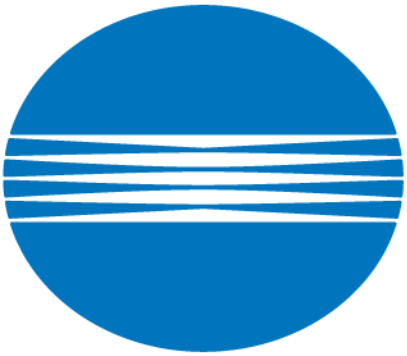


KONICA MINOLTA

Mplus

Digital copying – principle

II 4

Version 2.03

Contents

Module Training Overview

Participants

All employees and co-workers of Konica Minolta and our partners obtaining the M*plus* certification level:

Certified Maintenance Engineer

Course Target

At the end of this chapter you will have a better understanding of

- the working method of digital copiers,
- the basic technologies that facilitate digital copying,
- the basic differences between analogue and digital copiers,
- the basic parts of digital copiers,
- the basic process steps of digital copying.

This module is based on the module *Analogue copying – principles* (II 3), which is also a basis for the certification level *Certified Maintenance Engineer*. While the module *Analogue copying – principles* treats all aspects of analogue copying, this module focuses on aspects in which digital copiers differ from analogue copiers. If you are searching for information on e. g. PC drum cleaning or fusing, take a look at the module *Analogue copying – principles.*

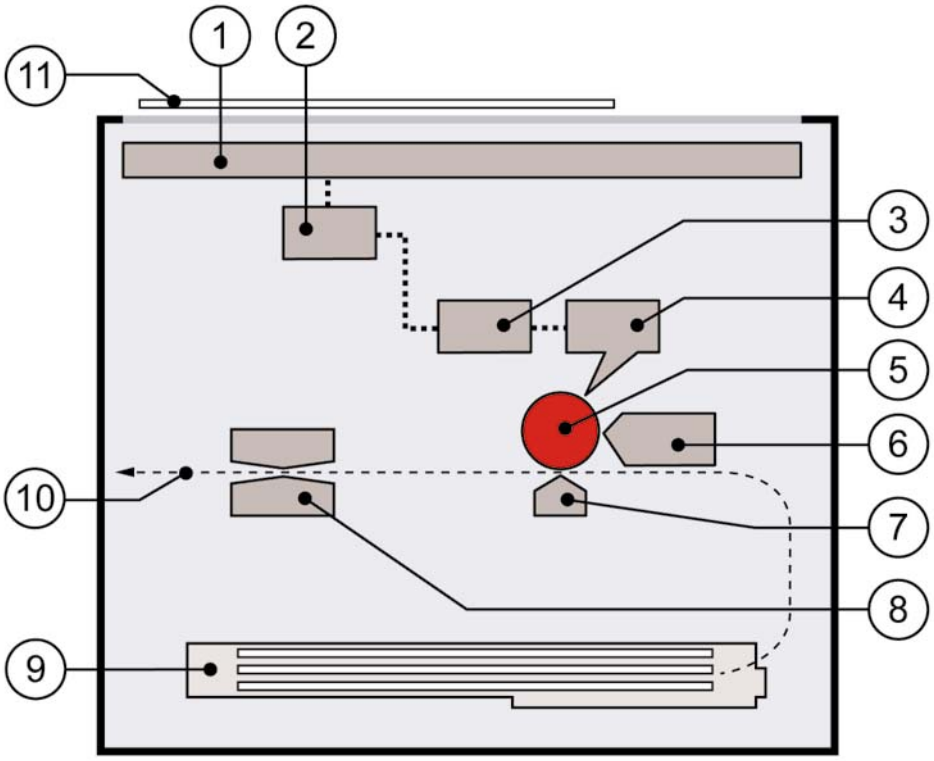
Note

At the end of each chapter you will find a section with review questions to help you to repeat and to learn the chapter's content. If you print out this document you can use the space after each question to write down your answers.

In the chapter "Review questions" at the end of this document all review questions are listed to help you to repeat the entire module.

1 The digital copying principle

1.1 The basic parts of a digital copier



1. The **scanning unit** scans the original and generates electrical signals representing the scanned original.
2. The **IR unit** converts the electrical signals provided by the scanner into digital data.
3. The **system control unit** uses the digital data provided by the IR unit to control the Laser.
4. The **Laser** exposes the photo conductor drum and thus generates an image on the drum surface corresponding to the digital data.
5. The **photo conductor drum** (PC drum) is the central element of the copier's printer part. Its specially coated surface is able to represent the original's image that is to be printed and to attract more or less toner depending on the represented image that is to be printed.
6. The **developing unit** prepares the toner and transports it near the PC drum's surface so that the surface can take over the toner.
7. The **transfer corona** transfers the toner from the PC drum's surface onto the copy paper.
8. The **fusing unit** fixes the toner on the paper surface.
9. The **cassettes** contain the copy paper.
10. The way the copy paper takes along the copier's elements.
11. The **original**.

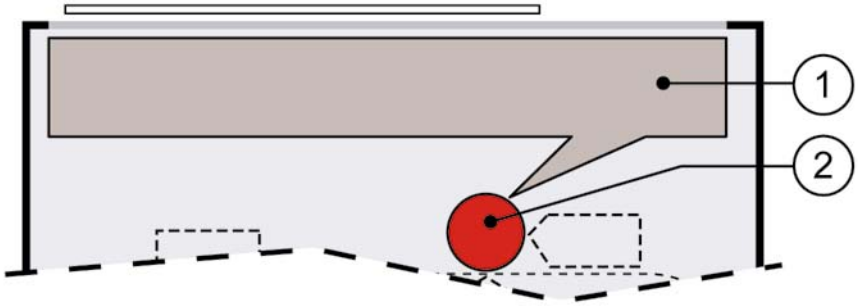
1.2 The basic differences between analogue and digital copiers

analogue copier

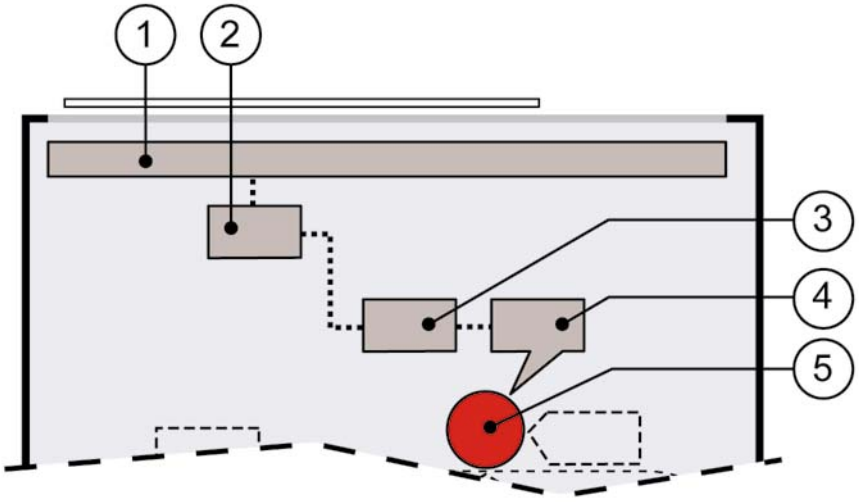
The analogue copier's exposure unit (A, 1) performs two tasks of the copying process simultaneously: The scanning of the original and the writing of the original's image onto the PC drum (A, 2).

copying as one indivisible step

The analogue copier is not able to perform these tasks divided from each other. The exposure lamp's light is reflected by the original and passed on by mirrors and lenses directly onto the PC drum in order to write the image onto the PC drum's surface. Scanning the original, exposing the PC drum and then printing the copy is a process that can't be interrupted and pursued afterwards, it has to be performed as one indivisible step.



Picture A: Analogue copier



Picture B: Digital copier

digital copier

dividing of scanning and exposure

The working method of a digital copier allows the dividing of scanning the original and exposing the PC drum.

The light reflected by the original is not lit directly onto the PC drum's surface, but is measured by a sensor and converted into digital data. Scanning the original and measuring the reflected light is done by the scanning unit (B, 1). The scanning unit contains a CCD (charge coupled device) that measures the light intensity of the light reflected by the original. The CCD generates electrical signals of different strength corresponding to the brightness of the reflected light. The IR

unit (B, 2) contains an A/D converter (analogue to digital converter) that converts the electrical signals into digital data.

The digital data is transferred to the system control unit (B, 3) where it is stored. To print the copy, the system control unit controls a Laser (B, 4) by using the data, and the Laser finally writes the image onto the PC drum (B, 5).

