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Communication and Timings:

Proposed flow chart of communication. (Master is referred as µC, Slave as HTPA module)

```
                    ┌─────────────────┐
                    │   µC Power On    │
                    └────────┬─────────┘
                             │
              ┌──────────────────────────────┐
              │      Master sends            │
              │  Broadcast/Search (Ctrl Msg 1)│
              └──────────────┬───────────────┘
                             │
              ┌──────────────────────────────┐
              │         HTPA response         │
              └──────────────┬───────────────┘
                             │
              ┌──────────────────────────────┐
              │  Master sends "Bind" (Ctlr Msg 4) │
              └──────────────┬───────────────┘
                             │
          Y        ╱ µC Main Loop ╲        N
      ◄──────────  ╲  Get T-Frame? ╱  ──────────►
                     ╲           ╱
         │                              │
  ┌──────────────┐              ┌──────────────┐
  │ µC: Send ,k' │              │ µC: Send ,t' │
  │   to HTPA    │              │    to HTPA    │
  └──────┬───────┘              └──────┬───────┘
         │                              │
         └──────────────┬───────────────┘
                        │
                 ┌─────────────┐  ◄───────────┐
                 │   Receive    │              │
                 └──────┬───────┘              │
                        │                      │
                 ┌─────────────┐               │
                 │   Process    │               │
                 └──────┬───────┘               │
                        │                       │
                  ╱ Stop Stream? ╲    N         │
                  ╲             ╱  ─────────────┘
                        │ Y
              ┌────────────────────────────┐
              │ µC: Send ,x'or ,X' to HTPA │
              └────────────────────────────┘
```
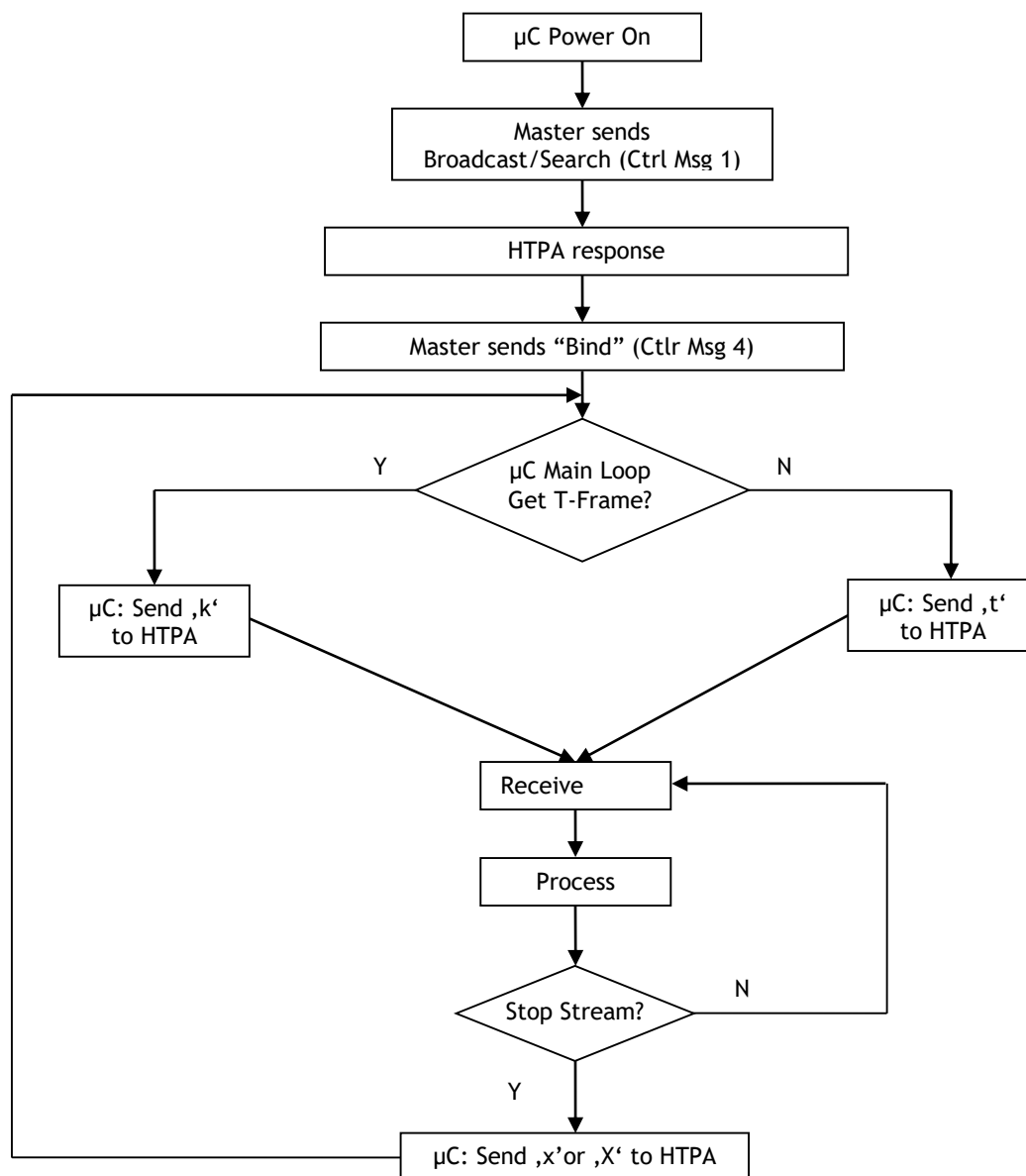
Communication via UDP:

