FrontColour 10

FrontColour10

COLOUR METER FOR ON-LINE OPERATION
USER'S MANUAL

The embedded software version V388 and later support all the features mentioned in this manual.

Optical system revision 6.06

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Unit information:

Model & Rev:	**Frontcolour 10**	**Rev:**
Serial number:		
Firmware V		
PCB's:		
Adjusted:		
Service Interval (hours):		

Made in Finland
Manual printed in Askola, Finland
PART #100181

2026-14

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Important warnings are highlighted in this manual with red color.
Recommendations are in blue and important instructions are in brown.

EC Declaration of Conformity

We

Visilab Signal Technologies Oy
Signal Technologies
Sepäntie 4
FI-07230 Askola
FINLAND

declare that the

FrontColour10 On-line Colour meter

meets the intent of the EMC directive 89/336/EEC. Compliance is based on the following harmonized standards:

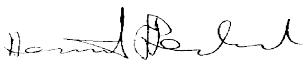
Emissions:

EN 50 081 part 2 (industrial environment):1993 referring to :
EN 55 011 radiated, Class A, Group 1
EN 55 011 conducted, Class A, Group 1

Immunity:

EN 50 082 part 2 (industrial environment):1992 referring to (both radiated and conducted fields):
EN 61000-4
IEC 1000-4
ENV 50140
ENV 50141
ENV 50204

I certify that the apparatus identified above conforms to the requirements of Council Directive 89/336/EEC.



Henrik Stenlund
managing director
15th July 2019

CE

Note for users:
When the apparatus identified above is connected by someone to become a part of an industrial control system, he is also responsible for the EMC compatibility of the resulting system. He is also liable of providing the necessary optical or galvanic isolations for signals and transient absorbers for other lines to conform to the EMC directives.

EC Declaration of Conformity

We

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Signal Technologies
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declare that the products which are put on the EU market:

FrontColour10 On-line Colour meter

meet the intent of the RoHS directive 2002/95/EC and the WEEE directive 2002/96/EC. Compliance is based on the following.

The instruments belong to Category 9 "Monitoring and Control Instruments" of the WEEE directive and thus are not required to fulfill the said directives.

I certify that the apparatus identified above conforms to the requirements of Council Directives 2002/95/EC and 2002/96/EC.

Henrik Stenlund
managing director
15th July 2019

Note:

In spite of the fact that the products are not required to fulfill the directives, we make every effort to comply with the directives in practice. When the Category 9 is moved to be covered the same requirements as other categories do, we are ready to certify that these products comply with the directives.

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1. Introduction and Taking into Use

We congratulate you for your decision of becoming a user of **FrontColour10** process colour meter. It has been designed for permanent mounting over a production line and to offer you as much colour information of your process as possible having also a great variety of useful features. Our intent has been to offer you a unique instrument serving you reliably for several years. To utilize all features in this product we recommend that you read the whole of this manual and also other guides and technical documentation shipped with this unit. This manual covers model's revision 6. The older revisions are no longer manufactured but are serviced normally. Refer for more details in the appendices. Refer to the mechanical drawings there.

FrontColour10 is a very accurate process colour transmitter for requiring conditions in paper machines and other comparable production machines. One can acquire the latest colour values into some control system in digital form either via the RS232/USB serial port (typically a PC) or via analog signals (5 Volts and 4-20 mA).
FrontColour10 is taken out of its package carefully and it should be inspected for any damage during shipping. If any damage is visible, contact the manufacturer or the representative from which the unit was bought. Note that in spite of being designed to fairly rough conditions it is still a sensitive optical instrument and it should be handled with care. Avoid any mechanical and thermal shocks to the meter. Especially sensitive is the light multiplexer motor which is easily damaged if it is being subjected to sharp shocks. There are no user-serviceable parts inside the meter.

The following items should be available:

1. **FrontColour10** *instrument*
2. *Program on a USB memory stick*
3. *User's manual (this)*
4. *Connection cables with connectors and a power source unit -PS , with cable lengths as ordered*
5. *Serial cable for PC operation*
6. *PC program user's manual*
7. RS232-to USB converter
8. Bluetooth-to USB converter and a USB-B cable *or a pair of cable replacement unit with Bluetooth*
9. *Other optional items ordered like reflectance standards and calibration standard colour tiles*

If something is missing, inform your dealer and he will ship any missing parts. The instrument is ready to use after connecting the cables and power.

Connecting the Cables and Starting the Meter

Refer to Figures 1A to 1B for various cable connections in typical applications. The cables are connected as follows. The two big connectors go to the instrument wall connectors and the other end of one of the cables (the Comm's marked connector) is in the distributing box. The other cable (the connector marked as Analog) is free for use for acquiring the analog signals. The box has a D9 connector for the PC serial cable and screw terminals for some of the analog signals. There are four analog outputs and one can select by software which of the available 20 colour signals go to which channel. Each signal has its own scaling and offset to accurately suit any needs. There are also two USB connectors on the side of the box. One is marked as **Service** is not recommended for the user. The other one is **Comm's** and when connected to a PC's USB port, overrides the serial communication.

The RS232 cable is connected to the box and its other end is plugged into your PC's serial port COM1 ...255 whichever has the connector of proper size and is available for testing purposes. In case you do not have the RS232 in your PC, there is a RS232-to USB converter module provided. Also, there is a pair of cable replacement modules using Bluetooth. One (slave module) is plugged to the power supply's RS232 connector and the other one (master module) to the PC's USB. The working distance can be up 100 meters.

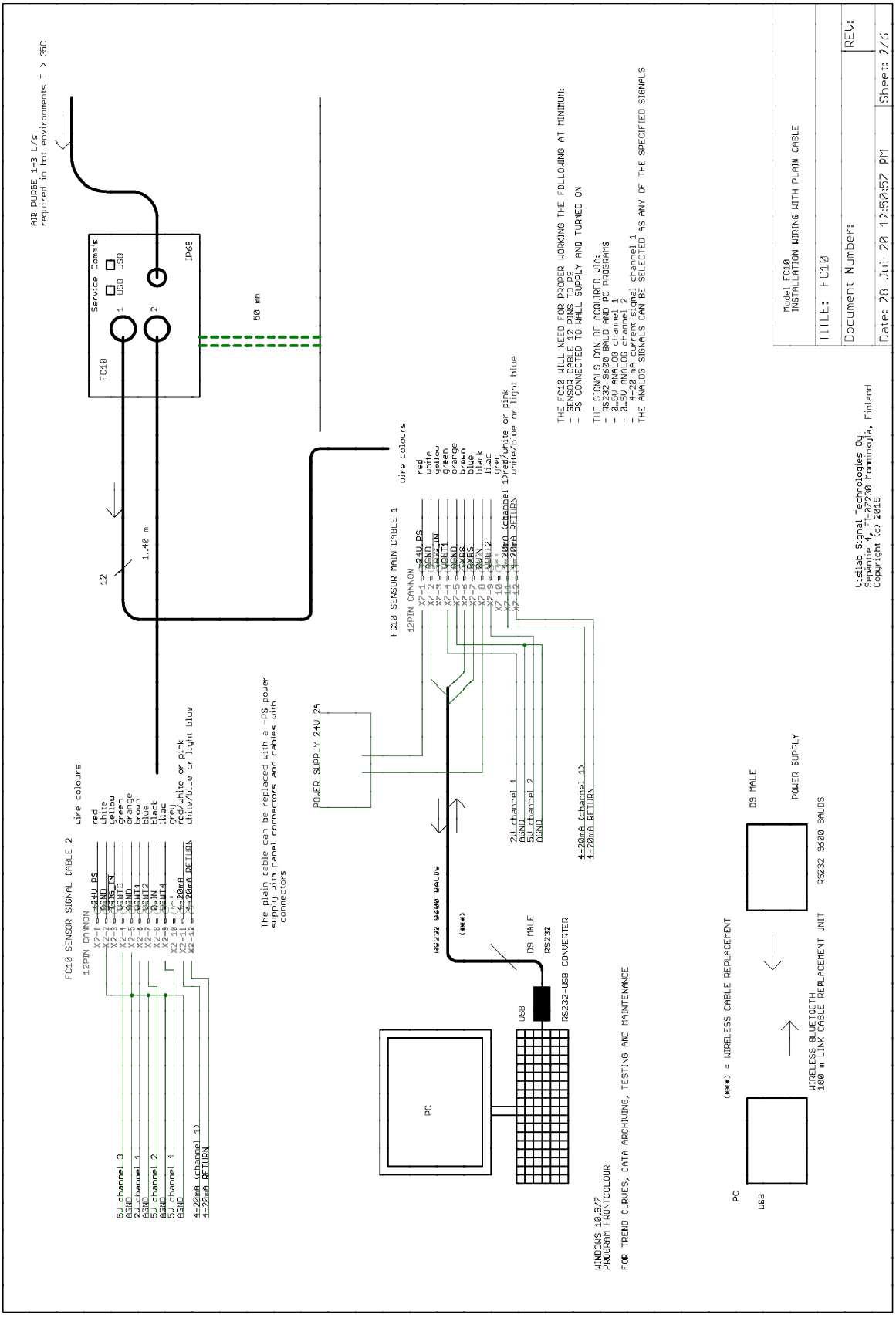


Figure 1A. Assembly of FrontColour10 for use with a PC without the -PS power supply unit, direct to cables.

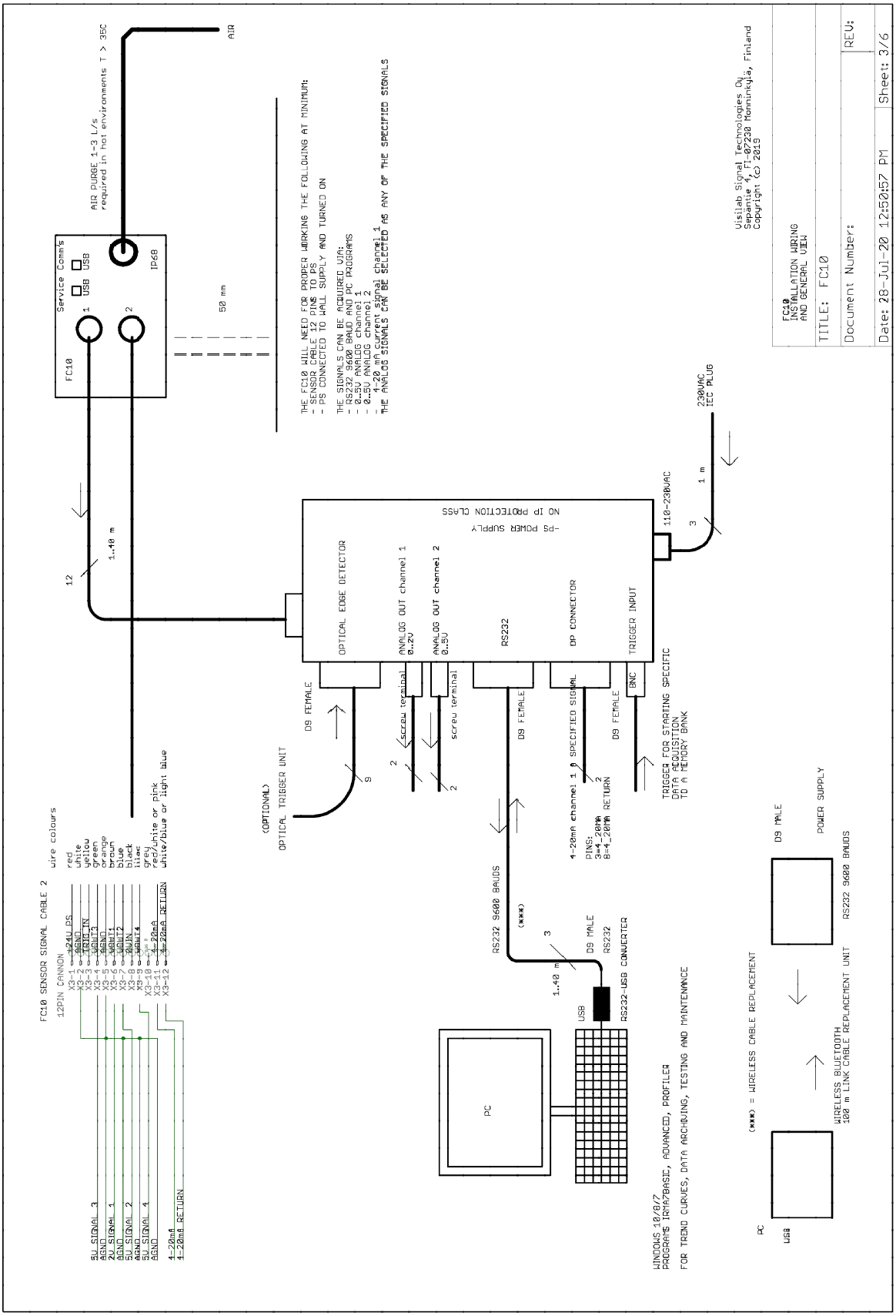


Figure 1B. Assembly of FrontColour10 for a PC applying the -PS power supply for distributing the signals

