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1 The Brontes colorimeter

The Brontes colorimeter is a tristimulus meter, meaning that the output of the Brontes is X,Y and Z from which other colour spaces can be derived. Many colour measurements do not require the actual colour spectrum to be measured but just colour and light intensity or reflection. In these cases a colorimeter often is the preferred device because it also has some advantages over spectrometers. Most significant advantages are :

- Faster
- Easier to use
- Easier to keep stable results in a production environment

The Brontes is very suitable to measure very small colour differences in a production line environment and do that for a very long time without the need for periodic calibrations.

For many users, the ability to measure very small differences is enough. For other users, also the absolute colour point of their sample is of great importance. For these customers, Admesy provides a calibration service or in case the user own a reference system they can perform this calibration themselves.

This application note is about how users of the Brontes colorimeter can calibrate their Brontes devices towards their own reference. The data presented in this paper is an actual customer example for the LCD industry.

2 Calibration of colour and luminance

Calibration of colour and luminance is usually performed using a calibration light source. The major problem in all of this, is that there's not a very accurate standard, which means that calibration light sources used all over the world give slightly different results. Typical problems of light sources :

- Not a flat spectrum, sometimes causing low S/N ratio in some areas of the spectrum
- Warm up time (every lamp needs time to reach a stable output)
- Lifetime (the calibration light source degrades over time)

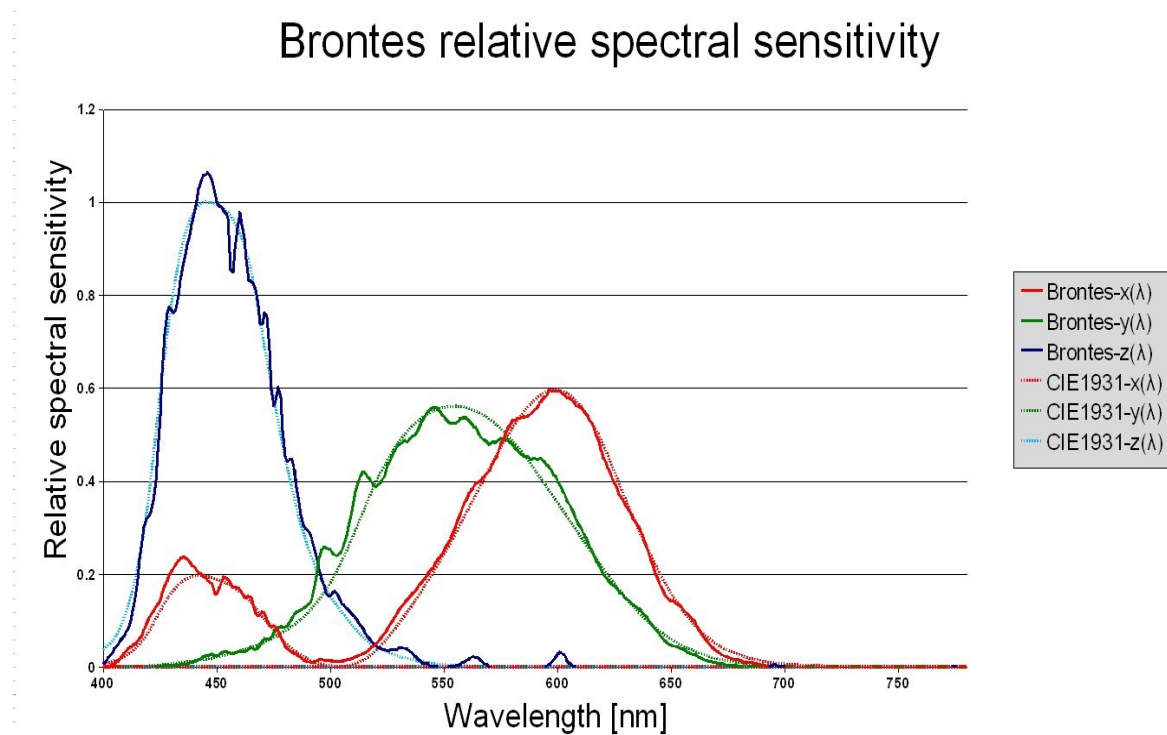
This also causes colour and luminance measurement to deviate when different measurement equipment is compared. This often causes confusion in an ever more demanding market.