Sent Char	Result/Received message
'a'/'A'	decreases/increases the FPS of the array
'G'	shows user settings for BIAS, BPA etc.
'h'	pushes binary EEDATA out
'i'/'I'	decreases / increases BIAS setting
'j'/'J'	decreases / increases BPA setting
'G'	Shows current configuration settings (CLK, BIAS, BPA,…)
'K'	send continous binary temperature datastream(µC-ADC)[K*10] Output of a complete cycle ***For a detailed Description of the serial order see Table2.***
'o'/'O'	decreases / increases REF_CAL setting
'r'/'R'	decreases / increases resolution
't'	Continuous binary voltage data of the sensor is transmitted. Output of a complete cycle ***For a detailed Description of the serial order see Table2.***
'x'	Stops Stream without prompt.
'X'	Stops Stream by sending "STOP!\r\n"

Please be aware, that the source and destination port has to be 30444.

Overview of packet numbers

Number of packets	Packet size [byte]	HTPA type
1	262	HTPA8x8
1	780	HTPA16x16
2	1058+1054	HTPA32x31
2	1292+1288	HTPA32x32d
5	1159+1157	HTPA60x40d
9	1285+1281	HTPA84x60d
10	1283	HTPA80x64d
17	1401+1149	HTPA120x84dR0
17	1401+1153	HTPA120x84dR2
30	1401 + 1057	HTPA160x120d

Packet numbers for HTPA32x32d and up are explained in more detail under their corresponding section of this document.

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Control Messages:

In the set of control messages, expressions in angled braces have to be substituted by following strings:

[IP]   insert IP in ASCII format, i.e.: *"192.168.240.122"*
[MACID]   insert MAC ID in ASCII format and hexadecimal, i.e.: *"00.1A.22.33.44.55"*
[AT]   insert index of array types in ASCII format

Array type	Index
HTPA 8x8	*"0"*
HTPA 16x16	*"1"*
HTPA 32x16	*"2"*
HTPA 32x32d	*"10"*
HTPA 80x64d	*"11"*
HTPA 120x84d	*"12"*
HTPA 84x60d	*"13*
HTPA 60x40d	*"14"*
HTPA 160x120d	*"15"*
HTPA 120x84dR2	*"16"*

[MCLK] insert Frequency of MCLK in ASCII format and kHz, i.e.: *"1050.1"*
[MSK]   insert subnet mask in ASCII format, i.e.: *"255.255.255.000"*
[DEVID]   insert 10 digit device ID in ASCII format, i.e. *"0123456789"* Range: 0000000000...
              4294967295
[MODT]insert index of Moduletype in ASCII format, i.e.: 005
[ADCRES]   insert ADC resolution in ASCII format, i.e.: *"16"* Range: 08...16

Set of control messages:

Message1:   "Calling HTPA series devices"   (only Ethernet device)
Conditions: Can be sent as Broadcast, or if device already known as normal packet.
Answer: "HTPA series responsed! I am Arraytype [AT] MODTYPE [MODT]\r\n
               ADC: [ADCRES]\r\n"
               Firmware version, date and author information.
               "I am running on [MCLK] kHz\r\n"
               "MAC-ID: [MACID] IP: [IP] DevID: [DEVID]\r\n"
               A second packet with calibration depending information is send.