The power adaptor is placed to the mains connection (230 V 50 Hz or any other local standard). Turn on **FrontColour10**. After a few seconds there should be bright light pulses coming out from the bottom window. If the instrument refuses to operate, check the cables again. If you are certain that everything has been done in a correct way, contact your local representative or the factory to get some help. **Do not look into the light beam.**

To get a better view of connecting the cables in your final process control system, we have supplied a schematic (Appendix 5). Your control/data acquisition system may be based either on RS232/USB (a PC) or standard analog voltage output / 4-20 mA. The communications lines, voltage output and trigger lines are isolated from the 24 Volts and protected for safe operation in difficult conditions in industrial control systems. The connector type presently in use is **ITT Cannon Trident TNM** IP65 classified with shell size 14. The codes for the parts used are: Standard receptacle 12 pins TNM14-12SKT STD192993-0033 TNMOS14-0012S1L, standard plug TR1412PMS1NB 192922-1270. The pin numbering is the same as in the schematic (from 1 to 12). The socket for the receptacle is T3P20FC1LX (crimp type) of 20 AWG and gold plated. The corresponding pin is T3P20MC1LX (crimp) 20 AWG gold plated. You can use any other fully compatible parts when necessary.

When the meter is running, you can connect it to the FrontColour PC program for immediate observation of the signals. The meter is precalibrated and carefully tested so you can use it as such. One may need to pay some attention to the basic colour configuration regarding the illuminator and UV power and the scaling of the analog signals if those signals are used.

Mechanical Assembly of the Meter

FrontColour10 colour meter is assembled as depicted in Appendix 4. The working distance is specified as 50 mm **from the bottom plane to the surface** to be measured. The distance is along the optical axis from the round light source window, not from the detection window which may have a support at the edges with unspecified thickness.

Cabling

When assembling to a traverse crossing the web, you should have cables that resist repeated bending in coiling and they should be especially designed for that purpose. The cables should be resistant to the conditions prevailing at the site of assembly. If pressurized air is required, use a pressure regulator and low pressure PVC, polyurethane or Silicone tubing to connect to the 8 mm quick connector. The air flow should be of the order of one liter / second to keep the meter's temperatures in control in warm conditions. If the surrounding temperature is high (> + 35C), extra air flow is recommended to keep the instrument cool (clearly below + 50C). **At high ambient temperatures (> + 30C), you should use cool air flow with thermally insulated tubing for it. It is the user's responsibility to arrange proper cooling for the meter.** **The guarantee does not cover damages caused by overheating.** The recommended operating temperature would be from + 25 to + 35 C for best results measured (as the optical head temperature). Using a Vortec cooler is not recommended due to the extremely high thermal stresses caused by it. It can be applied along the air tubing far away from the meter to let the temperature stabilize.

Anchor the electrical cables so that the connectors are not mechanically supporting them and the connectors are thus protected against repeated bending. That applies for the air tubing too. Support the air tubing along with the electrical cables if possible. **Do not apply high pressures into the air line!** The air flow resistance is low, a small pressure difference is good. A flow of 0.1 - 1 L/s is sufficient in most cases.

Testing

For installing the PC programs, refer to the PC program user's manual. Test your communication link as instructed there. After a successful test you can be assured that your **FrontColour10** will serve you for several years with minimal service. For troubleshooting, refer to Appendix 1.

2. Basic Features of the Instrument

Wavelength Range

The system operates with a high-power LED-based light source which is rated in such a way that it will work intermittently for several years without any need for servicing. The main LED works in the visible range 420 - 700 nm and another red (NIR) LED works above 700 nm close to 800 nm. The UV part is energized by a high-power UV LED which covers the range 380 - 420 nm. The visible and red leds are not controlled by the user and are factory adjusted. The UV led can be adjusted from 0 to 100% power. Since this is an integrating CCD detector, we are actually talking of exposure time 0.. 100 %, not of peak power which already has been fixed for all LEDs. Notice that the visible wavelength range for the human eye is normally limited between 410 - 700 nm. The range outside 380 - 760 nm is hardly detectable by eye. Therefore, light stimulation between 380 and 400 nm and 680 - 850 in normal lighting conditions are very difficult to observe by eye unless high power lighting is used. Therefore to see reliably the colours of a surface, the range 400 - 700 nm is most sufficient. In FrontColour10 the range is between 380 and 760 nm. Going outside that range produces no measurable results in the colour signals as also the CIE colour weighing functions go very close to zero. Figure 2.1 depicts the general view of the FrontColour10 architecture. Figure 2.2 shows how the colour signals are generated. Figure 2.3 shows an image of the sensor indicating the placement of the optics and the connector panel.

Result of Measurement

The number of colour values the meter indicates is 20. Some of them are defined as in the CIE colour standards. In the binder there is a separate document about the CIE colour variables and on how they are specified.

FrontColour10 is analyzing these 20 variables. They are the primary **tristimulus values X, Y, Z, the chromaticity coordinates x,y,z , the CIE L*a*b*, Yellowness J, TAPPI brightness R457, CIE whiteness W, CIE Tint, colour difference dEx (for L*, a*, b*), chromaticity C and hue H** . Also four special **Primary reflectance data R(lambda)** are obtained. Geometry is 0° /45° CIE 1964 10° observer. **D65, A, C, D50, D55 or D75 illuminants** are selectable. The tristimulus values X,Y,Z are **the most important** and the CIE colour variables are all based on them and only on them. They represent the spectral reflectivity of the surface weighed with the human eye's response curves and the illuminator selected. Therefore, X is related to red, Y to green and Z to blue colours. As is well known, to observe by vision the blue colour there is also some weighing for the red involved. This is not an instrumental feature but a mathematical construct specified in the standards and implemented in the analysis to precisely match how real people see actual colours.

The meter's internal temperature can be watched with the PC program to avoid overheating. If the temperature goes over 50 C the system shuts off and it needs restarting after cooling down to work again. In warm conditions, use of air purge is highly recommended as it will bring out the internal heat of the system (some 12 W) and also prevent the external heat to cause trouble. Use fresh clean air which is cooler than the ambient. Do not use a Vortec cooler since it is causing strong freezing effects to the optics causing the readings to jump up and down. The internal system is temperature compensated (+ 5 to + 50 C). There is an internal fan which is mixing the air balancing temperatures inside the cabinet.

Since the system is calibrating itself twice every second, it is extremely stable. The system is in addition phase-locked, removing any ambient light effects. It is immune to strong lights falling on the measuring spot unless they are in sync with the meter which is highly unlikely to happen. If that would happen, add some protective screen to isolate the external light. Everything in analyzing the colour variables is based on the Spectrolon reflectance standard used. All colour parameters are calculated after receiving the primary spectral reflectance data from the CCD, calibrated.

Each of the 20 variables have a scaling and offset the user can edit at will. Since the X, Y and Z are the primary variables, **their scaling will affect the rest of the variables directly** . So, if you see that there is a need to modify