Looking at the above items, it may be clear that comparing results of different measurement equipment isn't all that easy. The above problems are also difficult to solve since they result from pure physics of the used lamps.

2.1 Absolute colour and luminance of the Brontes

The Brontes colorimeter has a fixed tristimulus sensor. The characteristics of the sensor closely match the CIE1931 colour matching curves as used by many spectrometers to calculate colour. Within a spectrometer the measured spectrum can be multiplied by these curves and integrated. The resulting three values are X,Y and Z. The Brontes gives X,Y and Z straight away so spectral correction can not be performed.

The Brontes relative spectral sensitivity can be seen in the below graph.



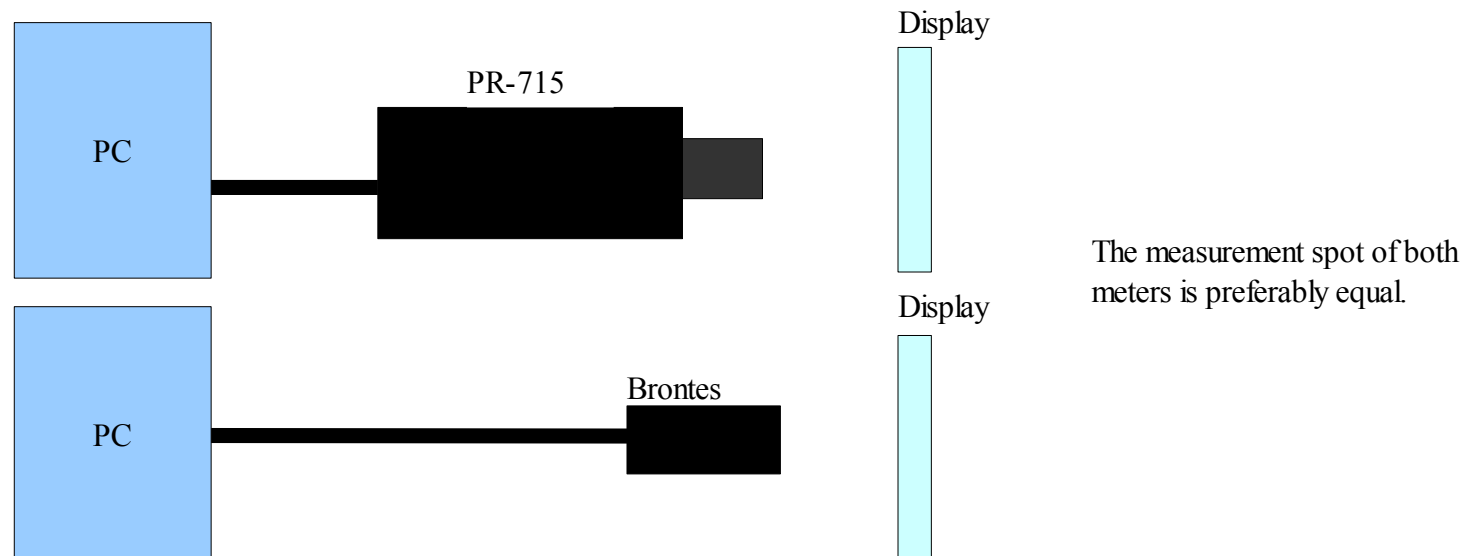
It can be seen that at some wavelengths in the spectrum the Brontes sensitivity differs a little from the CIE1931 colour matching curves.

