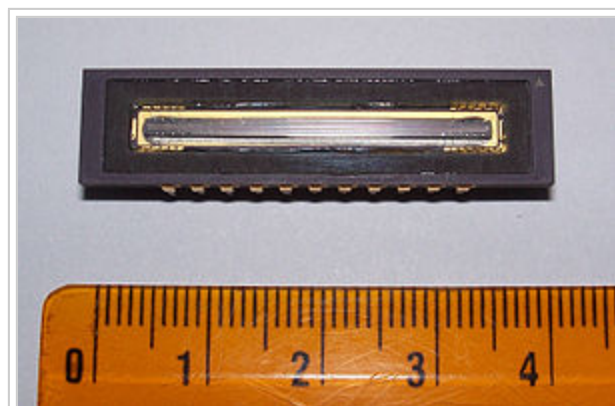
- Group 3 faxes conform to the ITU-T Recommendations T.30 and T.4. Group 3 faxes take between six and fifteen seconds to transmit a single page (not including the initial time for the fax machines to handshake and synchronize). The horizontal and vertical resolutions are allowed by the T.4 standard to vary among a set of fixed resolutions:
  - Horizontal: 100 scan lines per inch
    - Vertical: 100 scan lines per inch ("Basic")
  - Horizontal: 200 or 204 scan lines per inch
    - Vertical: 100 or 98 scan lines per inch ("Standard")
    - Vertical: 200 or 196 scan lines per inch ("Fine")
    - Vertical: 400 or 391 (note not 392) scan lines per inch ("Superfine")
  - Horizontal: 300 scan lines per inch
    - Vertical: 300 scan lines per inch
  - Horizontal: 400 or 408 scan lines per inch
    - Vertical: 400 or 391 scan lines per inch ("Ultrafine")
- Group 4 faxes conform to the ITU-T Recommendations T.563, T.503, T.521, T.6, T.62, T.70, T.411 to T.417. They are designed to operate over 64 kbit/s digital ISDN circuits. The allowed resolutions, a superset of those in the T.4 recommendation, are specified in the T.6 recommendation.<sup>[14]</sup>



The Dacom DFC-10—the first digital fax machine.  
[11]



The chip in a fax machine. Only about one quarter of the length is shown. The thin line in the middle consists of photosensitive pixels. The read-out circuit is at left.



CCD MN8051 Matsushita CCD side, monochrome 2048-bit linear sensor +cm (centimeters)



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