Message2:   "x Release HTPA series device"   (only Ethernet device)
Result: Device disables hardware IP filter. All packets except ARP's, DHCP requests,
               Broadcasts, Message1, Message3 and Message4 are discarded.
Answer: "HW-Filter released\r\n"

Message3:   "Bind HTPA series device"   (only Ethernet device)
Result: Device enables hardware IP filter. Only packets from sender IP, ARP's, DHCP
               requests and Broadcasts are accepted. Device accepts now the control characters
               listed in Table **"Communication via UDP"**.
Answer: "HW Filter is [IP] MAC [MACID]\n\r""
               Insert in the above string the IP and MAC-ID of the Sender from Message3.

Control Messages [continued]:

Message6:	"Set Emission to **[EPSILON]**"
Result:	The given emissivity **[EPSILON]** is written to the EEPROM. The emissivity can be used for customer specific purposes to compensate the radiation factor of different materials.
Answer:	"Emission changed to **[EPSILON]**%\r\n"

HTPA8x8d

Serial order of data in stream:

HTPA8x8d Temperature Mode	
Dataset	Value
0	Temperature of Pixel0 in K*10
1	Temperature of Pixel1 in K*10
2	Temperature of Pixel2 in K*10
3	Temperature of Pixel3 in K*10
...	...
63	Temperature of Pixel63 in K*10
64	el. Offset 0
65	el. Offset 1
...	...
127	el. Offset 63
128	VDD
129	TAmb
130	PTAT

HTPA8x8d Voltage Mode	
Dataset	Value
0	absolute Voltage of Pixel0 in digits
1	absolute Voltage of Pixel1 in digits
2	absolute Voltage of Pixel2 in digits
3	absolute Voltage of Pixel3 in digits
...	...
63	absolute Voltage of Pixel63 in digits
64	el. Offset 0
65	el. Offset 1
...	...
127	el. Offset 63
128	VDD
129	TAmb
130	PTAT

Each dataset consists of a 16-bit value, first the Low-Byte is send, then the High-Byte

Pixelmap:

0	1	2	3	4	5	6	7
8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31
32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63

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HTPA16x16d

Serial order of data in stream:

HTPA16x16d Temperature Mode	
Dataset	Value
0	Temperature of Pixel0 in K*10
1	Temperature of Pixel1 in K*10
2	Temperature of Pixel2 in K*10
3	Temperature of Pixel3 in K*10
...	...
255	Temperature of Pixel255 in K*10
256	el. Offset 0
257	el. Offset 1
...	...
383	el. Offset 127
384	VDD
385	TAmb
386	PTAT0
387	PTAT1
388	PTAT2
389	PTAT3

HTPA16x16d Voltage Mode	
Dataset	Value
0	absolute Voltage of Pixel0 in digits
1	absolute Voltage of Pixel1 in digits
2	absolute Voltage of Pixel2 in digits
3	absolute Voltage of Pixel3 in digits
...	...
255	absolute Voltage of Pixel255 in digits
256	el. Offset 0
257	el. Offset 1
...	...
383	el. Offset 127
384	VDD
385	TAmb
386	PTAT0
387	PTAT1
388	PTAT2
389	PTAT3

Each dataset consists of a 16-bit value, first the Low-Byte is send, then the High-Byte.

Pixelmap:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127
128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191
192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207
208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223
224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239
240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255

HTPA32x32d

Serial order of data in stream:

Dataset	Value		Dataset	Value
0	Temperature of Pixel0 in K*10		0	absolute Voltage of Pixel0 in digits
1	Temperature of Pixel1 in K*10		1	absolute Voltage of Pixel1 in digits
2	Temperature of Pixel2 in K*10		2	absolute Voltage of Pixel2 in digits
3	Temperature of Pixel3 in K*10		3	absolute Voltage of Pixel3 in digits
...	...		...	...
1023	Temperature of Pixel1023 in K*10		1023	absolute Voltage of Pixel1023 in digits
1024	el. Offset 0		1024	el. Offset 0
1025	el. Offset 1		1025	el. Offset 1
...	...		...	...
1279	el. Offset 255		1279	el. Offset 255
1280	VDD		1280	VDD
1281	TAmb		1281	TAmb
1282	PTAT0		1282	PTAT0
1283	PTAT1		1283	PTAT1
1284	PTAT2		1284	PTAT2
1285	PTAT3		1285	PTAT3
1286	PTAT4		1286	PTAT4
1287	PTAT5		1287	PTAT5
1288	PTAT6		1288	PTAT6
1289	PTAT7		1289	PTAT7

Column headers: HTPA32x32d Temperature Mode | HTPA32x32d Voltage Mode

Each dataset consists of a 16-bit value, first the Low-Byte is send, then the High-Byte.

Packets

Packet No.	Packet size	Packet contains
1	1292	Data of Pixel0 - Pixel645
2	1288	Data of Pixel646 to end of frame

Packet details for HTPA32x32d

Each dataset (except of packet index) consists out of a 16-bit value. For serial order of the datasets refer to section "serial order in Frame".

Pixelmap:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127
128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191
192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207
208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223
224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239
240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255

HTPA60x40d

Serial order of data in stream:

HTPA60x40d Temperature Mode	
Dataset	Value
0	Temperature of Pixel0 in K*10
1	Temperature of Pixel1 in K*10
2	Temperature of Pixel2 in K*10
3	Temperature of Pixel3 in K*10
...	...
2399	Temperature of Pixel2399 in K*10
2400	el. Offset 0
2401	el. Offset 1
...	...
2879	el. Offset 479
2880	VDD
2881	TAmb in K*10
2882	PTAT0
2883	PTAT1
2884	PTAT2
2885	PTAT3
2886	PTAT4
2887	PTAT5
2888	PTAT6
2889	PTAT7
2890	PTAT8
2891	PTAT9
2892	ATC0
2893	ATC1

HTPA60x40d Voltage Mode	
Dataset	Value
0	absolute Voltage of Pixel0 in digits
1	absolute Voltage of Pixel1 in digits
2	absolute Voltage of Pixel2 in digits
3	absolute Voltage of Pixel3 in digits
...	...
2399	absolute Voltage of Pixel2399 in digits
2400	el. Offset 0
2401	el. Offset 1
...	...
2879	el. Offset 479
2880	VDD
2881	TAmb in K*10
2882	PTAT0
2883	PTAT1
2884	PTAT2
2885	PTAT3
2886	PTAT4
2887	PTAT5
2888	PTAT6
2889	PTAT7
2890	PTAT8
2891	PTAT9
2892	ATC0
2893	ATC1

Each dataset consists of a 16-bit value, first the Low-Byte is send, then the High-Byte.

Packets

Packet details for HTPA60x40d		
Packet No.	Packet size	Packet contains
1	1159	Packet index 1 (8bit), data of Pixel0-Pixel578
2	1159	Packet index 2 (8bit), data of Pixel579-Pixel1158
3	1159	Packet index 3 (8bit), data of Pixel1159-Pixel1738
4	1159	Packet index 4 (8bit), data of Pixel1739-Pixel2318
5	1157	Packet index 5 (8bit), data of Pixel2319-el.Offset479 to end of frame

Pixelmap

0	1	2	3	4	5	6	...	57	58	59
60	61	62	63	64	65	66	...	117	118	119
.										.
.										.
.										.
2340	2341	2342	2343	2344	2345	2346	...	2387	2389	2399

HTPA80x64d

Serial order of data in stream:

HTPA80x64d Temperature Mode	
Dataset	Value
0	Temperature of Pixel0 in K*10
1	Temperature of Pixel1 in K*10
2	Temperature of Pixel2 in K*10
3	Temperature of Pixel3 in K*10
...	...
5119	Temperature of Pixel5119 in K*10
5120	el. Offset 0
5121	el. Offset 1
...	...
6399	el. Offset 1279
6400	VDD
6401	TAmb
6402	PTAT0
6403	PTAT1
6404	PTAT2
6405	PTAT3
6406	PTAT4
6407	PTAT5
6408	PTAT6
6409	PTAT7

