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[User's Manual]

CRT Colour Analyser
PM 5639/01/20/21/25

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1. Safety

Read this chapter carefully before installation and use of the instrument.

1.1 Introduction

The instrument described in this manual is designed to be used by properly-trained personnel only. Adjustment, maintenance and repair of the exposed equipment shall be carried out only by qualified personnel who are aware of hazards involved.

1.2 Safety Precautions

For the correct and safe use of the instrument, it is essential that both operating and servicing personnel follow generally accepted safety procedures in addition to the safety precautions specified in this manual. Specific warning and caution statements, where applicable, are found throughout this manual. Warning and caution statements and/or symbols are marked on the instrument where necessary.

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1.3 Caution and Warning Statements

Caution
Used to indicate correct operation or maintenance in order to prevent damage to, or destruction of equipment or other property.

Warning
Used to indicate a potential hazard that requires correct procedures or practices in order to prevent personal injury.

1.4 Impaired Safety Protection

Whenever it is likely that safe operation is impaired, the instrument must be made in-operative and secured against unintended operation. The appropriate servicing authority must be informed.

For example, safety is likely to be impaired if the instrument fails perform the intended measurements or shows visible damage.

1.5 Electrostatic Sensitive Devices

All ICs and many other semi-conductors are susceptible to electrostatic discharges (ESD).
Careless handling during repair can reduce life-time drastically.

When repairing, make sure that you are connected to the same potential as the mass of the set via a wrist wrap with resistance. Keep components and tools also at this potential.

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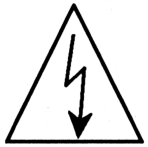
1.6 Symbols

Symbol:	Colour:	Explanation:
	Red	High voltage terminal: a terminal at which a voltage, with respect to another terminal or parts exists or may be adjusted to 1000V or more. (High voltage ≥ 1000V).
	Black/Yellow	Live part.
	Black/Yellow	To preserve the instrument from damage the operator must refer to an explanation in the User's Manual.

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WARNING:
When the instrument is connected to its power supply, terminals may be live, and the opening of covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts.
The instruments must be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair.
Capacitors inside the instrument may still be charged even if the instrument has been disconnected from all voltage sources.

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2. Introduction

2.1 General Information

The PM5639/01, PM 5639/20/21 CRT Colour Analysers and PM 5639/25 Miniature Colour Analyser are based on separate colour sensors which connects directly to the RS232 serial interface on standard PC's.

The "PM 5639/01 CRT Colour Analyser, PC" is intended for high-end studios, postproduction houses, and service facilities. The "PM 5639/20 and PM 5639/21 Industrial CRT Colour Analysers" are intended for automatic or semi-automatic production lines and high-end service facilities.

PM 5639/25 Miniature Colour Analyser is a high-speed analyser intended for automatic manufacturing system on small screen CRTs and for uniformity check on larger CRT screens .

The adjustment may include black level, the "colour of black", contrast level, "the colour of white" and the colour balance and luminance level (grey) at any point in between.

The PM5639/01 consists of a software package, one PM 5639/90 CRT colour sensor, one power supply, and cables necessary for the operation together with a PC.

The PM 5639/20 consists of a software package, one PM 5639/92 industrial CRT colour sensor, one power supply, and cables necessary for the operation together with a PC. The PM 5639/21 is identical to PM 5639/20 with the exception that this package includes two PM 5639/92 industrial CRT colour sensors, two power supplies, and two sets of cables.

The PM 5639/25 consists of a software package, one PM5639/93 Miniature colour sensor, one power supply and cables necessary for the operation together with a PC.

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The software package delivered with the different setups are identical for PM 5639/01, PM 5639/20 and PM 5639/21.

The software package for PM5639/25 is slightly different as the PM 5639/93 sensor includes a possibility to be with used either 4800 baud or 9600 baud communication speed.

The software packages consists of two separate parts:

1. A complete measuring system, including communication with the colour sensor and display facilities.

2. A software module system, which can be integrated into automatic and semi-automatic systems.

With the display software, the measuring results can be show directly as CIE values or as differences between the preprogrammed white reference and the actual colour (both graphically and numerically). The results can also be shown as relative RGB values.

The software modules make it possible for the user to program his/her own automatic adjustment routines for controlling mechanical screwdrivers, RC5, I2C, or other types of interfaces to the set during testing, and to control mechanical elements, which transport the set during testing, and move the colour sensor. This programming can be done in Basic, C, or Pascal.

The CRT Colour Analyser software can be used on IBM-compatible PCs.
For purpose of statistics, and quality control, the software allows storage of measurements for later examination or print of measuring reports for documentation.

For users who want to use double sensor setups (e.g. PM5639/21), the software can operate two measuring heads at the same time, and display the results simultaneously on the PC.

Special software features for PM5639/25

The display module PM 39_25 includes a parameter to select the communication speed. The default value is 4800 baud. To start the program with 9600 baud rate use the following syntax: “PM39_25/B:96”.

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The program includes a help page, which can be reached by: “PM39_25/?” or “PM39_25/h”.

The program may be used with two sensors operation simultaneously. The sensors have to operate with the same communications speed, either 4800 baud or 9600 baud.

The program CHGBAUD.exe is used to change the communication speed between 4800 baud and 9600 baud.

2.2 The Colour Sensor

The filters in the Colour Sensors to simulate the CIE Standard Observer response are very highgrade dichroic filters. This assures a stability and accuracy, which is quite difficult to obtain with conventional designs.

The PM 5639/90 CRT colour sensor, included in the PM 5639/01 package, is equipped with a suction disc, which makes it possible to attach the sensor to a monitor. This sensor operates in normal mode, giving about 3 measurements per second.

The PM 5639/92 Industrial Colour Sensor, included in the PM 5639/20 package and in the PM 5639/21 package, is a rugged and very fast sensor optimised for use in industrial environments. When used together with the display package both normal mode (about 3 measurements per second) and fast mode (about 10 measurements per second) can be used. The measuring rate can also be programmed to other rates when used together with the software modules (This will not influence the measurement rates in the display program). This sensor is equipped with a mounting bracket for mounting in automatic systems. The bracket is fitted with three 6mmØ self locking press-nuts.

The PM 5639/93 Miniature Colour Sensor, included in the PM 5639/25 package is a rugged and very fast sensor optimised for industrial use. With a measuring speed up to 15 measurements/second and a higher communication speed, it is the fastest sensor in the series. The small size of the sensor enables measurement of white uniformity even on small CRT screens.
Due to the small size also for the shadowing disc in the front, it is influenced by ambient light and has to be operated in dark environments for correct measurements.

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2.3 The Display Software Package

The colour sensor operates with CIE 1931 Standard Observer response filters, which make it possible to display absolute colour coordinates.

The following displays are included in the display software.

2.3.1 xyY Mode

The x and y coordinates are plotted in the central portion of the CIE 1931 diagram. The x, y, Y (luminance value), the correlated colour temperature, and the colour error (CIELUV) are shown numerically. The white reference point is shown as a box and the actual colour as a cross.

The colour error is calculated as the difference between the selected colour reference and the actual colour according to the CIE 1975 L*u*v* (CIELUV) colour space definition.

2.3.2 δxδyδY Mode

The differences δx and δy are plotted in a coordinate system with origin at the white reference point. The δx and the δy values, the luminance value Y, and the correlated colour temperature are shown numerically.

2.3.3 u'v'Y Mode

The 'u and v' (also named u* and v*) coordinates are plotted in the central portion of the CIE 1976 diagram. The u', v', Y (luminance value), and the colour error (CIELUV) are shown numerically. The reference point is shown as a box and the actual colour as a cross.

2.3.4 δu'δv'Y Mode

The differences δu' and δv' are plotted in a coordinate system with origin at the white reference point. The δu' and the δv' values, the luminance value Y, and the correlated colour temperature are shown numerically.

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2.3.5 uvY Mode

The u and v coordinates are plotted in the central portion of the CIE 1960 diagram. The u, v, Y (luminance value), and the colour error (CIELUV or JND) are shown numerically. The reference point is shown as a box and the actual colour as a cross.

2.3.6 δuδvY Mode

The differences δu and δv are plotted in a coordinate system with origin at the white reference point. The du and the δv values, the luminance value Y, and the correlated colour temperature are shown numerically.

2.3.7 XYZ Mode

The CIE 1931 XYZ values are shown as bar graphs. The values are the direct output from CIE standard observer response filters with the balance normalized to the selected with reference. The display is an RGB display without phosphor compensation. The Y output equals the luminance value.

2.3.8 XYZ Abs. Mode

The CIE 1931 values are shown as bar graphs. This display is identical to the XYZ mode, except that the values are normalized to a preselected absolute luminance value and white reference.

2.3.9 RGB Mode

Red, green, and blue values are shown as coloured bar graphs. The colour balance is relative to a selected white reference and phosphor. The display reference may be either one of the red, green, or blue inputs or the luminance. The phosphor compensation removes the ”crosstalk” (as specified by CIE standard observer response curves) between the red gun and the blue and green bars (and the same for the other possibilities).

2.3.10 RGB Abs. Mode

This display is identical to the RGB Display, except that, on top of the normalized to a white reference and phosphor, the display is normalized to a preselected absolute luminance value.

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2.4 Package Contents

The PM 5639/01 CRT Colour Analyser, PC package includes:

- 1 CRT colour sensor PM 5639/90
- 1 power supply box for the sensor
- 1 interface cable for use between PC and power supply box (sub-D connectors)
- 1 interface cable for use between power supply box and colour sensor (FCC68 connectors)
- 1 mains cable
- 1 3.5” 1.44 MB floppy disk containing the complete software
- 1 carrying case
- 1 User’s Manual

The PM 5639/20 Industrial Colour Analyser package includes:

- 1 industrial CRT colour sensor, PM 5639/92
- 1 power supply box for the colour sensor
- 2 interface cables for use between PC and power supply box (sub-D connectors)
- 1 mains cable
- 1 3.5” 1.44 MB floppy disk containing the complete software
- 1 User’s Manual

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The PM 5639/21 Industrial CRT Colour Analyser (double sensor version) package includes:

- 2 industrial CRT colour sensor PM 5639/92
- 2 power supply box for the sensor
- 4 interface cables for use between PC and power supply box (sub-D connectors)
- 2 mains cable
- 1 3.5” 1.44 MB floppy disk containing the complete software
- 1 User’s Manual

The PM 5639/25 Miniature Colour Analyser package includes:

- 1 Miniature CRT colour sensor, PM 5639/93
- 1 power supply box for the colour sensor
- 2 interface cables for use between PC and power supply box (sub-D connectors)
- 1 mains cable
- 1 3.5” 1.44 MB floppy disk containing the complete software
- Rubber shadow ring for PM5639/93
- 1 User’s Manual

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3. Technical specifications

3.1 Safety Characteristics

This instrument has been designed and tested in accordance with Safety Class I requirements of IEC Publication 348 (Safety Requirements for Electronics Measuring Apparatus), and has been supplied in a safe condition. This manual contains information and warnings, which must be followed to ensure safe operation and to retain the apparatus in a safe condition.

3.2 Performance Characteristics

Properties expressed in numerical values with stated tolerances are guaranteed by the DK-Audio organization in your country. Specified non-tolerance numerical values indicate those that could be nominally expected as a mean of a range of identical instruments.

The following specifications apply to a measurement with an illuminant D6500 standard monitor at a luminance level of 80 Cd/m^2 (23.3 ftL) and at an ambient temperature between +15°C (+59°F) and +30°C (+86°F).

3.3 Measuring Modes

The colour sensor can be operated in two different modes:

- MX mode
- XYZ mode

Operation in the MX mode requires that the compensation matrix in the colour sensor is used when calculation absolute values.
In the XYZ mode this calculation is done automatically in the sensor. The accuracy for the xy chromaticity coordinates is based on the measured MX values including the compensation matrix.

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3.4 Product data PM 5639/01/20/21

3.4.1 Chrominance Measurements

Accuracy:
Better than 0.002
Repeatability:
Better than 0.002

3.4.2 Luminance Measurements

Luminance:
0.1 to 1000 Cd/m^2 (0.03 to 300 ftL)
Accuracy:
Better than 2%, ±1 digit
Repeatability:
Better than 3%, ±1 digit

3.4.3 XYZ Bars

Accuracy:
Better than 1%
Repeatability:
Better than 1%

Luminance (Y):
Better than 2%, 1 digit

3.4.4 RGB Bars

Accuracy:
Better than 1%
Repeatability:
Better than 1%

Luminance (Y):
Better than 2%, ±1 digit

3.4.5 Measuring Rate

Normal mode:
~3 measurements/second
Fast Mode:
>10 measurements/second

3.4.6 Settling Time

Within 1% after 1 second

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3.4.7 Sensor communication

Baudrate: 4800
Databit: 8
Stopbit: 2
Parity: None

3.5 Product data PM 5639/25

3.5.1 Chrominance Measurement

Accuracy: xy values better than 0.002
Repeatability: xy values better than 0.002

3.5.2 Luminance Measurement

Luminance: 0.1 to >1000 Cd/m^2
Accuracy: Better than 2% ±1 digit
Repeatability: Better than 3% ±1 digit

3.4.4 Measuring Rate

The signal filtering in the A/D converter system has in the PM 5639/93 Small Industrial Colour Sensor been optimised for fast response. The colour sensor should therefore only be used in fast mode.

Measuring Rate:

Up to ~ 15 measurements/second
Response to light level changes:
<450 ms down to 200 ms depending upon the number of required changes in gain steps, in automatic gain step mode.

3.4.5 Sensor Communication

Baudrate: 4800 or 9600 (programmable)
Databit: 8
Stopbit: 2
Parity: None

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3.5 Memory

3.5.1 White References

The white references are stored in a separate file in the computer. The number of white references are limited by the available RAM in the computer. The white references may be given names consisting of up to 15 characters.

5.5.2 CRT/Phosphors

The phosphor compensation matrices are stored in a separate file in the computer. The number of phosphors is limited only by the avail-able RAM in the computer. The phosphor can be given a name consisting of up to 15 characters. The phosphors are unique to each colour sensor and may be used with the sensor, which was used for their generation.

3.5.3 Setups

Program Setup
A program setup includes all information necessary to restore a complete measuring setup with several display windows. The individual program setups are stored as files on the disk, and the number of program setups are limited only by the storage capacity on the computer (hard)disk.

Display setup
A display setup includes all information necessary to restore a single display window. The display setups are stored as individual files on the disk and the number of display setups are limited only by the storage capacity on the computer (hard)disk.

Configuration File
A configuration file is a file, which contains information on the program setups at the time the program was exited. When the program is restarted, the program setup will be the same as when the program was exited. When exiting the program, the user is asked whether the configuration

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file should be updated. If the file is updated, the next time the program is used it will start out in the same mode as it was in when it was exited.

3.5.4 Measurements

Single measurements may be named and stored in the controlling computer. The measurements are stored as individual files on the disk and the number which can be stored is limited only by the storage capacity of the computer (hard)disk.

3.6 Factory Programming

3.6.1 White Reference

D6500
x = 0.313, y = 0.329
3200 K
x = 0.423, y = 0.399 on the black body curve
9300 K
x = 0.285, y = 0.293 on the black body curve

Other white references can be generated by means of the "Learn white reference" function as measurements or entered directly (as xy, u'v' or uv chromaticity coordinates in the CIE-displays only).

When a white reference has been generated, it should be saved by means of the save white reference function, for later use.

3.7 Power

The colour sensor is powered from a supply box inserted between the PC and the colour sensor.

Mains consumption:
85-250 V AC 2.5 VA. 48 to 65 Hz
Colour sensor consumption:
5 V DC (±0.2 V), 50mA
3.8 Environmental Conditions

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Operating temperature:
10 to + 40°C (+50 to +104°F) (non-condensing)
Storage temperature:
-10 to +70°C (-14 to 158°F)

Test:

Vibration:	IEC 68-2-5F;5-50-200Hz; 0.7mm p-p/50m/s2
Bump:	IEC 68-2-29 part 2;350m/s2; 1000 bumps in 3 directions

Operating:
Repetitive bump: <120m/s2

3.8 Safety & EMI (EMC)

Safety according to IEC348 class 1
Electro-magnetic interference:
In accordance with EN55022, class B (Emission), EN50082-1/1992 part 1 (immunity).