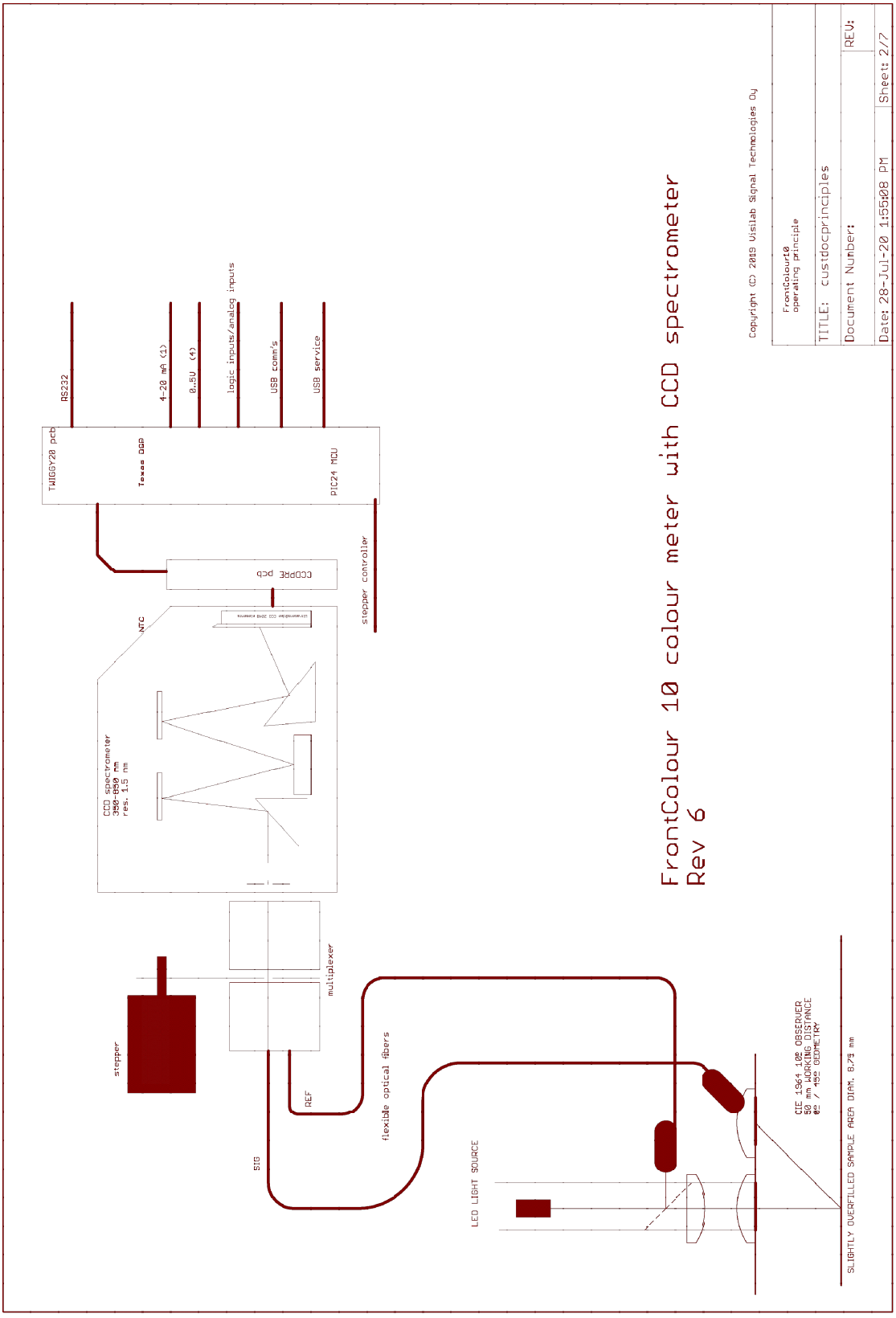


Figure 2.1 General view of FrontColour10

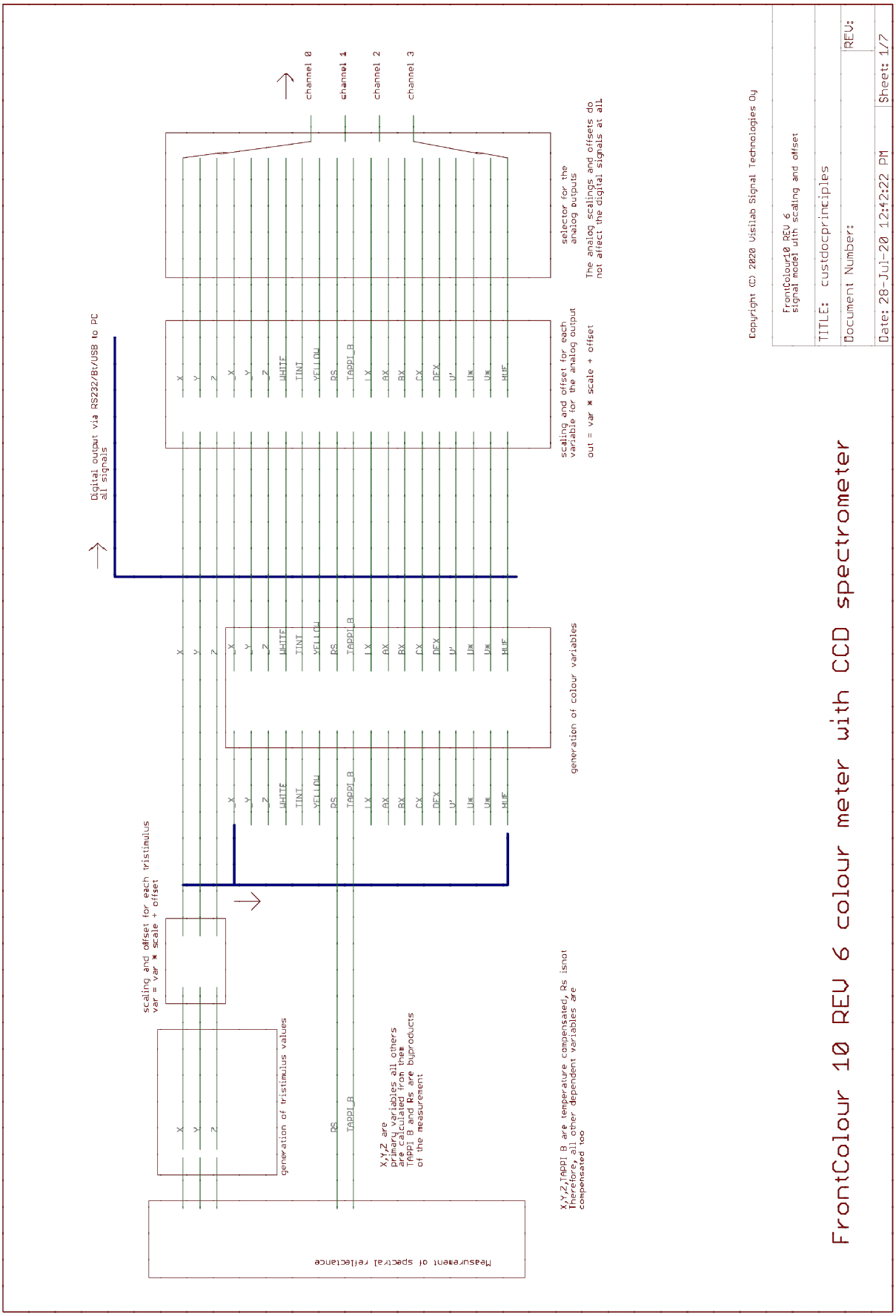
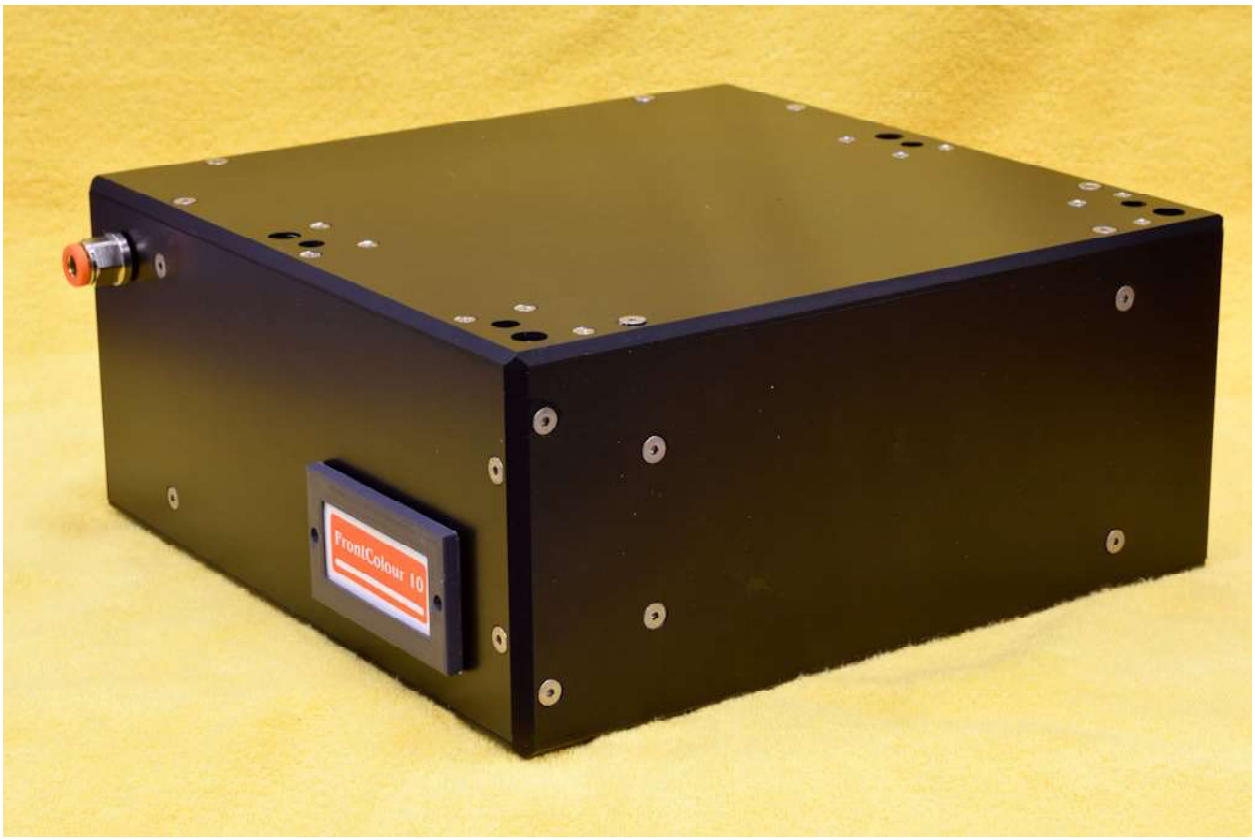


Figure 2.2 Colour signal scheme with scaling

Figure 2.3 Images of the instrument





the set X,Y,Z and some other variables, do the X,Y,Z first and then check if there is any need left for the other variables. The editing is done in the FrontColour PC program.

Similarly, there is a scaling and offset for each of these signals to be sent to the analog outputs. Four of them can be selected at any time for that purpose. One can thus prepare each signal in this respect beforehand. While using the system he can then pick up whichever signal he wishes to the analog channels without having to start matching or calibrating the scaling again. Since the scaling is arbitrary, the responsibility for proper use of it is left to the user. The output signals are generated with a 12 bit DAC having four channels. The input data is clipped if it appears to drive outside the range of 0..5 Volts. The 4-20 mA conversion chip is fed with a 0..2 Volt signal so some care is needed to match it correctly.

The sampling rate for colour values is 2 Hz. The light source applied in the instrument has a LED system with a radiating power of the order 5 W. The sensing is made from one angle on the perimeter around the light source. The basic geometry is 0/45 degrees. The exciting light goes perpendicularly towards material surface and the scattered light is sensed via the sensing head.

FrontColour10 has the latest enhanced and new features are in the following.

- **The working distance has been increased to 50 mm**
- **The user can use his own reflectance standard for calibration as long as he knows the spectral behavior of it and is able to write a text file of the response curve**
- **a reduced noise level, especially in requiring high-speed web measurements**
- **the PC program is called FrontColour. It operates in Windows 7/8/10 and future versions. The second program FrontColourConfig is mainly for system configuration and calibration. New versions for free downloading will appear on Visilab's website**

Please note that the manufacturer reserves the right to make manufacturing and design choices for each unit delivered in order to offer the best possible meter for each application.

Operating Characteristics

FrontColour10 is equipped with a few interfaces for acquiring the colour variables measured. The main communication is intended to be made via RS232 serial port which is converted to USB with a proper dongle if no RS232 exists in the PC. There are also two **USB-B** type connectors but only the one marked as **Comm's** is reserved for this purpose. The other one is for service operations only. If the Comm's USB port is used the RS232 is disabled but released as soon as the USB connector is removed. The third option is to plug in an **RS232-Bt slave** module to the power supply's RS232 connector and another **Bt-USB master** node to the PC's USB port. This will allow working wireless up to about 100 meters away from the sensor. The remaining interface is the set of four analog signals, one 4-20 mA / 2 Volt and three 5 Volt signals. The colour signals of any of the 20 available to be sent to these channels can be both selected and scaled with a slope and an offset.

The baud rate is 115200 bauds by default to both the communications and Service ports. If one needs to change them, use the Service USB port and apply a terminal emulator program to do it. There will be a simple menu visible if the meter is turned on. There are two options, (B = 115200 bauds, b = 9600 bauds). By pressing either one will change BOTH port's speeds to the same and the new setting is saved. The terminal program will not show anything unless you change the terminal's own baud rate to match to what you just changed. The high speed will

run fine with short cables and the low speed will work with cables up to 40 meters. Using a low baud rate will make data acquisition a bit slower.

There is a Low Power Mode available while the mill has a service or vacation period. In the PC program, you have the option of setting the operating mode to be STOPPED. The meter quickly recovers from it and one is able to measure again either by repowering the meter or by setting the same mode to STARTING. In longer mill production stoppages it is highly recommended to turn off the FrontColour10 altogether and start it when needed.

The instrument is made to withstand industrial environments. Reliability in that sense means both mechanical and electrical endurance and repeatability of the obtained colour information. The whole instrument is protected according to **IP67** withstanding dust and water splashes (with the air outlets excluded and windows supposed to be cleaned). Regular checking of the optical surfaces is required in difficult conditions when a new system is assembled in order to learn its future behavior.