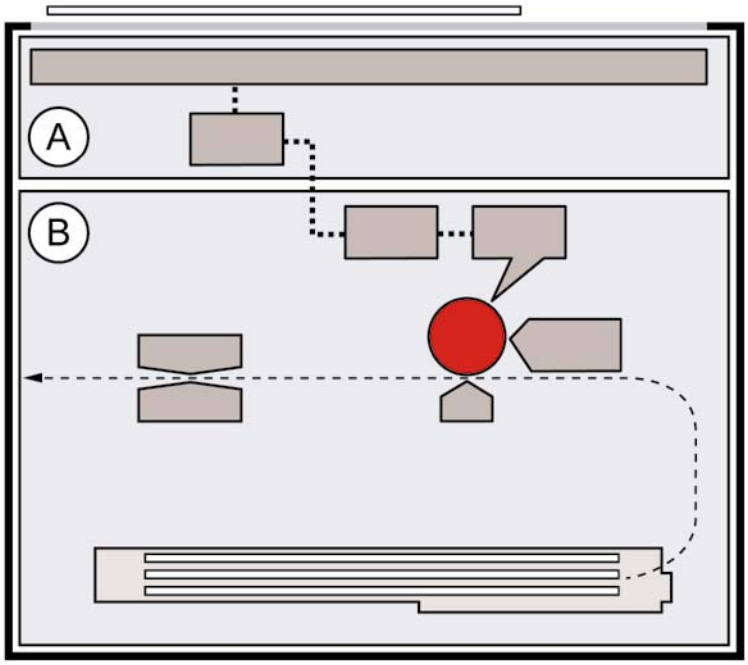
Because a digital copier stores the original's image in the form of digital data, the copying process can be interrupted without losing the original's image information.

digital copier as combination of scanner and printer

By dividing the copy process into a scanning process and a printing process, the digital copier appears to be a combination of a scanner and a printer. The scanning unit and the IR unit are here referred to as the input part of the copier (C, A), and the system control unit, the Laser, the PC drum and the rest of the copier including developing, fusing and paper exit are referred to as the output part of the copier (C, B).

Note

With the digital copier, the term *exposure* refers to the Laser exposure of the PC Drum. The so-called *exposure lamp* is not related to the exposure of the drum; the exposure lamp illuminates the original in the scanning process. The term exposure lamp refers to analogue copying technique where the light of the exposure lamp is actually led onto the PC Drum to expose the drum surface.



Picture C: Digital copier, input part and output part

Both input part and output part of a copier may be realized as two stand-alone devices, a scanner and a printer connected by a data line. Also the working method of digital copiers may be used to distribute the printing of one voluminous copy job to several other copiers by distributing the data across data lines.

1.3 A brief introduction to digital image processing

pixels

Images that can be handled by a computer do have a certain shape. A digital image consists of a number of basic elements – the so-called pixels. By definition, the pixel is the “smallest picture element”. These units are indivisible and discrete. The term “pixel” derives from the words “picture” and “element” with the term “picture” shortened to “pix”.

position, colour

Each pixel does have a certain position inside the image and a certain colour. The position and the colour of each pixel is described by a code, e. g. numbers, that represent the position of the pixel within the digital image in terms of a coordinate system.

If you look at a digital image, e.g. on the screen of a computer, all the pixels together create the illusion of an image. If you magnify the image sufficiently, the illusion of the picture vanishes and you will recognize the single pixels.

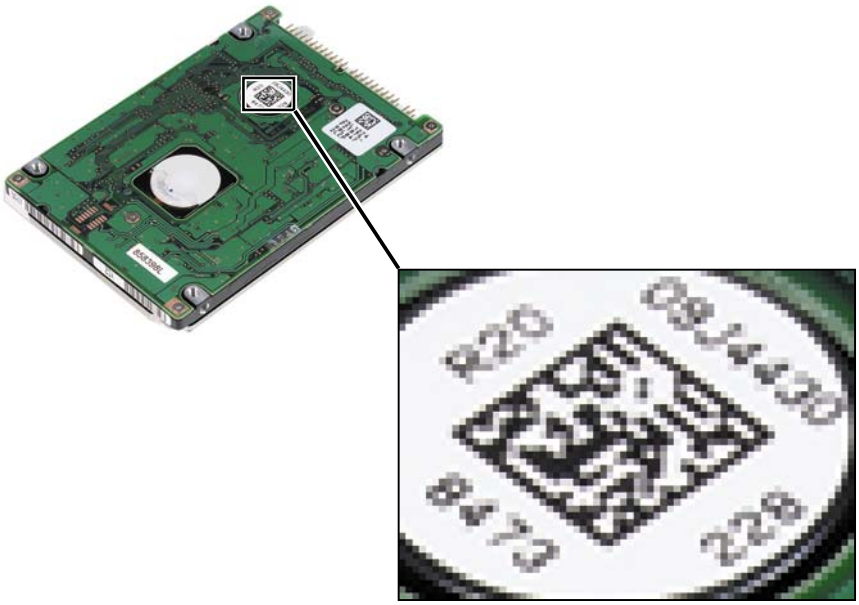


image processing

When a digital image is manipulated by image processing, actually the code attached to the pixels is manipulated. By changing the code attached to the pixels the image as a whole is changed.

digital code

If you create a new digital image with your computer, the computer automatically generates the digital code describing your image. If an image already exists, e.g. as a photography or a painting, and you want to utilize it in digital form, at first the digital code describing the image has to be generated. For example, this is done by the

scanning unit

scanning unit of a digital copier. An original is lit up and the reflected light is measured by a device and translated into the digital code.

The device is not able to recognize the image as a whole. It contains little elements and each element simply measures the light reflected by the section of the image being opposite to the element. The section of the original now exists in the form of a digital code as a pixel being part of the corresponding digital image. By this, the whole image is translated into digital code and utilized for digital image processing.

printer

If a digital image has to be printed, the code representing the image is used to control the printer. According to the code, the printer applies e.g. ink drops to a paper sheet. All the ink drops together on the paper sheet create again the illusion of an image.

1.4 Basics of the Laser working method

A Laser is an artificial light source. Laser is the abbreviation of **L**ight **a**mplification by **s**timulated **e**mission of **r**adiation.

To understand the working method of the Laser unit, some basic knowledge about the structure of atoms and the nature of light are useful. Read the M*plus* module "Colour – basics and principle" to get related information on that.

light emission

A material may emit light if energy is fed into the material, e.g. metal begins to glow when it is heated up sufficiently. The effect of light emission is a result of electrons getting into an excited state by the supply of energy and getting back into their base state by emitting energy in the form of light and photons respectively.

supply of energy

excited/base state

spontaneous/ induced emission

If a material is heated up and begins to glow, the electrons of the material's atoms get back from the excited state into the base state spontaneously and without external influence. This is called spontaneous emission. The Laser uses the so-called induced emission. A suited material, e.g. ruby or argon, is "heated up" so most of the electrons are in an excited state. If now a photon is sent into the material, e. g. by a conventional light source like a flash light, and hits an electron being in an excited state, the electron gets back into the base state and emits an additional photon. The photon emitted by the electron has the same direction, frequency and wavelength like the photon being sent into the material. The photon being sent in is the stimulation or induction. It is amplified by the additional photon being emitted by the electron.

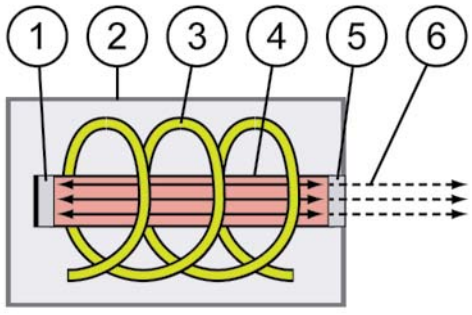
opposite mirrors

permanent light wave

The material is mounted between opposite mirrors. The mirrors reflect the emitted photons back into the material and a permanent light wave that provides the continuing emission of photons is generated inside the material. One of the mirrors is permeable (if the photons pass the mirror in a certain angle) and reflects only the most part of the photons, so that a part of them passes that mirror. This is the Laser beam, which is sent out by the Laser.

Laser beam

1. Mirror
2. Mirrored housing
3. Flash light
4. Laser material (e.g. ruby crystal)
5. Semi-permeable mirror
6. Laser beam



The Laser beam has a high energy because its photons all have the same direction and wavelength, and the beam can be controlled exactly because of the external stimulation by the photons sent into the material.

The Laser used in today's laser printers and digital copiers are based on semiconductor technology. These Laser diodes don't consist of

the components described above but are manufactured as integrated circuits at small dimensions.

