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Investigation and Exploration of Network Power Consumption in Set Top Boxes, VOIP Telephones and Games Consoles

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Location of the test

The tests were carried out at the Australian Digital Testing Pty Limited (ADT) testing facility at Glendenning.

Quality assurance

ADT has a quality management system accredited to the AS/NZS ISO9001:2008 quality management standard – certificate number 14116. The quality management system is audited by NCSI.

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The three product types and the respective models tested for this research project are as follows:

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    - Siemens Gigaset A58IP model
    - NetComm V905 model
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- Game Consoles
  - Microsoft XBox 360
  - Sony PlayStation 3
  - Nintendo Wii

For the complex STBs tested the results showed little or no use of power scaling. However there is some opportunity for power scaling by power managing tuners and hard disk drives. Some scope for reduced power consumption was also evident.

For the VOIP phones tested the results showed a limited level of power scaling albeit quite small. By comparing the results of various models there is evidence that there is scope for reducing power consumption.

One particular area of note is the use of linear regulators in the VOIP phones tested to supplement the voltage supplied by the external power supplies. The result is more power wastage than if a multi-voltage switch mode of external power supply was used.

For the game consoles tested there was no power scaling used. The results of the tests clearly showed the increased power consumption needed for high level graphics processing. There is evidence that improvements in power consumption could be achieved through better management of auto power down and standby modes.

Scope of work

Australian Digital Testing undertook the following tasks:

1. Selected and purchased representative models of games consoles, complex set-top boxes servicing Pay television and Voice over Internet Protocol phones spanning a wide range of energy efficiency levels.

2. Determined, in consultation with leading experts in the network standby field, the various functional modes and capabilities of each product for which distinct power measurements can be made. This included operation on networks of varying bandwidth (data throughput per second), latencies, and type (wired and wireless, satellite vs. cable vs. fibre-optic, etc.). Conducted the associated power measurements in order to characterize typical, highly efficient and highly inefficient product performance.

3. Conducted tear-down analysis and thermal imaging, as needed, to ascribe power consumption for various functions to observable differences in product design, power conversion approaches, and device programming.

4. Assessed opportunities for these products to identify themselves on the network via a unique electronic signature. Quantitatively documented the extent to which each tested product scales its power consumption to changes in functionality or throughput. Assessed opportunities for creating efficiency metrics for those product categories based on the degree of power scaling present in each product type.

Background of the three product groups

Complex STBs

Broadcast STBs

In Australia and many parts of the world the only access to complex STBs is through the subscription television providers. This enables the subscription television provider to protect the very carefully guarded conditional access schemes they operate ensuring no unauthorised use (or pirating) of their services. For this project, the complex STBs connected to Austar and Foxtel satellite subscription TV platforms.

No STBs were tested that accessed cable services. ADT was advised that there hasn't been any extension to cable services in Australia for several years. In fact even where cable is available the main subscription service providers are connecting any new subscribers to the satellite broadcast platform.

The satellite broadcast platform is a well defined platform with a fixed bandwidth so only one bandwidth has been tested.

These limitations to the testing should not be considered severe. As explained in the tear down analysis later in the report, the main factors governing the power consumption of this type of STB are the chip set, the power supply, the number of tuners within the STB and the maintenance of conditional access keys. These factors contribute more significantly to energy consumption than the type of broadcast platform.

IP STB

The Internet Protocol (IP) STB tested was a Telstra T-Box.

The T-Box connects only through a Telstra BigPond account. As the speed of the connection for ADSL2+ connections depends on the distance from the nearest exchange, there was not a great deal of flexibility in being able to change connection speeds for the testing. In any event the analysis shows that the predominant power consumption comes from the chip set, number of tuners within the STB and power supply rather than the speed of the ADSL connection.

IP phones

Three types of IP phones were selected for testing. Each type is explained below.

Handset with network connection

This type of IP phone has a hand set and plugs directly into an ADSL enabled telephone line to establish the IP connection.