3.9 Mechanical Data

3.9.1 Dimensions

PM5639/90 CRT colour sensor

Diameter of house:	108 mm (4.25”)
Diameter of suction pad:	120 mm (4.75”)
Height:	135 mm (5.25”)
Weight:	250 g (0,55 lbs)

PM5639/92 Industrial CRT colour sensor

Diameter of housing:	108 mm (4.25”)
Diameter of rubber shadow pad:	120 mm (4.75”)
Height:	70 mm (2.8”)
Weight:	250 g (0.55 lbs)

PM5639/93 Miniature Colour Sensor

Diameter of housing:	40 mm (1.6”)
Diameter of rubber shadow pad:	60mm (2.37”)
Length:	204 mm (8.0”)
Weight:	280 g (0.62 lbs)

Power supply box

Size:	185 x 105 x 65 mm (7.3 x 4.2 x 2.6”)
Weight:	1.1 kg (2.4 lbs)

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Carrying case PM 5639/01
Size: 450 x 450 x 170 mm (17.7 x 17.7 x 6.7”)

3.10 Hardware Requirements

- IBM PC AT/286/386/486/, PS/2 or compatible
- 512 Kbytes RAM
- One floppy disk drive
- MS-DOS, PC-DOS or DR-DOS (version 3.3 or higher)

- Serial port COM1 (RS232C interface, address 03F8HEX, interrupt IRQ4) and/or serial port COM2 (RS232C interface, address 02F8 HEX, interrupt IRQ3)

- Printer port LPT1 (address 378 HEX) and/or Printer port LPT2 (address 278 HEX)

The software is delivered on 1.44 MB 3.5” floppy disk.
The software is EGA- and VGA-compatible. For full use of the display facilities, a 100% compatible IBM EGA/VGA graphic adapter is recommended.
The software can be run from a floppy disk, but the use of harddisk is recommended.

3.11 Software Compatibility

The software for the full display facilities is supplied in the form of “exe” files whish should not be modified by the user.

The software modules for automatic measuring setups are supplied as source files, which can be modified and included in user software. The software is fully documented and the software source modules are in Quick Basic, Turbo, Pascal, and Borland C++.

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3.12 File Overview

The disks contain the file “FILELIST.DOC”. This file is a list of the files contained on the disks. A brief description of the content of each file is included. The “FILELIST.DOC” file can be printed by means of any word processor or text editor.

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INSTALLATION AND OPERATING INSTRUCTIONS

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4. Installation

4.1 Initial Inspection

Check the contents of the package for completeness and possible damage. If the contents are incomplete or damaged, a claim should be filed with the carrier immediately, and the DK-Audio Sales or Service organization should be notified in order to facilitate the repair or replacement of the instrument.

4.2 Safety Instructions

4.2.1 Grounding

Before any other connection is made, the instrument must be connected to a protective ground conductor via the three-core mains cable.

Before connecting the equipment to the building installation mains, please ensure that the building installation protective ground wire functions properly.

WARNING: Any disconnection of the protective conductor inside or outside the instrument or disconnection of the protective ground terminal is likely to make the instrument dangerous. Do not disconnect intentionally.

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4.2.2 Mains Switch

For this instrument, the power supply line shall contain a switch or another adequate means for disconnection from the mains.

4.2.3 Safety Opening Covers and Replacing Parts

WARNING: The opening of covers or removal of parts, except those to which access can be gained by hand, is liable to expose live parts. Accessible terminals may also be live. The instrument must be disconnected from all voltage sources before it is opened for any adjustment, replacement, or repair.
Capacitors inside the instrument may still be charged even if the instrument has been disconnected from all voltage sources. If maintenance or repair of the opened instrument is unavoidable, it should only be carried out by a skilled person who is aware of the hazards involved.

4.2.4 Main Voltage Setting

Different power cords are available for various voltage outlets. The type of cord supplied depends on the version of the instrument ordered.

NOTE: If it is necessary to adapt the main plug to fit local conditions, this should be done by a qualified person.

The power supply for the PM 5639/01/20/21/25 is a switch-mode power supply that covers input voltages between 85 and 250 V AC RMS. This makes adaptation to local mains voltage unnecessary.

4.2.5 Replacement of fuses

CAUTION: Make sure that only fuses of the specified voltage and with the required rated current are used for replacement. Short- circuiting of fuse holders are prohibited.

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4.3 Making a Back-Up Copy of Software

Before starting the installation process, a back-up copy of the original software diskette should be made.

Keep your PM 5639 Software back-up copy in a location different from that of your original diskette.

For your convenience and protection, we do not copy-protect the PM 5639 Software, but please remember that we do so only for your convenience. If others ask for a copy, please be fair and ask them to buy their own.

If you want to run software from a hard disk, please copy the files from the floppy disk to the hard disk.

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4.4 Connections

4.4.1 Colour Sensor

CAUTION: Do not make or remove any connections between the parts with power on the instrument or with the colour sensor mounted on a CRT.

Use the cables supplied with PM 5639 to connect the colour sensor, the power supply box, and the serial port on the PC.

Switch on the computer and start the program.

4.4.2 Mechanically/Electrically Ground

CAUTION: Assure that no voltage higher than 100 volt is obtained between electrical ground (signal connectors) and mechanical ground (earth connector and box).

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5. Operating Instructions

5.1 General Information

The PM 5639 package includes several different software modules. The software has two different parts:

- A complete display and measuring system, which may be used in manual or semi-automatic measuring systems.

- A number of software modules which may be integrated by the user into automatic setups. The software modules are fully documented and the source codes are supplied in order to facilitate integration.

5.2 The Display Package

5.2.1 Starting the PM 5639 Display Software

Before the display Software package is started for the first time backup copy of the disk should have been made. See Paragraph 4.3

5.2.2 Running the Display Software on a Harddisk

The display software coming with the different instruments has a completely identical functionality. The display program coming with PM 5639/01 is named PM39_01.EXE, the display program coming with PM 5639/20 and PM 5639/21 is named PM39_20.EXE and the program for PM5639/25 is named PM39_25.EXE.

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These names have to be used to start the program. Please observe that both display software can operate with two colour sensor at the same time.

Make sure the PC is in the subdirectory into which the software has been copied.

- PM 5639/01:
  Type PM39_01 and press **ENTER**
- PM 5639/20 and PM 5639/21:
  Type PM39_20 and press **ENTER**
- PM 5639/25:
  Type PM39_25 and press **ENTER**

To start to PM5639/25 in 9600 baud communication type PM5639_25/B:96
- The PTV TV Test Equipment logo appears on your screen together with the software serial number
- Press ENTER to get to the display software main display screen

Running the Display Software from a Floppy-Disk System
Make sure the DOS prompt A (B if the B floppy drive is used) is shown on the screen.

- Insert the working copy of the display software program in drive A (B)

- PM 5639/01:
  Type PM39_01 and press **ENTER**
- PM 5639/20 and PM5639/21:
  TypePM39_20 and press **ENTER**

- PM 5639/25:
  Type PM39_25 and press **ENTER**
  To start to PM5639/25 in 9600 baud communication type PM5639_25/B:96
- The PTV logo appears on your screen together with the software serial number
- Press **ENTER** to get the display software main display screen

5.3 Operating the Menus

This software package operates in a “window” manner without the option of mouse control. The colour sensor(s) attached to the PC uses the port(s) normally reserved for the mouse.

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The top line is called the ***Main Menu Line*** and the bottom line is called the ***Status Line***. The ***Main Menu Line*** is enabled by pressing **F10** or by pressing **ALT** and highlighted first letter of the item. An item in the ***Main Menu Line*** is chosen by use of the cursor controls (arrow left and arrow right) and then selected by pressing **ENTER** or the cursor control arrow down. The menu field is then enabled, and the selection can be made by means of the cursor controls up/down and selected by pressing **ENTER**. Some of the most frequently used keys are described in the ***Status Line***. Some often used commands are also accessible by direct operating short-cut keys. A description of these keys and their functions are given below.

Active display

Some of the commands only work on the active display. Only one of the measuring displays can be active at a time. The active display is indicated by the presence of a blue/grey bar at the top of the display. To select which display is to be active, press **F6**. For the user to change the settings of a display, the display must be active. Displays which are not active can perform measurement, but it is not possible to change their characteristics.

When a display editing window is opened, readout of the measurements is stopped, although the colour sensor(s) are still measuring. When changes are made only to the display formats, the display of measuring results restarts automatically once the editing windows are closed.

To close a menu field or a display editing window or return to the display mode from the ***Main Menu Line***, press the **ESC** key.

The status of the measuring system is shown in the lower right corner of the screen. **CTRL** + **F9** will either restart or stop the measurements.

In the display editing windows, a square indicates the active selection. The cursor – indicated by a green/grey ribbon – may be moved from field to field by pressing the **TAB** key and inside the field, press either the **SPACE BAR** or the **ENTER** key. Pressing the **SPACE BAR** changes the selection without closing the window, leaving the user free to change other selections in the window. Pressing the **ENTER** changes the selection, closes the window, and then the measuring process can be restarted with the altered parameters.

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5.4 The Main Menu Line

5.4.1 File

Start/Stop Measuring CTRL + F9
Starts of stops the measuring system. At the start command, the colour sensor is initialised and the measurements displayed. The status of the measuring system is shown in the lower right corner of the screen. When the sensor is operating, the results may not be displayed if windows other than display windows are open on the screen.

Normal/Fast Mode
Used to switch between the normal and fast measuring mode. In the normal mode the measuring rate is about 3 times per second, in the fast mode about 10 times per second. The status, either Normal or Fast is written in the lower right corner of the screen. The fast mode is only available, when the software is used together with the PM 5639/92 Industrial Colour Sensor. If two sensors are used, both have to be of the industrial type (PM 5639/92) in order to use the fast mode.
Although the PM5639/93 Miniature colour sensor can be set to Slow mode, it has been optimised for fast response, and should therefore only be used in the Fast mode.

Information
Displays information on the computer and free memory.

Exit Program ALT + X
Ends the software execution. Before exiting the program, the user is asked whether the configuration file should be updated. If the configuration file is updated, the program will re-start in the same mode as it was exited.

5.4.2 Edit

Display Setup
Display the setup for the active display and the menu to change the setup.

Text On/Off F9
Switches the text part of the active display on or off.

Display Status
Display the status of the active display.

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Generate Report
This command generates a measuring report. The report can be either printed out or filed. The report includes the measured CIE values and active display references. A text field at the button of the report makes it easy for the user to enter up to three lines of text for information.

Scale Down CTRL + F8
Takes the display gain mode down one step. The display scale is indicated by a “ruler” below the display in the CIE modes and by percentages in the RGB/XYZ modes.

Scale Up ALT F8
Increases the display gain mode one step.

Autoscale F8
Takes the active display into the highest gain mode where the measured colours remains inside the display area. The total number of different scales is three.

5.4.3 Learn

White Reference
Used to learn a new white reference for the measuring system. The white reference may either be the last display measurement of the active display or entered directly as CIE values. The reference includes the luminance level for ease of use. In RGB mode the white reference can only be entered by means of the use measurement procedure.

Phosphor
Used to learn the measuring system the characteristics of a phosphor and establish a phosphor matrix of the measured CRT. The phosphor matrix is then named and stored in the display software. The phosphor matrix for each colour sensor is unique, and may only be used with the head used when it was generated. The software uses the internal serial number to identify the different colour sensors.

5.4.4 Save

Program Setup
Used to name and save complete program setups for later use with the Restore Setup command. The program setup saved is the complete setup in use at the time it is saved.

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Display Setup
Used to name and save display setups for later use with the Restore Display Setup command. The display setup saved is the active display setup.

Measurement
Used to save the last measurement of the active display for later use with the Restore Measurement command.

White Reference
Used to save the white reference of the active display. This may later be retrieved by the Restore White Reference command. This command may also be use to change the name of a white reference.

Phosphor
Used to save the phosphor of the active display. This command can only be used when an RGB display is the active display.

5.4.5 Restore

Program Setup
Used to restore complete program setups previously stored by means of the Save Program Setup command.

Before this command is executed, all open measuring displays must be closed.

Display Setup
Used to restore a single measuring display setup stored by means of the Save Display Setup command. This command opens an extra display on the screen. The restored display becomes the active display.

Measurement
Used to restore a measurement stored by means of the Save Measurement command. This command opens an extra window containing the measurement.

White Reference
Used to restore white reference previously stored by means of the Save White Reference command. When a

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white reference is restored, it becomes active for the active display. If the same white reference is wanted in several displays, simply use the function in each different active display, use **F6** to choose whish display to become active.

Phosphor
Only used with an active RGB display. Used to restore a phosphor crosstalk compensation matrix previously stored by means of the Save Phosphor command. The phosphor becomes active for the active RGB display. If the same phosphor is wanted in several displays, simply use the function in each different active display, use **F6** to choose which display to become active.

5.4.6 Display

Open CIE ALT + F1
Opens a new display for CIE chromaticity measurements. The new display becomes the active display.

Open RGB/XYZ ALT + F2
Opens a new display for RGB or XYZ measurement. The new display becomes the active display.

Size/Move CTRL + F5
Moves and changes the size on the active display. The arrow keys move the display, and the shift arrow keys change the display size. Press **ENTER** to end the Size/Move command.

Next F6
Selects the display to be activated. The **F6** key toggles between the displays on the screen. The active display is indicated by the blue/grey bar at the top of the display.

Close Alt+ F3
Closes the active display. The display setup is lost when this command is used. Before the command is executed and the display setup lost, a warning is given. To store the display setup, use the *Save Display Setup* command before closing the display.

Close All
Closes all open displays. The complete program setup is lost when this command is used. Before the command is executed and the program setup lost, a warning is given. To save the complete measurement setup, use the *Save Program Setup* command before closing the displays.

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5.4.7 Help

Index
Displays the master index of the help entries. Use the arrow keys to make your selection. Then press **ENTER**.

Help on Help
A brief description of the help system.

About
Indicates the version of the PM 5639 CRT Colour Analyser display program, including the software serial number.

5.5 The Status Line

Alt+X: Exit Program
Program execution is exited; the setup and display parameters may be saved to enable restart of the program in the same mode as it was in when exited.

F1: Help
Context-sensitive help function. This function is active in every mode of the program except when error and warning messages are displayed. The function gives help information on the place/command from which it was called.

F10: Menu
Enables the ***Main Menu Line***. When the ***Main Menu Line*** is activated, measurement readout is stopped temporarily. The readout restarts automatically when the ***Main Menu Line*** is exited.

Normal/Fast
This field indicates the status of the colour sensor. The colour sensor may be either in the normal mode or in fast measuring mode.

NOTE: Fast mode can only be selected, if the software is used together with Industrial Colour Sensors (PM 5639/92). If two sensors are used both have to be of the industrial type.

Fast mode is default for PM5639/93, as this has been optimised for fast repsonse; the sensor should therefore only be used in fast mode.

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Sensors Measuring /Sensors Stopped
This field indicates whether the colour sensors are measuring or measurement has stopped. The colour sensors may be performing measurements even if they are not being displayed. The display of measurements is stopped every time the ***Main Menu Line*** is activated.
Measurement display is also stopped in the display background if two displays are placed on the top of each other on the screen.

5.6 Description of Editing Functions

The *Display Setup* command in the *Edit* window is the editing window for the active display. At least one display must be opened before this command can be used.

The *Edit Display Setup* window changes with the active display, which may be either a CIE or an XYZ/RGB display.

Several of the fields in the editing window have more than one option.

The green/grey cursor can be moved from field to field by means of the **TAB** button.

Within the fields, the cursor is moved by use of the arrow up/down keys.
Pressing the **SPACE BAR** changes the selection in the field to the value indicated by the cursor.
Pressing **ENTER** changes the selection and closes the window.

5.6.1 Edit Display Setup (CIE)

COM Port
This field indicates which port the active display is receiving measuring results from. It is possible to select either COM Port 1 or COM Port 2.

Display Text
This field indicates whether the numerical readout text part of the active display is enabled or not. The numerical field may be enabled or disabled. Disabling the text leaves more room in the display for the graphical readout.

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Luminance Unit
The scale for the numerical readout of the measured luminance can be changed between Cd/m2, NIT and ftL.

Mode
A number of different CIE chromaticity displays may be selected.

CIE 1931 xy
The chromaticity coordinates are measured. A part of the CIE 1931 xy colour triangle is shown. The white reference is displayed as a box and the measured colour as a cross.