1.5 Summary

In contrast to analogue copiers, which project the light reflected from the original directly onto the PC drum (with the help of the exposure unit's mirrors and lens), the digital copier converts this light into digital image data (with the help of a CCD sensor and an A/D converter). The digital image data is stored and then used to control a Laser that actually exposes the PC drum. Thus, the copy process can be divided into a scanning process and a printing process, and the copier may be divided into an input part (scanner) and an output part (Laser printer).

The digital image data generated by scanning the original describes the image in the form of pixels. A digital image is built up from a matrix of pixels, each with a defined position inside the image and with a particular colour. All the image's pixels together create the illusion of the image as a whole. The image's pixels are generated according to the output of the CCD sensor. The CCD consists of little light-sensitive elements and each element only measures the light reflected of a small area of the original. This area then is represented by a pixel of the corresponding digital image. The digital image data can be manipulated by digital image processing and then be used to control the printer, which applies ink dots/ toner particles to the paper accordingly.

Laser beams – as they are used for the exposure of the PC drum – are light waves that all have the same direction, frequency, and wavelength and thus have a high energy. They are generated with the help of special material like ruby or argon, and their generation is based on effects that occur if energy is fed into the material and electrons of that material jump to higher energy levels and back again. Laser used in today's Laser printers are realised as small integrated circuits based on semiconductor technology.

1.6 Review questions

- Describe the basic differences between analogue and digital copiers!

- Why is a digital copier separable into a scanner and a printer?

- What makes up a digital image?

2 The enhanced possibilities of digital copiers

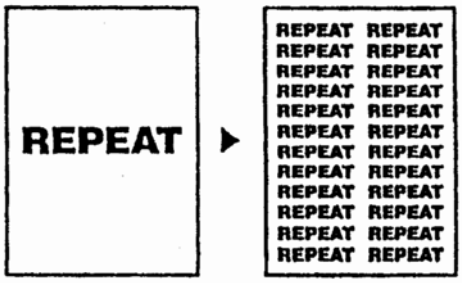
By making a detour along generating and storing digital data corresponding to the original first and then controlling a Laser by this data to expose the PC drum, a variety of creative possibilities and enhanced copier functions is presented.

2.1 Creative possibilities

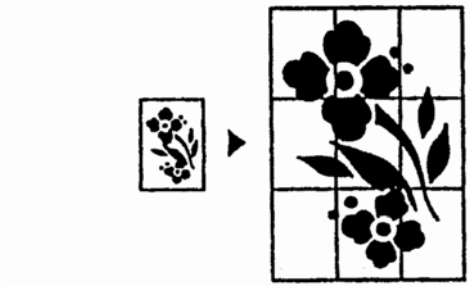
Once the image data is generated, it may be manipulated in order to alter the original's image, so the copy does not have to show an exact reproduction or a limited magnification or reduction.

Here are some examples a digital copier may offer for manipulating an original's image:

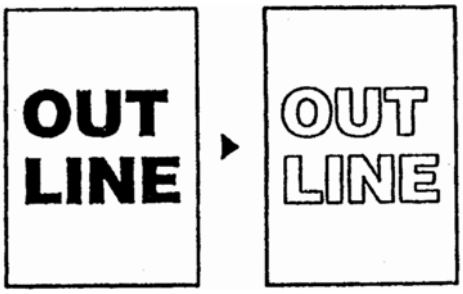
- Image repetition:
  The original's image is shown repeated on the copy.



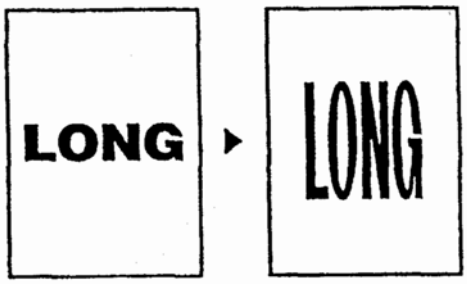
- Multiple zoom:
  The original's image may be enlarged by several factors.



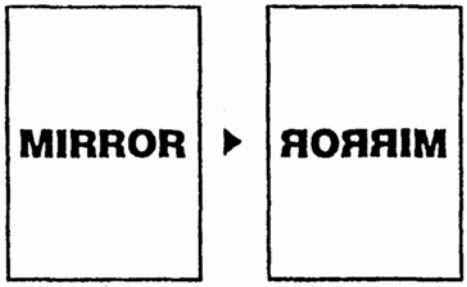
- Outline:
  Only the outlines of the original's image appear on the copy.



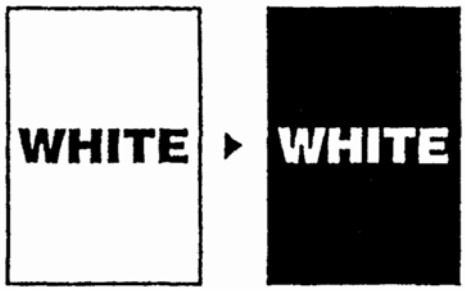
- X/Y zoom: The original's image is distorted vertically or horizontally.



- Mirror image: The original's image is mirrored.



- Inverted image: For example, black and white areas of the original's image are inverted into white and black areas on the copy.



2.2 Additional functions

Beside the creative possibilities of digital copiers to manipulate the original's image itself, there are several additional functions in comparison with an analogue copier:

scanning one time printing repeated

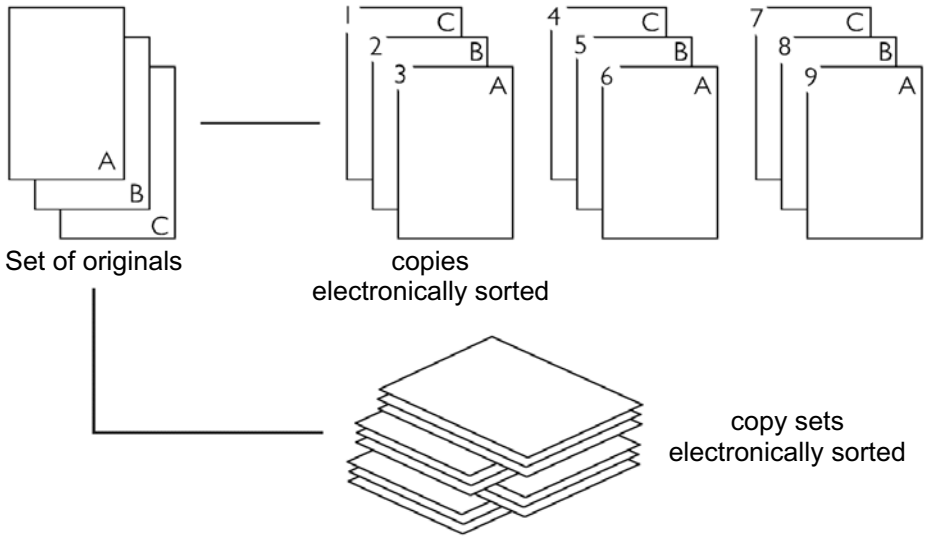
- If the copier's storage space that takes up the data of the original's image is large enough, a complete set of several pages can be scanned and copied/printed several times afterwards. If you want to copy ten pages, for example, the digital copier scans all the ten pages within a single run, stores the data of all ten pages and then prints the set of ten copies as often as you want to. Because all the original's image data is stored by the copier after one scanning run, the originals don't have to be scanned for a second or more times to get more than one set of copies.

electronically sorting

- Each set of copies can easily be sorted electronically, so the copies of a set are sorted in the same sequence as the originals, even if the set of originals is retracted in the reverse sequence.

sorted exit of copy sets

- If a digital copier is equipped with paper cassettes that take up copy paper sheets both in vertical and in horizontal format, sets of copies can be given out sorted without using a sorter. The copy sets are given out vertically and horizontally by turns, so the sets inside the copy stack can be divided easily from each other.



2.3 Summary

The working method of digital copiers allows the manipulation of a scanned image before it is printed. Using the digital image data generated by scanning the original, the image e.g. can be zoomed or distorted and image elements can be reduced to their outlines or can be inverted.