The Brontes colorimeter provides the user not with the spectral data, but the X,Y and Z value, meaning that calibration can only be performed on those values.

In order to measure absolute colour and luminance the Brontes colorimeter can be calibrated towards a reference system. Since many users require the Brontes to measure the same results for their in-line production as their laboratory results, this way of calibration is explained further in this document.

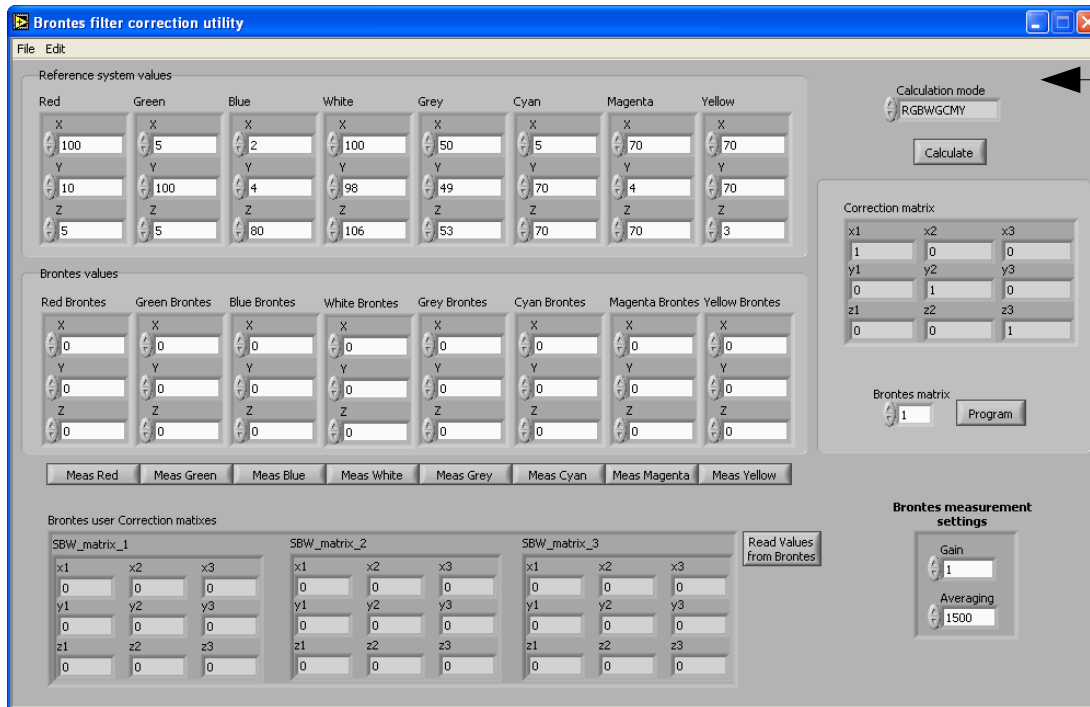
3 Calibration of the Brontes using a Photo Research PR-715

The described calibration includes a Photo Research PR-715 lab grade spectrometer and small mobile LCD's (Mobile phone/PDA) using white LED back light. The test set up is shown in the diagram below :



The Brontes can be calibrated by applying a 3x3 matrix. This matrix can be calculated using measured values of both the reference system and the Brontes. Admesy supplies software that will calculate the matrix from these measured values. Up to three calibration matrices can be stored in the Brontes. In case more are required, additional methods exist.

The Brontes calibration software is called Brontes_Filter_UTILITY. The software and user manual are supplied with the Brontes and can be found on the Admesy web site : http://www.admesy.nl/brontes_soft.php



The Brontes filter correction utility,
used for calibration.

4 Calibration

For the following calibration, the display was measured using four images :

- Full screen Red
- Full screen Green
- Full screen Blue
- Full screen White
- Full screen mid grey level

More colours are allowed, but in principle the calibration stays the same. The resulting matrix is at all times a 3x3 matrix.

