PROFILES AND CALIBRATION

For the Harlequin® Host Renderer SDK and Harlequin® MultiRIP™

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GLOBAL GRAPHICS® software

Contents

Harlequin profiles and calibration

1 Profiles and calibration

Harlequin format profiles serve the same general purpose as ICC profiles, but are different in format and content.

Harlequin profiles contain a particular set of calibration data and/or color characterization data for an output device. The variations in content allow for different device capabilities and for use with or without the Harlequin color management options.

Harlequin profiles do not follow the ICC profile specification, but they do contain all the information needed to produce accurate color on the relevant output device. The Harlequin RIP can also install ICC profiles so that they are usable by color management options in the RIP.

The description given here does not aim to support the creation of a new profile, and the color characterization section of the Harlequin profile format is deliberately left undocumented.

This description does provide enough information to allow OEMs to make the use of profiles more accurate and easier for users. OEMs can choose to:

- Copy typical profiles and modify the linearization aim values to use values measured for a particular output device.
- Add measurement systems and data for measuring instruments known to be in common use with OEMs systems. Equally, OEMs can suppress measurement systems that OEMs do not wish their users to use.
- Customize or translate the comments visible to users of the OEM's implementation of the RIP.

Section 1.1 describes the locations and uses of profiles in a RIP installation. Later sections describe the contents of profiles in detail.

1.1 Locations and uses

Profiles exist in the `SW` directory, in places that are chosen in a way that can depend upon the plugin implementation, the capabilities of the device, the use of the profile, and the source of the data. When modifying profiles, it is important to identify the correct profile.

Before a list of the specific places in which to find profiles, here are some general comments.

Profiles describe a device operating in a specific color space. Most devices can only operate in a single color space, so storing the profiles in a location identified only by the device is enough to ensure that profiles for different color spaces are never put in the same location. Some devices, though, can operate in two or more color spaces. To avoid ambiguity for these devices, their profiles are put into locations specific to both the device and the color space.

ICC profiles are always installed into color space specific locations.

The RIP can associate each output device with a special profile called `Linear`. This profile is a container of calibration aim values for the device when HCPS is not active. Most devices have a device-specific `Linear` profile, stored somewhere specific to that device and its output plugin. Where a device does not have its own `Linear` profile, the aim values come from the system default `Linear` profile instead.

The `Linear` profile is used as the default curve for device calibration, and as such plays an important part of the calibration process.

Section 1.1.1 through Section 1.1.4 describe the common uses of profiles and where they are located.

Note: In many of the listed directories, there may be multiple profiles used for different colorants or output media, or for multiple instances of devices.

Note: These are locations for Harlequin format profiles only. Harlequin does not suggest a standard location for ICC profiles. (There is a full transfer of relevant data when ICC profiles are installed as Harlequin format profiles and it is not necessary to store ICC profiles within the RIP directory system afterwards.) While you should store ICC profiles as securely as other important master data, any safe location is suitable. A location outside the RIP directory system may make it easier to maintain a single, controlled, source of ICC profiles.

1.1.1 Device profiles

These are profiles related to a particular output device, which is not a printing press. All devices are related to a Harlequin output plugin, which can have its files organized in two ways: grouped into a single directory or not.

There are two *alternative* locations used to store profiles for directory-structured plugins, that is, plugins for which there is a single top-level directory within the `SW/devices` directory. If there is a device-specific `Linear` profile, it should also be located in one of these directories.

```
SW/devices/plugin_name/Profiles/colorspace/device_name/
SW/devices/plugin_name/Profiles/device_name/
```

If the plugin executable is placed directly in the `SW/devices` directory, the associated device profiles are always linked to a color space and stored in:

```
SW/devices/Profiles/colorspace/device_name/
```

1.1.2 Press profiles

Press profiles are intended to be used for output to printing presses. In version 5.0 and later, these profiles may be used when producing color separations. Press profiles are stored here:

```
SW/config/Press/Profiles/colorspace/Press/
```

In version 5.0 and earlier versions, the only color space for which Harlequin supply standard profiles is CMYK.