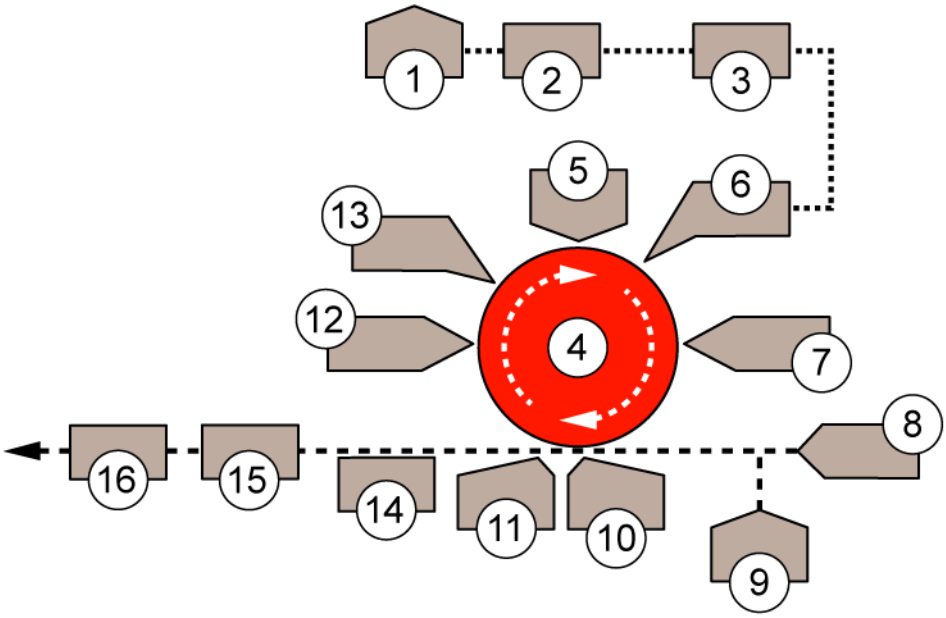
Beside these creative possibilities, digital copiers may offer addition functions compared to analogue copiers, such as scanning one time and printing repeatedly and electronically sorted copies and copy sets.

2.4 Review questions

- Name the creative possibilities of digital copiers!

- What benefits do digital copiers offer compared with analogue copiers?

3 The steps of the digital copying process – overview



3.1 Scanning (1)

The exposure lamp lights up the original and the light reflected by the original's surface is led onto the CCD that measures the light intensity. The different light intensities are converted into electrical signals of different strength.

3.2 Image processing of the IR unit (2)

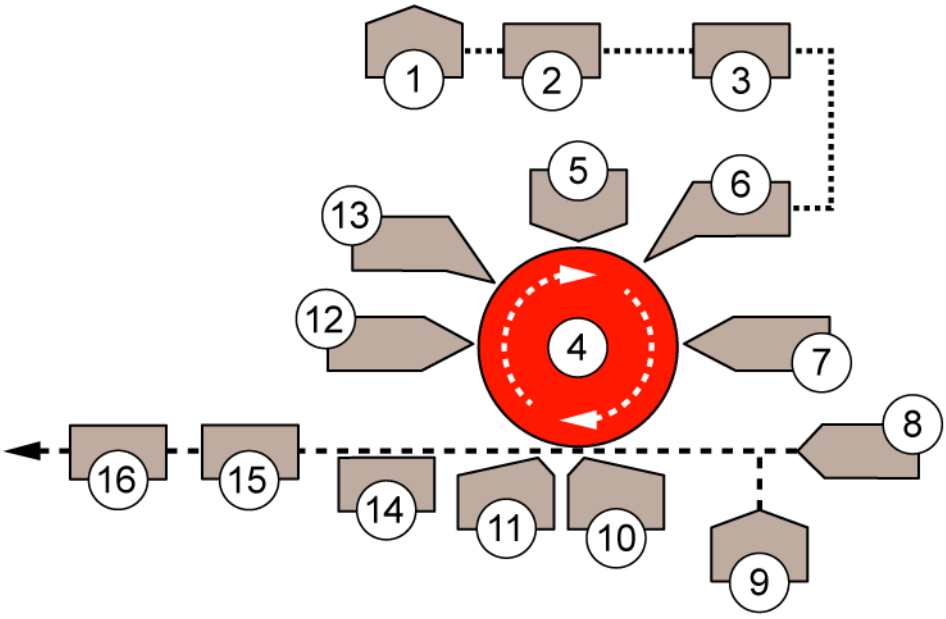
The IR unit converts the electrical signals provided by the sensor into digital data. Then, by several different procedures, the digital data is corrected and optimised, e.g. to correct irregularities of the exposure lamp or the sensor. Afterwards, the data is transferred to the system control unit.

3.3 Image processing of the system control unit (3)

The system control unit receives the data from the IR unit and compresses and stores the data. By compressing the data the amount of data that can be stored is raised. Before the data is transferred to the print unit, the data is decompressed again.

3.4 The photo conductor drum (4)

The photo conductor drum (PC drum) consists of an aluminium cylinder coated with an organic, light sensitive semiconductor material. Such PC drums are called organic photo conductor drums (OPC drums).



3.5 Charging of the PC drum (5)

The charging unit charges the PC drum's surface evenly with a negative charge along the drum's width. The charging unit contains a charging corona providing an electrical field and a scorotron grating that distributes the charge evenly onto the drum surface.

3.6 Print unit and Laser exposure (6)

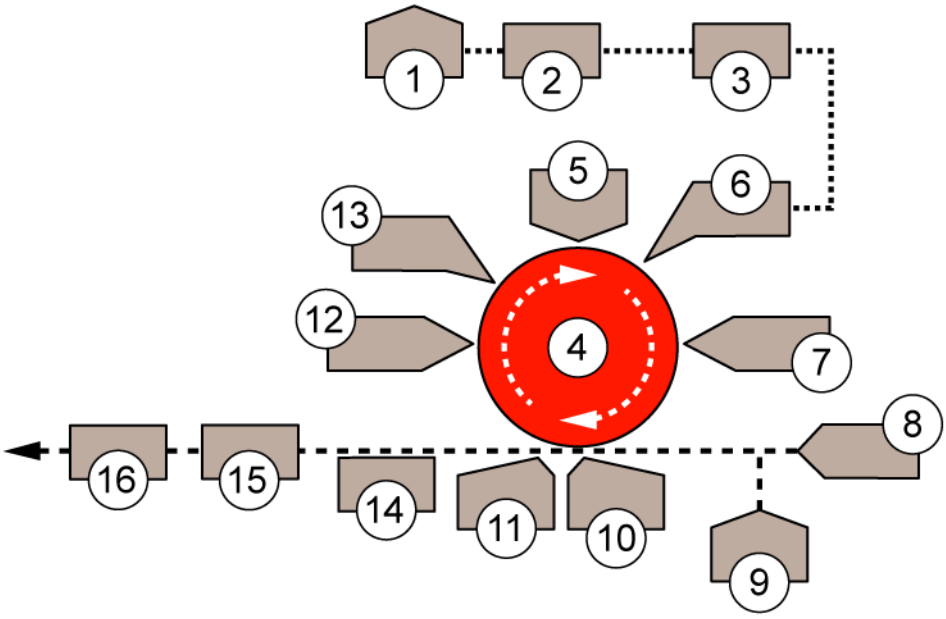
The print unit receives data from the system control unit and controls the Laser beam that is pointed at the PC drum. Previously the drum surface has been charged evenly. Now the drum surface is discharged by the Laser beam.

To reproduce the varying brightness of the original's image, the Laser does not vary the brightness of its beam but generates little spots onto the drum surface. To produce areas representing different brightnesses, the Laser spots are generated more or less compact on the drum surface.

By this, a latent copy of the original or its manipulated image is generated on the drum surface in the form of differently charged areas.

3.7 Development (7)

The toner in the developing unit is charged negatively. The sleeve roller of the developing unit brings the toner near to the drum surface. The negatively charged toner is pushed off the negatively charged sleeve roller attracted by the discharged areas of the drum surface. By this, a powder image corresponding to the original's image is generated on the drum surface.



3.8 Paper feed (8/9)

By paper feed rollers and transport rollers copy paper is fetched from the paper cassettes (9) or from the manual paper feed (8) and led along the PC drum.

3.9 Image transfer (10)

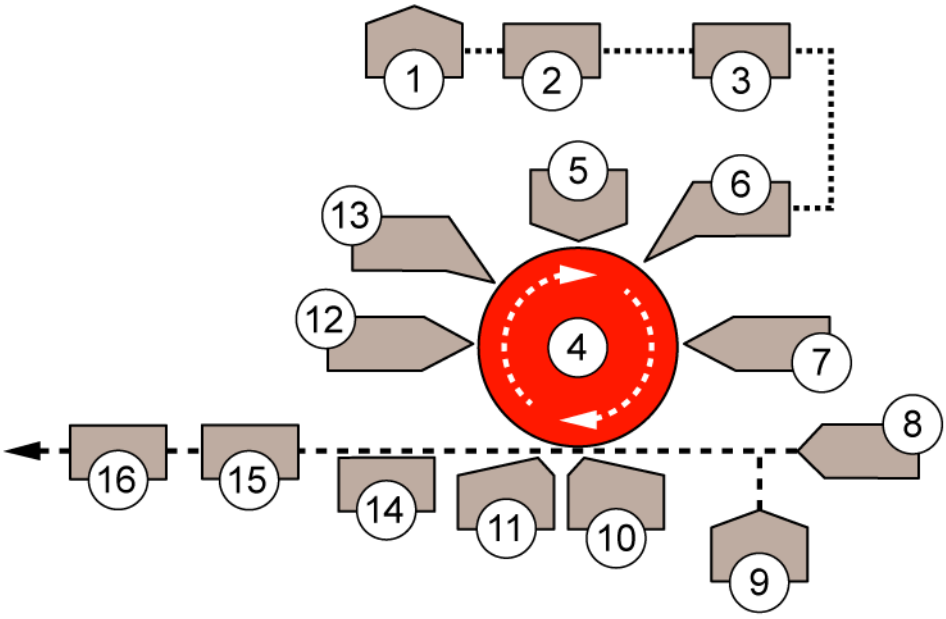
Underneath the copy paper a transfer corona provides an electrical field that charges the paper positively. The positive charge of the paper attracts the negatively charged toner and takes it over.