The measured values can be seen in the table below :

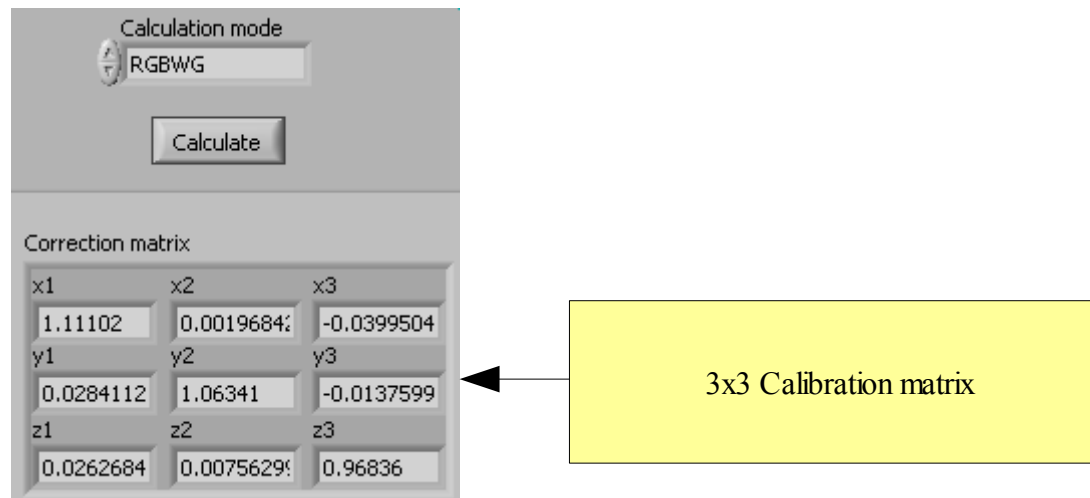
Reference system values				
Red	Green	Blue	White	Grey
X 94.56	X 112.9	X 65.51	X 270.6	X 84.46
Y 51.76	Y 197.6	Y 37.94	Y 285	Y 83.84
Z 5.15	Z 42.61	Z 310.1	Z 365.9	Z 151.2
Brontes values				
Red Brontes	Green Brontes	Blue Brontes	White Brontes	Grey Brontes
X 84.59	X 102.19	X 70.47	X 257.9	X 77.39
Y 46.24	Y 183.38	Y 38.45	Y 267.26	Y 74.21
Z 5.88	Z 42.87	Z 322.2	Z 367.35	Z 146.82

Photo Research PR-715 values

Brontes values

Illustration 1: Measured reference and Brontes values

After the values have been input in the filter utility, the “Calculate” button can be clicked in order to calculate the 3x3 correction matrix.