HTPA80x64d Voltage Mode	
Dataset	Value
0	absolute Voltage of Pixel0 in digits
1	absolute Voltage of Pixel1 in digits
2	absolute Voltage of Pixel2 in digits
3	absolute Voltage of Pixel3 in digits
...	...
5119	absolute Voltage of Pixel5119 in digits
5120	el. Offset 0
5121	el. Offset 1
...	...
6399	el. Offset 1279
6400	VDD
6401	TAmb
6402	PTAT0
6403	PTAT1
6404	PTAT2
6405	PTAT3
6406	PTAT4
6407	PTAT5
6408	PTAT6
6409	PTAT7

Each dataset consists of a 16-bit value, first the Low-Byte is send, then the High-Byte.

Packets

Packet details for HTPA80x64d		
Packet No.	Packet size	Packet contains
1	1283	Packet index 1 (8bit), data of Pixel0-Pixel640
2	1283	Packet index 2 (8bit), data of Pixel641-Pixel1281
3	1283	Packet index 3 (8bit), data of Pixel1282-Pixel1922
4	1283	Packet index 4 (8bit), data of Pixel1923-Pixel2563
5	1283	Packet index 5 (8bit), data of Pixel2564-Pixel3204
6	1283	Packet index 6 (8bit), data of Pixel3205-Pixel3845
7	1283	Packet index 7 (8bit), data of Pixel3846-Pixel4486
8	1283	Packet index 8 (8bit), data of Pixel4487-el.Offset7
9	1283	Packet index 9 (8bit), data of el.Offset8-el.Offset648
10	1283	Packet index 10 (8bit), data of el.Offset649 to end of frame

Each dataset (except of packet index) consists out of a 16-bit value. For serial order of the datasets refer to section "serial order in Frame".

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Pixelmap:

0	1	2	3	4	5	6	...	77	78	79
80	81	82	83	84	85	86	...	157	158	159
.										.
.										.
.										.
5040	5041	5042	5043	5044	5045	5046	...	5117	5118	5119

WiFi Application Shield

HTPA84x60d

Serial order of data in stream

HTPA84x60d Temperature Mode	
Dataset	Value
0	Temperature of Pixel0 in K*10
1	Temperature of Pixel1 in K*10
2	Temperature of Pixel2 in K*10
3	Temperature of Pixel3 in K*10
...	...
5039	Temperature of Pixel5039 in K*10
5040	el. Offset 0
5041	el. Offset 1
...	...
5759	el. Offset 719
5760	VDD
5761	TAmb
5762	PTAT0
5763	PTAT1
5764	PTAT2
5765	PTAT3
5766	PTAT4
5767	PTAT5
5768	PTAT6
5769	PTAT7
5770	PTAT8
5771	PTAT9
5772	PTAT10
5773	PTAT11
5774	PTAT12
5775	PTAT13
5776	ATC0
5777	ATC1

HTPA84x60d Voltage Mode	
Dataset	Value
0	absolute Voltage of Pixel0 in digits
1	absolute Voltage of Pixel1 in digits
2	absolute Voltage of Pixel2 in digits
3	absolute Voltage of Pixel3 in digits
...	...
5039	absolute Voltage of Pixel5039 in digits
5040	el. Offset 0
5041	el. Offset 1
...	...
5759	el. Offset 719
5760	VDD
5761	TAmb
5762	PTAT0
5763	PTAT1
5764	PTAT2
5765	PTAT3
5766	PTAT4
5767	PTAT5
5768	PTAT6
5769	PTAT7
5770	PTAT8
5771	PTAT9
5772	PTAT10
5773	PTAT11
5774	PTAT12
5775	PTAT13
5776	ATC0
5777	ATC1

Each dataset consists of a 16-bit value, first the low-Byte is send, then the high-Byte.