CIE 1931δxδy
The difference between the CIE 1931 and chromaticity coordinates for the measured light and reference light are shown numerically and in coordinate system.

CIE 1976 u'v'
The chromaticity coordinates are measured. A part of the CIE 1976 u'v' triangle is shown. The white reference is displayed as a box and the measured colour as a cross.

CIE 1976 δu'δv'
The difference between the CIE 1976 u'v' chromaticity coordinates for the measured light and reference light are shown numerically and in a coordinate system.

CIE 1960 uv
The chromaticity coordinates are measured. A part of the CIE 1976 uv colour triangle is shown. The white reference is displayed as a box and the measured colour as a cross.

CIE δuδv
The difference between the CIE 1960 uv chromaticity coordinates for the measured light and reference light are shown numerically and in a coordinate system.

Colour Error
The colour error displayed is the difference between the actual measured colour and the colour of the reference white. The error may be displayed either as CIELUV or as JND. The CIELUV error is calculated according to the definition in "Commission Internationale De l'Eclairage, Recommendations on uniform colour spaces – colour-

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difference equations psychometric colour terms, supplement no 2 to CIE publication no 15, 1978".

The colour difference in the display software is calculated by means of the following formula, which assumes equal luminance of the reference and the measured light.

$\Delta E = [(1300 \times \Delta u')^2 + (1300 \times \Delta v')^2]^{1/2}$ (CIELUV)

The psychometric size of the CIELUV unit is such that 1 CIELUV closely equals what an average human being can perceive as a colour difference.

THE JND *(Just Noticeable Difference)* unit is calculated in the CIE 1960 uv chromaticity system by means of the following formula:

$\Delta E = [\Delta u^2 + V^2]^{1/2} / 0.00384$ (JND)

This calculation dies take into account any luminance differences between the actual measured light and an established reference level.

5.6.2 Edit Display Setup (XYZ/RGB)

COM Port
This field indicates which port the active display is referring to. It is possible to select either COM Port 1 or COM Port 2.

Display Text
This field indicates whether the numerical readout text part of the active display is enabled or not. The numerical field may be enabled or disabled. Disabling the text leaves more room in the display for the graphical readout.

Luminance Unit
The scale for the numerical readout of the measured luminance can be changed between Cd/m2, NIT and ftL.

Mode
It is possible to choose between a number of different RGB/XYZ displays.

The first four field select XYZ between a number of different XYZ and RGB displays with either horizontal or vertical bars in the displays.

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The last five selections are different depending on whether XYZ or RGB is selected.

Survey of XYZ modes

ZYX/X

This displays shows three bars, which correspond to the output from the three CIE filtered channels in the colour sensor. The balance between the three bars is normalized to the selection white reference. The levels of the three bars are normalized so that the X-bar response is at the centre of the display.

XYZ/Y

This display shows three bars with correspond to the output from the three CIE filtered channels in the colour sensor. The balance between the three bars is normalized to the selected white reference. The levels of the three bars are normalized so the Y-bar response is at the centre of the display. The output from the Y channel in the colour sensor equals the luminance value.

XYZ/Z

This display shows three bars which correspond to the output from the three CIE filtered channels in the colour sensor. The balance between the three bars is normalized to the selected white reference. The levels of the three bars are normalized so that the Z-bar response is at the centre of the display.

XYZ/ xx.x cd/m^2 (NIT or ftL)

This display shows three bars, which correspond to the output from the three CIE filtered channels in the colour sensor. The balance between the three bars in normalized to the selected white reference. The levels of the three bars are normalized to the luminance level specified. The luminance reference level can be changed by deleting the old level and entering a new one directly from the numeric keyboard.

Survey of RGB modes:

RGB/R

The display shows three bars, which correspond to the output from the three CIE filtered channels in the colour sensor. The balance between the bars is normalized to the selected white reference and compensated by the phosphor matrix. The levels of the three bars are normalized so that the RED bar is at the centre of the display.

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RGB/G

The display shows three bars, which correspond to the output from the three CIE filtered channels in the colour sensor. The balance between the bars is normalized to the selected white reference and compensated by the phosphor matrix. The levels of the three bars are normalized so that the GREEN bar is at the centre of the display.

RGB/B

The display shows three bars, which correspond to the output from the three CIE filtered channels in the colour sensor. The balance between the bars is normalized to the selected white reference and compensated by the phosphor matrix. The levels of the three bars are normalized so that the BLUE bar is at the centre of the display.

RGB/Luminance

The display shows three bars, which correspond to the output from the three CIE filtered channels in the colour sensor. The balance between the bars is normalized to the selected white reference and compensated by the phosphor matrix. The levels of the three bars are normalized to the measured luminance.

RGB/ xx.x cd/m^2 (NIT or ftL)

This display shows three bars, which correspond to the output from the three CIE filtered channels in the colour sensor. The balance between the bars is normalized to the selected white reference and compensated by the phosphor matrix. The levels of the three bars are normalized to the absolute level specified. The luminance reference level can be changed by deleting the old one and entering a new one directly from the numeric keyboard.

5.6.3 Display Status

The status of the active display is shown. The serial number of the sensor used in the active display is shown together with COM port number used for this display. The software revision of the software in the sensor is shown. The active white reference is shown in CIE 1931 xy, CIE 1976 u'v', and CID 1960 uv chromaticity coordinates.
No editing is possible in this window.

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5.7 Description of Learning Functions

The Learn function is used to generate new white references and new phosphor matrices for use in the RGB display.

5.7.1 Learn White Reference

Name Ref.
In this field the name of the new reference should be entered. The name is entered directly from the keyboard, up to 15 characters.

Measure
This field is used to take a new measurement as the basis for the white reference. To take a new measurement and use this for the reference, select the measured field and press **ENTER**. If this function is not used, the white reference will be the last taken measurement before the ***Main Menu Line*** was enabled.

CIE 1931 coordinates
CIE 1976 coordinates
CIE 1960 coordinates

CIE Modes
These three fields contain the chromaticity of the last measurement. When these fields are selected, they can be edited by means of the keyboard. If one of the chromaticity coordinates is changed, the coordinates in the other system are changed accordingly.

RGB/XYZ Modes
These three fields contain the chromaticity coordinates of the last measurement. The field cannot be selected and editing is not possible in these modes.

To finish the ***Learn White Reference*** procedure, select *OK* and press **ENTER**.

Note: After using the ***Learn White Reference*** procedure it is advisable to use the ***Save White Reference*** command, in order to save the white reference for future use.

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5.7.2 Learn Phosphor

This command can only be used when the active display is of an RGB type.

Name Phosphor
The name phosphor field is used to name a new phosphor matrix. To generate a new phosphor matrix a calibration procedure must be followed. This procedure establishes reference points used for the calculation of the compensation matrix.

Sensor ID
The Sensor ID field shows the serial number of the sensor. The phosphor matrices are individual for each sensor and may not be used with sensors other than the one used for the generation. An exception to this is the factory programmed EBU and SMPTE"C" phosphor matrices. These phosphor matrices are averages of different EBU and SMPTE"C" phosphors. For the greatest degree of accuracy generating phosphors with the actual CRT is recommended.

Learn Phosphor Procedure

1. Select the *Name Phosphor* field and write the name of the new phosphor – up to 15 characters can be used

2. Select the *Red Reference* Field
3. Turn on the red gun only on the measured CRT
4. Press **SPACE BAR** to start the red calibration. The program gives an OK to confirm the calibration

5. Select the *Green Reference* field
6. Turn on the green gun only to the measured CRT
7. Press **SPACE BAR** to start the green calibration. The program gives an OK to confirm the calibration

8. Select the *Blue Reference* field
9. Turn on the blue gun only on the measured CRT
10. Press **SPACE BAR** to start the blue calibration. The program gives an OK to confirm the calibration

Select *OK* or *Cancel* to finish the ***Learn Phosphor*** procedure.

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The new phosphor becomes the active phosphor of the display, which was active when ***Learn Phosphor*** mode was entered.

Note: After the ***Learn Phosphor*** procedure is followed, using the ***Save Phosphor*** command is recommended to save the phosphor compensation matrix for future use.

5.8 Description of Save Functions

5.8.1 Save Program Setup

The save program setup command is used when the complete program setup is to be used later. A setup includes all the parameters, of the complete setup. The measuring setup is named and saved on the disk.

Directory
The field indicates the actual directory used for saving the program setup. The file extension for program setups is “PGM”.

Files
Displays the subdirectories and the “PGM” files in a directory.

- To change to a subdirectory, move the cursor to the name of the subdirectory. Press **ENTER** to select the name and **ENTER** again to go to the subdirectory

- To change to a parent directory, move the cursor to \... Press **ENTER** to select and **ENTER** again to go to the directory

- To change to another disk drive select the letter in brackets. Press **ENTER** to select and **ENTER** again to change drive

- Find the directory in which the program setup is to be saved, press **TAB** to select the name field, write the name, and then press **ENTER** to save. An existing name may be reused by moving the cursor to the name and pressing **ENTER** to select it.

  A previously made program setup may be deleted by

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selecting the program setup and pressing the **DELETE** button on the keyboard.

5.8.2 Save Display Setup

The save display setup command is used when a single display is to be use later. A display setup includes all the parameters of the active display. The display setup is named and saved on the disk.

Directory
The field indicates the directory used in which the display setup is saved. The file extension for display setups is “DIS”.

Files
Displays the subdirectories and the “DIS” files in a directory.

- To change to a subdirectory, move the cursor to the name of the subdirectory. Press **ENTER** to select the name and **ENTER** again to go to subdirectory.

- To change to a parent directory, move the cursor to \… Press **ENTER** to select and **ENTER** again to go to the directory.

- To change to another disk drive select the letter in brackets. Press **ENTER** to select and **ENTER** again to change drive.

- Find the directory in which the display setups is to be saved, press **TAB** to select the name field, write the name, and then press **ENTER** to save. An existing name may be reused by moving the cursor to the name and pressing **ENTER** to select it.

  A previously made display setup may be deleted by selecting the display setup and pressing the **DELETE** button on the keyboard.

5.8.3 Save Measurement

The save measurement command is used when a single measurement is to be used later. The measurement includes all the parameter of the display used in making the measurement is named and stored on the disk.

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Directory
This field indicates the directory used in which measurements are saved. The file extension for measurements is "MSM".

Files
Displays the subdirectories and the "MSM" files in a directory.

- To change a to a subdirectory, move the cursor to the name of the subdirectory. Press **ENTER** to select the name and **ENTER** again to go to the subdirectory.

- To change to a parent directory, move the cursor to \... Press **ENTER** to select and **ENTER** again to go to the directory.

- To change to another disk drive select the letter in brackets. Press **ENTER** to select and **ENTER** again to change drive.

- Find the directory in which the measurements is to be saved, press **TAB** to select the name field, write the name, and then press **ENTER** to save. An existing name may be reused by moving the cursor to the name and pressing **ENTER** to select it.

  A previously made measurement may be deleted by selecting the measurement and pressing the **DELETE** button on the keyboard.

5.8.4 Save White Reference

The save white reference command is used whenever a new white reference is to be saved for later use.

The CIE coordinates of the white reference are displayed for the user´s information. To change the coordinates, use the Learn White Reference command.

Save Ref.
The Save Reference field indicates the name of the white reference used in the active display. Delete the name and write a new one, or use the existing name. It is possible to change or delete the factory white references. The name of the white reference may consist of up to 15 characters.

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References
This field shows the names of existing references. If one of the existing names is to be reused, select this field and press **SPACE BAR** to move the name to the Save Ref. field. When a name is reused, the white reference previously under this name is overwritten and lost. To delete an existing white reference, find the white reference by using the cursor keys in the reference field and then press **DELETE** on the keyboard.

5.8.5 Save Phosphor

This menu can only be used when the active measuring display is an RGB one.

Save Phosphor
The Save Phosphor field indicates the name of the active phosphor compensation matrix. Write a new name or use the existing one.

Sensor ID
This field is for information only. The field shows the serial number of the colour sensor.

Phosphors
The Phosphors field lists the existing phosphor matrices. The content of the existing phosphor matrix is overwritten by the new phosphor matrix data if an existing name is reused. To reuse a name, move the cursor to this field by means of the **TAB** key, then use the cursor control to select the name to be reused. Press the **SPACE BAR** to move the Save Phosphor field.

Select *SAVE* to save a phosphor.

An existing matrix can be deleted, by finding the phosphor matrix in the Phosphors field using the cursor and pressing **DELETE** on the keyboard.

Note: It is not possible to delete a phosphor matrix, which is in use in any of the displays on the screen.

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5.9 Description of Restore Functions

5.9.1 Restore Program Setup

The restore program setup command is used to recall a complete measuring setup from the disk. A setup includes all the parameters of the complete setup.

Directory
This field indicates the directory used to recall the program setup. The file extension for program set-ups is “PGM”.

Files
Displays the subdirectories and the “PGM” files in a directory.

- To change to a subdirectory, move the cursor to the name of the subdirectory. Press **ENTER** to select the name and **ENTER** again to go to the subdirectory.

- To change to a parent directory, move the cursor to \… Press **ENTER** to select and **ENTER** again to go to the directory.

- To change to another disk select the letter in brackets. Press **ENTER** to select and **ENTER** again to change drive.

- Find directory from which the program setup is to be restored, then press **ENTER** to move the file name to the name field.

Name
This field contains the name of the program setup file to be restored. Select this field and press **ENTER**.

5.9.2 Restore Display Setups

The restore display setup command is used to restore a single display from the disk file. A display setup includes all the parameters needed to re-establish a measuring display.

Directory
This field indicates the directory used for recall of display setup. The file extension for display setups is “DIS”.

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Files
Display the subdirectories and the “DIS” files in a directory.

- To change to a subdirectory, move the cursor to the name of the subdirectory. Press **ENTER** to select the name and **ENTER** again to go to the subdirectory.

- To change to a parent directory, move the cursor to \… Press **ENTER** to select and **ENTER** again to go to the directory.

- To change to another disk select the letter in brackets. Press **ENTER** to select and **ENTER** again to change drives.

- Find the directory from which the display setup is to be restored, press **ENTER** to select the name field, and then press **ENTER** to restore.

Name
This field contains the name of the display setup file to be restored. Select the field and press **ENTER**.

5.9.3 Restore Measurement

The restore display setup command is used to restore a singe measurement from the disk file. A measurement includes the full display in use at the time the measurement was saved.

Directory
This field indicates the actual directory used to restoring of the measurement. The file extension for measurement is “MSM”.

Files
Displays the subdirectories and the “MSM” files within a directory.

- To change to a subdirectory, move the cursor to the name of the subdirectory. Press **ENTER** to select the name and **ENTER** again to go to the subdirectory.

- To change to a parent directory, move the cursor to \… Press **ENTER** to select and **ENTER** again to go to the directory.

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- To change to another disk select the letter in brackets. Press **ENTER** to select and **ENTER** again to change drive.

- Find the directory from which the measurement is to be restored, press **ENTER** to select the name field, and then press **ENTER** again to restore.

Name
This field contains the name of the measurement file to be restored. Select this field and press **ENTER**.

5.9.4 Restore White Reference

The restore white reference is used to restore a saved white reference so that it can be used in the active display.

The CIE coordinates of the white reference are displayed as information in the left side of the display. The coordinates always correspond to the white reference indicated by the cursor in the Restore Ref. field.

Restore Ref.
This field shows the name of the reference to be restored. The name changes according to the selection made in the Reference field.

References
This field shows the names of the existing references. Select the white reference you wish to restore, then press **ENTER** or select *RESTORE*. The restored white reference becomes active in the display, which was active when the *Main Menu Line* was activated.

5.9.5 Restore Phosphor

This command can only be used when the active display is an RGB one.

The restore phosphor command is used to restore saved phosphor so it can be used in the active display.

Restore Phosphor
The field shows the name of the phosphor to be restored. The name changes according to the selection made in the Phosphor field.

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Sensor ID
This field is for information only. The field shows the serial number of the colour sensor.

Phosphors
The field shows the names of the existing phosphors. Select the phosphor you wish to restore, then press **ENTER** or select *RESTORE*. The restored phosphor is now used in the display, which was active at the time *Main Menu Line* was activated.

5.10 Automatic Start

When the display program **PM39_01.EXE**, **PM39_20.EXE** or **PM39_25:EXE** is started, the PTV logo appears on the screen together with the software serial number. Press **ENTER** to get the display program main display screen. The default measuring setup is then opened and the measured may be started by use of the **Ctrl+F** key. This keyboard operation can be overruled by use of the following DOS parameter transfer option.