3.10 Paper separation (11)

Because the paper's and the drum's charge are different, the paper tends to stick to the drum. To prevent a paper jam, the paper's positive charge is neutralized by the electrical field of the separation corona, and additional mechanical separation fingers are put against the drum surface.

3.11 Drum cleaning (12)

The cleaning unit contains a lip that wipes remaining toner off the PC drum and a device that transports this toner into a collecting tank or back into the developing unit.



3.12 Main erasure (13)

To erase the latent copy (the differently charged areas on the drum surface) the drum surface is lit up by the main erasure lamp. The main erasure lamp consists of several special lamps or LEDs. By the light of the main erasure lamp the drum surface is discharged completely.

3.13 Paper transport (14)

A carriage belt leads the paper with the toner on it to the fusing unit.

3.14 Fusing (15)

The fusing rollers press the toner onto the paper and additional heat melts the toner simultaneously.

3.15 Paper exit (16)

Paper exit rollers lead the paper out of the copier. Alternatively, the paper may be led towards a sorter or towards a duplex unit.

3.16 Review questions

- What are the steps of the digital copying process?

4 Parts and process steps in detail

In this chapter, the parts of digital copiers and the process steps of digital copying that differ from analogue copiers and copying will be introduced to you.

While the analogue copier leads the light reflected by the original directly onto the PC drum, the digital copier takes several steps to measure the light, convert it into digital data, process the data and to control the Laser to expose the PC drum.

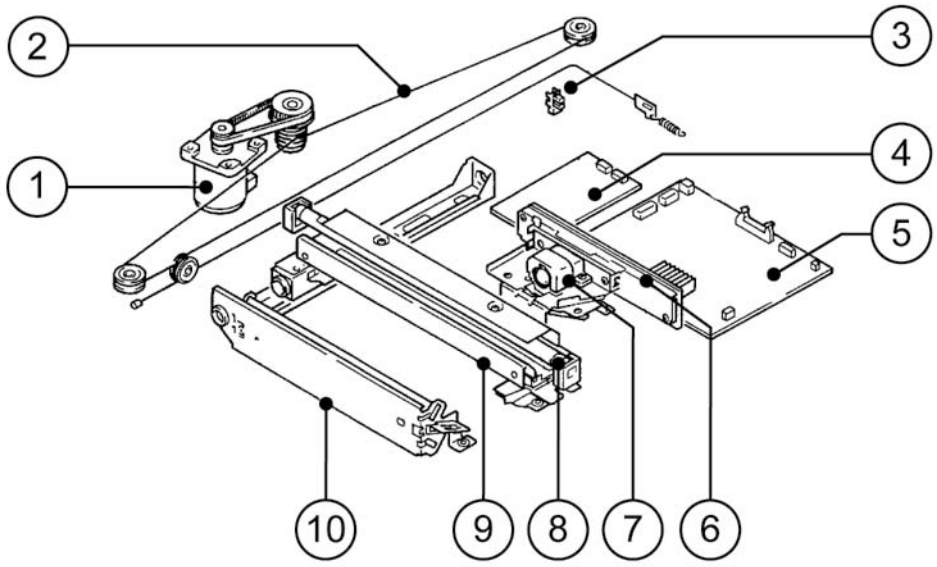
4.1 The IR unit

scanner hardware circuit boards

The IR unit consists of the scanner hardware and several circuit boards (also known as PWB: Printed Wiring Board) to control the hardware, like the scanner motor or the exposure lamp, and to generate and process the digital data.

The mechanical part of the IR unit is similar to an analogue copier's exposure unit with its mirrors and the lens, but the light is led onto the CCD.

CCD



1. Motor of the lamp carriage
2. Lamp carriage drive cable
3. Home position sensor
4. Exposure lamp inverter PWB
5. Digital image processing PWB
6. CCD board
7. Lens
8. Exposure lamp
9. Lamp carriage
10. Mirror carriage

To scan an original, the motor moves the lamp carriage with the exposure lamp along the original. The light reflected by the original is

led by the mirrors and through the lens onto the CCD. The CCD is mounted directly on the CCD board.

4.2 Generating the digital image data

CCD photoelectric elements

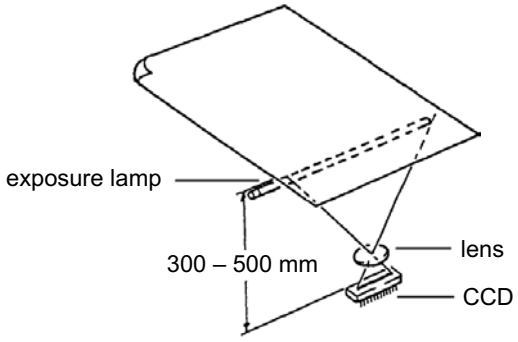
A/D converter

The CCD (charge coupled device) consists of lots of photoelectric elements. Each element converts the intensity of the incident light into a corresponding electrical charge. This electrical charge generates a voltage, and the voltage is converted into digital data by an A/D converter (analogue-to-digital converter), which is part of the analogue image processing PWB. The generated digital data is transferred to the digital image processing PWB.

There are two major types of scanners, the reduction type and the contact type, both using different optics and CCDs:

reduction type scanner

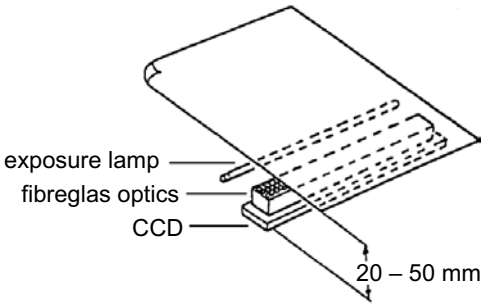
The reduction type scanner uses a CCD that is smaller than the width of the original. The light reflected by the original is focused by a lens onto the smaller width of the CCD. The way the light takes from the original to the CCD is between 300 mm and 500 mm long.



Picture A: Reduction type scanner

contact type scanner

The contact type scanner uses several CCDs that are arranged in a row in order to cover the whole width of the original. The light reflected by the original is led through fibreglas optics onto the multiple CCD. The way the light takes from the original to the CCD is 20 mm to 50 mm long. The contact type scanner can be fitted into a more compact housing.



Picture B: Contact type scanner

Reduction type scanners are more frequently used than contact type scanners. Today, contact type scanners are no longer used in Minolta copiers. The disadvantage of contact type scanners – e.g. used in the CF 70/80 - is, that several CCDs have to be combined to a multiple CCD. By using several CCDs, the contact type scanner is much more costly than the reduction type scanner. Besides the price of a multiple CCD, the single CCDs have to be synchronized with each other and the data that is delivered by each CCD has to be put together with the data of the other CCDs. (In former Minolta copiers,

this is done by the 5-channel-synthesis - a step of the IR unit's image processing. 5-channel-synthesis means, that five CCDs are combined and each CCD delivers its signals via a channel of its own to the following image processing.)

