The cx2341x driver

Non-compressed file format

The cx23416 can produce (and the cx23415 can also read) raw YUV output. The format of a YUV frame is 16x16 linear tiled NV12 (V4L2_PIX_FMT_NV12_16L16).

The format is YUV 4:2:0 which uses 1 Y byte per pixel and 1 U and V byte per four pixels.

The data is encoded as two macroblock planes, the first containing the Y values, the second containing UV macroblocks.

The Y plane is divided into blocks of 16x16 pixels from left to right and from top to bottom. Each block is transmitted in turn, line-by-line.

So the first 16 bytes are the first line of the top-left block, the second 16 bytes are the second line of the top-left block, etc. After transmitting this block the first line of the block on the right to the first block is transmitted, etc.

The UV plane is divided into blocks of 16x8 UV values going from left to right, top to bottom. Each block is transmitted in turn, line-by-line.

So the first 16 bytes are the first line of the top-left block and contain 8 UV value pairs (16 bytes in total). The second 16 bytes are the second line of 8 UV pairs of the top-left block, etc. After transmitting this block the first line of the block on the right to the first block is transmitted, etc.

The code below is given as an example on how to convert V4L2_PIX_FMT_NV12_16L16 to separate Y, U and V planes. This code assumes frames of 720x576 (PAL) pixels.

The width of a frame is always 720 pixels, regardless of the actual specified width.

If the height is not a multiple of 32 lines, then the captured video is missing macroblocks at the end and is unusable. So the height must be a multiple of 32.

Raw format c example

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

static unsigned char frame[576*720*3/2];
static unsigned char framey[576*720];
static unsigned char frameu[576*720 / 4];
static unsigned char framev[576*720 / 4];

static void de_macro_y(unsigned char* dst, unsigned char *src, int dstride, int w, int h)
{
unsigned int y, x, i;

// descramble Y plane
// dstride = 720 = w
// The Y plane is divided into blocks of 16x16 pixels
// Each block in transmitted in turn, line-by-line.
for (y = 0; y < h; y += 16) {
        for (x = 0; x < w; x += 16) {
        for (i = 0; i < 16; i++) {
                memcpy(dst + x + (y + i) * dstride, src, 16);
                src += 16;
        }
        }
}
}

static void de_macro_uv(unsigned char *dstu, unsigned char *dstv, unsigned char *src, int dstride, int w, i
{
unsigned int y, x, i;

// descramble U/V plane
// dstride = 720 / 2 = w
// The U/V values are interlaced (UVUV...).
// Again, the UV plane is divided into blocks of 16x16 UV values.
// Each block in transmitted in turn, line-by-line.
for (y = 0; y < h; y += 16) {
        for (x = 0; x < w; x += 8) {
        for (i = 0; i < 16; i++) {
                int idx = x + (y + i) * dstride;

                dstu[idx+0] = src[0];  dstv[idx+0] = src[1];
                dstu[idx+1] = src[2];  dstv[idx+1] = src[3];
                dstu[idx+2] = src[4];  dstv[idx+2] = src[5];
                dstu[idx+3] = src[6];  dstv[idx+3] = src[7];
                dstu[idx+4] = src[8];  dstv[idx+4] = src[9];
                dstu[idx+5] = src[10]; dstv[idx+5] = src[11];
                dstu[idx+6] = src[12]; dstv[idx+6] = src[13];
                dstu[idx+7] = src[14]; dstv[idx+7] = src[15];
                src += 16;
```

```
        }
        }
}
}

/*********************************************************************/
int main(int argc, char **argv)
{
FILE *fin;
int i;

if (argc == 1) fin = stdin;
else fin = fopen(argv[1], "r");

if (fin == NULL) {
        fprintf(stderr, "cannot open input\n");
        exit(-1);
}
while (fread(frame, sizeof(frame), 1, fin) == 1) {
        de_macro_y(framey, frame, 720, 720, 576);
        de_macro_uv(frameu, framev, frame + 720 * 576, 720 / 2, 720 / 2, 576 / 2);
        fwrite(framey, sizeof(framey), 1, stdout);
        fwrite(framev, sizeof(framev), 1, stdout);
        fwrite(frameu, sizeof(frameu), 1, stdout);
}
fclose(fin);
return 0;
}
```

Format of embedded V4L2_MPEG_STREAM_VBI_FMT_IVTV VBI data

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This section describes the V4L2_MPEG_STREAM_VBI_FMT_IVTV format of the VBI data embedded in an MPEG-2 program stream. This format is in part dictated by some hardware limitations of the ivtv driver (the driver for the Conexant cx23415/6 chips), in particular a maximum size for the VBI data. Anything longer is cut off when the MPEG stream is played back through the cx23415.

The advantage of this format is it is very compact and that all VBI data for all lines can be stored while still fitting within the maximum allowed size.

The stream ID of the VBI data is 0xBD. The maximum size of the embedded data is 4 + 43 * 36, which is 4 bytes for a header and 2 * 18 VBI lines with a 1 byte header and a 42 bytes payload each. Anything beyond this limit is cut off by the cx23415/6 firmware. Besides the data for the VBI lines we also need 36 bits for a bitmask determining which lines are captured and 4 bytes for a magic cookie, signifying that this data package contains V4L2_MPEG_STREAM_VBI_FMT_IVTV VBI data. If all lines are used, then there is no longer room for the bitmask. To solve this two different magic numbers were introduced:

'itv0': After this magic number two unsigned longs follow. Bits 0-17 of the first unsigned long denote which lines of the first field are captured. Bits 18-31 of the first unsigned long and bits 0-3 of the second unsigned long are used for the second field.

'ITV0': This magic number assumes all VBI lines are captured, i.e. it implicitly implies that the bitmasks are 0xffffffff and 0xf.

After these magic cookies (and the 8 byte bitmask in case of cookie 'itv0') the captured VBI lines start:

For each line the least significant 4 bits of the first byte contain the data type. Possible values are shown in the table below. The payload is in the following 42 bytes.

Here is the list of possible data types:

```
#define IVTV_SLICED_TYPE_TELETEXT       0x1     // Teletext (uses lines 6-22 for PAL)
#define IVTV_SLICED_TYPE_CC             0x4     // Closed Captions (line 21 NTSC)
#define IVTV_SLICED_TYPE_WSS            0x5     // Wide Screen Signal (line 23 PAL)
#define IVTV_SLICED_TYPE_VPS            0x7     // Video Programming System (PAL) (line 16)
```