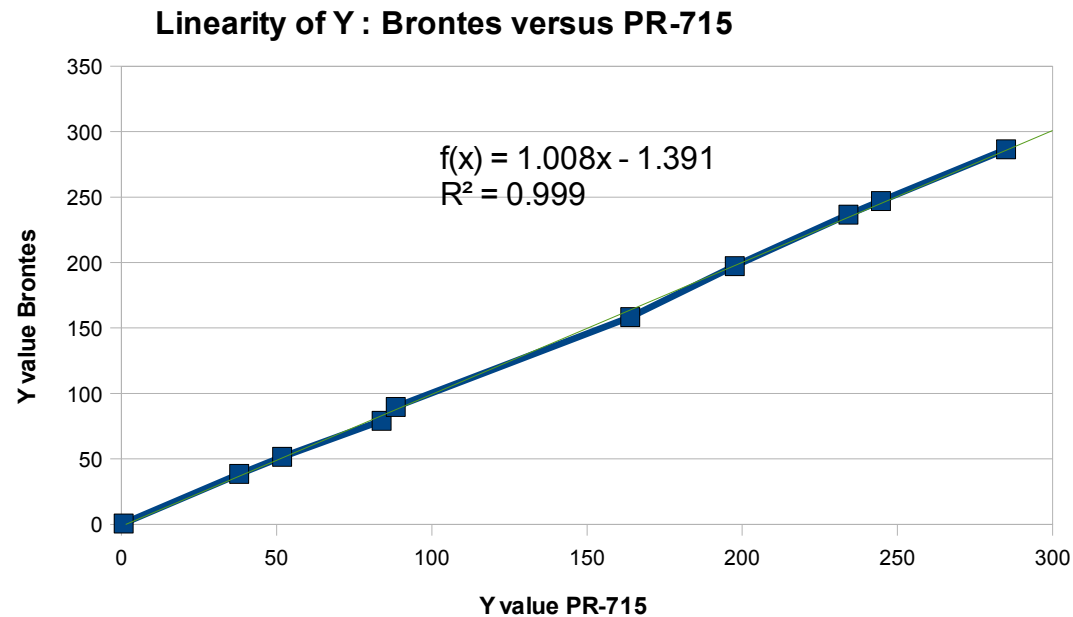
The matrix can be stored in either one of the three user calibration areas in the Brontes and be used in all other Brontes applications.

Note : When measuring the values using the Brontes the calibration matrix in the Brontes main application should be set to “OFF”.

5 Calibration results

After the calibration matrix has been stored, it can be verified that the Brontes measures according to the reference system.

The following graphs show luminance (Y) values of the Brontes compared to the reference system, after calibration. The same linearity is found for X and Z.



The following table shows typical calibration results

comment	Yref	xref	yref	Ybrontes	x_brontes	y_brontes	Delta x	Delta y
white	285	0.294	0.309	286.48	0.295	0.310	0.001	0.001
red	51.76	0.624	0.342	51.49	0.611	0.335	-0.013	-0.006
green	197.6	0.320	0.560	197.32	0.316	0.556	-0.004	-0.004
blue	37.94	0.158	0.092	38.46	0.157	0.092	-0.002	0.000
Grey 50%	83.84	0.264	0.262	79.09	0.264	0.260	0.000	-0.002
Grey 75%	163.9	0.273	0.277	158.27	0.272	0.274	-0.001	-0.003
cyan	234.2	0.232	0.307	236.59	0.232	0.305	0.000	-0.002
magenta	88.34	0.282	0.158	89.67	0.280	0.157	-0.002	0.000
yellow	244.7	0.414	0.493	247.01	0.409	0.488	-0.005	-0.004

It can be seen that most colours match very close to the reference system. The Red colour shows some deviation which is a result of very saturated colour and the Brontes deviation from the CIE1931 curves. For different red colours (less saturated) the result will be a closer match.

Note that the above are typical results from a customer application. Some outliers can be expected, but in general the match is very close to the reference system for all colours. It is also possible to calibrate for less saturated colours or chose different reference points. This may result in a better match for certain colours.

Looking at the above results and considering that the Brontes is not lab grade equipment like the PR-715, it is clear that the Brontes can be used for absolute measurement of colour for in-line applications. The typical deviations as seen above can also be found between different brands of spectrometers as they all depend on calibration light sources.

6 Considerations

The calibration as shown in this report is valid for the measured type of display only. It may be used for other displays with similar back light spectrum but the Brontes needs to be recalibrated for other types of displays.

This means that when the Brontes has been calibrated on a display that uses a CCFL back light, it can not be used to measure displays that use LED back lights unless a new calibration is carried out.

Since the Brontes sensor itself is fixed the calibration will be valid for a very long time. It is however advisable to check/recalibrate once every year.

When calibrating multiple Brontes devices it is recommended to calibrate one against the reference system and the other Brontes devices toward this reference Brontes. When calibrating one Brontes against another, the results are better than found in the above table. The typical maximum difference in x,y is lower than 0.003.