Packets

Packet details for HTPA84x60d		
Packet No.	Packet size	Packet contains
1	1285	Packet index 1 (8bit), data of Pixel0-Pixel641
2	1285	Packet index 2 (8bit), data of Pixel642-Pixel1283
3	1285	Packet index 3 (8bit), data of Pixel1284-Pixel1925
4	1285	Packet index 4 (8bit), data of Pixel1926-Pixel2567
5	1285	Packet index 5 (8bit), data of Pixel2568-Pixel3209
6	1285	Packet index 6 (8bit), data of Pixel3210-Pixel3851
7	1285	Packet index 7 (8bit), data of Pixel3852-Pixel4493
8	1285	Packet index 8 (8bit), data of Pixel4494-el.Offset95
9	1281	Packet index 9 (8bit), data of el.Offset96 to end of frame

Pixelmap

0	1	2	3	4	5	6	...	57	58	59
60	61	62	63	64	65	66	...	117	118	119
.										.
.										.
.										.
4980	4981	4982	4983	4984	4985	4986	...	5037	5038	5039

WiFi Application Shield

HTPA120x84d

Serial order of data In stream

HTPA120x84d Temperature Mode	
Dataset	Value
0	Temperature of Pixel0 in K*10
1	Temperature of Pixel1 in K*10
2	Temperature of Pixel2 in K*10
3	Temperature of Pixel3 in K*10
...	...
10079	Temperature of Pixel10079 in K*10
10080	el. Offset 0
10081	el. Offset 1
...	...
11759	el. Offset 1679
11760	VDD
11761	TAmb
11762	PTAT0
11763	PTAT1
11764	PTAT2
11765	PTAT3
11766	PTAT4
11767	PTAT5
11768	PTAT6
11769	PTAT7
11770	PTAT8
11771	PTAT9
11772	PTAT10
11773	PTAT11

HTPA120x84d Voltage Mode	
Dataset	Value
0	absolute Voltage of Pixel0 in digits
1	absolute Voltage of Pixel1 in digits
2	absolute Voltage of Pixel2 in digits
3	absolute Voltage of Pixel3 in digits
...	...
10079	absolute Voltage of Pixel10079 in digits
10080	el. Offset 0
10081	el. Offset 1
...	...
11759	el. Offset 1679
11760	VDD
11761	TAmb
11762	PTAT0
11763	PTAT1
11764	PTAT2
11765	PTAT3
11766	PTAT4
11767	PTAT5
11768	PTAT6
11769	PTAT7
11770	PTAT8
11771	PTAT9
11772	PTAT10
11773	PTAT11

Each dataset (except of packet index) consists out of a 16-bit value. For serial order of the datasets refer to section "serial order in Frame".

Packets

Packet details for HTPA120x84d		
Packet No	Packet size	Packet contains
1	1401	Packet index 1 (8bit), data of Pixel0-Pixel699
2	1401	Packet index 2 (8bit), data of Pixel700-Pixel1399
3	1401	Packet index 3 (8bit), data of Pixel1400-Pixel2099
4	1401	Packet index 4 (8bit), data of Pixel2100-Pixel2799
5	1401	Packet index 5 (8bit), data of Pixel2800-Pixel3499
6	1401	Packet index 6 (8bit), data of Pixel3500-Pixel4199
7	1401	Packet index 7 (8bit), data of Pixel4200-Pixel4899
8	1401	Packet index 8 (8bit), data of Pixel4900-Pixel5599
9	1401	Packet index 9 (8bit), data of Pixel5600-Pixel6299
10	1401	Packet index 10 (8bit), data of Pixel6300-Pixel6999
11	1401	Packet index 11 (8bit), data of Pixel7000-Pixel7699
12	1401	Packet index 12 (8bit), data of Pixel7700-Pixel8399
13	1401	Packet index 13 (8bit), data of Pixel8400-Pixel9099
14	1401	Packet index 14 (8bit), data of Pixel9100-Pixel9799
15	1401	Packet index 15 (8bit), data of Pixel9800-el.Offset419
16	1401	Packet index 16 (8bit), data of el.Offset420-el.Offset1119
17	1149	Packet index 17 (8bit), data of el.Offset1120 to end of frame

Each dataset (except of packet index) consists out of a 16-bit value. For serial order of the datasets refer to section "serial order in Frame".

Pixelmap

0	1	2	3	4	5	6	…	117	118	119
120	121	122	123	124	125	126	…	237	238	239
.										.
.										.
.										.
9960	9961	9962	9963	9964	9965	9966	…	10077	10078	10079

Temperature calculation:

The module is already transmitting calculated temperatures if character "K" was sent from the master. For details about the temperature calculation please see the datasheet of the sensor.