Reflectance Calibration

FrontColour10 colour meters are designed according to the CIE standards' requirements. They are manufactured according to small tolerances. **FrontColour10** can be recalibrated by using an external reflectance standard. Usually it is ordered with the meter and will come with a plastic holder for it made by Visilab. The standard is mounted into the holder and locked with a swivel. The holder fits the meter's bottom at the corner where the light comes out and hits the standard's surface. The holders main purpose is to maintain the 50 mm distance while calibrating, very accurately. The reflectance standard must not be touched by hand on the white surface. If that happens, the surface needs to be cleaned out properly. The calibration procedure is very simple and is executed with the PC program **FrontColourConfig**. See the pictures 3.1 and 3.2 of how it is mounted and placed at the meter. You can also use your own reflectance standard. For that purpose you need to have the spectral reflectance curve data at hand to create a numeric text file to be fed to the meter. Refer to the instructions in the program manual.

Colour Tile Calibration

Colored tile standards are available and they arrive with a special plastic holder too. A tile is placed to the holder and secured with the swivel. The tile must not fall on the floor as it will brake into pieces. These are very expensive little tiles. Each tile has a different colour and the corresponding CIE L*a*b* values are reported for the set. They are measured with an instrument which is NIST traceable or equivalent by the original manufacturer (not made by Visilab). They are just as sensitive on the active surface and must be handled with great care, no fingers on the ceramic surface. Using the colour tiles is not actually a calibration but usually users track the instrument stability, especially if they have very exceptional or high chromaticity colours. The normal procedure is to measure all tiles and make note of the L*a*b* values (or any other variable of interest). During the years, one can compare the new readings to the old ones. If any change is detected its cause should be found and corrected. The usual reason is dust over the optical surfaces. The correct way is to clean up and if this is not sufficient, perform the reflectance calibration. Then one can continue using the system.

Wavelength Calibration

The internal CCD spectrometer has been calibrated according to its wavelength in factory and most likely never needs any maintenance as it has no moving parts. If any suspicion arises, one can do some checking of it with the wavelength calibrator applying its specific holder. The WL calibrator is mounted in the holder, locked lightly with a screw to keep it steady for the operation and power turned on. The WL calibration procedure is in the PC program and it is highly recommended that the old calibration coefficients are first read to the program before starting the calibration. Then the calibration is started which is a quick action. The spectral data is then downloaded to the PC program for display. Then one can scale the spectrum to see it better as the spectrum curve will rely heavily on the scaling and offset becoming easily outside the screen. Then one can change the three calibration coefficients slightly and redisplay the resulting curve. There are spectra both on the horizontal scale and on the

vertical scale and the strongest peaks should coincide along the calibration line shown. Usually, if some need for adjustment arises, it is the offset part which might be changed a little. The slope and the quadratic parts should most likely never be touched. If a need for recalibration has been recognized and new coefficients have been established, one can send the new coefficients to the meter and finish the calibration routine. It is wise to make notes of the old coefficients just in case and be able to restore them if some mistake was made. The coefficients can also be saved in text format to a file in the PC program.

On-line use

For on-line applications the meter can be assembled over the production line in a fixed position or into a traversing mechanism. This model is intended for continuous use of at least 100 000 hours. That would give a theoretical continuous service interval of about 15 years. Colour data acquisition can be done with a PC through the serial port RS232/USB. It is possible to build a network of **FrontColour10**'s each having different node address by using Visilab's LAN232 unit. The standard program is able to handle one unit only and a special version is required to acquire data from all units. The packet protocol used in data transfer is a private, very reliable, fault tolerant and fast. More data can be acquired from the manufacturer of technical details.

Contact Visilab for more information, pricing and availability. Visilab may also have other new interesting products.

3. Use of the Instrument

The FrontColour10 is intended to be used continuously measuring a running production line but can be used in laboratory mounted into a fixture just as well. One can get the colour information either via the PC program or via the analog signals. Configuration of the meter is made with the PC program. When the configuration is correct usually there is no need for changing any of it.

The PC program allows to set up the basic colour system with the illuminator (D65, D50, D55, A, C, D75). The UV excitation power level can be set and the reflectance calibration should be performed with that level if modified. While measuring, the UV level can then be turned on or off at will. The UV will cause fluorescence in those materials which contain FWA (fluorescence whitening agent) which is very common in papers and plastics. When the UV is turned off the X,Y,Z signals will usually change since part of the exciting light is missing altogether between 380 and 420 nm. That may be a dilemma. It can be "solved" partly by adjusting a zero level reflectance reading. That can be made with a single parameter in the PC program and saved for later use. Of course, it is a bit tricky and may cause surprises later on. One is then assuming the no-fluorescing reflectance of the lower part of the spectrum. That may be completely different from expected.

While measuring there may appear a need for adjusting some particular variable. All of them can be adjusted with gain and offset. However, it is recommended not to adjust the X,Y,Z-variables at all since they will directly affect all other variables. There is an option in the program to make a fine adjust to the a*b* variables without changing anything in the meter itself (the recipe system). This maintains the meter fully CIE standard compatible at all times.

The analog output of four signals can be selected from any of the 20 available and they have the gain and offset settings as well affecting only the analog outputs.

One can acquire data from the meter either **slow** or **fast** on the pages marked accordingly. The slow acquisition receives **all 20 data items at each call** and thus reserve a rather long time. The signals can be turned off and not be shown on the display if not interesting and they are not saved either. Those signals which are displayed will be saved after each 4096 points of data. The typical data rate is one point per 2 seconds and can be up to 32000 seconds. The saving is always done automatically for the selected signals and thew operation continues until stopped.

The fast acquisition will inquire for each variable separately according to need and can be faster, down to 2 points/ sec. The signals selected will be saved automatically after receiving 4096 points or when stopped.

While measuring, one can watch any of the signals on the Numeric page, a big number and a curve. The source can be either the fast or the slow acquisition and any signal acquired can be selected. The head temperature is only available in the fast one. If a signal is not selected for acquisition its value shown will be zero.

There is an Archives page both for watching the incoming data and for calculation of statistics of those and any earlier archived data. One can move the cursors to select the range over which the data is analyzed.

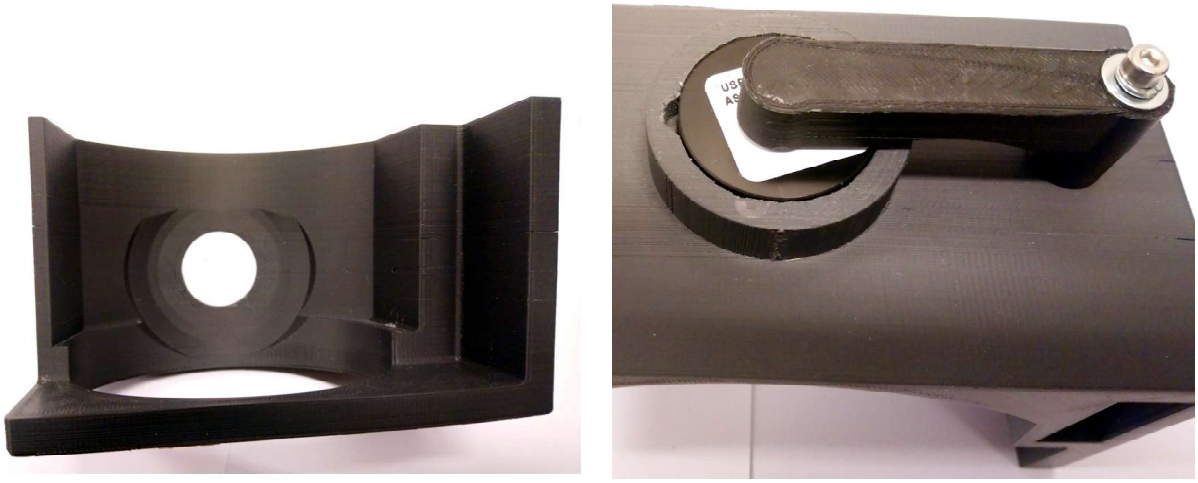
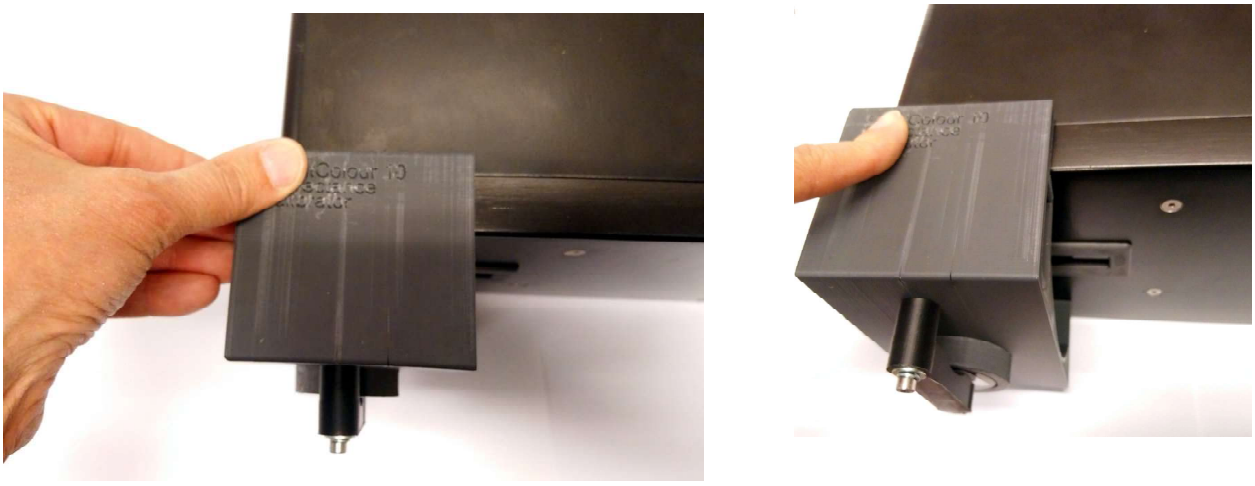


Figure 3.1 The reflectance standard mounted in its holder. Notice the use of the swivel which is important to hold it in place tightly. The standard must fit snugly to the bottom of its holder else the working distance will be incorrect. Do not touch the white surface at any time. You can store the reflectance standard in its holder by putting it to a clean plastic bag and storing it to a safe place. Blow off any dust or dirt on the inside of the holder to avoid strong reflections or attenuation of the light beam. If your Spectralon standard is of different dimensions than the WS-1 used, contact Visilab for a proper support for it.

Figure 3.2 The reflectance standard mounted at the colour meter. The holder must fit tightly to the bottom of the meter else the working distance or angle will be incorrect. The standard is to be held on its place when the WHITE point is measured, not when the BLACK point is measured. When the BLACK point is requested there should be nothing under the meter within 200 mm.