The option has following syntax:
PM 5639/01
PM39_01 [/**M**[:ON] Ω :OFF]] [/**F** [:FILE]]
PM5629/20/21
PM39_20 [/**M** [:ON Ω :OFF]] [/**F**[:FILE]]
PM 5639/25
PM39_25 [/**M**[:ON] Ω :OFF]] [/**F** [:FILE]]

/M:ON Specifies the measurement to start automatically after display of the PTV logo for 10 sec.

/M:OFF Specifies the measurement NOT to start automatically.
/M:OFF is the default setting.

/F:FILE Specifies the setup file FILE.PGM to be used at start up.
The PGM file is a program setup file previously saved in the program.
The default file is the default configuration file PM5639.CFG

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/? This help display, also /h and /H.

Example PM 5639/01
PM39_01 /M:ON /F:MYFILE

Example PM 5639/20/21
PM39_20 /M:ON /F:MYFILE

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6. The Software Modules

6.1 General Information

The software modules included in the Colour Analyser software package are delivered as compiled program files and source code files. The files make it possible for the user to integrate the Colour Analyser into user-defined (automatic) applications.

The software consists of several library functions, all integrated in a communication module.

The programs are written in Borland C++ 3.0, TURBO PASCAL 7.0 and QUICK BASIC 5.5.

6.2 Borland C++ 3.0 Communication Module

This communication module is written in Borland C++ 3.0, but should be able to apply to most C-compilers with only minor modifications.

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The communication module consists of several functions that can be implemented in any C-program written in Borland C++.

To use these functions:

In the Borland C++ 3.0 IDE-environment:
- Open a project and add the file **PM39IO.C.** In the module where the communication functions are to be used, include the file **PM39IO.H.**

Using the command-line compiler in DOS:
- Add the files **PM39IO.C** and **PM3920.H** to your makefile.

For both methods; be sure to compile with the case-sensitive Link Option on.

An example using the functions specified in PM39IO can be found in the file called **DEMO.C.**

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The following functions are available in the module (listed in order of functionality):

Open_TIME_TICK PM39IO

Function Installs an interrupt handler for the interrupt $1C_{HEX}$.

Syntax
```
#include <pm39io.h>
int Open_TIME_TICK (void);
```

Remarks Open_TIME_TICK prevents possible timeout error during communication with the Colour Sensor. It installs an interrupt handler for the interrupt $1C_{HEX}$, which is generated every timetick by the BIOS-interrupt 08_{HEX}. The new interrupt handler decreases a variable timeout_ok at every timetick (18.2 times/second) until 0.

Open_TIME_TICK is used to generate a timeout-condition in case of no communication with the Colour Sensor and should be implemented before any serial COM port is opened.

Open_TIME_TICK should only be called once even though two serial ports are opened.

Open_TIME_TICK can be omitted in a user program but in case of no communication with the coloursensor the programme is most likely to hang-up.

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See also **Open_COM**
List of Return Values.

Return value Open_TIME_TICK returns 0 on success or 8 if the interrupt handler already has been installed.

Close_TIME_TICK PM39IO

Function Restores the original interrupt handler for the interrupt $1C_{HEX}$.

Syntax #include <pm39io.h>
int Close_TIME_TICK(void);

Remarks Close_TIME_TICK restores the interrupt handler for the interrupt $1C_{HEX}$ which was saved when Open_TIME_TICK was installed.

See also **Open_TIME_TICK**
List of Return Values.

Return value Close_TIME_TICK returns 0 on success or 7 if the interrupt handler was not installed when this function was called.

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Open_COM PM39IO

Function Opens a serial port for communication with the Colour Sensor.

Syntax
#include <pm39io.h>
int Open_COM (int COM_Port, int Baud_Rate);

Remarks The parameter COM_Port specifies the serial communication port to be opened:

For standard PC
COM1 port-I/O at $3F8_{HEX}$, IRQ 4
COM2 port-I/O at $2F8_{HEX}$, IRQ 3
COM3 port-I/O at $3E8_{HEX}$, IRQ 4
COM4 port-I/O at $2E8_{HEX}$, IRQ 3

For the PS/2:
COM1 port-I/O at $3F8_{HEX}$, IRQ 4
COM2 port-I/O at $2F8_{HEX}$, IRQ 3
COM3 port-I/O at 3220_{HEX}, IRQ 3
COM4 port-I/O at 3228_{HEX}, IRQ 4

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The parameter Baud_Rate specifies the baudrate of serial communication port specified by COM-Port. Possible baudrates are:
Baud4800 which set the port at 4800 baud,
Baud9600 which set the port at 9600 baud.

Open_COM will initialise the specified serial port and local variables in the modules PM39IO.C, preparing the system for measuring with the Colour Sensor.

It is possible to open the two serial COM ports at the same time. These two ports must be connected to IRQ 3 and IRQ 4.

It is NOT possible to open two serial COM ports, which shares the same hardware interrupt.

Before using this function be sure to call the function Open_TIME_TICK. This should only be done once even though two serial ports are to be opened.

See also **Open_TIME_TICK, Close_COM**
List of Return Values.

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Return value Open_COM returns 0 on success otherwise:

1	Not enough memory to allocate variables
2	Serial COM port not supported
4	Serial COM port already installed
14	Wrong baudrate

Close_COM PM39IO

Function Closes a serial COM port formerly opened by Open_COM.

Syntax
```
#include <pm39io.h>
int Close_COM (int COM_Port);
```

Remarks Close_COM closes the serial communication port specified by the parameter COM_Port.

See also **Open_COM**
List of Return Values.

Return value Close_COM returns 0 on success otherwise:

2	Serial COM port not supported
3	Serial COM port was not installed

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Command_To_COM PM39IO

Function Transmits a command to the Colour Sensor.

Syntax
```
#include <pm39io.h>
int Command_To_COM (int COM_Port, char* str);
```

Remarks Command_To_COM transmits a command specified by the parameter str to the Colour Sensor via the serial port specified by the parameter COM_Port.

See also **List of Commands, List of Return Values.**

Return value Command_To_COM returns 0 on success otherwise:

2	Serial Com port not supported
5	Timeout transmitting data to serial COM port

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Start_Measuring PM39IO

Function Starts measuring in the Colour Sensor.

Syntax #include <pm39io.h>
int Start_Measuring (int COM_Port);

Remarks Initialise measuring in the Colour Sensor connected to the serial port specified by the parameter COM_Port. The measuring rate will depend upon the **integration time** in the Colour Sensor.

See also **Set_Integration_time, Get_Integration_Time, Stop_Measuring, List of Commands, List of Return Values.**

Return value Start_measuring returns 0 on success otherwise:
2 Serial COM port not supported.
5 Timeout transmitting data to serial COM port.

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Stop_Measuring PM39IO

Function Stops measuring in the Colour Sensor.

Syntax #include <pm39io.h>
in Stop_Measuring (int COM_Port);

Remarks Stops measuring in the Colour Sensor connected to the serial COM port specified by the parameter COM_Port.

See also **Start_Measuring, Command_To_COM**
List of Commands, List of Return Values.

Return value Stop_Measuring returns 0 on success otherwise:
2 Serial COM port not supported.
5 Timeout transmitting data to serial COM port

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Set_Integration_tTime PM39IO

Function Sets an integration time in the Colour Sensor.

Syntax #include <pm39io.h>
int Set_Integration_Time (int COM_Port, int time);

Remarks Set_Integration_Time specifies the number of measurements the Colour Sensor connected to the serial Com port specified by the parameter COM_Port handles per second. The parameter time is expressed in units of 0.5 ms where a time of 250 gives app. 3 measurements/second while a time of 25 gives app. 10 measurements/second.

Default value is 250, ie. app. 3 measurements/second.

To calculate the number of measurements/second the equation below can be used as a guideline:

Measurements/second = 1000/(1.2xtime+60)
Please note that this function is not supported by all types of colour sensor.

See also **Comman_To_COM, Get_Integration_Time**
List of Commands, List of Values.

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Return value Set_Integration_Time returns 0 on success otherwise:
2 Serial COM port not supported
5 Timeout transmitting data to serial COM port
9 Integration time is out of range

Get_Integration_Time PM39IO

Function Gets the integration time in the Colour Sensor.

Syntax #include <pm39io.h>
float Get_Integration_Time (int COM_Port);

Remarks Get_Integration_Time gets the actual integration time in the Colour Sensor connected to the COM port specified by the parameter COM_Port. The integration time is a value between 2.5 and 25.0, ie. the return value is 10 times smaller than the value used to set the integration time.

See also **Comman_To_COM, Set_Integration_Time**
List of Commands, List of Values.

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Return value Get-Integration_Time returns the integration time on success otherwise:

-2 Serial COM port not supported
-5 Timeout transmitting data to serial COM port
-6 Timeout receiving data from COM port

Get_ID PM39IO

Function Gets the ID information from the Colour Sensor.

Syntax

```
#include >pm39io.h>
int Get_ID (int COM_Port, IDINFO* SensorID);
```

Remarks GET_ID returns information about the Colour Sensor in the structure specified by the parameter SensorID:

Company:	Company name ie. “DK-Audio”
NC:	Sensor code number e.g. “400810978930
KuNo:	Sensor serial number e.g. “Ku000000”
Software Rev:	The Colour Sensor software version e.g. “02.0”
Sensor Type:	A number ≠ 0 and ≠ 16 which specifies the function of the Colour Sensor.

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See also **Command_to_COM**
List of Commands, List of Return Values.

Return Value Get_ID returns 0 on success otherwise:

2	Serial COM port not supported
5	Timeout transmitting data to serial COM port
6	Timeout receiving data from serial COM port
13	Wrong sensor

Get_Measurement PM39IO

Function Gets a measurement from the Colour Sensor.

Syntax
```
#include <pm39io.h>
int Get_Measurement (int COM_Port, MEASINFO* Meas);
```

Remarks Get_Measurement receives a measurement (CIE 1931 XYZ values) from the Colour Sensor connected to the serial COM port specified by the parameter COM_Port and calculates three different CIE-coordinates ie.

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CIE 1931 xy-coordinates
CIE 1976 u'v'-coordinates
CIE 1961 uv-coordinates

The measurement received will be the most recently transmitted values from the Colour Sensor ie. there is no buffer for older measurements.

See also **List of Commands, List of Return Values.**

Return value Get_Measurement returns 0 on success otherwise:

2	Serial COM port not supported
6	Timeout receiving data from serial COM port
10	White reference values NOT calculated
11	Overload
12	Lowlight

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List of Variables

Predefined variables/constans/definitions in **PM39IO.H:**
Two structures have been defined in the **PM39IO.H** module:
A structure called **IDINFO** used to contain the ID-information from the Colour Sensor, and the structure **MEASINFO** used to contain the measuring results from the Colour Sensor, ie.:

```
typedef struct {
        char Company [12];      /* ie. “DK-AUDIO” */
        char KuNo [9];          /* eg. “KU000000” */
        char nc [13];           /* ie. “400819978930” */
        char SoftwareRev [5]    /* eg. “02.0 */
        int SensorType;         /* MUST be <>0 and <>16 */
}IDINFO

typedef struct {
        int |Oerror;            /* Copy of return value, (error code) */
        float X, Y, Z;          /* Received CIE 1931 XYZ values */
        float whr[6];           /* Calculated CIE values: */* CIE 1931 xy, CIE 1976 u’v’, CIE 1960 uv */
}MEASINFO;
```

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Com1 to COM4 has been defined as 0 to 3 ie.

```
#define COM1 0
#define COM2 1
#define COM3 2
#define COM4 3
```

Baudrate definitions:

```
#define BAUD4800 4800
#define BAUD9600 9600
```

Predefined variables/constans/definitions in **PM39IO.C:**

Definitions:

```
#define_ENABLE_INTERRUPT asm {sti}
#define_DISABLE_INTERRUPT asm {cli}
#define_ENABLE_INTR_8259 asm {mov al 0x20; out 0x20, al}
```

Variables:

```
volatile timeout_ok          /* Timeout_ok will, when greater than zero, decrease by one every time tick */
char*PM39IOErrorTxt[14]      /* Text for the different error codes in PM39IO.C */
```

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List of Commands

The following list of the commands used to communicate with the Industrial Colour Sensor.
These commands can be used together with the PM39IO command: Command_To_COM.
Please note that ALL commands should be terminated with a semicolon ";" or a comma "," (the commands is given to the Colour Sensor as an abbreviation):

Command	Abbreviation	Function
Measure continous	MC	The Colour Sensor transmit data continuously
Measure stop	MS	The Colour Sensor stops transmitting data immediately
Forced integration time request	F?	The Colour Sensor transmits the integration time in 0.5 ms.
Identity request	I?	The Colour Sensor transmits the identity information, ie. Company: ie. "DK-AUDIO" NC: ie. "400810978930" KuNo: eg. "Ku000000" SoftWare Rev: eg. "02.0"

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Command	Abbreviation	Function
Memory address	MA n	Selects an address n in the internal EEPROM in the Colour Sensor
Read memory	RM	Reads a byte in the EEPROM in the Colour Sensor, address specified by the command MA
Store in memory	SM n	Stores byte n in EEPROM in the Colour Sensor, address specified by the command MA. The address in the EEPROM is incremented after this operation
Set integration time	SI n	Sets integration time in the Colour Sensor, time n specified in 0.5 ms.
Set baud rate	SB n	Sets the baud rate in the connected sensor. n = 48 selects 4800 baud; n = 96 selects 9600 baud
		Note: This command is not available with all sensor types. See the sensor specifications.

Other commands used during factory calibration, (these commands will have an effect on the Colour Sensor therefore these commands should be avoided in order for the Colour Sensor to function correctly): TM, FG, MO, SO, ST, NR, RN, XY, MX, WR

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List of Return Values

The following is a list of all the return values, (error codes), that the function in the PM39IO module can return.

Return Value	Explanation
0	**No error** Success, no errors detected.
1	**Not enough memory to allocate variables** Some of the variables are allocated dynamically during RUN-time. If the available memory is too small, this error occurs.
2	**Serial COM port not supported** The specified COM port is greater than 4 or less than 1. Only COM port 1 to 4 are supported, or the specified serial COM port are physical absent.
3	**Serial COM port was not installed** Trying to communicate with the Colour Sensor without having opened the serial COM port, which it is connected. Before using any commands be sure to have opened the specified serial COM port with the command Open_COM (int COM_Port);

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Return Value	Explanation
4	**Serial COM port already installed** Trying to open the same serial COM port twice.
5	**Timeout transmitting data to serial COM port** Timeout occurred during transmitting data to the Colour Sensor via the serial COM port. Since there is no handshake in the communication with the Colour Sensor this error indicates a fault in the UART, which handles the specified serial COM port.
6	**Timeout receiving data from a serial COM port** Timeout occurred during receiving data from the Colour Sensor. Be sure to check the cables and to ensure that the power supply is on.
7	**_TIME_TICK was not installed** Trying to close the __TIME_TICK function even though it hasn't been opened.
8	**_TIME_TICK already installed** Trying to open the _TIME_TICK function twice.

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Return Value	Explanation
9	**Integration time out of range** The specified time is to low or to high. The range of the integration time is: 25<=time <=250, where 25: gives app. 10 measurement per second and 250: gives app. 3 measurement per second.
10	**White reference value NOT calculated** The white reference values were not calculated because the values for X, Y or Z were too small, calculated as: (X + Y + Z) <0.01.
11	**Overload** The sensor in at least one of the channels is overloaded by too much light.
12	**Lowlight** The luminance has to be greater than or equal to 0.1 Cd/m^2, (~0.03 ftL).
13	**Wrong sensor** The attached Colour Sensor can not be used with this software package.
14	**Wrong baudrate** The specified baudrate is not supported.

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6.3 Turbo Pascal 7.0 Communication Unit

This communication unit has been written in Borland Turbo Pascal 7.0, but should be able to apply to most Pascal-compilers with only minor modifications.

The unit has also been compiled and tested in Borland Turbo Pascal 5.5, i.e. the software also applies to this version.

The communication unit consists of several functions that can be implemented in any Pascal-program written in Borland Turbo Pascal 5.5 or later.

To use these functions:
-Compile the **PM39IO.PAS** unit and include it the Pascal-program using the USES-statement.