1.1.3 System default profiles

These profiles are defaults. Each is called `Linear`, and used only if a device has no `Linear` profile in its own plugin directory.

```
SW/config/Profiles/colorspace/
```

In version 5.0 and earlier versions, Harlequin supply profiles for the color spaces: CMYK, Gray, and RGB.

1.1.4 Emulation profiles

Emulation profiles are for use with HFCS only. They are held in:

```
SW/config/Profiles/Emulations/
```

1.2 Contents of profile files

The Harlequin format profile file contains several well defined sections, some of which are optional. The full list is:

- Initial labels contained in PostScript-language comments.
- The start of the overall `/Profile` dictionary. In versions before version 5.0, this extends to the end of the file and contains all the following items. In version 5.0,this dictionary ends after the `Linearization` section.
- Further labels within the `/Profile` dictionary. Some of these values are visible in the text window shown in the **Output Profile** section of the New Color Setup dialog box when using any HCPS option. See Section 1.6, page 8 for details.
- An optional, but almost always present, `Linearization` array containing dictionaries of aim values and other data for each color. See Section 1.7, page 10 for details.
- An optional color data section. In version 5.0, this is the `/ProfileColorData` dictionary; in earlier versions of the RIP this comprises the equivalent keys, but held in the `/Profile` dictionary. See Section 1.9, page 13 for a brief description.

This description concentrates on the `Linearization` section.

See Section 1.4 for a discussion of the permitted syntax and Section 1.5, page 6 for an example of a profile file. First, Section 1.2.1 describes why some content is optional and Section 1.3 discusses the use of ICC profiles.

1.2.1 Optional content

Both the linearization data and the color characterization data are optional, and can be present in, or absent from, a given profile in any combination.

- Where a profile does not contain linearization data, that is, the `Linearization` array is absent, this implies that the device does not support calibration through the RIP. This may be because the device has a self-calibration function.

  Note: The Harlequin RIP calibration editor disables calibration editing when such a profile is selected. The selected profile is a user choice in the calibration edit dialog box when using any HCPS option. Without HCPS, the selected profile is the device `Linear` profile (or the system default if there is no device-specific `Linear` profile).
- Where a profile does not contain color characterization data, the profile is not intended for use with HCPS. The `Linear` profiles used as device or system defaults are examples

Combining the above cases, the `Linear` profiles for self-calibrating devices contain neither linearization nor color characterization data.

1.3 Profiles created by installing ICC profiles

Some ICC profiles contain adequate color measurement information to allow them to be used to produce Harlequin format profiles. When these profiles are installed in the RIP, the HFCS and HSCS options can use Harlequin Rendering Intents as well as ICC Rendering Intents.

As in Harlequin profiles, ICC profiles have optional sections. The RIP must take account of this variability when users install ICC profiles.

One such optional section is calibration data:

- An ICC profile can contain calibration data, in which case the RIP copies that data into the installed profile.

- In many cases, ICC profiles do not contain calibration data. When installing such profiles, the RIP copies the calibration data from the device `Linear` profile into the installed profile. This can result in imperfect color matching, because the calibration assumed by the original profile creator is not identical to that in the `Linear` profile, but in most cases the result of this procedure is either perfect or "close enough". Where the result is not good enough, it becomes necessary to adjust the calibration by the use of Tone Curves.

1.4 Format and syntax

Profiles are created using the ASCII encoding defined in Section 3.2.2 of the *The PostScript® Language Reference Manual* (2nd Ed). The allowed characters are the printable subset of the ASCIII character set and the characters space, tab, and newline.

Though the header looks like a fragment of Level 2 PostScript language, the structure is more constrained than an arbitrary PostScript-language file. This is because it is read directly rather than using the interpreter.