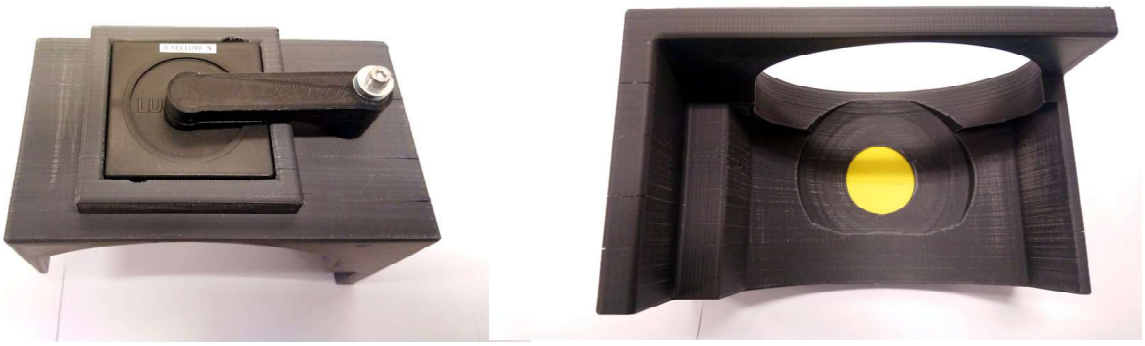


Figure 3.3 The colour tile standard mounted in its holder. Notice the use of the swivel which is important to hold it in place tightly. The standard must fit tightly to the bottom of its holder else the working distance will be incorrect. Do not touch the ceramic surface at any time.

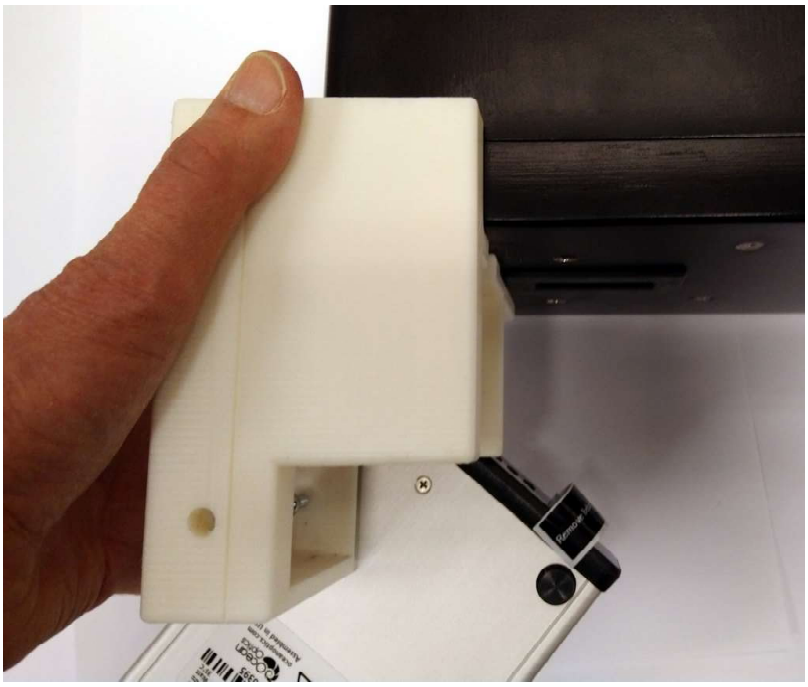
Figure 3.4 The colour tile standard mounted at the colour meter bottom. The holder must fit tightly to the bottom of the meter else the working distance or angle will be incorrect. The standard is to be held on its place while the colour parameters are acquired to see if any changes are observable.





Figure 3.5 The WL calibrator in its holder. The calibrator must fit snugly to the bottom of its holder else the working angle will be incorrect. The distance is not critical but the beam should hit the receiver window properly. Do not look into the light when the calibrator is turned on. The light comes out from the small hole which is normally covered with a screw cap. Remove the cap before operating and turn on the calibrator for a few minutes before using it. The calibrator is battery operated and does not need a charger cable at this time. If the battery is dead, you can use it and charge the battery at the same time. Do not let the battery be empty for a longer period of time.

Figure 3.6 The WL calibrator holder at the colour meter. The holder must fit tightly to the bottom of the meter else the working angle will be incorrect. The standard is to be held on its place while the WL calibration task is acquiring data. That is a rather short operation and then you can remove the calibrator.



The CIE colour difference variable can be zeroed on the Colour Systems page (target) and then one can watch that particular signal to see any changes in the process colour.

Read the PC program user's guide before operating it.

Hints for Use

The instrument is not dropping-proof. Avoid all mechanical shocks to the optical head! Contrary to expectations, the most sensitive part is the light source motor which does not tolerate sharp shocks.

1. Apply only clean air for flushing. The air must absolutely not contain any pump oil fumes. Those are very common in pressurized air lines in many mills. They will destroy sensitive instruments quickly. If this can not be arranged, then use an external air cooling not entering the instrument

2. Do not heat up the optical head! It is fully temperature compensated but sudden temperature changes may cause temporary deviations to the colour readings. In field measurements, avoid moving the meter from cold weather to warm rooms or vice versa. Else there will be increased standard deviation of the colour values. Let the meter settle for a while (60 min) to the environmental temperature.

3. Best web noise rejection and accuracy is achieved with the MEDIUM or SLOW filtering. The SLOW one is very, slow.

1. The Colour meter is NOT classified for installation and use in explosive environments! It is, however, safe since it does not generate sparks nor static and has no hot surfaces.

Appendix 1. Servicing

The service needs of the **FrontColour10** colour meter are minor in the current Rev 6. The only practical service which is important is the cleaning of the optical surfaces (windows). That should be done with a soft cloth. Do not use any solvents! Dust may accumulate in dusty conditions and some external air purge will help to reject it.

The light source expected life is more than 100 000 h and also the optical multiplexer stepping motor the same or more. The service requires skills, tools and adjustments and are outside the scope of the user. The manufacturer or your local representative will take care of them. The service costs are reasonable and at the same time the whole instrument gets a good check. The embedded software is upgraded if a new release is available, including the PC program upgrade. The light source's parts are replaced at servicing if considered necessary.

Replacement of the LED driver cards

Turn off the power before attempting to do any service operations inside the FrontColour 10 instrument.

The light source LED driver cards can be replaced with new ones if they have failed. Replacement is a rather simple job with ordinary small tools. There are three LED cards, one for VIS (visible), one for UV and one for IR (red). The cabinet is opened very carefully with no big force used since there are sensitive cables and parts inside. Slowly separate the bottom plate from the cabinet cover over a table, not the floor. Place the cabinet cover very close to the bottom plate to avoid straining the cables.

The light source is at one end of the system and you should recognize the three LED drivers. Make note of each of the cables how they are placed (take photos). Take the spare cards sent to you and disconnect the cable connectors, one by one, from the old cards and connect to the new cards at the same positions and into same angle. Do not put them upside down. Remove the M3 nuts from the cards and carefully remove them. Place the new cards at the same places and restore the nuts. Use binders to latch the cables as they were. Check that all cables are as they were in the first place. There should be no loose wires nor cables. Place the cabinet cover back on its place very carefully and fix the screws.

Perform reflectance calibration after this and you are ready to proceed normally.

Appendix 2. Technical Specifications of the Colour meter (Rev. 6.03)

Device:	An independent **process colour meter for continuous use** applying novel colour measuring technology. Measurement is done with a fast and sensitive CCD spectrometer to obtain a wide dynamic range in requiring on-line systems. The meter contains all parts necessary for running it, no external control boxes are needed. The colour meter supports the following interfaces to external world: RS232 PC connection, USB, one 4-20 mA and four voltage outputs for DCS. One trigger input is available for incrementing the reel counter. The meter is designed for long-term use with minimal service needs. The response speed is at least one point / sec service to all interfaces but the raw speed is four points / sec. The data delivered consists of CIE L*a*b* basic parameters and other common CIE defined variables plus some unique ones.
Application areas:	Reflective on-line and laboratory measurement of colour parameters of products for quality control and materials research. This instrument is targeted to all manufacturing QC, testing and research, independent of target material when colour is required. This meter does not do transmission measurements. Thus it is not able to directly perform any opacity compensation when measuring a sheet and to get the resulting reel or stack colour. A black/white reflectance backing unit with a synchronization is required for estimating reel colour and opacity. Liquid measurements can be made with a caution. Solid surfaces are preferred to comply with the CIE standards as the reflecting emitting volume is specified to be a planar surface. Main applications in paint and pigment manufacturing, printing, part manufacturing, auto industry, plastics, pulp and paper, fiber products.
Uses:	Measurement of all colour parameters, colour coordinates, reflectance, whiteness, brightness, yellowness and green/red tint according to CIE definitions. Due to its small spot size it is able to observe small-scale variations in colour.
Light source:	Wideband LED light source offering primary excitation from **420 to 760 nm**. The resulting reflectance signal can be synthesized for analyses to behave as the standard **D65, A, C, D50, D55, D75**. The UV part from 380 to 420 nm can be turned on/ off separately to avoid excitation of optically active fluorescing substances. The **UV** power is independently controllable in small steps in the range of 0..100 % to match particular customer requirements. **The UV wavelength range is from 380 to 420 nm.**
Detection:	The CCD spectrometer is able to measure throughout the full range from 350 to 850 nm. However, a narrower range is quite sufficient for accurate measurement of colour according to the CIE standard requirements. The spectral wavelength resolution is approximately 1.6 nm and CIE colour tables with 1 nm steps are used in calculations.
Geometry:	0°/45° with **one** sensing angle. This is a **CIE 1964 10°** observer, **category B** device for high accuracy and repeatability requirements. The measuring spot size is 8.75 mm in diameter. The measuring distance is specified at 50 mm.

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Analyses:

- **primary X, Y, Z**
- **chromaticity coordinates x,y,z**
- **CIE whiteness W**
- **CIE Tint T**
- **Yellowness J**
- **a special Primary reflectance data R(lambda) at a preselected wavelength**
- **TAPPI brightness R457**
- **L*, a*, b*, chromaticity C**
- **colour differences for L*, a*, b***
- **CIE v', u*, v***
- **hue H**

These analyses are made inside the meter and all data are transferable to other systems via the interfaces. Refer to corresponding standard publications for details for the indicated variables. Further CIE and other colour system variables can be calculated in the PC program based on what are produced by the meter.

Available selections: Illuminant: **D65** (default) **/ A / C / D50 / D55 / D75**
Colour system: **CIE L*a*b* and CIE L*u*v***
UV Excitation: **0..100 % with an uncalibrated by power but rather stable UV source**

Compatibility: Design and implementation according to **CIE 1964** basic standard of colorimetry with full consideration of **CIE 15:2004** and **CIE 176:2006**. Also other relevant documentation and standards of the professional field are used.

Distance: **50 mm** from the meter's bottom to the surface. Tolerance is +/- 2 mm with minimal effect on colour coordinates and on other resulting value. The reflectance itself will vary slightly according to distance and for accurate reflectance and brightness values the distance should be kept at the nominal setting. **Full compliance to the standard's requirements are obtained at the precise distance with a planar material parallel to the sensor bottom.**

Calibrations: The instrument is calibrated with a NIST traceable reflectance standard and checked against NIST traceable colour standards. These standards are available as optional accessories for tracking the long-term stability. Recalibration or checking by user is possible in laboratory conditions. The reflectance standard can be a user-defined element while the knowledge of its spectral behavior is known and can be written into a numeric text file. That can be uploaded to the meter for calibration with it.

Resolution: 0.001 units in digital values transferred, 1.5 mV in voltage output (scalable)

Repeatability: Typically 0.1 or better in x,y,z coordinates, 0.7 in X,Y,Z stimulus

Accuracy: Better than 0.05 or better units in x,y,z, 0.5 in X,Y,Z stimulus

Stability: Better than 30 ppm / year and the temperature coefficient is better than 3 ppm /C, both referring to the full range used in chromatic coordinates x,y,z. The X,Y,Z are the ones temperature compensated and everything else will follow that.