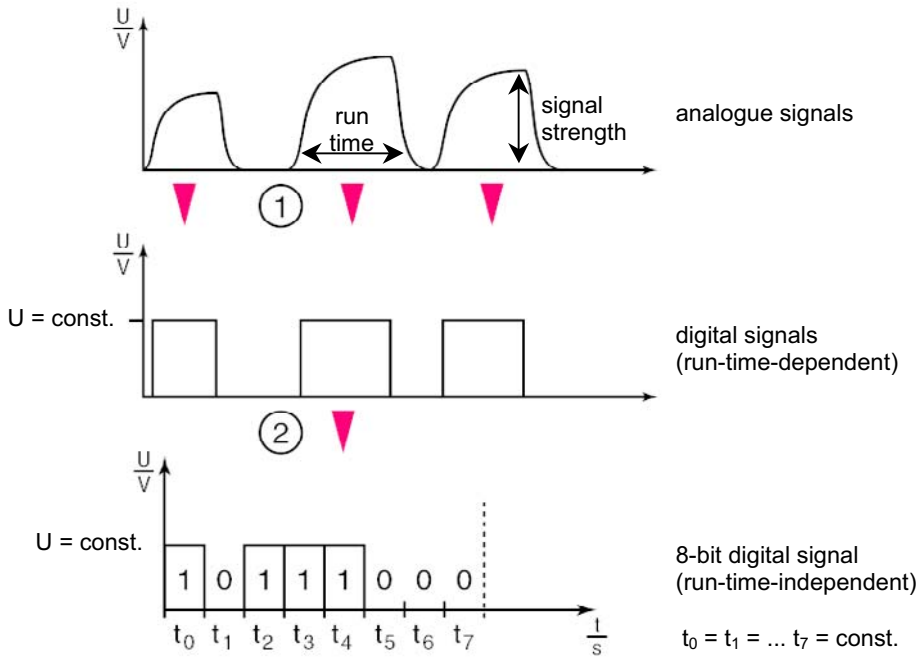
Although the mechanism of reduction type scanners with several moving parts (e.g. the lamp carriage and the mirror carriage) is more complex, a reduction type scanner is cheaper than a contact type scanner. Therefore Minolta copiers now exclusively use reduction type scanners.

A/D conversion

To actually win digital image data, the analogue voltage signals produced by the CCD have to be converted into digital data by an A/D converter.

Analogue signals depend on the signal's run time and – if the analogue signals e.g. are sent across a longer distance - they can be falsified by electrical attenuation. The digital signals, which are finally won by A/D conversion, do not depend on the run time. They can be handled as clearly defined quantities, which can be sent across long distances and especially can be stored and processed.

The A/D conversion consists of two basic steps. The initial analogue signals differ concerning their strength (voltage of the signal) and their run time (duration of the signal). First, the analogue signals are converted into run-time-dependent digital signals (C, 1). These digital signals all have the same strength (voltage), but they still differ concerning their run time. Second, the run-time-dependent digital signals are converted into digital signals with constant run time – these finally produced digital signals are run-time-independent (C, 2). Each run-time-independent digital signal can be seen as one of the two digital conditions "0" and "1".



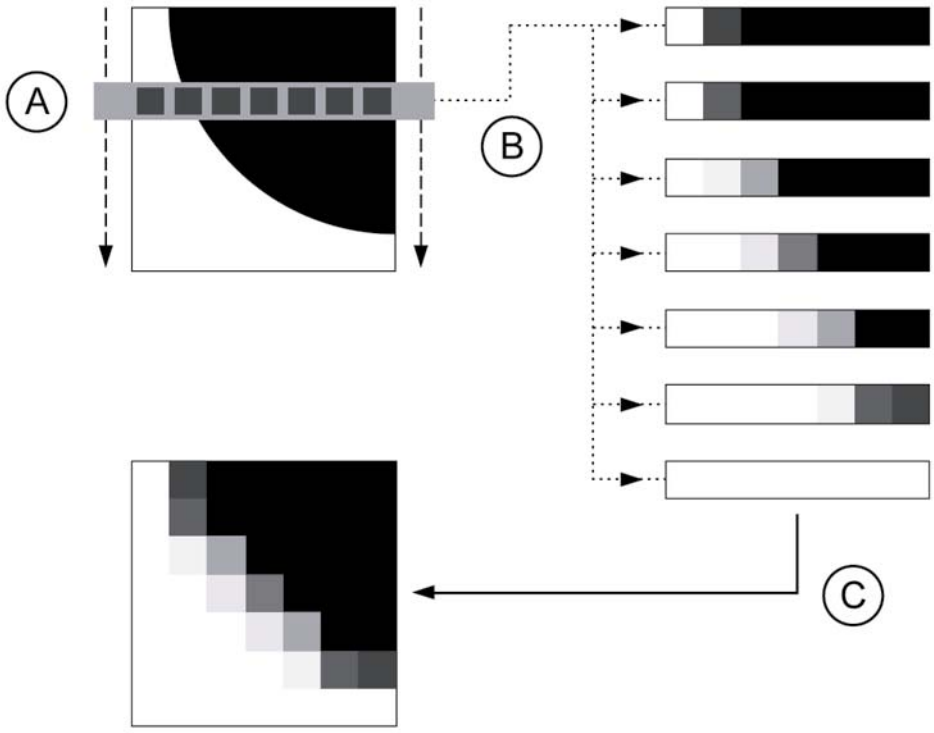
Picture C: A/D conversion, steps

Run-time-depending digital signals can be distinguished by the duration of the signal itself – the meaning of a certain signal is characterised by the duration of the signal. For example, a signal with a long run time represents “white”, a signal with a medium run time represents the “grey”, and a signal with a short run time represents “almost black”. One run-time-independent signal can represent only two conditions “0” and “1” – e.g. black and white. Therefore one run-time-dependent signal is converted into a number of run-time-independent signals.

The A/D conversion used by Minolta copiers converts one run-time-dependent signal into eight run-time-independent signals that belong together. This 8-bit value may represent 256 different conditions – e.g. 256 different halftones from white up to black. For example, a signal with a long run time representing the colour white may be converted into an 8-bit value “1111 1111” (= 255); a signal with a run time that is a little shorter and that represents the colour light grey may be converted into an 8-bit value “1111 0101” (= 245).

Whether run-time-dependent signals have to be converted into 8-bit digital values or e.g. 4-bit values or 16-bit values, depends on the required degree of accuracy. 4-bit values can only represent 16 different conditions or halftones respectively, 16-bit values allow the representation of up to 65536 different halftones. Because 256 different halftones are enough to generate smooth halftone transitions within an image, Minolta copiers work with 8-bit digital image data.

While scanning, the lamp carriage moves the exposure lamp step by step along the original and the reflected light is led onto the CCD by the mirrors and the lens (D, A). With each step, the CCD takes a "picture" of a line of the original. Each photoelectric element measures the light intensity of a single spot or pixel of the line. By this, the whole image is generated line by line, each line consisting of a row of pixels (D, B). When the image is printed, the single lines are put together again (D, C).



Picture D: The scanning of the original and the digital image

4.3 Processing of the digital image data

The processing of the digital image data mainly consists of different steps to correct and optimise the data. Here, the major steps of image data processing are introduced:

shading compensation

- The first step of image data processing is the shading compensation. The image data is a result of light that was emitted by the exposure lamp, reflected of the original and measured by the CCD. The exposure lamp and the CCD may not work perfectly, especially if they are used for a period. The exposure lamp may light up the original irregularly and the single photo elements of the CCD may differ concerning their sensitivity. By this, the image data is falsified compared to the original. The deviations are detected automatically. When a copying process is started, the exposure lamp is turned on and positioned under the shading sheet. The shading sheet is just a white sheet so normally all signals delivered by scanning should represent the colour white. The signals actually delivered by the scanning of the shading sheet are compared to the signals that are expected to represent the colour white. By comparing the actual signals to the expected signals, the deviation is detected and a correction factor is calculated. The shading compensation uses this correction factor to correct the image data generated by the actual signals.

A/D conversion

- The A/D converter generates the digital image data.

zoom factor

- If the user selects a zoom factor, the image data has to be manipulated according to the selected factor. The data generated through scanning represents the original in its actual scale. By manipulating this original data according to the selected zoom factor, data representing a reduction or a magnification of the original is generated.

MTF correction

- The MTF correction (**M**odulation **T**ransfer **F**unction) manipulates the data to control the sharpness of lines and characters and to smooth edges inside the image.

IR image correction

- If the user selects e.g. a darker or brighter copy, the IR image correction manipulates the image data according to the user´s selection.

8-bit/1-bit data conversion

- The digital image data was originally generated as 8-bit data. This means that each pixel e.g. represents one out of 256 possible greyscales between black and white. The 8-bit/1-bit data conversion converts 8-bit data into 1-bit data. After conversion, each pixel can represent one of two possible values only, black or white. To prevent that all the different greyscales contained by the image appear as black and white areas, the 8-bit/1-bit data conversion uses the raster method. Through the raster method an area is represented by a combination of black and white picture elements. For example, a dark grey area is not converted into an area of only black pixels but converted into an area of mainly black and a few white pixels, so that the area appears as a dark grey and not as a black one (the raster method is described in the M*plus*

module *Digital copying – technical realisation* (II 7, certification level ASE)).

memory

The processed data is sent to the copier's memory. To raise the amount of data that can be stored by the memory, the arriving data is compressed. Before the data is sent towards the printer unit, it is decompressed again:

input memory

- The data arriving step by step from processing first is stored in an input memory. The input memory is able to store an amount of data roughly corresponding to one DIN A3 page.

data compression

- Through a special circuit the data coming from the input memory is compressed.

coding memory

- The compressed data is transferred into the coding memory. The coding memory is able to store an amount of compressed data corresponding to 100 and more pages (depends on the actual storage capacity).

data decompression

- By a special circuit the compressed data coming from the coding memory is decompressed again.

output memory

- The decompressed data is transferred into the output memory. In the output memory, the data may be manipulated a last time according to user selections like turning of the image or shifting of the image.