PostScript-language notation is used for convenience, but the only permitted operators are these: `<<`, `>>`, `[`, and `]` . The position of newlines is important for recognition of the keys (that is, key/value pairs appear one per line), and this is directed by the reader rather than by the contents of the file, so the order is important. No computation can be used to derive values: for example, `[72 72]` is allowed where appropriate, but `[72 dup]` is not.

The normal rules for PostScript syntax of objects apply — strings are expressed using parentheses. In versions of the RIP before version 4.5, any strings *containing* parentheses must have those parentheses escaped with a backslash.

Comments are permitted, but not in the `/Profile` section and not when placed on the same line as a key. Even where permitted, the use of comments is discouraged.

In summary, because the PostScript-language interpreter is not used to parse the file, it is best to be as conservative as possible when creating profiles.

1.5 Example profile

This edited example of a profile for an output device illustrates the structure of Harlequin profiles.

For version 5.0, the original file (or a subsequent update) is:

```
SW/config/Press/Profiles/CMYK/Press/SWOP (CGATS TR001)
```

For version 4.5, the equivalent file (or a subsequent update) is:

```
SW/config/Press/Profiles/Press/SWOP (CGATS TR001)
```

There are extra comments in this listing to help clarify the overall structure of the profile. Three periods (…) are used to show where sections of large data arrays and sections repeated for other color channels have been omitted to save space in this document.

```
%!PS-Adobe-3.0
%%Title: SWOP (CGATS TR001) Profile
%%Creator: Harlequin
%%CreationDate: January 31, 1996
%%For: Harlequin
%%Copyright Harlequin Limited, 1996 All Rights Reserved.
%%EndComments

/Profile  <<
/ProfileVersion  1
/ProfileID       (/unique/string/1996/01/31/13/00/00)
/LastModified    (1996/01/31/13/00/00)
/ProfileColorSpace   /DeviceCMYK
/DeviceType      (SWOP (CGATS TR001))
/DeviceSerialNumber  (Unknown)
/MediaType       (SWOP standard paper)
/ColorantType    (SWOP standard inks)
/Resolution      [2400 2400]
/Halftone        << /Frequency 133 /SpotFunction (Euclidean) >>

/ValidForComment        (Use for calibrated CGATS Type 1 (SWOP))
/ValidForDeviceTypes    [(SWOP (CGATS TR001))]
/ValidForMediaTypes     [(SWOP paper)]
/ValidForColorantTypes  [(SWOP inks)]
/ValidForResolutions    /Any
/ValidForHalftones      /Any
/Comments              (Linear %dot on film)

/Linearization  [
  <<  /ChannelName          (Cyan)
      /ChannelColor         /Cyan
      /DefaultCurve         [ 0.0 0.0 1.0 1.0 ]
      /ConversionTables     [
      <<
        /TableName          (Status T)
        /SubtractPaperWhite  true
        /TableValues
          [  0.130000 1.00  ...  1.290000 0.00 ]
        /Filter             (Cyan)
      >>

      <<
        /TableName          (% Dot)
        /TableValues
          [  0.130000 1.00  ...  1.290000 0.00 ]
        /ConversionFormula  (Murray-Davies)
        /Filter             (Cyan)
      >>

       <<
        /TableName          (Dot Gain)
        /TableValues
          [  0.130000 1.00  ...  1.290000 0.00 ]
        /Relative           true
        /ConversionFormula  (Murray-Davies)
        /Filter            (Cyan)
      >>
```

```
    ] >>

    <<  /ChannelName         (Magenta)
        /ChannelColor        /Magenta
...     % Details for Magenta omitted
    ] >>

... % Dictionaries of tables for other process colors omitted.
... % There can be fixed spot color channels on suitable devices.
... % There must be a Default channel on devices that allow
... % arbitrary spot colors.

    <<  /ChannelName          (Default)
        /ChannelColor         /Default
        /DefaultCurve         [ 0.0000  0.0000  1.0000  1.0000 ]
        /ConversionTables  [
        <<
          /TableName         (% Dot)
          /TableValues       [ 0 1 100 0 ]
        >>
        <<
          /TableName  (Dot Gain)
          /TableValues  [ 0 1 100 0 ]
          /Relative true
        >>
    ] >>
]       % End of Linearization section

/MeasurementDataPresent true
>>      % End of Profile dictionary

%### Color data follows (do not edit this line) ###
/ProfileColorData
<<
...     % Keys and values, including large tables, omitted
>>
```