An example using the functions specified in PM39IO can be found in the file: **DEMO.PAS.**

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The following functions are available in the module, (listed in order of functionality):

Open_TIME_TICK PM39IO

Function Installs an interrupt handler for the interrupt $1C_{HEX}$.

Declaration Function Open_TIME_TICK: integer;

Remarks Open_TIME_TICK prevents possible timeout errors during communication with the Colour Sensor. It installs an interrupt handler for the interrupt $1C_{HEX}$, which is generated every timetick by the BIOS-interrupt 0.8_{HEX}. The new interrupt handler decreases a variable **timeout_ok** at every timetick (18.2 times/second) until 0.

Open_TIME_TICK is used to generate a timeout-condition in case of no communication with the Colour Sensor and should be implemented **before** any serial COM port is opened.

Open_TIME_TICK should only be called once even though two serial ports are opened.

Open_TIME_TICK can be omitted in a user program but in case of no communication with the Colour Sensor the programme is most likely to hang-up.

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See also **Open_COM**
List of Return Values.

Return value Open_TIME_TICK returns 0 on success or 8 if the interrupt handler already has been installed.

Close_TIME_TICK PM39IO

Function Restores the original interrupt handler for the interrupt $1C_{HEX}$.

Declaration Function Close_TIME_TICK: integer;

Remarks Close_TIME_TICK restores the interrupt handler for the interrupt $1C_{HEX}$, which was saved when Open_TIME_TICK was installed.

See also **Open_TIME_TICK**
List of Return Values.

Return Value Close_TIME_TICK returns 0 on success or 7 if the interrupt was not installed when this function was called.

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Open_COM PM39IO

Function Opens a serial port for communication with the Colour Sensor.

Declaration Function Open_COM (COM_Port, Baud_Rate: integer):integer;

Remarks The parameter COM_Port specifies the serial communication port to be opened:

For standard PC
COM1 port-I/O at $3F8_{HEX}$, IRQ 4
COM2 port-I/O at $2F8_{HEX}$, IRQ 3
COM3 port-I/O at $3E8_{HEX}$, IRQ 4
COM4 port-I/O at $2E8_{HEX}$, IRQ 3

For the PS/2:
COM1 port-I/O at $3F8_{HEX}$, IRQ 4
COM2 port-I/O at $2F8_{HEX}$, IRQ 3
COM3 port-I/O at 3220_{HEX}, IRQ 3
COM4 port-I/O at 3228_{HEX}, IRQ 4

The parameter Baud_Rate specifies the baudrate of the serial communication post specified by COM_port. Possible baudrates are:

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Baud4800 which sets the port at 4800 baud.
Baud9600 which sets the port at 9600.

Open_COM will initialise the specified serial port and local variables in unit PM39IO.PAS, preparing the system for measuring with the Industrial Colour Sensor.

It is possible to open two series COM ports at the same time. These two ports must be connected to IRQ 3 and IRQ 4. It is NOT possible to open two serial COM ports, which shares the same hardware interrupt.

Before using this function be sure to call the function **Open_TIME_TICK.** This should only be done once even though two serial ports are to be opened.

See also **Open_TIME_TICK, Close_COM**
List of Return Values.

Return Value Open_COM returns 0 on success otherwise:

2	Serial COM port not supported
4	Serial Com port not installed
14	Wrong baudrate

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Close_COM PM39IO

Function Closes a serial COM port formerly opened by Open_COM.

Declaration Function Close_COM (COM_Port: integer): integer;

Remarks Close Open_COM closes the serial communication port specified by the parameter COM_Port.

See also **Open_COM**
List of Return Values.

Return Value Close_COM returns 0 on success otherwise:
2 Serial COM port not supported
3 Serial COM port was not installed

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Command_To_COM PM39IO

Function Transmits a command to the Colour Sensor.

Declaration Function Command_To_COM (COM_Port: integer; str: string): integer;

Remarks Command_To_COM transmits a command specified by the parameter str to the Colour Sensor via the serial port specified by the parameter COM_Port.

See also **List of Commands, List of Return Values.**

Return Value Command_To_COM returns 0 on success otherwise:

2 Serial CoOM port not supported

5 Timeout transmitting data to serial COM port

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Start_Measuring PM39IO

Function Starts measuring in the Colour Sensor.

Declaration Function Start_Measuring (COM_Port: integer):integer;

Remarks Initialise measuring in the Colour Sensor connected to the serial port specified by the parameter COM_Port. The measuring rate will depend upon the **integration time** in the Colour Sensor.

See also **Set_Integration_time, Get_Integration_Time, Stop_Measuring**
List of Commands, List of Return Values.

Return Value Start_Measuring returns 0 on success otherwise:

2 Serial COM port not supported

5 Timeout transmitting data to serial COM port

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Stop_Measuring PM39IO

Function Stops measuring in the Colour Sensor.

Declaration Function Stop_Measuring(COM_Port: integer):integer;

Remarks Stops measuring in the Colour Sensor connected to the serial COM port specified by the parameter COM_Port.

See also **Start_Measuring, Command_To_COM**
List of Commands, List of Return Value.

Return Value Stop_Measuring returns 0 on success otherwise:
2 Serial COM port not supported
5 Timeout transmitting data to serial COM port

Set_Integration_Time PM39IO

Function Sets an integration time in the Colour Sensor.

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Declaration Function Set_Integration_Time (COM_Port, time: integer): integer;

Remarks Set_Integration_Time specifies the number of measurements the Colour Sensor connected to the serial COM port specified by the parameter COM_Port handles per second. The parameter time is expressed in units of 0.5 ms where a time of 250 gives app. 3 measurements/second while a time of 25 gives app. 10 measurements/second.

Default value is 250, ie. app. 3 measurements/second.

To calculate the number of measurements/second the equation below can be used as a guideline:

measurements/second = 1000/(1.2 x time + 60)

See also **Command_To_COM, Get_Integration_Time**
List of Commands, List of Return Value.

Return Value Set_Integration_Time returns 0 on success otherwise:

2 Serial COM port not supported
5 Timeout transmitting data to serial COM port
9 Integration time out of range

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Get_Integration_Time PM39IO

Function Gets the integration time in the Colour Sensor.

Declaration Function Get_Integration_Time(COM_Port;integer; **var** time real):integer;

Remarks Get_Integration_Time gets the actual integration time in the Colour Sensor connected to the COM port specified by the parameter COM_Port. The integration time is a value between 2.5 and 25.0, ie. the return value is ten times smaller than the value used to set the integration time.

See also **Command_To_COM, Set_Integration_Time**
Lis of Commands, List of Return Value.

Return Value Get_Integration_Time returns 0 on success, giving the integration time in the variable time on success, otherwise:

1	Error in received data
2	Serial COM port not supported
5	Timeout transmitting data to serial COM port
6	Timeout receiving data from serial COM port

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Get_ID PM39IO

Function Gets the ID information from the Colour Sensor.

Declaration Function Get_ID(COM_Port: integer; **var** SensorID: IDINFO): integer;

Remarks Get_ID returns information about the Colour Sensor in the record specified by the parameter SensorID:

Company:	Company name ie. “DK-AUDIO”.
NC:	Sensor code number e.g. “400810978930”.
KuNo:	Sensor serial number e.g. “Ku000000”.
SoftWare Rev:	The Colour Sensor software version e.g. “02.0”.
Sensor Type:	A number <> 0 and <> 16 which specified the function of the Colour Sensor.

See also **Command_To_COM**
List of Commands, List of Return Value.

Return Value Get_ID returns 0 on success otherwise:

1	Error in received data
2	Serial COM port not supported
5	Timeout transmitting data to serial COM port
6	Timeout receiving data from serial COM port
13	Wrong sensor

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Get_Measurement PM39IO

Function Gets a measurement from the Colour Sensor.

Declaration Function Get_Measurement (COM_Port: integer; **var** Meas: MEASINFO): integer;

Remarks Get_Measurement receives a measurement (CIE 1931 XYZ values) from the Colour Sensor connected to the serial COM port specified by the parameter COM_Port and calculates three different CIE-coordinates i.e.

CIE 1931 xy-coordinates
CIE 1976 u'v'-coordinates
CIE 1961 uv-coordinates

The measurement received will be the most recently transmitted measurement from the Colour Sensor ie. there is no buffer for older measurements.

See also **List of Commands, List of Return Value.**

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Return Value Get_Measurement returns 0 on success otherwise:

1	Error in received data
2	Serial COM port not supported
6	Timeout receiving data from serial COM port
10	White reference values NOT calculated
11	Overload
12	Lowlight

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List of Variables

Predefined variables/constans/definition in **PM39IO.PAS:**

A record called IDINFO used to contain the ID-information from the Colour Sensor, and the record **MEASINFO** used to contain the measuring results from the Colour Sensor, ie.:

```
IDINFO = record
        Company: string [12];          {ie. “DK-AUDIO” }
        KuNo: string [8];              {e.g. “Ku000000”}
        nc: string [12];               {ie. “400810978930”}
        SoftWare Rev: string [4]       {e.g. “02.0”}
        Sensor Type: integer;          {MUST be <> 0 and <> 16}
end;
```