Measuring Speed:	The colour meter delivers two fresh readings / second of colour coordinates. The value (selected as one of available variables) is updated at the same speed to the voltage output with a maximum time delay of 0.5 s. The latest values are sent to all interfaces. The internal raw speed is two analyzes / sec, available to external interfaces at the same speed, depending on interface loading and baud rates.
Compensations:	All tristimulus signal data X,Y,Z are compensated against instrument temperature and other internal variables. No attempt is made to compensate against thermochromic effects. Also the TAPPI Brightness is temperature compensated as it is independent of the XYZ.
Data retention:	All configuration settings are nonvolatile, no loss of data when power is off. The data retention time is at least 40 years in the Flash memory.
Filtering of signal:	Selectable total step response time to full accuracy: FAST: 2 s, MEDIUM: 5 s, SLOW: 25 s
Dynamic range:	The dynamic range of the basic raw reflectance signal is 21 bits or more
Warm-up time:	Less than 60 s from turning the power on to reach a good working measurement accuracy, full accuracy within 10 minutes
Environmental:	Operating temperature range +5..+40 C (+60 C with air purge). The colour meter has an internal thermometer, with which the user is warned of a too hot environment. That temperature signal is available to the user. The colour meter's box is IP67 classified. Measurements in more requiring environments (high temperature, dust, high moisture %RH) is not recommended and will require a further enclosure and air purge or other suitable protective arrangements. An internal cooling system attempts to prevent overheating by moving extra heat to the outer surface of the instrument's metal box. The box is hermetically sealed to avoid dust and moisture problems.
Operating cycle:	Continuous
Control interfaces:	The colour meter can also be used with any version 7/8/10+ 32/64 bit Windows PC compatible with the industry standard, either via the **RS232** at 9600 / 115200 bauds using a reliable packet protocol. The **user interface** is a graphical program in Windows for colour coordinate real-time trend, downloading of data series, instrument settings, calibration and statistics. It enables continuous operation. A USB V2.0 interface is also available with a standard type B USB connector on the meter's panel. The switch for selecting either RS232 or USB is automatic.
Status information:	Status bytes available via RS232 / USB indicating all the most important settings and statuses of the colour meter.
Output data:	Analog output selections redirected to any channel available: **- X, Y, Z, x, y, z, Whiteness W, Tint T, Jyel, R(lambda), TAPPI Brightness,** **- CIE Lab: L*, a*, b*, C*, dEab*, v', u*, v*, Hue** The primary signals are available in all interfaces by selection or by default, depending on interface. The optional signals can be selected per channel. The calibrated reflectance spectrum is also transferable from the sensor as a separate operation via RS232/USB to the PC program. If a wavelength calibration is required, the raw spectral data is available in the same way. In the PC program's Diagnostic task, the various spectra and signals are available for maintenance and tracking of instrument reliability.

Voltage output: Four voltage outputs are available as a standard feature (for a primary or optional data, selected by user). The signal can be scaled with a multiplier and an offset. The range is 0..2 Volts in one (same as the 4-20 mA channel) and 0..5 Volts in three channels generated by a 12 bit DAC.

Current output: One 4 - 20 mA active current loop is for the reflectance signal (or another signal as above). The signal can be scaled with a multiplier and an offset. This signal corresponds to the first of the signal output channels, acting parallel with the first voltage output.

Power source: External power 24 V (18..28 V) 500 mA (peak 1000 mA at start-up). The typical power dissipation is 12 W corresponding to a DC current of 0.50 A. The power is fed in through the 12-pin communications connector. The power supply -PS belongs to the delivery. It has a number of connectors to the external systems.

External connections: ***Available on the power supply -PS panel and at the 12-pin ITT-Cannon connector 1 (Comm's):***

RS232: regular full-duplex lines. The private packet protocol supports a local area network with one master and up to 125 slaves. The connector is a D9 female connector with regular wiring for a PC on the -PS panel.
TRIGGER IN: a falling edge sensitive logic input as a TTL level signal (3.3 V to 5 V) to increment a reel counter. A mechanical switch can also perform the same action. The -PS panel has a BNC connector or a screw terminal for it.
SIGNAL OUT: two voltages 0..2 V and 0..5 V for channel 1 and 2 signals. The -PS panel has two screw terminals or BNC connectors for them.
POWER SUPPLY: Voltage 24 V +/-10 %
4-20 mA: An active current output for a selectable signal (channel 1). The current loop is able to supply its own 24 Volt power.

Available in the 12-pin ITT-Cannon connector 2 (Analog) :

TRIGGER IN: a falling edge sensitive logic input as a TTL level signal (3.3 V to 5 V) to increment the reel counter. A mechanical switch can also perform the same action. This is a parallel copy of the signal in the upper Cannon connector.
SIGNAL OUT: four voltages 0..5 V for channel 1..4 signals. One 4 - 20 mA output for a selectable signal (channel 1). The current loop is active and able to supply its own 24 Volt power.
POWER SUPPLY: Voltage 24 V +/-10 %

Available on the panel:

USB V2.0 (Comm's): A USB type B connector directly connectable to a PC. The Windows driver is quickly installed for it. The USB port is **optional** with the RS232 and is not used simultaneously **(automatically switched)** . In the PC, it will be used like a new RS232 port with no changes to other PC program operation. The USB module is powered by the external cable.

USB V2.0 (Service): A USB type B connector directly connectable to a PC. The Windows driver is quickly installed for it. This USB port is used only for **Service** operations and baud rate setting of the meter itself with a terminal program.

Enclosure: IP67 classified Aluminum case with oxidation, protected from dust and splash water, dimensions (LxHxW) **270x270x120** mm, weight about 3.5 kg. Four M8 and four M10 threads for mounting. The connectors are located on one of the smaller end panels (270x120 mm). For very difficult measuring conditions a purge air quick connector for a standard 8 mm air tubing is available. It is used for keeping the instrument cool in warm environments.

Service interval: It is recommended to check the meter every three years to make sure there are not too high environmental stresses on the instrument. Also, the internal software and other programs would be upgraded. The PC program's latest version can always be downloaded from Visilab's website with its manual.

User maintenance: Maintenance consists of regular cleanup of optical windows removing collected dust and of monthly checking against an optional reflectance standard. Reflectance calibration is an optional user task if a proper standard is available with a known reflectance spectrum. A simple checking is usually sufficient to see the proper reflectance value coming out and no specific operation is required. When the standard is in place, the X,Y,Z readings should be very close to the neutral point values regarding the proper illuminator in use.

Guarantee: Two years from delivery, does not cover wearing parts, like the connectors.

EM compatibility: Conforms to the requirements of Directive **89/336/EEC** and is accordingly CE-marked. All interfaces are efficiently protected against overvoltages, ESD and other surges. However, some care is required regarding the voltage outputs, not to overload them or to feed any external voltage to them. They will lose their accuracy with a too heavy loading (> 1 mA). The trigger input is diode-protected to clip external voltages to 5 Volts. Excessive external voltage feed may still cause damage. Self-healing fuses are used in main circuits to allow a normal recovered operation after an internal overloading event.

CIE compatibility: Conforms to the requirements of **CIE 15:2004** and **CIE 176:2006**. The measurement is based on **CIE 1964 10 deg** observer. The design is made according to CIE definition of **Category B** instrument or better.

Software: The program **FrontColour** operates in Windows 10/8/7 and future systems. The software bundle belongs to the meter and has free upgrading via internet on the manufacturer's web site. This software is a full-featured tool for handling all colour measurement data and essential configurations. It can be operated continuously for archiving of all selected data. It has features for retrieving old data, statistics and reporting. The program can operate via either USB, RS232 or Bluetooth. The **FrontColourConfig** program is similarly working and is used for making a basic setup of the instrument at installation time and calibrations and has some data caquisition too.

Other accessories: **- a galvanically isolated RS232-to USB conversion dongle** is supplied with the sensor for direct connection of the power supply unit to any PC with a free USB port.

- a laser pointer helping in installation in requiring positions to succeed in accurate working distance. It has two lasers whose spots are required to meet at the proper working distance on the target surface. Operation is controlled manually at the PC

- Bluetooth: A standard wireless Bluetooth V2.0 interface with a maximum of 100 m operating range. It uses the communication protocol for creating a serial port at 115200 bauds. A corresponding PC dongle is supplied with the sensor for use at a 100 m range in good conditions. The Slave Bluetooth module is placed at the power supply since the FrontColour10 itself is mounted in a metal case preventing its operation.

CIE compatibility: Conforms to the requirements of **CIE 15:2004** and **CIE 176:2006**. The measurement is based on **CIE 1964 10 deg** observer. The design is made according to CIE definition of **Category B** instrument or better.

Optional Accessories: **- a set of ceramic colour standards** (available separately from other vendors like Lucideon Ltd U.K.)

- a Spectralon reflectance standard (available separately from other vendors like AMS Technologies in Germany)

- a wavelength calibration light source is available from vendors like Ocean Insight in The Netherlands. The CCD spectrometer stability is of very high degree and very likely does not require any recalibrations since it does not have any moving parts.

- a USB extension lead of 3 meters

- a dust cover for keeping the meter clean in environments containing dust, it is made of polycarbonate sheets

- holders for flat samples, colour tiles, the reflectance standard and wavelength calibrator, made of polymer

Appendix 3. Troubleshooting the Meter

In cases where you meet troubles in getting the meter working correctly you may need assistance. Visilab is able to help you but to alleviate our burden, please check the following points before calling us.

A. Symptom: No colour signal to the PC program

1. Is the meter correctly powered? Are you sure? Is there some light coming out of the bottom of the meter? If yes, the meter is receiving power and is running. If not, check the power cable from the PS. It should be connected to a 230 VAC or 110 VAC wall inlet.
2. Is the RS232 cable correctly plugged at both ends? Has it been damaged? If yes, fix it.
3. Are you sure that the COM port you are using in the program is actually the one you have connected the cable into? **This is absolutely the most frequent reason for communication problems with the meter.** Change the port selection in the program's Communications page.
4. If done all right thus far and still no connection is established with the meter, the baud rate may be incorrect.
5. One source of confusion may arise if the high-speed serial communication is in use, either in the software or in the meter, but not in both.

C. Symptom: No Colour signal from the analog outputs but the PC program and Colour readings are correct.

1. Check the cables for proper connection
2. Check the voltage output connectors at the PS and cable ends. Does it look damaged? Is there water or dirt on it?
3. Check to see if the meter is in Low Power mode instead of Normal mode. Turn it into Normal mode.

D. Symptom: The Colour signal is incorrect.

1. Are you using the correct working distance? This is the common reason for getting invalid results.
2. Is the head temperature too high? It should normally be below +45 C. Has the meter been subject to very high ambient temperatures? If you are using air flow, are you sure the flow has been continuous without any breaks? If the temperature has risen too much, irreversible damage (or at least changes to some important parameters) have been caused to the meter. In mild cases there is no serious damage. In severe cases the optical head must be checked and readjusted.
5. Are the windows clean? A usual cause for malfunctioning is dust over glasses or heavy water condensation in difficult conditions. Please clean the windows.

E. Symptom: The Colour meter is powered but does not offer sensible colour data. There is no light coming out of the meter but the communications is working

1. Since the meter is powered and the communications is working, check the internal temperature. If the temperature reading is very high the meter is possibly overheated and it has been put to Low Power Mode to prevent any damage. Also, a faulty thermistor measuring the internal temperature may cause something like this. There is a spare thermistor inside the meter and it can be taken into use programmatically. Contact Visilab to find out how it is done.

If all attempts show no proper indication of a working meter, contact us. Do not send back the meter without our permission.

Appendix 4. Mechanical Installation the Meter

In the following is described the issues of mechanical assembly of the Colour meter.