Router with analog hand set connection

This type of IP phone is basically a router but with a normal handset connection which plugs into a separate conventional hand set.

ADSL enabled router/modem

An ADSL router/modem has a conventional handset connection. It can be connected to a network or used independently through an ADSL capable conventional telephone line. These units were tested with an independent telephone line and also with router connection to a computer network.

Game consoles

The game console market is dominated by products from three companies being, Microsoft Xbox, Sony PlayStation 3 and Nintendo Wii. Each of these consoles was tested with a number of different games and while connected to the internet.

The testing demonstrated that the graphics capability largely determines the power consumption of the games console. The power consumption of the Nintendo Wii, which has the poorest graphics capability, compared favourably to the Microsoft Xbox and the Sony PS3, which had significantly higher graphics capability.

Test methods and analysis

Complex STBs

Overview of power consumption testing

The testing for the complex STBs was conducted in two modes:
1. The operational (active mode) and
2. standby power mode

Each STB was separately measured in these modes and then each STB was monitored in standby mode for an extensive period of time to see whether the STB changed between differing standby (low power) modes in order to perform secondary functions.

Power measurements of complex STBs

Table 1 below contains the results of the power consumption testing for each of the two complex STBs. To determine the impact of the operation of the hard disk drive (HDD), measurements were taken with and without the HDD connected or powered. The results show that there is a 2.8W difference for the Austar MyStar STB and a 3.8W difference for the Foxtel IQ2 STB. In the supplier's data sheets for the HDDs used in these complex STBs the claimed power consumption was less than 5W.

The Austar MyStar STB measured up to 2.5W difference depending on the 'on mode' being measured whereas the Foxtel IQ2 STB showed virtually no change between each 'on mode'. It is possible that this is due to the way caching and buffering is designed to perform within each complex STB model.

As will be discussed later, it is important not to underestimate the contribution that the tuners have to the overall power consumption. Neither the Foxtel IQ2 STB nor the Austar MyStar STB continuously manages the power of the tuners in 'on mode' regardless of whether the STB is being used.

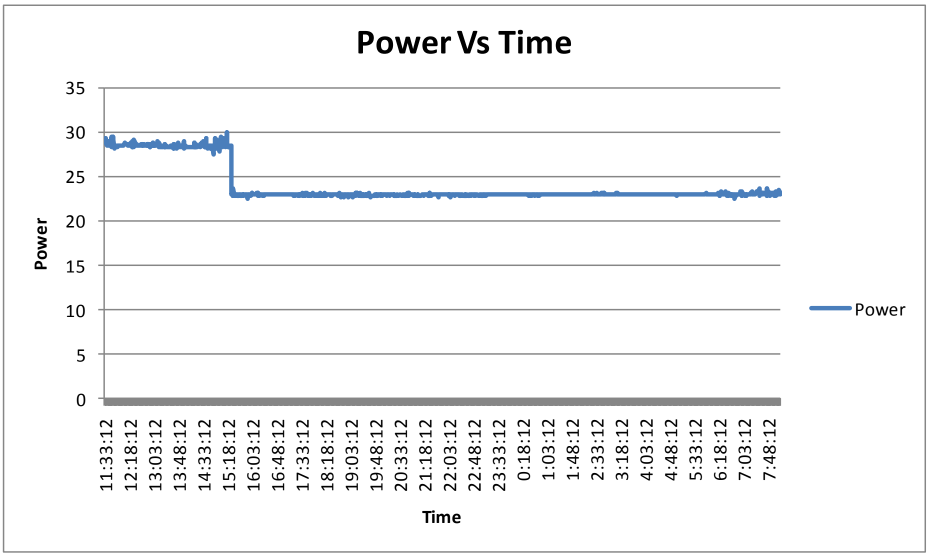
Table 1: Power measurement results for complex STBs