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```
MEASINFO = record
        |Oerror: integer;          {Copy of return value, (error code)}
        X, Y, Z: real              {Received CIE 1931 XYZ values}
        whr: array [0..5] of real; {Calculated CIE values:}
                                   CIE 1931 xy, CIE 1976 u'v', CIE 1960 uv}
end;
```

COM1 to COM4 have been defined as constants namely 0 to 3.

Baud4800 and Baud9600 have been defined as constants namely 4800 and 9600.

const PM39IOErrorTxt {Text for the different error codes in PM39IO.PAS}

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List of Commands

The following is a list of the commands used to communicate with the Industrial Colour Sensor.
These commands can be used together with PM39IO command: Command_To_COM.
Please note that all the commands should be terminated with a semicolon ";" or a comma "," (the command is given to the Colour Sensor as an abbreviation):

Command	Abbreviation	Function
Measure continuous	MC	The Colour Sensor transmits data continuously
Measure stop	MS	The Colour Sensor stops transmitting data immediately
Forced integration time request	F?	The Colour Sensor transmits the integration time in 0.5 ms
Identity request	I?	The Colour Sensor transmits the identity information, ie. Company: ie."DK-AUDIO" NC: eg. "400820978930" KuNo: eg. "Ku000000" SoftWareRev: eg. "02.0"

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Command	Abbreviation	Function
Memory address	MA n	Selects an address n in the international EEPROM in the Colour Sensor.
Read memory	RM	Reads a byte in the EEPROM in the Colour Sensor, address specified by the command MA.
Store in memory	SM n	Stores by n in EEPROM in the Colour Sensor, address specified by the command MA. The address in the EEPROM in incremented after this operation.
Set integration time	SI n	Sets integration time in the Colour Sensor, time specified in 0.5 ms.
Set baud rate	SB n	Sets the baud rate in the connected colour sensor. n = 48 selects 4800 baud; n = 96 selects 9600 baud Note: This command is not valuable with all sensor types. See the sensor specifications.

Other commands used during factory calibration, (these commands will have a non permanent effect on the Colour Sensor and should be avoided in order for the Colour Sensor to function correctly): TM, FG, MO, SO, ST, NR, RN, XY, MX, WR

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List of Return Values

The following is a list of all the return values, (error codes), that the functions in the PM39IO module can return.

Return Value	Explanation
0	**No error** Success, nor error detected.
1	**Error in received data** The string(s) received from the industrial Colour Sensor could not be converted to an integer, (or real).
2	**Serial COM port not supported** The specified COM port is greater than 4 or less than 1. Only COM port 1 to 4 are supported, or the specified serial COM port are physical absent.
3	**Serial Com port was not installed** Trying to communicate with the Colour Sensor without having opened the serial COM port to which it is connected. Before using any commands be sure to have opened the specified serial COM port with the opening command Open_COM (int COM_Port);

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Return Value	Explanation
4	**Serial COM port already installed** Trying to open the same serial port twice.
5	**Timeout transmitting data to serial COM port** Timeout occurred during transmitting data to the Colour Sensor via serial COM port. Since there is no handshake in the communication with the Colour Sensor this error indicates a fault in the UART, which handles the specified serial COM port.
6	**Timeout receiving data from serial COM port** Timeout during receiving data from the Colour Sensor. Be sure to check the cables and to ensure that the power supply is on.
7	**_TIME_TICK was not installed** Trying to close the _TIME_TICK function even though it hasn't been opened.
8	**_Time_TICK already installed** Trying to open the TIME_TICK function twice.

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Return Value	Explanation
9	**Integration time out of range** The specified time is too low or too high. The range of the integration time is: 25 <=time <=250, where 25: gives app. 10 measurement per second and 250: gives app. 3 measurement per second.
10	**White reference values NOT calculated** The white reference values were not calculated because the values f X, Y or Z were too small, (calculated as: (X + Y + Z) < 0.01)
11	**Overload** The sensor in at least one of the channels is overloaded by too much light.
12	**Lowlight** The luminance has to be greater than or equal to 0.1 Cd/m^2. (~0.03 ftL).
13	**Wrong sensor** The attached Colour Sensor can not be used with this software package.
14	**Wrong baudrate** The specified baudrate is not supported.

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6.4 BASIC Demonstration Program

This demonstration has been written in Quick Basic 4.5, but should be able to apply to most BASIC-compilers/interpreters with only minor modifications.

To accommodate as many BASIC-compilers/interpreters as possible, the program does not use advanced structures, labels etc..

The demonstration program consists of a main routine and 10 subroutines, each called by the linenumber in which it starts. These routines are:

Line	Name
5	Main program
1000	Initialise serial COM port
1050	Wait for serial data and timeout
1100	Start measuring in the Colour Sensor
1150	Stop measuring in the Colour Sensor

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1200 Set integration time in the Colour Sensor
1300 Get integration time in the Colour Sensor

1400 Get ID from the Colour Sensor
1800 Receive measurement from serial COM port

2000 Error handler routine
2200 Colour Sensor error routine

The following description is based on the line numbers in the BASIC-file, DEMO.BAS, which is also printed at the end of this text *(please refer to Appendix A).*

Line 5 - 994: Main Program

The program to demonstrate the use of the industrial Colour Sensor uses the serial COM port COM1.

Line 10 – 170 initialise variables and constants used throughout the example.

Line 180 redirects any hardware-error to the subroutine 2000: the error handler routine.

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Line 190 – 570 generates a display for showing the measurements from the Colour Sensor.

Line 570 – 994 initialises the serial COM port: COM1, sets the number of measurement per second to app. 10 and display two results: The CIE 1931 XYZ values and the CIE 1931 xy-coordinates together with the luminance.

To end the demonstration press **ESCAPE.**
Line 1000 –1020: Initialise the serial COM port.

Two variables are used to define the serial COM port:

The string COMPORT$ contains the COM port to open, e.g. “COM2”, while COMNO contains the filenumber to associate with the serial COM port and COMBAUD contains the baudrate for the COM port. The baudrate may be either 4800 or 9600.

The serial COM port is opened for both input and output, and is initialised to 4800 or 9600 baud, 8 data-bit, 2 stop-bit, no parity. Furthermore it is set to ignore timeout from CS, (Clear to Send) and DS, (Data Carrier Detect).

Line 1050 – 1090: Wait for Serial Data or Timeout

This routine has been added to prevent the program from crashing in case of any errors receiving data from the Colour Sensor.

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The routine enters a loop until data has been received from the serial COM port, tested by the BASIC command, **LOC**, or a predefined time-period has been exceeded, (in this program-example a period of 3 seconds has been defined by the variable TIMEOUTMAX).

Line 1100 –1120: Start measuring in the Colour Sensor

Issue the “Start measuring”–command to the Colour Sensor.
Please refer to the List of Commands.

The Colour Sensor starts transmitting measurements continuously to the serial COM port. The measurements transmitted will be CIE 1931 XYZ-values.

Line 1150 – 1170: Stop measuring in the Colour Sensor

Issue the “Stop measuring”-command to the Colour Sensor.
Please refer to the List of Commands.

The Colour Sensor stops transmitting measurements.

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Line 1200 –1245: Set integration time in the Colour Sensor.

Issue the “Set integration time”-command to the Colour Sensor.
Please refer to the List of Commands.

It is possible to specify the approximate of measurements per second the Colour Sensor will transmit via the serial COM port. The variable INTEGRATIONTIME is expressed in units of 0.5 ms where a value of 250 gives app. 3 measurements/second and a value of 25 gives app. 10 measurements/second.

Default value in the Colour Sensor is set to 250 ie. app. 3 measurements/second.

To calculate the number of measurements/second the calculation below can be used as a guideline:
measurements/second = 1000/(1.2 x integrationtime + 60)

The allowed range for the value of INTEGRATIONTIME is;
25 <= INTEGRATIONTIME <=250

If this range is exceeded the error-variable COMERROR will be set to 3, otherwise it will be set to zero, 0.
Please note that this function is not supported by all types at colour sensor.

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Line 1300 – 1360: Get integration time from the Colour Sensor

To read the actual integration time in the Colour Sensor issue the “Forced integration time”-command to the Colour Sensor. *Please refer to the List of Commands.*

The value received is expressed in units of 5 ms, ie. the integration time received will be a value between 2.5 and 25.0. Please note that this is 10 times less than the number used to set the integration time.

Line 1400 – 1675: Get ID from the Colour Sensor

To get information about the Colour Sensor connected to the serial COM port, issue the “Identity request”-command to the Colour Sensor.
Please refer to the List of Commands.

After issuing this command the Colour Sensor will transmit a string with the following information separated by commas:

Company:	ie. “DK-AUDIO”
NC:	Sensor code no eg. “400810978930”
KuNo:	Sensor serial no. eg. “KU000000”
SoftWareRev:	Colour Sensor revision eg “02.0”

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For the software to operate correctly is essential that the Colour Sensor is programmed to use together with the software. To ensure that the right Colour Sensor is used it is necessary to read information in built-in EEPROM memory.

This is done by issuing two commands to the Colour Sensor. The first command defining the address of the internal EEPROM, the second command reading the information at that location.

The information read is a byte, which MUST be ≠ 0 and ≠ 16. If any of these values is received the error-variable COMERROR is set to 7.

Line 1800 – 1995: Read latest measurement from the Colour Sensor

This routine demonstrates how to receive measurements from the Colour Sensor. After issuing the command “Start measuring” to the Colour Sensor it will transmit measurements continuously, thereby leaving out the necessity to ask for measurements.

To ensure that the measurement read is the latest, all previous measurements, which might be in the input-buffer have to be deleted. This is done by reading all data in the input-buffer saving only the last measurement. By using the BASIC command, **LINE INPUT #COMNO, INDATATMP$** a complete measurement is read into the variable INDATATMP$. The measurement is a string of 20 characters terminated with a Carriage Return, 0DHEX, ie.

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characters 1 to 6 : X-value
character 7 is a comma
characters 8 to 13 : Y-value
character 14 is a comma
character 15 to 20 : Z-value

After converting these strings to floating point variables using the BASIC-command, **VAL** the values are checked for LOWLIGHT and OVERFLOW, ie.
OVERFLOW has occurred whenever the received X-value is lower than or equal to –0.5, while **LOWLIGHT** occurred whenever one of the received values are less than or equal to 0.01.

The CIE-coordinates are stored in the floating point array WHR(6) as:
CIE 1931 xy-coordinates x = WHR(0), y = WHR(1)
CIE 1976 u'v'-coordinates u' = WHR(2), v' = WHR(3)
CIE 1960 uv-coordinates u = WHR(4), v = WHR(5)

While the received measurement, CIE 1931 XYZ-values, are stored in the variables; X, Y, Z.

In case of no errors ALL the variables will be calculated and the error-variable COMERROR set to zero, 0.

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Error conditions:

If the sum of the received values are too small, (X+Y+Z <= 0.01), the CIE coordinates will not be calculated and COM-ERROR is set to 4.

If the received X-value is less than –0.5, (x <= -0.5) there is too much light for the Colour Sensor to operate correctly, and COMERROR is set to 5.

If any of the three received values are less than 0.01, (X <= 0.01 and Y <= 0.01 and Z <= 0.01), there is not enough light for the Colour Sensor to operate correctly, and COMERROR is set to 6.

If a timeout occurred trying to receive a measurement from the Colour Sensor COMERROR is set to 2.

Line 2000 – 2120: Error handler

The error handler routine traps any hardware-errors during communication with the Colour Sensor. In order for the routine to work the BASIC-command, **ON ERROR GOTO 2000** has to be inserted at the beginning of the program.

In this example only two errors are detected:

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1. Communications buffer overflow, (BASIC ERR = 69)

To ensure that the measurement read from the Colour Sensor always is read in “real-time” i.e. data should not be delayed in the input-buffer, the input-buffer is only read during calls to subroutine 1800: **Read latest measurement from the Colour Sensor,** in which case the buffer is emptied. If the time between call to subroutine 1800 are to long, the input-buffer will generate an overflow.
To flush the input buffer the serial COM port is closed and re-opened.

2. Device unavailable, (BASIC ERR = 68)

This error occurs if trying to open a serial COM port, which is not physical present in the computer. The routine generates an error message, (the calling of the subroutine 2200), and ends the demonstration immediately.

Line 2200 – 2240: Colour Sensor Error handler

This routine prints an error-message based upon the variable COMERROR, which specifies the type of error, and the string-array ERRORTXT$(COMERROR), which contains the explanation for the generated error.

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List of Commands

The following is a list of commands used to communicate with the Industrial Colour Sensor. These commands can be issued to the Colour Sensor using the BASIC-command, PRINT #COMNO. “command”;
Please note that all the commands should be terminated with a semi-colon “;” or a comma “,” (the command is given to the Colour Sensor as an abbreviation):

Command	Abbreviation	Function
Measure continuously.	MC	The Colour Sensor transmits data continuous
Measure stop	MS	The Colour Sensor stops transmitting data immediately.
Forced integration time request	F?	The Colour Sensor transmit the integrated time in units of 5 ms.
Identity request	I?	The Colour Sensor transmits the identity information, ie. Company: ie. “DK-AUDIO” NC: eg. “400810978930” KuNo: eg. “KU000000” SoftWareRev: eg. “02.0”

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Command	Abbreviation	Function
Memory address	MA n	Selects an address n in the inernal EEPROM in the Colour Sensor.
Read memory	RM	Reads a byte in the EEPROM in the Colour Sensor, address specified by the command MA.
Store in memory	SM n	Stores byte n in EEPROM in the Colour Sensor, address specified by the command MA. The address in the EEPROM is incremented after this operation.
Set integration time	SI n	Sets integration time in the Colour Sensor, time n specified in 0.5 ms.
Set baud rate	SB n	Sets the baud rate in the connected Colour Sensor. n=48 selects 4800 baud; n=96 selects 9600 baud. Note: This command is not available with all sensor types. *See the sensor specifications.*

Other commands used during factory calibration, (these commands will have a non permanent effect on the Colour Sensor and should be avoided in order for the Colour Sensor to function correctly): TM, FG, MO, SO, ST, NR, RN, XY, MX, WR

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SERVICE INSTRUCTIONS

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7. General

7.1 Safety

WARNING: The opening of covers or removal of parts, except those to which access can be gained by hand, is liable to expose live parts. Accessible terminals may also be live.

The instrument must be disconnected from all voltage sources before performing any adjustment, replacement, maintenance, or repair which requires the instrument to be opened. If adjustment, maintenance, or repair of the opened instrument is unavoidable, it must only be carried out by a skilled person who is aware of the hazards involved.

7.1.1 Replacement of Components

Components, which are important for the safety of the instrument may only be renewed by components obtained during your local DK-Audio representative.

See the List of Spare Parts (Chapter 9) for further information.

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8. Description of the block diagram

8.1 Main Function of the Colour Sensor

The colour sensor circuits form an intelligent measuring device, which receives optically filtered light from a monitor CRT. This information is converted into numerical values corresponding to the light levels. Then the XYZ or MX values are transmitted in digital serial form (RS232) to the connected PC, where the measuring results are presented in different ways.

CAUTION: Since the colour sensor is a highly sophisticated circuit, and most of its components are critical for performance, **any** attempt to service the colour sensor (including opening cover) must be followed by a recalibration. This calibration can only be done by DK-Audio.

8.1.1 Input Amplifier & Pre-Filter

The optically filtered light from the CRT is fed into three highly stable photodiodes, which individually receives the red, green, and blue light and thereby generate proportional signal currents. These very small photodiode signals are current to voltage transformed, and the same time low pass filtered by active filters build around high precision operational amplifiers. As a result of the TV scanning technique a mainly field frequent AC component is superimposed on the wanted DC signal. The input low pass filters remove most of the AC component while the remaining part is removed later by an active filter stage.

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8.1.2 Gain Selector

The gain of the three input amplifiers are individually defined by use of three highly accurate six-step gain selectors, which are software calibrated. The actual selection of gain steps are controlled by the microcontroller, which sets the gain individually for each channel in order to obtain an output signal in a certain range.

8.1.3 2nd order Low Pass Filter

To complete the pre-filtering performed in the input filter each of the channels are further equipped with a second-order active low pass filter. The overall filter response assures, that problems with TV raster scanning interference or aliasing problems in the analogue-to-digital conversion process are avoided.

8.1.4 Input Selector

The input selector consists of an analogue multiplexer (MUX), which under control of the microcontroller, feeds the channel signal through to the A/D converter one by one in a cyclic base.

8.1.5 Analogue to Digital Converter

The A/D converter converts the analogue input voltage to a pulse with a corresponding duration. A timer function in the microcontroller finally converts the pulse duration into a numerical value representing the conversion result. The converter is of the dual slope integrating type, and has a very high resolution.

8.1.6 Microcontroller

The microcontroller continuously measures the three input signals and communicates with the connected display unit along the RS232 line. The microcontroller cor-

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rects the measured values with the initial calibration data, which are stored in an EEPROM, before the results are transmitted via the RS232 line. A watch-dog function will reset the microcontroller in case of abnormal program execution and serves as a power on/off reset.

8.1.7 Power Supply

Power is fed from the separate power supply unit in the form of a stable 5V supply. The 5V is converted to approximately ±8V in the RS232 interface IC to correspond to RS232 specifications. This ±8V supply is regulated to ±5V in linear regulators to give a smooth and stable analogue power supply.

8.1.8 Connections

“XA#” on the block diagram indicates the pin numbers on the 9 pole female connector on the colour sensor.

XA Connector:

Pin:	Function:
1	NC
2	RXD
3	TXD
4	NC
5	GND (0V)
6	NC
7	NC
8	NC
9	+5v

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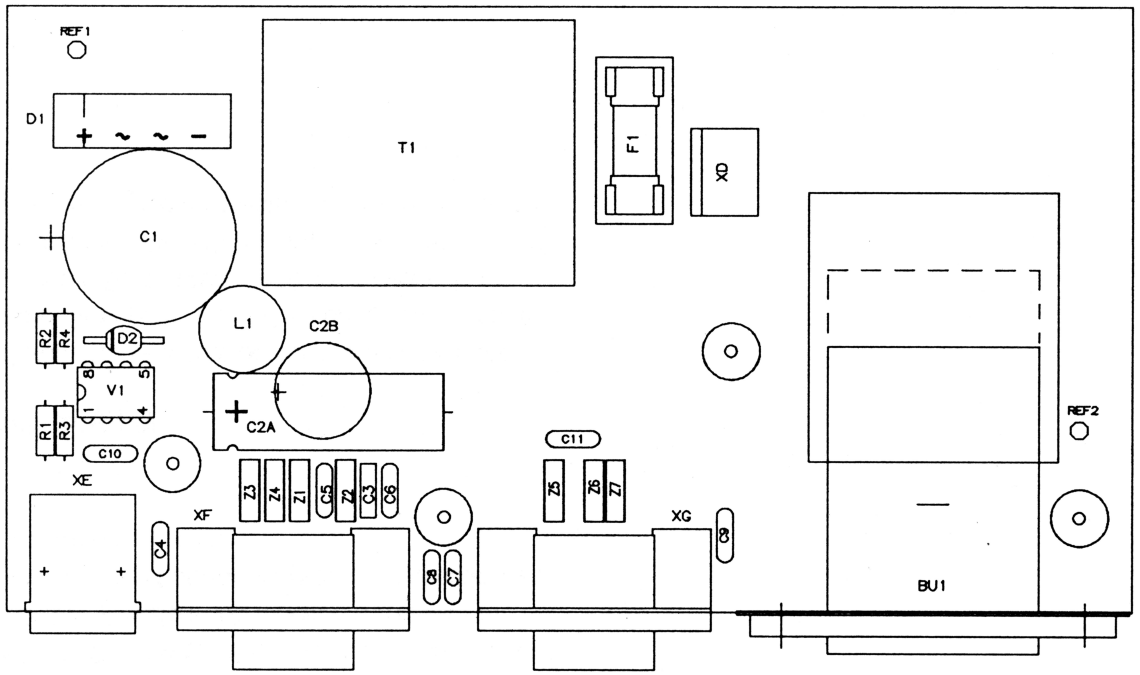

Fig. 8-1 Component location – Power Supply

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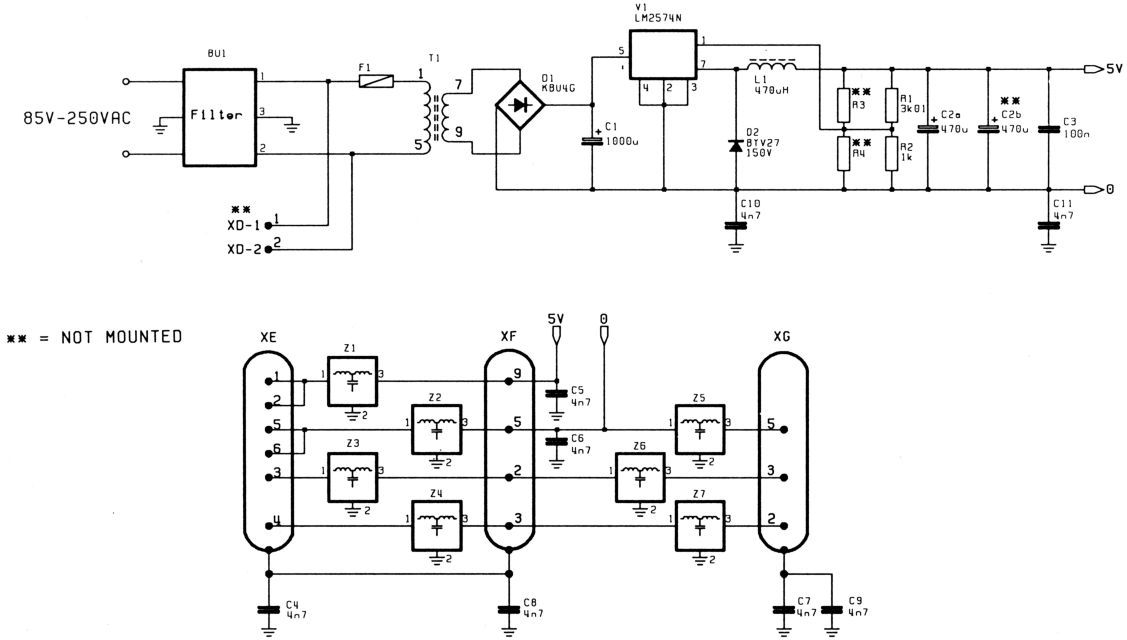

Fig. 8-2 Circuit diagram – Power Supply

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9. List of Spare Parts

Ordering number	Description
4008 105 03040	9/9-pole interface cable for use between power supply box and colour sensor (and for use between PC and power supply box)
4008 105 03120	9/25-pole interface cable for use between PC and power supply box
4008 105 00020	Mains cable (Euro)
4008 105 00030	Mains cable (US)
4008 105 01390	Mains cable (UK)
4008 108 04860	Rubber shadow ring for PM5639/93

Power supply box

4008 109 85880	Power Supply box complete

Item	Ordering number	Description
T1 (S)	4008 100 12200	Mains transformer
BU1 (S)	4008 103 60160	Mains connector and filter
F1 (S)	2422 086 00008	Fuse 100 mA fast 5x20 mm

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Item	Ordering number	Description
XE	2422 025 10236	6-pole connector, female
XF	2422 025 09755	9-pole connector, male
XG	2422 025 11993	9-pole connector, female
V1	9322 052 61682	LM2574HVN
D1	4008 102 60180	Type 2 rectifier, 0.8A
D2	9335 435 10112	BYV27-150
C1	2222 058 58102	1000U, +/-20%, 63V
C2	2222 118 90508	470U, -10+50%, 25V
C3	2222 370 11104	100N +/-10%, 63V
C4-11	2222 630 19472	4N7, +/-10%, 100V

(S) = Safety Component

Components, which are important for the safety of the instrument may only be renewed by components obtained during your local DK-Audio Organization.

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APPENDICES

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Appendix A – Demonstration Program (industrial version)

Listing of the demonstration program file, DEMO.BAS