Distance

Observe first the most important factor, the measuring distance from the running web. The working distance is 50 mm. **You can check it also by turning on and off the pilot lasers.** The spots should meet at the working distance.

Angles

The angle of the running web is not important along the web plane.

The meter's bottom plane and the web should be parallel. Error in this will reflect itself in the colour signals as they are not according to the CIE standard.

Mounting

The meter has four M10x1.5 and four M8x1.0 threads in the cabinet and is supposed to be mounted from them. Four bolts are sufficient for a relaible mounting.

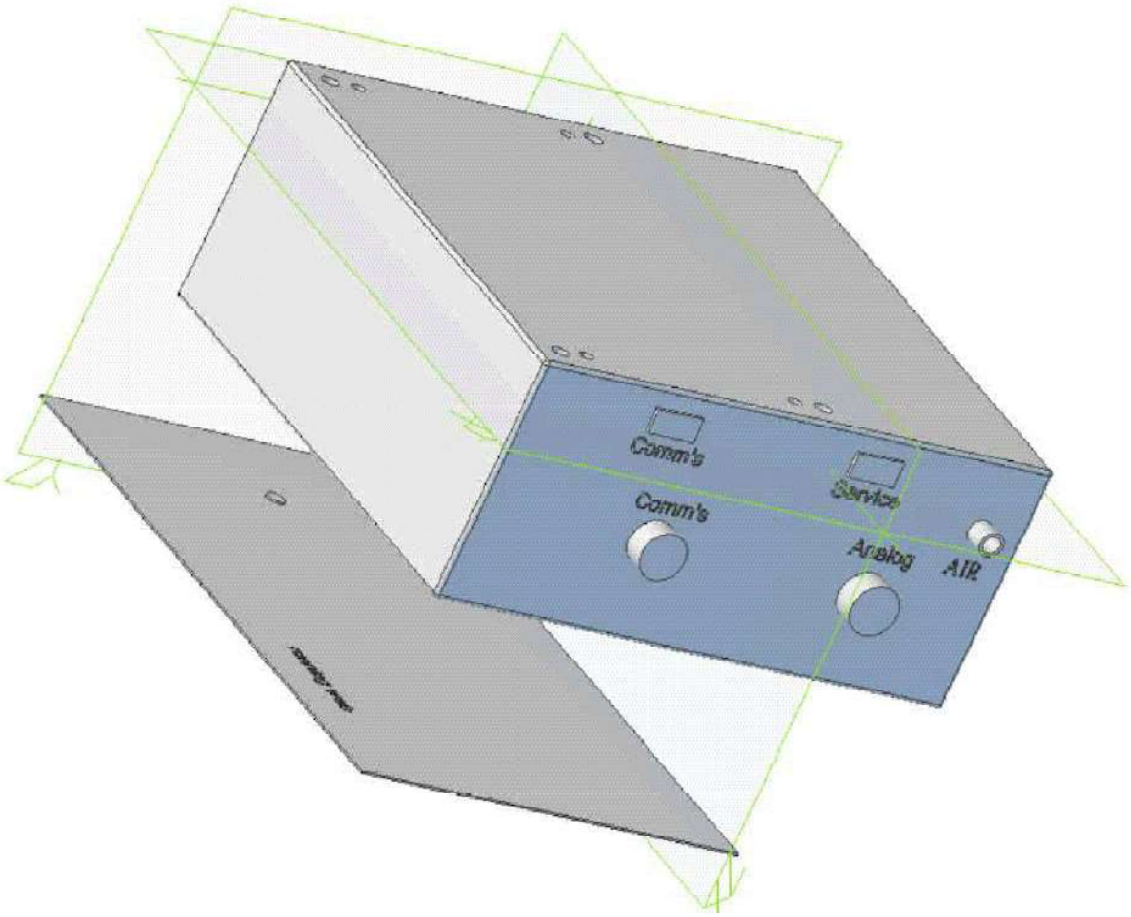


Figure L4-1. Mechanical assembly of FrontColour10 Colour meter (not to scale) relative to the surface below it to be measured

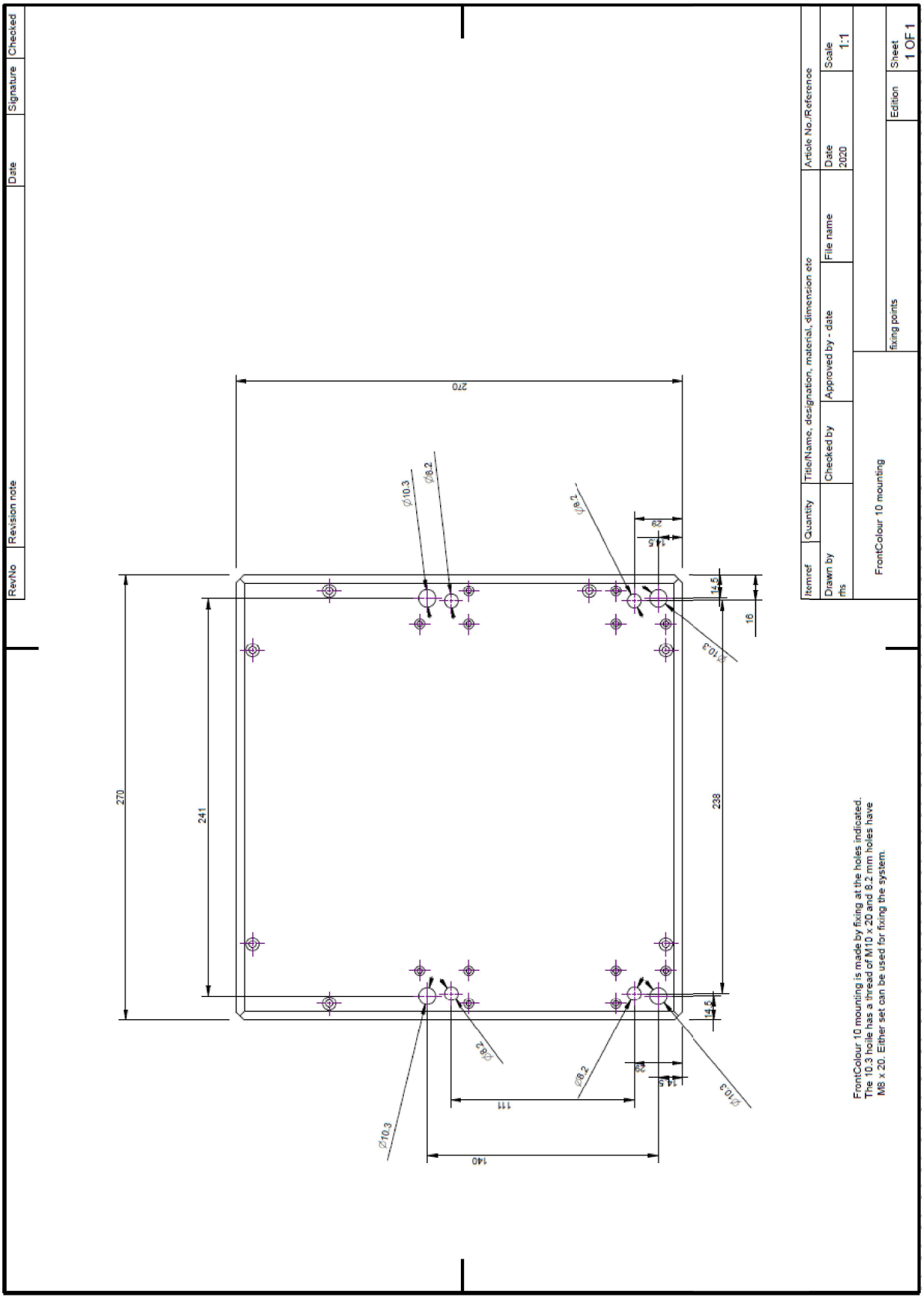


Figure L4-2. Mechanical assembly fixing points of FrontColour10 Colour meter (not to scale)

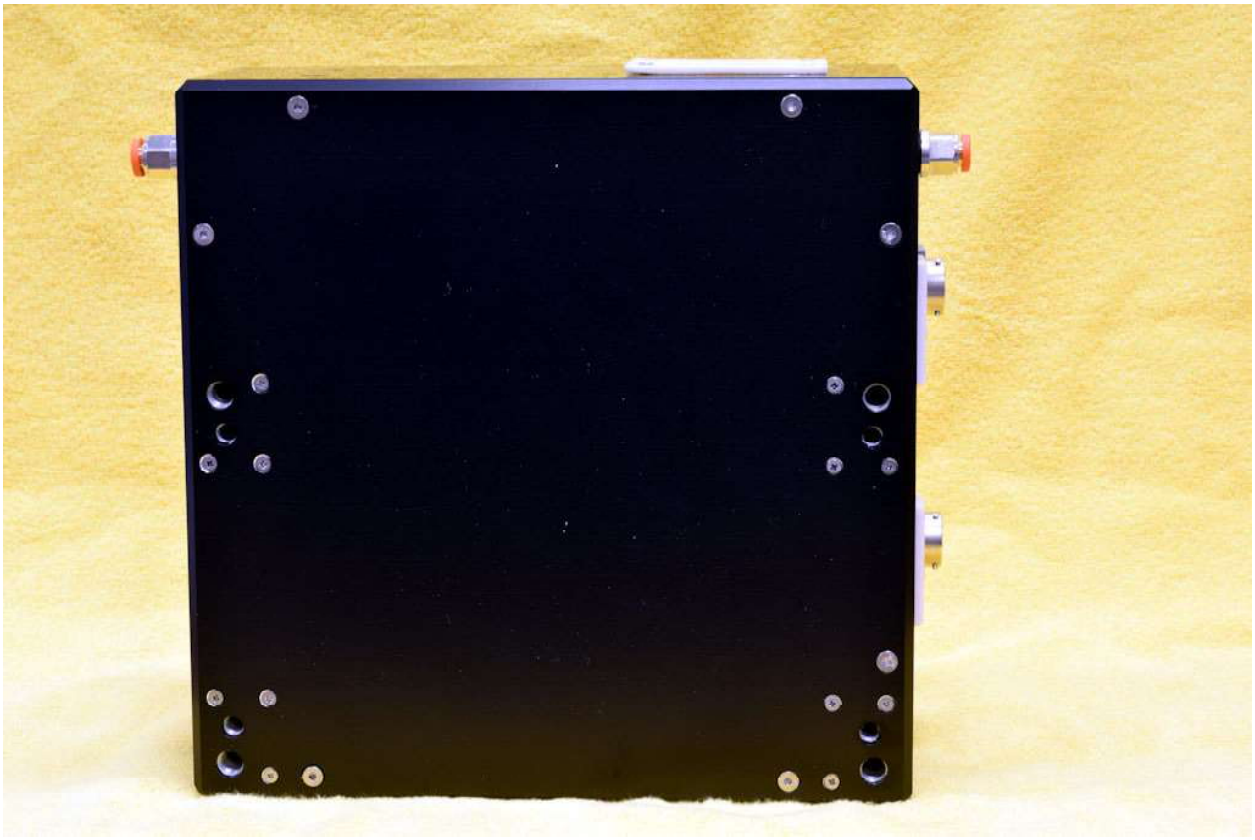


Figure L4-3. Mechanical assembly of FrontColour10 Colour meter (not to scale)