Finally the data is sent to the printer unit.

4.4 Print unit and Laser exposure

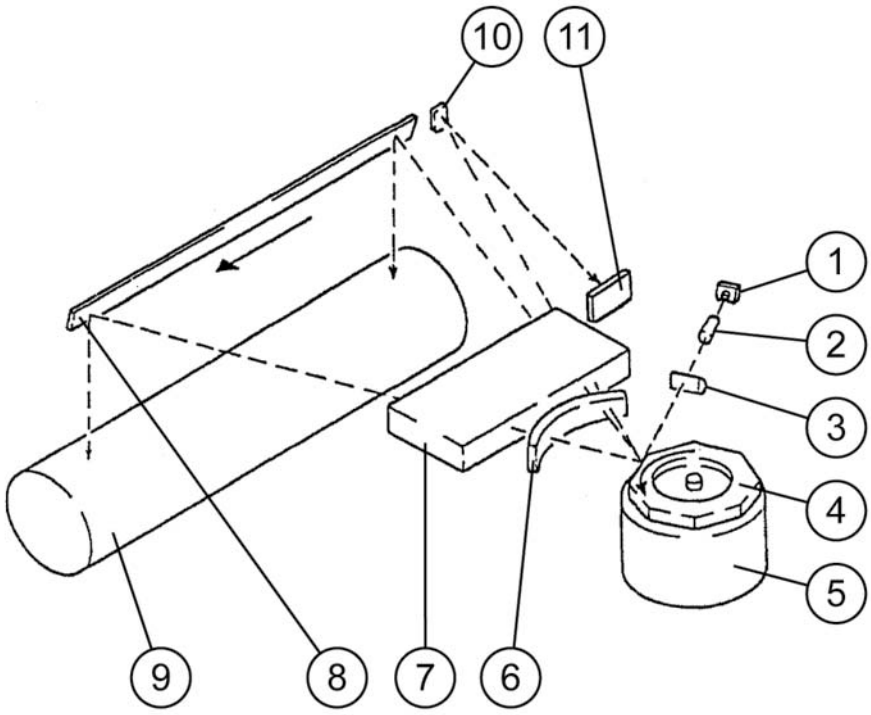
The photo conductor drums (PC drums) used by digital copiers are the same ones as in analogue copiers. Also the charging of the PC drum is the same as in analogue copiers. The surface of the PC drum, coated with the photo conductor material, is evenly negatively charged by a charging corona.

Laser

While analogue copiers lead the light reflected by the original directly onto the PC drum, digital copiers use the generated digital image data to control a laser. The laser beams controlled by the data erase the charge of drum surface and by this "draw" the latent image onto the drum surface.

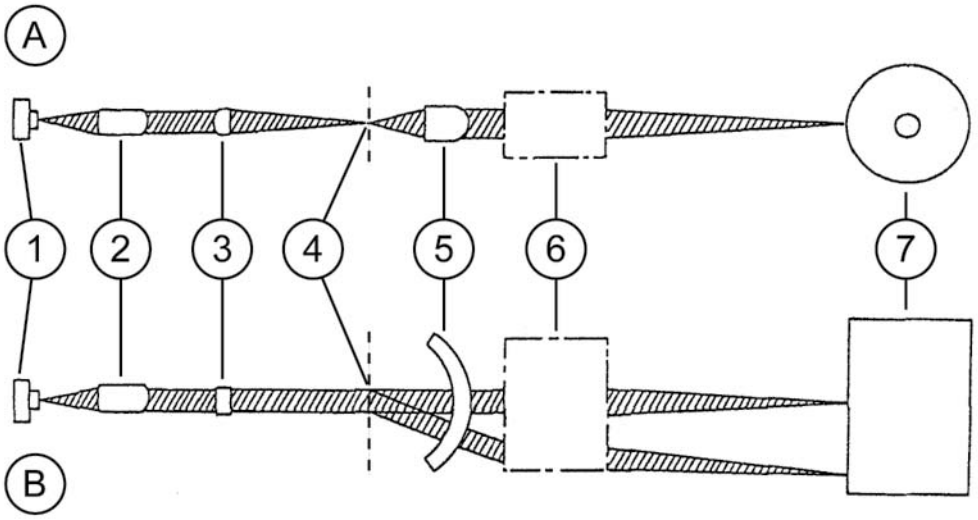
print unit

The print unit mainly consists of the laser diode and several optics and mirrors.



Picture A: Print unit, elements

1. Laser diode
2. Collimating lens
3. Cylindrical lens
4. Polygon mirror
5. Pology mirror motor
6. Toroide lens
7. f-theta lens
8. Mirror
9. PC drum
10. SOS mirror
11. SOS sensor



Picture B: Print unit, Laser beam (A: side view, B: view from above)

collimating lens

The light emitted by the laser diode (B, 1) first reaches the collimating lens. Because the laser beam is dispersed the collimating lens orientates the laser beams, so that all the laser beams are parallel to each other (B, 2).

cylindrical lens polygon mirror

A cylindrical lens (B, 3) focuses the laser beams onto the facets of the rotating polygon mirror (B, 4; indicated by the line).

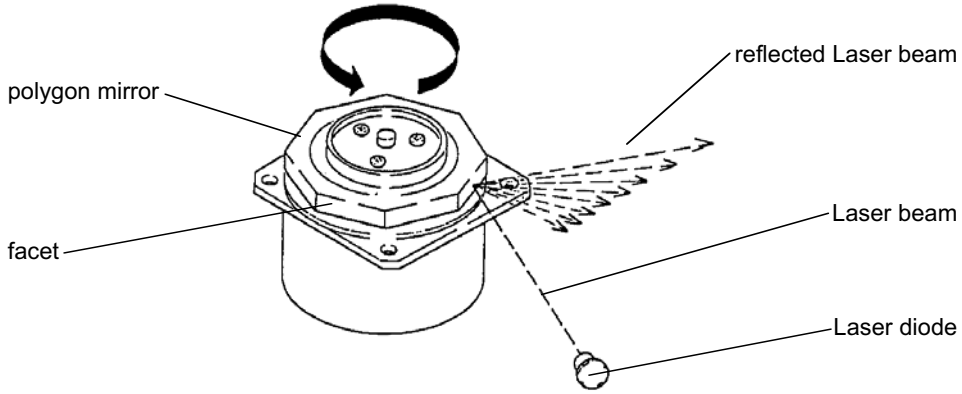
toroide lens

Behind the polygon mirror the light passes the toroide lens (B, 5). Because the laser beams are dispersed by the polygon mirror the toroide lens orientates the laser beams parallel again. Then the laser

f-theta lens

beams pass the f-theta lens (B, 6). The f-theta lens focuses the laser beam on the PC drum's surface (B, 7) and provides a regular movement of the laser beam across the PC drum's width.

The image on the drum surface is created line by line with the help of the rotating polygon mirror. The laser beam strikes a facet of the polygon mirror. Because the polygon mirror rotates, the reflected laser beam moves from one side to the other and creates a line of the latent image on the drum surface (C) in this way.

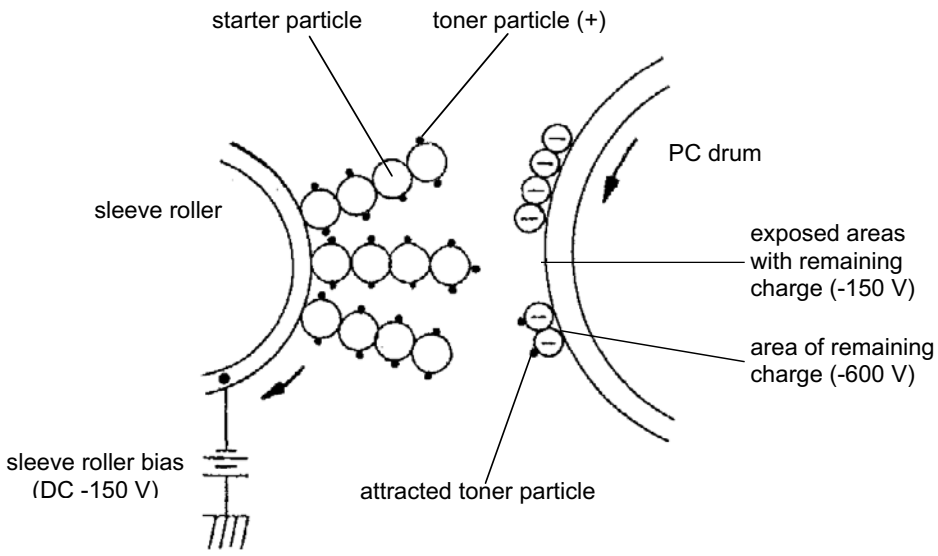


Picture C: Polygon Mirror

4.5 Developing

In addition to the exposure, also the digital copier's development differs from the analogue copier's development.