1.6 Keys in the Profile dictionary

The `Profile` dictionary contains a set of keys used to label the profile.

Table: Keys in the Profile dictionary

`ProfileVersion` *integer*

The version of the Harlequin profile format, to which this profile conforms. It must be `1` for all profiles to date (up to and including version 5.0).

`ProfileID` *string*

Unique identifier for the profile. Typically, Harlequin uses a string composed by combining computer and user names with the date and time. For example: `(/UniqueMachine/User/1996/01/31/13/00/00)`.

`LastModified` *string*

The last modification date and time of the profile. It is expressed numerically in the order: year, month, day, hour, minute, second. For example: `(1996/01/31/13/00/00)`.

`ProfileColorSpace` *name or array of strings*

The color space described by the profile. Versions of the RIP before version 5.0 support only a name, for example, `/DeviceCMYK`.

Version 5.0 also supports an array of strings, where each string names a colorant: for example, `[ (HexCyan) (HexMagenta) (HexYellow) (HexBlack) (HexOrange) (HexGreen) ]`. These must be colorant names for an actual output device and the `Linearization` array in this profile must contain entries for all the colorants. Version 5.0 release 0 supports this array form for linearization only, and *not* color characterization.

`DeviceType` *string*

The type of the device used to prepare the profile format. This is an arbitrary string, but its contents should be as informative as possible. For example: `(SWOP (CGATS TR001))`.

`DeviceSerialNumber` *string*

The serial number (if any) of the device used to prepare the profile format. This is an arbitrary string, but its contents should be as informative as possible. For example: `(EST2001547)`. We suggest that you use `(Unknown)` where the serial number is unknown or not applicable.

`MediaType` *string*

The type of the media used to prepare the profile. This is an arbitrary string, but its contents should be as informative as possible. For example: `(SWOP standard paper)`.

`ColorantType` *string*

The type of colorants used to prepare the profile. This is an arbitrary string, but its contents should be as informative as possible. For example: `(SWOP standard inks)`.

`Resolution` *array of two integers*

The hardware resolution used to prepare the profile, expressed in dots per inch. For example: `[2400 2400]`.

`Halftone` *dictionary*

The screen used to prepare the profile. The values do not appear in the RIP user interface. For example: `<< /Frequency 133 /SpotFunction (Euclidean) >>`.

Note: `/Frequency` can have a value of zero for some screens, principally those supplied by Harlequin Dispersed Screening (HDS). This is a Harlequin convention used to show that these screens do not have a conventional frequency.

`ValidForComment` *string*

This string appears in the RIP user interface as a general comment on the applicability of the profile.

`ValidForDeviceTypes` *array of strings*
`ValidForMediaTypes` *array of strings*
`ValidForColorantTypes` *array of strings*

These strings, one or more per key, appear in the RIP user interface as specific comments on the applicability of the profile.

`ValidForResolutions` *name or array of strings*
`ValidForHalftones` *name or array of strings*

Version 5.0 supports only the name value `/Any`, showing that the profile is suitable for all resolutions and halftones. Future versions of the RIP may support other values. The RIP user interface reports the `/Any` value using the string `any.Comments`*string*

This string can be used to give a comment additional to that in `ValidForComment`. This string also appears in the RIP user interface.