```
5       'DEMONSTRATION WRITTEN IN QUICKBASIC 4.5

10      COMPORT$    = "COM1"        'Serial Communication port COM1
20      COMNO       = 1             '           -"-
25      COMBAUD     = 4800          Baudrate for COM1

30      'COMPORT$   = "COM2"        'Serial communication port COM2
40      'COMNO      = 2             '           -"-
45      'COMBAUD    = 4800          'Baudrate for COM2

50      MAXTIMEOUT  = 3             'Timeout value for 3 seconds.

60      DIM WHR (5)                 'Array for CIE coordinates, (xy, uv & u'v')
70      DIM IDINFO$ (4)             Array for Identity Information from the
                                    'Colour Sensor
80      DIM IDPOS (2)               'Temporary Array.
90      DIM ERRORTXT$ (7)
```

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```
100     'Error messages:

110     ERRORTXT$ (0)= "No error"
115     ERRORTXT$ (1)= "Serial COM port not supported"
120     ERRORTXT$ (2)= "Timeout receiving data from serial COM port"
130     ERRORTXT$ (3)= "Integration time out of range"
140     ERRORTXT$ (4)= "White reference values NOT calculated"
150     ERRORTXT$ (5)= "Overload"
160     ERRORTXT$ (6)= "Lowlight"
170     ERRORTXT$ (7)= "Wrong sensor"
175     ERRORTXT$ (8)= "Wrong baudrate"

180     ON ERROR GOTO 2000          'Error handler routine

190     '
200     '*********Main program*********
210     '

220     COLOR 7, 1, 1
230     CLS

240     COLOR 0, 7, 7
250     LOCATE 1, 1
290     PRINT                   "DK-Audio A/S, Marielundvej 37D, DK-2730 Herlev, Denmark "
```

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```
270     COLOR 14, 1, 1
280     LOCATE  2, 3
290     PRINT               "PM5639 Industrial Colour Sensor Demonstration Program"

300     COLOR 15 1, 1
310     LOCATE 5, 2
320     PRINT               "Shows measurements from the PM5639 Industrial Colour Sensor"
330     LOCATE 7, 2
340     PRINT               "in CIE 1931 XYZ coordinates:"
350     LOCATE 13, 2

360     PRINT               "in CIE 1931 xyz coordinates"

370     LOCATE 19, 9
380     PRINT  ----------"STATUS"----------

390     LOCATE 20, 9
400     PRINT               "  I                                    I  "

410     LOCATE 21, 9
420     PRINT               "  I                                    I  "
430     LOCATE 22, 9
440     PRINT               "  I                                    I  "
```

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```
450     LOCATE 23, 9
460     PRINT           " ---------------------------------------------- "

470     COLOR 14, 1, 1
480     LOCATE 9, 22
490     PRINT                       " X       Y       Z"

500     LOCATE 15, 22
510     PRINT                       "x         y       Y"

520     LOCATE 24, 9
530     PRINT                       "press  <ESC>  to EXIT";

540     COLOR 15, 1, 1

550     LOCATE 21,  21
560     PRINT                       "Initialising Colour Sensor. Please Wait!"

570     GOSUB  1000                 "Initialise the serial COM port.
575     IF COMERROR = 0 then
580     INTEGRATIONTIME = 25
590     GOSUB 1200                  'Set integration time in the Colour Sensor' (a value of 25
                                    gives app. 10 measurements/s)
```

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```
610     IF COMERROR = 0 THEN
620     GOSUB 1300                  'Get integration time from the Colour Sensor

630     IF COMERROR = 0 THEN

640     GOSUB 1400                  'Get ID from the Colour Sensor
650     IF COMERROR = 0 THEN

660     GOSUB 1100                  'Start measuring in the Colour Sensor

670     DO

680     GOSUB 1800:                 'Receive LATEST measurement

690     IF COMERROR = 0 THEN
700     IF DATAREADY = 1 THEN

710     LOCATE 21,  12
720     PRINT                       "                       "
730     DATAREADY = 0

740     LOCATE 10,  22
750     PRINT USING                 "######.## ######.## ######.##"; X; Y; Z
```

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```
760     LOCATE 16,  22
770     PRINT USING                 "#####.## #####.## #####.##"; WHR (0); WHR (1); Y

780     END IF
790     ELSE

800     LOCATE 10,  22
810     PRINT                       "                           "

820     LOCATE
830     PRINT                       "                           "

840     GOSUB 2200
850     END IF

860     LOOP WHILE INKEY$ <> CHR$ (27)
870     END IF
880     END IF
885     END IF
890     END IF
900     IF COMERROR <> 0 THEN
910     GOSUB 2200
```

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```
915     STARTTIMER = TIMER              'Make a 2 seconds delay
917     TIMEOUT = 0

919     WHILE (TIMEOUT < 2)
922     TIMEOUT = TIMER – STARTTIMER
924     WEND
930     END IF

940     LOCATE 21,  12
950     PRINT                           "                                "

960     LOCATE 21,  23
970     PRINT                           "Beginning to shut down. Please Wait!"
972     STARTTIMER = TIMER              ' Make a 2 seconds delay

974     TIMEOUT = 0
976     WHILE (TIMEOUT < 2)
980     TIMEOUT = TIMER – STARTTIMER

990     GOSUB 1150                      *Stop measuring in the Colour Sensor
991     CLOSE #COMNO                    'Close Serial COM port.
992     COLOR 7 ,  0,  0
993     CLS
994     END
```

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```
'Subroutines:
' 1000: Initialise serial COM port.
' 1050: Wait for Serial Data and Timeout.
' 1100: Start measuring in the Colour Sensor.
' 1150: Stop measuring in the Colour Sensor.
' 1200: Set integration time in the Colour Sensor.
' 1300: Get integrated time from the Colour Sensor.
' 1400: Get ID from the Colour Sensor.
' 1800: Receive measurement from serial COM port.
' 2000: Error handling routine.
' 2200: Colour Sensor error handling.

'Variables used:
'INDATA$          : Data received from serial COM port.
'INDATATMP$       : Temporary data received from serial COM port.
'SENSORTYPE       : Identity for the Colour Sensor.
'INTEGRATIONTIME  : Integration time in the Colour Sensor.
'DATAREADY        : Data received from the Colour Sensor.
'MAXTIMEOUT       : Timeout constant (2 seconds).
'STARTTIME        : Used to make timeout
```

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```
'COMPORT          : The serial COM port.
'COMNO            : Number of serial COM port.
'COMERROR         : Variable to hold a communication error.
'WHR (5)          : Array for CIE coordinates
'IDINFO$          : Identity of the Colour Sensor.
'IDPOS (2)        : Temporary array.
'ERRORTXT$ (7)    : Communication error text.
'X,  Y,  Z        : CIE 1931 XYZ-values

1000    '
1005    '********"******** Initialise the serial COM port ***************************
1010    '
        'Open serial COM port: COMPORT as COMNO:
        'Baudrate: 4800 or 9600 baud
        'Databit: 8, Stopbit:  2,  Parity: NONE

1015    IF (COMBAUD <> 4800) AND (COMBAUD <> 9600) THEN
1016    COMERROR = 8
1917    ELSE
1018    IF (COMBAUD = 4800) THEN
1020    OPEN COMPORT$ + "4800, N, 8, 2, BIN, CS, DS" FOR RAMDOM AS COMNO
1022    ELSE
1025    OPEN COMPORT$ + " :9600, N,8, 2, BIN, CS, DS" FOR RANDOM AS
        COMNO
```

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```
1035    END IF
1036    END IF
1040    RETURN

1050    '
1055    '******** Wait for Serial Data or Timeout**********
1060    '

1065    STARTTIME = TIMER
1070    TIMEOUT = 0             'Establish timeout for MAXTIMEOUT sec.
                                'Loop until data received from the serial
                                'COM port, COMNO, or timeout occurred.
1075    WHILE ((LOC(COMNO) = 0) AND (TIMEOUT < MAXTIMEOUT))
1080    TIMEOUT = TIMER – STARTTIME
1085    WEND

1090    RETURN

1100    '
1105    '*********Start measuring in the Colour Sensor***********
1110    '
1115    PRINT #COMNO,  "MC; ";      'Transmit start command to Colour Sensor.
                                    'connected to serial COM port: COMNO.
```

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```
1120  RETURN

1150  '
1155  '********Stop measuring in the Colour Sensor********
1160  '

1165  'PRINT #COMNO,  MS; ";          ' Transmit stop command to Colour Sensor.
                                      'connected to serial COM port COMNO.
1170 RETURN

1200  '
1205     '******** Set integration time in the Colour Sensor
1210     '
         'The allowed range for the integration timer
         'is: 25 <= INTEGRATIONTIME <= 250
1215     IF ((INTEGRATIONTIME >= 25) AND (INTEGRATIONTIME <= 250))
              THEN

         'Transmit integration time to the
         'Colour Sensor
1220     PRINT #COMNO,  "SI  + STR$ (INTEGRATIONTIME) + " ; " ;
```

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```
1225  COMERROR = 0                    'No error.
1230  ELSE
1235  COMERROR = 3                    'Error:  Integration time out of range.
1240  END IF
1245  RETURN

1300   '
1305   '******** Get integration time from the Colour Sensor
1310   '
1315  PRINT #COMNO,  "F?; ";          'Transmit "Send integration time" command to 'the Colour Sensor
1320  GOSUB 1050                      'Wait for data or timeout

1325  IF (TIMEOUT <  MAXTIMEOUT) THEN

1330  LINE INPUT #COMNO, INDATA$:

1335  INTEGRATIONTIME = VAL (INDATA$:
1340  COMERROR = 0                    'No error
1345  ELSE
1350  COMERROR = 2                    'Timeout receiving data from serial COM port
1355  END IF
1360  RETURN
```

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```
1400    '
1404    '******** Get ID from the Colour Sensor********
1410    '

1415    PRINT #COMNO,  "MS; ";      'Stop measuring in the Colour Sensor

1420    CLOSE #COMNO                'Flush serial input buffer by closing and
                                    'opening the serial COM port.
1430    PRINT #COMNO, "I?; ";       'Get ID from the Colour Sensor
1435    GOSUB 1050                  'Wait for serial Data

1440    IF (TIMEOUT < MAXTIMEOUT) THEN

1445    LINE INPUT #COMNO,  INDATA$
1450    IDPOS (0) = INSTR (1  INDATA$,  ", ")
1455    IDPOS (1) = INSTR (IDPOS (0)  +  1,  INDATA$,  ", ")
1460    IDPOS (2) = INSTR (IDPOS (1)  +  1,  INDATA$,  ", ")

1465    IDINFO$ (0) = LEFT$ (INDATA$,  IDPOS (0)  - 1)
1470    IDINFO$ (1) = MID$ (INDATA$,  IDPOS (0)  +  1,  IDPOS (1)  - IDPOS (0) - 1)
1475    IDINFO$ (2) = MID$ (INDATA$,  IDPOS (1)  +  1,  IDPOS (2)  - IDPOS (1) - 1)
1480    IDINFO$ (3)  = RIGHT$ (INDATA$,  LEN (INDATA$)  - IDPOS (2)  -  1)
```

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```
1485   PRINT #COMNO,  "MA61;  ";
1490   PRINT #COMNO,  "RM; ";              'Get info about SensorType

1495   GOSUB 1050                          'Wait for serial Data
1500   IF  (TIMEOUT < MAXTIMEOUT) THEN

1505   LINE INPUT #COMNO,  INDATA$
1510   SENSORTYPE = VAL (INDATA$):          'Sensortype MUST be > 31 AND < 48

1515   IF  ((SENSORTYPE <> 0) AND (SENSORTYPE <> 16)) THEN
1520   COMERROR = 0                        'No error
1525   ELSE
1530   COMERROR = 7                        ' Wrong sensor
1535   END IF
1545   ELSE
1550   COMERROR = 2                        'Timeout receiving data from serial COM port
1555   END IF

1560   ELSE
1565   COMERROR = 2                        'Timeout receiving data from serial COM port
1670   END IF
1675   RETURN
```

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```
1800    '
1805    '******** Read latest measurement from the Colour Sensor********
1810    '

1820    GOSUB 1050                      'Wait for serial data

1825    IF (TIMEOUT < MAXTIMEOUT) THEN

1830    LINE INPUT #COMNO,  INDATA$
1835    INDATA$ = INDATATMP$

1840    WHILE ((NOT EOF (COMNO)) AND (LOF(COMNO) > 20)):
                                        'Locate latest measurement
1845    INDATA$ = INDATATMP$            Keep a copy of the measurement
1850    LINE INPUT #COMNO,  INDATATMP$  'Empty input-buffer

1855    WEND

1860    IF (LEN (INDATA$) = 20) THEN
1865    INDATATMP$ = INDATA$
1870    END IF

1875    IF (LEN (INDATATMP$) = 20) THEN
```

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```
1880    DATAREADY = 1
1885    X = VAL (LEFT$ (INDATA$,  6))
1890    Y = VAL (MID$ (INDATA$,  8,  6))
1995    Z = VAL (RIGHT$ (INDATA$,  6))

1996    IF (X < -.5) THEN

1898    IF (X < .01) AND Y > .01) AND (Z > .01) THEN
1900    SUMXYZ = X +Y + Z
1905    DIVISOR = X + 15 * Y + 3 * Z

1910    IF  ((SUMXYZ > .01) AND (DIVISOR > .01)) THEN

1915    WHR (0) = X / SUMXYZ
1920    WHR (1) = Y / SUMXYZ
1925    WHR (2) = 4 * X) / DIVISOR
1930    WHR (3) = 9 * Y) / DIVISOR

1935    WHR (4) = WHR (2)
1940    WHR (5) = (6 * Y) / DIVISOR

1945    COMERROR = 0                    'No error
```

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```
1950    ELSE
1955    COMERROR = 4                    'White reference values NOT calculated
1960    END IF

1962    ELSE
1964    COMERROR = 6                    'Lowlight
1965    END IF

1966    ELSE
1967    COMERROR = 5                    'Overload
1968    END IF

1970    END IF
1980    ELSE
1985    COMERROR = 2                    'Timeout receiving data from serial COM port
1990    END IF
1995    RETURN

2000 '
2005 '********Error Handler********
2010    '
```

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```
2015    IF ERR = 69 THEN                ‘Communications buffer overflow
2025    CLOSE #COMNO                    ‘Flush input buffer by closing and opening
2030    GOSUB 1000                      ‘the serial COM port.
2035    END IF

2090    IF ERR = 68 THEN                    ‘Device unavailable
2092    COMERROR = 1
2093    GOSUB 2200

2094    STARTTIMER = TIMER                  ‘Make a 2 seconds delay
2095    TIMEOUT = 0

2097    WHILE (TIMEOUT < 2)
2097    TIMEOUT = TIMER – STARTTIMER
2098    WEND

2099    END

2100    END IF

2120    RESUME

2200    ‘
2205    ‘********Colour Sensor Error handler
2210    ‘
```

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```
2215    LOCATE 21,  12
2220    PRINT "