Remember: The analogue copier's toner is charged positively. The positively charged toner is attracted by the negatively charged areas of the PC drum's surface. The negative charge of areas where only less toner or no toner at all shall be attracted was reduced or completely erased through the exposure. Where no exposure took place the drum surface remains more negative than the sleeve roller. The low bias of the sleeve roller (-150 V) prevents that toner particles are attracted by exposed areas with a remaining charge (A).



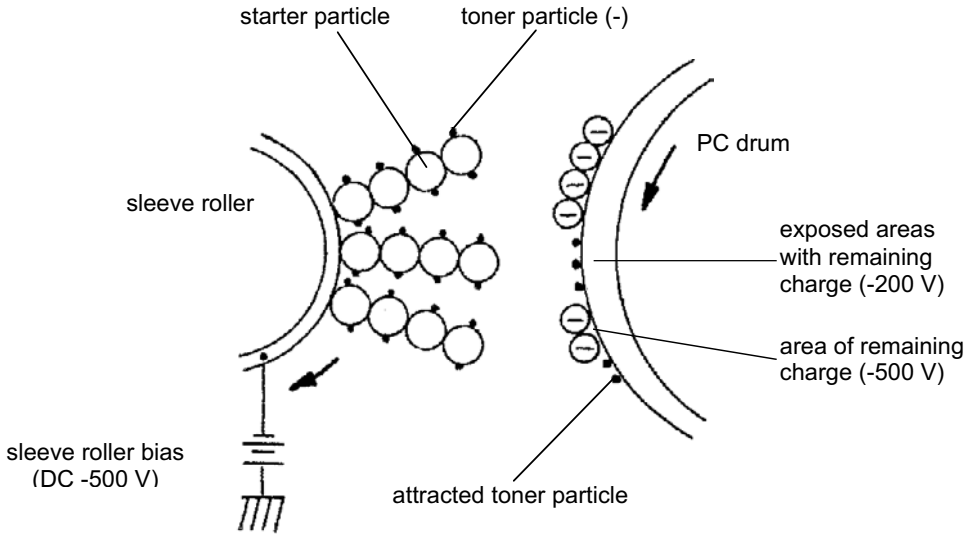
Picture A: Development, analogue copier

negatively charged toner

The digital copier's toner is charged negatively. The negatively charged toner is attracted by the areas of the PC drum's surface, where the negative charge was erased by Laser exposure. The Laser of the digital copier exposes areas and so erases their charge where toner shall be attracted, and leaves areas unexposed with full negative charge where no toner shall be attracted.

sleeve roller

The unexposed areas have a negative charge of -500 V. The exposed areas still have a remaining charge of up to -200 V. To drive the negatively charge onto this areas, the sleeve roller has a high bias of -500 V. Because the sleeve roller and the unexposed areas of the drum surface have a high negative charge and the exposed areas only have a low negative charge, the negatively charged toner is attracted by the exposed areas – compared to the sleeve roller and the unexposed areas, the exposed areas seem to be “positive”.



Picture B: Development, digital copier

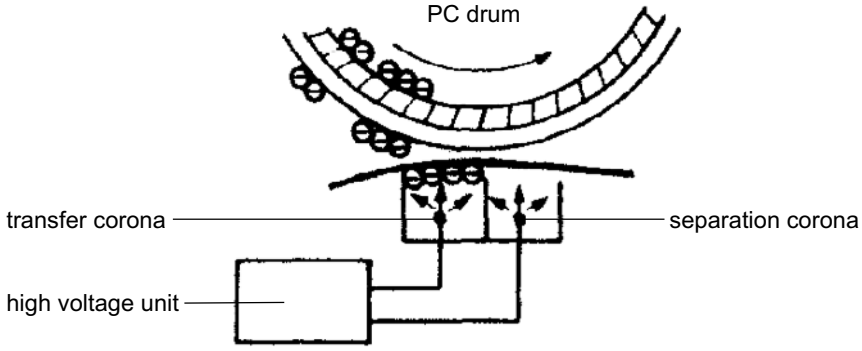
4.6 Image transfer and paper separation

The image transfer and paper separation of analogue and digital copiers work in similar ways.

transfer corona

Remember: In analogue copiers the toner is transferred from the PC drum's surface onto the copy paper through a transfer corona underneath the paper sheet. The transfer corona is provided with a high negative direct current by the high voltage unit and charges the paper sheet negatively. By the negative charge of the sheet, the positively charged toner is attracted and moves onto the paper sheet.

Because the toner of digital copiers is charged negatively, the transfer corona of the digital copier is provided with a high positive direct current. The transfer corona charges the paper sheet positively and by this the negatively charged toner is pulled down onto the sheet.



separation corona

As the paper separation of analogue copiers, the one of the digital copier works with a separation corona provided with a high alternating current by the high voltage unit. The alternating current neutralizes the charge and the paper sheet comes off the PC drum by its stiffness and weight.

4.7 Summary

The IR unit is responsible for scanning the original. Similar to analogue copier's exposure units, it consists of motor-driven lamp- and mirror carriages, but the light reflected from the original is projected onto a small CCD sensor and several circuit boards process the generated image data.

Systems that use mirrors and a lens to project the light onto the CCD are called reduction type scanners. Alternatively, scan systems may use glass fibre optics that directly projects the light onto a wide CCD. Such systems are called contact type scanners.

As CCDs generate analogue electrical signals, these signals have to be converted into digital signals by an A/D converter. The A/D converter converts run-time-dependent analogue signals into run-time-independent digital signals that only can represent two basic conditions (e.g. "0" and "1").

As the IR unit does not scan the entire original at once, but line for line, the corresponding data has to be put together to make the digital image. The initial digital image data then is processed in several steps to realise user settings, to optimise the data for output, and to reduce the amount of data before the data is stored in the copier's memory.

From the memory the digital data is sent to the print unit, where the Laser is controller by the data. The most important parts of the print unit are the Laser diode, several lenses that help to project the Laser beam correctly onto the PC drum, and a rotating polygon mirror that realises the construction of the image on the drum surface line by line.

The developing basically works in the same way with analogue and digital copiers. But in contrast to analogue copiers, the toner particles used in digital copiers are charged negatively and other voltages are applied to the PC drum and the sleeve roller.

To transfer the toner particles from the drum surface onto the paper, the transfer corona charges the paper positively and makes the paper attract the negatively charged toner. To separate the paper from the PC drum after developing, a transfer corona applies a high alternating voltage to the paper and discharges it.

4.8 Review questions

- Which way does the light reflected from the original take?

- In which way does the scanning unit basically work?

- In which way are the CCD's signals converted into digital image data?

- Which are the steps of the data processing before the image data is sent to the copier’s memory?

- Describe the way of the Laser beam from the Laser diode to the PC drum via the optics and mirrors of the print unit! Which specific task does each optics perform?

- What are the differences between the analogue and the digital copier's developing?

- Are there any major differences between the analogue and the digital copier's image transfer and paper separation?

5 Review questions

Chapter 1

- Describe the basic differences between analogue and digital copiers!
- Why is a digital copier separable into a scanner and a printer?
- What makes up a digital image?

Chapter 2

- Name the creative possibilities of digital copiers!
- What benefits do digital copiers offer compared with analogue copiers?

Chapter 3

- What are the steps of the digital copying process?

Chapter 4

- Which way does the light reflected from the original take?
- In which way does the scanning unit basically work?
- In which way are the CCD’s signals converted into digital image data?
- Which are the steps of the data processing before the image data is sent to the copier’s memory?
- Describe the way of the Laser beam from the Laser diode to the PC drum via the optics and mirrors of the print unit! Which specific task does each optics perform?
- What are the differences between the analogue and the digital copier's developing?
- Are there any major differences between the analogue and the digital copier's image transfer and paper separation?