`Linearization` *array of dictionaries*

Within this linearization array, there is one dictionary for each channel. Each dictionary defines a channel by name, defines a default transfer curve, and defines at least one conversion table between values used internally by the RIP and values in schemes used by common measuring devices. See the following table for details of the individual keys in the dictionaries.

Apart from the process colors supported by the device, there can be channels for named spot colors. On devices that can support arbitrary spot colors, there should always be a `Default` channel: this dictionary is used for any spot colors not given a named channel. `MeasurementDataPresent` *boolean*

Required, for version 5.0 or later. This boolean is `true` if there is a following top-level dictionary called `ProfileColorData`, and must be `false` in all other cases. (`Linear` profiles are the profiles most likely to have a `false` value.) Typically, this is the last key in the `Profile` dictionary.

Note: For profiles used with versions of the RIP before version 5.0, this key does not exist and the characterization data appears as additional keys and values within the `Profile` dictionary.

1.7 Linearization data

The keys in the linearization section are:

Table: Keys in Linearization dictionaries

`ChannelName` *string*

Required. The name that appears in the RIP user interface for the color represented by this channel. For example: `(Cyan)`.

`ChannelColor` *name*

Required, but only for versions before version 5.0. Deprecated for use with version 5.0 and later versions: in its place, use the `Filter` key in dictionaries stored under the `ConversionTables` key described below.

`ChannelColor` is the name used to identify the channel in PostScript-language code. For example, it might be `/Cyan`, `/HexCyan`, or `/Default`.

`DefaultCurve` *array of pairs of reals*

Required. A correction curve to be applied before any calibration. This curve applies a correction to the device to produce values stored in the conversion tables. From version 5.5r1, `DefaultCurve` is applied *in addition* to any other calibration. Therefore, if no other calibration curve is applied only `DefaultCurve` is used. If any other calibration is present `DefaultCurve` is added to it.

The minimal correction curve is a linear one defined by just the pairs 0,0 and 1,1: represented by `[ 0.0 0.0 1.0 1.0 ]`.

`ConversionTables` *array of dictionaries*

Required. Within this array there is one dictionary for each measurement system. Each dictionary represents a measurement system and corresponding aim values. See the following table for details of the individual keys in the dictionaries.

Table: Keys in ConversionTables dictionaries

`TableName` *string*

Required. The name of the measurement system used for the values in the `TableValues` array of this dictionary. Typical values are: `(Status T)`, `(% Dot)`, and `(Dot Gain)`. These are all standard systems supported by the RIP as ways to enter measured data into the calibration system. See Section 1.8, page 12 for a full list of recommended names,

`SubtractPaperWhite` *boolean*

Optional, but recommended. When present and true, the measurement for paper white is subtracted from all other values before performing any calculations with the values. (The intent is compensate for small errors near the white point with different measuring instruments.)

`Filter` *string or name*

Optional. The name of the filter to be used on the measuring instrument. For example, it might be `/Cyan`, `/Magenta`, `/Yellow`, `/Visual` (for black), or `/Default`. The value to use is obvious for four-color process inks but may need to be a best approximation for spot colors. A value of `/Default` means that Genlin lists the filters supported on the measuring instrument, for the user to make an interactive choice. When this key is not present, Genlin uses the value of `ChannelColor` to deduce a suitable filter.

`Relative` *boolean*

Optional, but useful only when the values in the table are in `% Dot` (or in density with the `ConversionFormula` supplied) and require conversion to `Dot Gain`. When present and `true`, this key means that the values are given relative to the nominal value, rather than absolute. For example, this key must be **true** when specifying dot gain.

`TableValues` *array of pairs of reals*

Required. Each pair represents, in order, a measured value (or aim value) and the RIP nominal value (SNV) that produced it. The first pair represents values for paper-white. The last pair represents solid color.