Figure L4-4. Mechanical dimensions of model **FC10,** not to scale

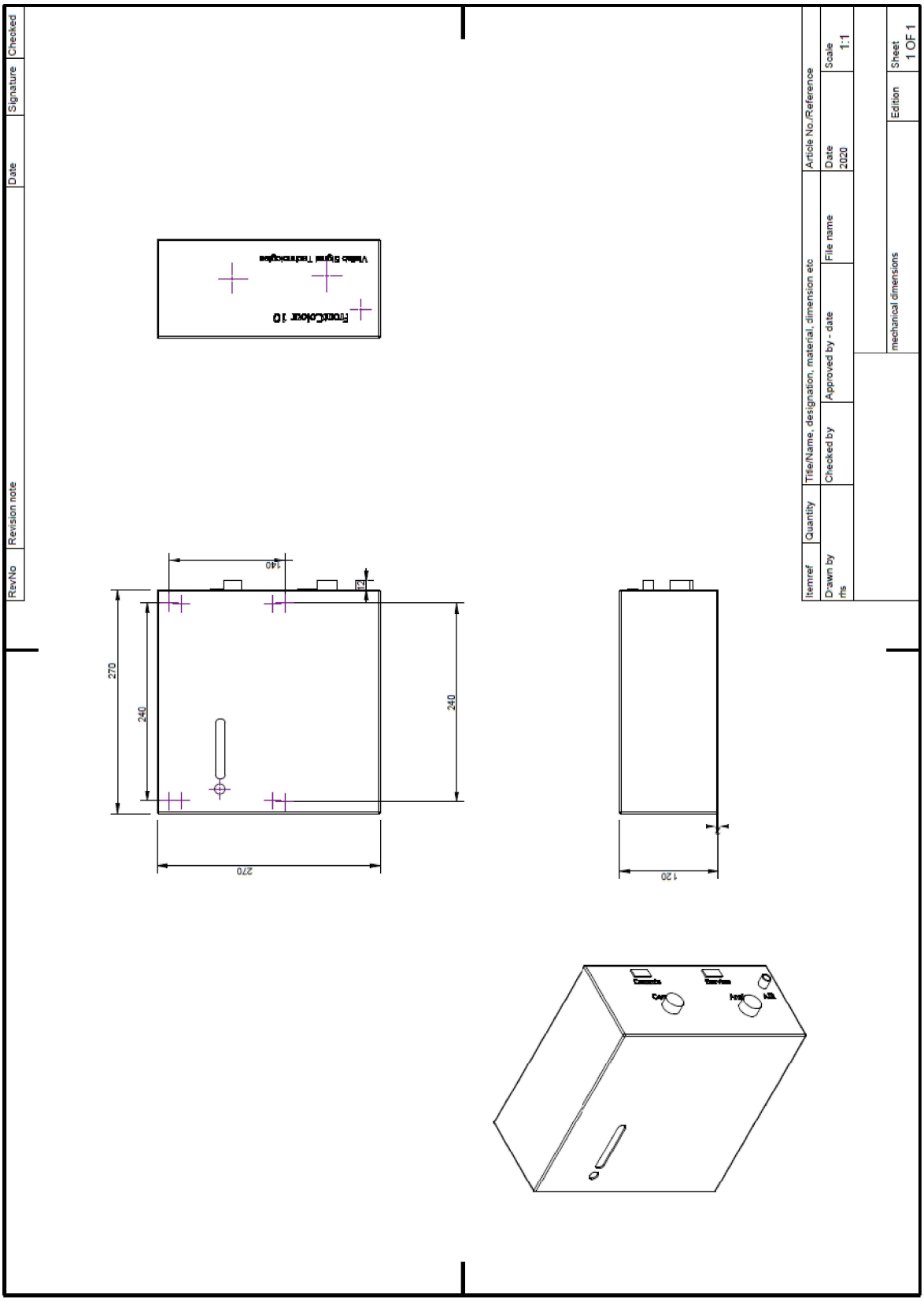
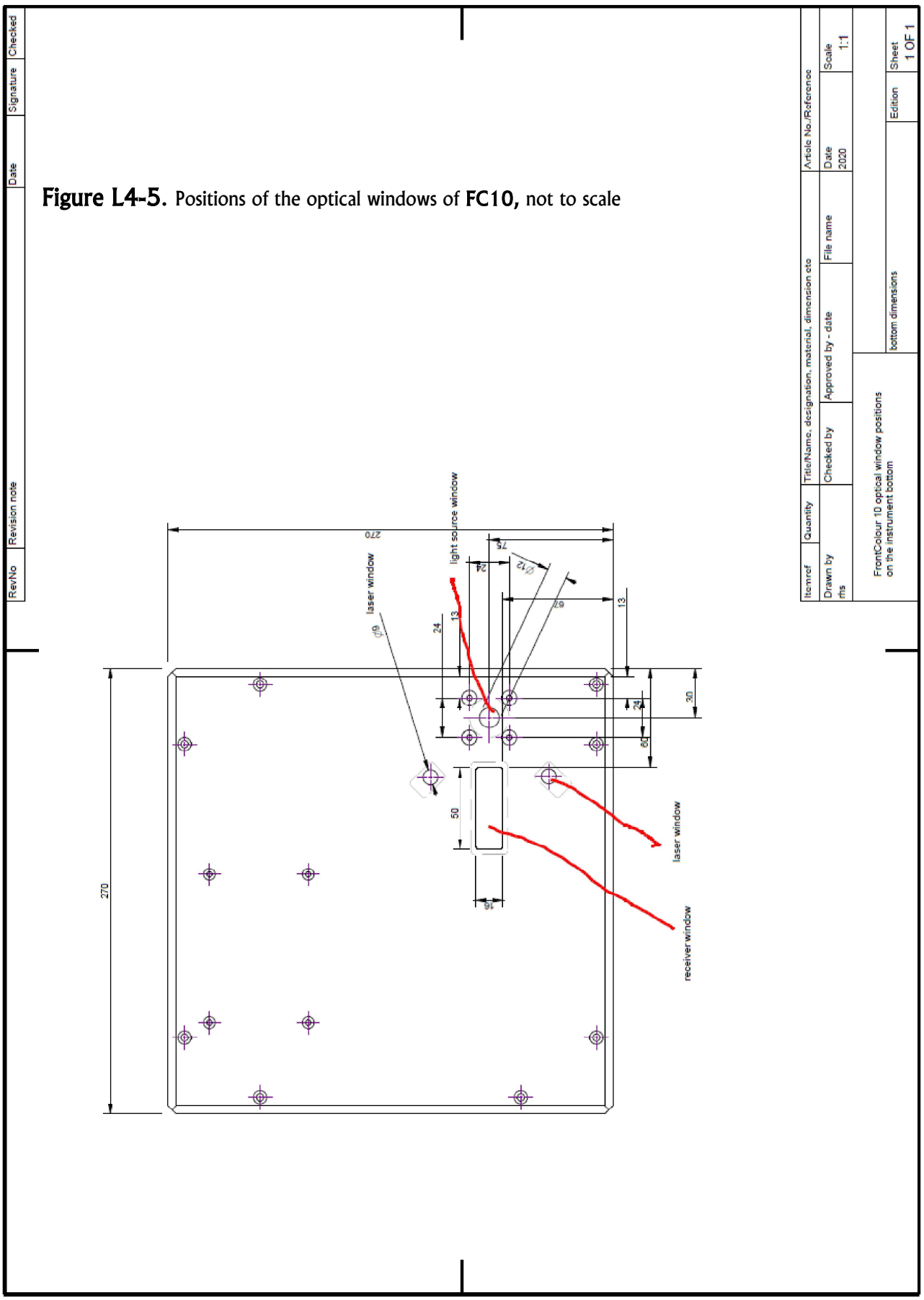


Figure L4-5. Positions of the optical windows of **FC10,** not to scale



The four M10 or M8 bolts are for fixing the instrument

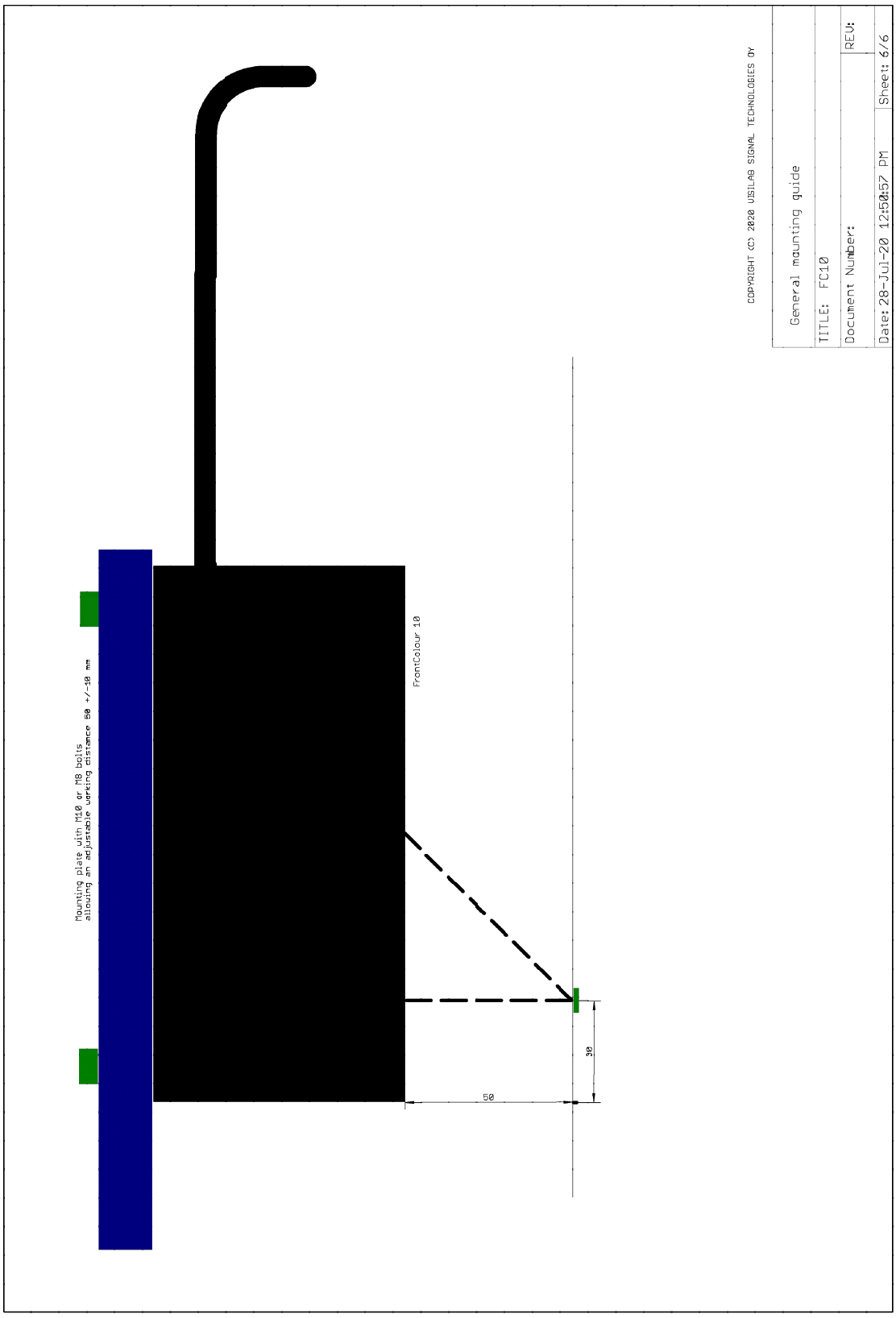


Figure L4-6. General mounting guide of **FC10,** not to scale

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