2225    LOCATE 21,  12
2230    PRINT "Error no." + STR$ (COMERROR) + ":  " + ERRORTXT$ (COMERROR)
2240    RETURN
```

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Appendix B – Errors and General Messages

B. 1 General Error Messages

Error #	Description
0	**No display has been opened.** The applied function requires that a display window has previously been opened.
1	**Error opening display. Maximum number of displays exceeded.** Trying to open too many displays. It is possible to open a maximum of 6 displays at one time.
5	**File not found.** The specified file could not be found in the current directory.

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Error #	Description
6	**Only filenames with extension <.XXX> are allowed.** Trying to save a file with an extension other than the default, ie. In Save Program Setup : .PGM In Save Display Setup : .DIS In Save Measurement : .MSM
9	**Display has to be of RGB-type to learn a phosphor.** The applied function only works in RGB-mode. In order to learn a phosphor an RGB-display has to be open and active.
10	**Display has to be of RGB-type to restore a phosphor.** The applied function only works in RGB-mode. In order to restore a previously saved phosphor from the disk an RGB-display has to be open and active.
11	**Display has to be of RGB-type to save a phosphor.** The applied function only works in RGB-mode. In order to save a phosphor to the disk an RGB-display has to be open and active.

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Error #	Description
12	**Value out of range.** One of the following errors have occurred: During Display Setup in RGB/XYZ: The range of the absolute reference value has been exceeded. During Learn White Reference: The white reference measured/specified are illegal. Colours outside the CIE 1931 Chromaticity Diagram are not allowed.
13	**Reference MUST have a name.** Trying to leave the “Learn White Reference”-menu without having named the reference.
14	**Phosphor MUST have a name.** Trying to leave the “Learn Phosphor”-menu without having named the phosphor.

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Error #	Description

15 **Reference already exists.**

Default names can not be overwritten.

Three different White Reference files comes with this software-package:

D6500	(fty)
3200 Cor.	(fty)
9300 Cor.	(fty)

The three default references are protected and can not be overwritten.

16 **One (or more), phosphor have not been learned.**

Trying to leave the “Learn Phosphor”-menu without having learned all three colours.

18 **Timeout receiving data from the Colour Sensor in <COMX>.**

The Colour Sensor connected to the serial port COMX, where COMX is COM1 or COM2, does not respond.

Check all cables between the computer, power-supply and the Sensor to ensure proper communication.

Try leaving the program and power-off the computer.

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Error #	Description
19	**Unable to open specified file.** The file specified could not be opened.
20	**Setup not available for restored measurement.** The active display is a restored measurement. A restored measurement result can not be altered.
21	**Restore not available for restored measurement.** It is not possible to restore a White Reference or a Phosphor into a display containing a restored measurement.
22	**Learn not available for restored measurement.** It is not possible to learn a White Reference or a Phosphor in a display containing a restored measurement.
23	**Error in received measurement; Lowlight in one or more channels.** The amount of light in one or more channels during Learn Phosphor are too low. Increase the level of the measured channel.

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Error #	Description
26	**Unable to open specified COM port <COMX>.** It is not possible to open the specified communication port in COMX, where COMX is COM1 or COM2.
31	**Unable to open Help system: Help-file not found.** The helpfile PM5639.HLP was not found in the current directory.
32	**Unable to open Help system: Index-file not found.** The helpfile PM5639.NDX was not found in the current directory.
33	**Unable to open Help system: Help-file has been corrupted.** The helpfile PM5639.HLP has been corrupted. *Please note that this file should NOT be altered in any way.*
34	**Unable to open Help system: Index-file has been corrupted.** The helpfile PM5639.NDX has been corrupted. *Please note that this file should NOT be altered in any way.*

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Error #	Description
35	**Help system is not available.** The help-system was not initialised during program startup due to an error caused by one, (or more), of the above described errors, (i.e. error 31-34). The presence of the help system is only checked during startup, i.e. error 31-34 will only occur during that time.
37	**Filename has to be specified.** When saving on a disk or restoring from a disk the filename has to be specified.
38	**Unable to open specified COM port. Wrong Sensor connected to <COMX>.** The Colour Sensor connected to the serial port COMX, where COMX is COM1 or COM2, is not manufactured to operate with this software-package.
39	**Phosphor already exists. Default names can be overwritten.** The Phosphors that comes with this software-package are read only and can be overwritten.
41	**Unable to read file. File has been saved with an old software revision.** It may not be possible to use files containing setup, white reference etc. saved with an old software revision.

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Error #	description
42	**Specified filename is not allowed.** It is not possible to specify filenames, which are illegal to DOS, i.e. the following names are not allowed; LPT1, LPT2, COM1, COM2, NUL, PRN, CON and AUX.
43	**Illegal or no measurements in display, file can not be saved.** The amount in one or more of the channels are too low to save a measurement.
44	**FAST mode not supported by connected sensor(s).** The function “FAST-mode” is not available with at least on of the connected Colour Sensors.

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B. 2 General Disk DOS-Errors

These errors are adapted from DOS.
Please consult your DOS-manual if any of these errors should occur.

Error #	Description
4	Disk is write protected
4	Unknown disk unit ID
4	Disk drive not ready
4	Unknown command
4	Disk data error (CRC)
4	Bad request
4	Disk seek error
4	Non-DOS disk
4	Disk sector not found
4	Write error

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Error #	Description
4	Read error
4	General failure
4	Reserved
4	Invalid disk change

B. 3 General Printer DOS-Errors

The errors are adapted from DOS.
Please consult your DOS-manual if any of these errors should occur.

Error #	Description
36	Printer NOT selected
36	Printer out of paper
36	Printer I/O-error
36	Printer time out

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B. 4 General Warning Messages

Message #	Description
2	**File already exists. Overwrite existing file?** Warning given when about to overwrite an existing file on the disk.
3	**Reference already exists. Overwrite existing reference?** Warning given when about to overwrite an existing White Reference on the disk.
7	**About to delete white reference.** Warning given when about to delete White Reference on the disk.
8	**About to delete phosphor.** Warning given when about to delete Phosphor on the disk.
24	**Phosphor already exists. Overwrite existing Phosphor?** Warning given when about to overwrite an existing Phosphor on the disk.

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Message #	Description
27	**About to exit the program. Overwrite the existing configuration file?** When existing the program it is possible to save the configuration in a file which makes it possible to restart the program the same way it was left. Please note that the program always will start with measuring mode stopped.
28	**Do not really want to exit?** Warning given to ensure that the user really wants to exit the program.
30	**About to close active display. OK to proceed?** Warning given when about to close the ACTIVE display, i.e. the display being edited.
40	**About to close ALL active displays. OK to proceed?** Warning given when about to close ALL the displays on the screen.

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B. 5 General Notice Messages

Message #	Description
25	**Be sure to apply a <XXX> window on the CRT.** Where XXX is Red, Green or Blue This message will appear during Learn Phosphor as a reminder to adjust the monitor to a window with the colour about to be learned.
Overload	This message occurs if there is too much light in one or more of the three channels.
Lowlight	This message occurs if the value in one or more of the three channels is less than 0.01.
!!!Printing!!!	This message occurs when printing a report to a printer

Please note that code 17 and 29 have not been implemented.

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Appendix C – PM 5639 Application

C. 1 General

Ensuring a high standard of picture quality has become even more important with the increasing interchange of program material from different sources such as TV studios and production houses. The PTV CRT Colour Analyser PM 5639 assists in this process by meeting the demand for easy control and adjustment of the colour “white” and brightness on any colour monitor.

The PM 5639/01 consists of a colour sensor, which is put onto the CRT and a software package giving displays on a standard PC. The PM 5639/20 and the PM 5639/21 consists of either one or two colour sensors, which can be mounted in some kind of mechanical fixture to keep the sensor(s) at the CRT. These sensors also operate together with a software package giving displays on a standard PC.

PM 5639/25 consists of a high-speed, miniature colour sensor, which is put onto the CRT and a software package giving displays on a standard PC. Multiple miniture sensor can be put on the same screen for white uniformity adjustments

The colour sensor uses an advanced signal processing system to establish the correct measurement independent of the field rate. The colour sensors works with all field rates, HDTV system, progressive and interlaced system.

The colour sensor operates independent of the types of phosphor in use in the CRT. This is made possible through the use of a the concept, which relies on a optical filters that parallel the colour response of the human eye as defined by the CIE 1931 standard observer. This, together with a traceable calibration, assures a correct white reference on any CRT monitor.

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C. 2 Areas of Application

The main application of the PM 5639 is to align the colour of “white” and brightness of CRT colour monitors. The monitors can be of the following sorts:
-Measuring monitors (“Grade 1”)
-Surveillance monitors (“Grade 2”)
-RGB computer monitors
-Consumer colour TVs
-Graphic display monitors

The monitors should be adjusted in accordance with the manufacturer’s instructions, which usually include an adjustment procedure carried out in one of the following ways:
-From the front plate of the monitor with or without tools (screwdriver)
-From the back of the monitor with or without tools (screwdriver)
-From the inside of the monitor with or without tools (screwdriver)

Initial Monitor Set-Up
Calibration can be done in two different ways, by using either one of the CIE modes or the RGB mode. The difference is the display, and that it is possible to use the CIE modes independent of the phosphor. In the RGB mode the instrument needs to know what phosphor you are using. The phosphors can either have been stored previously or you can create a new set.

To obtain highest accuracy, turn the monitor on and allow it to warm up for at least half an hour. Video input should be either a test pattern of colour black or some other low luminance level video signal or constantly changing video information, such as program material. When testing, it is not advisable to leave a high intensive video signal (e.g. colour bars) on a monitor for a long time.

After establishing purity, convergence, vertical and horizontal linearity, then select a white reference, and use this for the adjustment (most television systems have standardized on D6500 as a white reference).

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Case 1 – Use of CIE modes

- Select a 15 percent Window or Colour Black with the brightness turned up slightly (LUM value of about 1.3 cd/m2 (or 1-3 NIT or 0.3-1 ftL) Adjust the screen (low Light, Black Level R, G & B controls) to make the dot enter the reference box in the CIE mode.
- Select a 100 percent Window Pattern. Using the contrast control to adjust the luminance to about 80 cd/m^2 (80 NITs, 25 ftL). Adjust the CRT gain (high light, white Gain R, G & B controls) so that the dot coincides with the reference box in the CIE display. Return to the 15 percent Window Pattern and check the Black Level adjustments. Depending on how interactive the controls are on the monitor under adjustment, it may be necessary to go back and forth between 15 and 100 percent several times to establish a good grey scale. For best results use the highest resolution on the Colour Analyser.
- Select PLUGE signal to set Black Level on the monitor. The monitor should be placed in normal viewing conditions and the brightness control adjusted in such a way that the “blacker-than-black” part of the signal disappears in the black, while the “whiter-than-white” is still visible.
- Select a 100 percent Window Pattern to set the white level. The luminance of the white window should be adjusted to 80 cd/m2 (80 NITs. Note: SMPTE recommends 35 ftL or approx. 120 cd/m2) by use of the contrast control.

A colourbar is needed to adjust the chroma gain.

- On a PAL monitor use the split-field EBU colourbar with 75% white for this adjustment. With only the blue gun switched on the intensity of the blue bar is set to the same intensity as the “white” area in the bottom part of the screen.
- On a NTSC monitor use the SMPTE colourbar with the reversed blue bar and the red and green guns switched off. Adjust all the blue-coloured fields to the same intensity using the hue and saturation controls.
- To check the results of the adjustment use a 2- or 10-step grey scale test pattern and a good video source of program material.

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Case 2 – Use of RGB mode.

If the phosphor is unknown and not in the phosphor list, it is necessary to "Teach" the instrument the phosphor. This is possible by using the LEARN facility. The teaching process will remove the cross interaction between the three guns in the RGB display. After use of the LEARN facility it is possible to adjust one of the guns and only the corresponding bar will respond. This is very convenient when calibrating several monitors with the same phosphors using the RGB display. The following procedure should be followed once the instrument has adapted the phosphors.

Select a 15 percent Window pattern or Colour Black pattern with the brightness turned up slightly (LUM value of about 1-3 cd/m^2 (or 1-3 NIT or 0.3- 1 ftL). Adjust the three bars, all three at the same level. It may be necessary to readjust the brightness to keep a convenient luminance level. If it is possible to adjust all three guns on the monitor, one of the guns may be used as a reference in the display; otherwise use the luminance as reference.

-Select a 100 percent Window pattern. Use the contrast control to adjust the luminance to about 80 cd/m^2 (80 NITs, 25 ftL).

Adjust the CRT gain (high light, white gain R, G & B controls), to centre the three bars at the same level. It may be needed to adjust the contrast to keep luminance level. Return to the 15 percent Window pattern and check the black level adjustments.

-Depending on how interactive the controls are on the monitor being adjusted, it may be necessary to go back and forth between 15 and 100 percent several times to establish a good grey scale. For the best result use the highest resolution on the colour analyser.

-Select a PLUGE signal to set the black level of the monitor. The monitor should be placed in normal viewing conditions and the brightness control adjusted in such a way that the blacker-than-black part of the signal disappears in the black, while the whiter-than-black is still visible.

-Select a 100 percent Window pattern to set white level. The luminance of the white window should be adjusted to 80 cd/m2 (80 NITs, Note: SMPTE recommends 35 ftL, approx. 120 cd/m^2) by means of the contrast control.

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A colour bar is needed to adjust the chroma gain.
-On a PAL monitor use the split-field EBU colourbar with 75% white for this adjustment. With only the blue gun switched on the intensity of the blue bar is set to the same intensity as the “white” area in the bottom part of the screen.
-On NTSC monitor use the SMPTE colourbar with the reversed bar, and the red and green guns switched off. Adjust the all blue-coloured fields to the same intensity using the hue and saturation controls.

-To check the result of the adjustment use a 5- or 10 step grey scale test pattern and a good video source of program material.

C. 3 Problem Areas

Monitors should always be adjusted in the mode that they are most often used, i.e. adjust the black to white grey scale with the monitor in colour mode. The monochrome mode may give you a slightly different colour of white because it bypasses the decoder used in the colour mode.
Test patterns should also have a colour burst on to make sure the colour decoder is not being bypassed. If the monitor is a combination composite and component monitor, set its grey scale in the mode most often used.

The 80 cd/m^2 peak white setting used in the procedure is for a low ambient light environment. If room lighting around the monitor is bright, higher black and white levels will be necessary.

If the purity of a monitor is less than perfect, the grey scale may not appear to be consistent over the entire screen. Grey scale tracking, in absolute terms, should be measured at one point on the screen, preferably by centre. It is measured by changing the intensity of the

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Window pattern and watching the cross moving in the CIE display on the PM 5639. The three channels should always equal each other; i.e. the dot does not move when window pattern levels are changed.

If hum is present on the screen, the beating between the field frequency and the line frequency will result in a vertical moving intensified “bar” in the picture. The bar moves at a speed corresponding to the difference between the two frequencies. The bar can be either moving up, moving down, or standing still. A very slow-moving bar will result in a jitter colour analyser display. A bar may result in an adjustment, which is not correct. If the interference is of an order which is disturbing it is usual possible to see the bar in a flat-field picture.

Colour Temperate and Correlated Colour Temperature
The colour temperature of a light source is defined as the temperature of the black body emitting light equal to that light. The black body is sometimes called a Plankian radiator. The chromaticities of the black body are much like the chromaticities for various phases of daylight or the light from a Tungsten lamp. If, for example, a lamp has a chromaticity point coinciding with the chromaticity of a Plankian radiator at temperature T = 6000 K, the lamp is said to have a “colour temperature of 6000 K”. If the chromaticity point of the lamp does not coincide with the Plankian radiator at any temperature, the temperature which gives the chromaticity point closest to the lamp is chosen to specify the “correlated colour temperature”. The nearest chromaticity point is the point perceived to give the light which best approximate to the light from the lamp. This means that two different lamps may have the same correlated colour temperature, but they look different! It is therefore safer to specify the chromaticity coordinates than only the colour temperature.

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The white D references are defined by the chromaticity coordinates (xy, u'v', or uv) of the light, which best approximates the various phases of daylight as defined by CIE. The chromaticity coordinates of the different Daylight references are not coincident with the black body curve. This means that 6500 K must often be understood as a correlated colour temperature; a better expression would be D6500 or D65 indicating a point on the daylight curve.

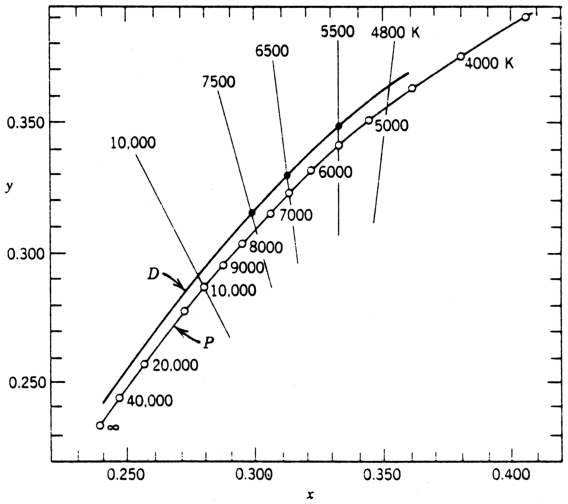

Fig C-1. Portion of the CIE 1931 (x,y)-chromaticity diagram showing daylight locus (D) and Planckian locus (P) with a few isotemperature lines. Light sources places on each of the isotemperature lines has equal correlated colour temperature.