The measured values either appear directly in the units suggested by the measurement system given by `TableName`, or in a form that can be converted to these units. Where a conversion is to be used, the `/ConversionFormula` key must appear and specify the conversion.

The SNV numbers are in the range 0 through 1.0. The value 0 is used to represent maximum colorant and the value 1.0 to represent minimum colorant. SNV values represent the input values to the device indirectly, because the value is (1.0 - SNV) (depending on the color space) (The actual value sent to the device depends on the calibration.) In terms used by *The PostScript® Language Reference Manual* (2nd Ed), these represent additive color values.

Note: The nominal values in this table need not be the same as the ones used for patch values on the printed target and shown as labels in the Edit Calibration dialog box. The RIP interpolates between the values given here to arrive at values used on the target. There should be enough pairs to record the transfer curve faithfully. Most reasonable curves should not require more than 30 pairs (but the maximum number allowed is much larger).

`ConversionFormula` *string*

Optional, but required when the values in the `TableValues` array require conversion. The only possible value is `(Murray-Davies)`, in which case the `TableValues` array would hold density values and `TableName` would be `% Dot`.

1.8 TableName values

Each color channel in the profile has a series of conversion tables. Each table represents a measurement system and corresponding values.

The table name gives an indication of the measurement system and, in some cases, the measuring instrument used to provide the data. (Having a table name that identifies the instrument allows for a table of values tailored to the exact characteristics of that instrument.)

OEMs can use any table name meaningful to their users, but for consistency with tables supplied by Harlequin, we recommend a list of names. For version 5.0 and later versions, the recommended names are these:

`Status T` — ANSI Status T, not specifying the measuring instrument. (ANSI Status T is an American density standard.)

`Status T (X-Rite)` — ANSI Status T measured with an X-Rite densitometer.

`Status T (Gretag)` — ANSI Status T measured with a Gretag densitometer.

`% Dot` — Values calculated from density measurements using the Murray Davies formula. Minimum density is represented as 0%, maximum density as 100%. The density measurement units can be Status T or DIN density.

Note: If you are defining a new profile, you may prefer to use `Positive % Dot`, as a more obvious pairing with `Negative % Dot`.

`Dot Gain` — Dot gain values are calculated from %Dot values or density measurements. The difference (loss or gain) from an input value requested (in the range 0% through 100%) to the value measured and calculated in %Dot is the Dot Gain.

`Positive % Dot` — No color laid down is represented as 0%, solid color as 100%.

`Negative % Dot` — No color laid down is represented as 100%, solid color as 0%.

`DIN (Gretag)` — DIN density measured with a Gretag densitometer. DIN density is a German density standard, widely used in Europe.

`DIN (X-Rite)` — DIN density measured with an X-Rite densitometer.

`Status E (X-Rite)` — Status E density measured with an X-Rite densitometer. Status E is the American equivalent of DIN density.

`DIN NB (Gretag)` — DIN NB (narrow band filter) density measured with a Gretag densitometer.

`DIN NB (X-Rite)` — DIN NB density measured with an X-Rite densitometer.

`Status I (X-Rite)` — Status I density measured with an X-Rite densitometer. Status I is a narrow-band response similar to the DIN NB response.

Note: This is a list of alternatives, allowing selection of the appropriate tables for particular users and applications. No channel requires all of these conversion tables.

1.9 Characterization data

`ProfileColorData` *`dictionary`*

Optional color data, with its presence being flagged by the key `MeasurementDataPresent` in the `Profile` dictionary having the value `true`. These keys provide characterization data used with HSCS and HFCS. These keys are not needed for calibration.

Harlequin does not publish the contents or format of this dictionary because both remain subject to change. Any editing of earlier parts of an existing profile must leave this dictionary unchanged. If you are creating a new profile for linearization, do not include this section.

Note: For profiles used with versions of the RIP before version 5.0, this dictionary does not exist and the characterization data appears as additional keys and values within the `Profile` dictionary.

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Profiles and calibration

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