		Set Top Box			
Brand Identifier		AUSTAR MyStar		FOXTEL IQ2	
Model		DST8040AUS/T600		TDS851NF	
		Connected to HDD (W)	Disconnected from HDD (W)	Connected to HDD (W)	Disconnected from HDD (W)
On Mode	On play	26.01	23.3	26.3	22.5
	Recording	28.6		29.1	
	Play back	28.6		29.2	
	Pause	27.2		29.2	
Standby Active High Mode		21.83		25.18	
24 Hour Standby Mode (Average)		21.98059		24.0058	

Foxtel IQ2 STB

The data log of the standby power for the Foxtel IQ2 STB is shown in Figure 1. This illustrates the STB automatically switching from a 'standby active high mode' of just under 29W to a 'standby active low' mode of around 23W. It is highly likely that this is not caused by network switching (external control) but rather a timer in the STB designed to detect no viewer activity. If the viewer does not interact with the STB for a 4 hour period, the STB is placed into a lower standby power mode.

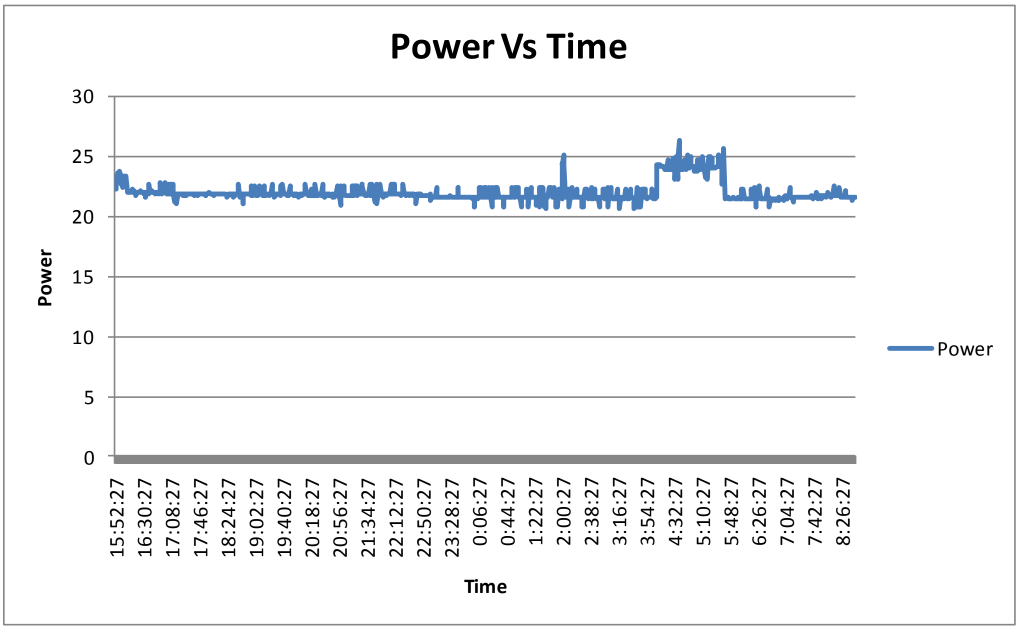
Figure 1: IQ2 standby log over 20 hours



Austar MyStar STB

Figure 2 below shows the results of overnight monitoring the standby power for the Austar MyStar STB. The result shows that at 4:30 am the STB increased power consumption by between 2W and 2.5W. It is likely that this occurred when the STB was downloading data such as electronic program guide information and/or conditional access information. This occurs due either to an internal timer in the STB or as a result of communication over the broadcast network. As the STB always operates in an active standby mode, it is capable of detecting and receiving information from the broadcast network.

Figure 2: Austar MyStar standby log over 12 hours



Telstra T-Box

The Telstra T-Box has both internet-sourced content and a free-to-air HD tuner. The power consumption of the various combinations of receiving and recording were tested and the results are shown in Table 2

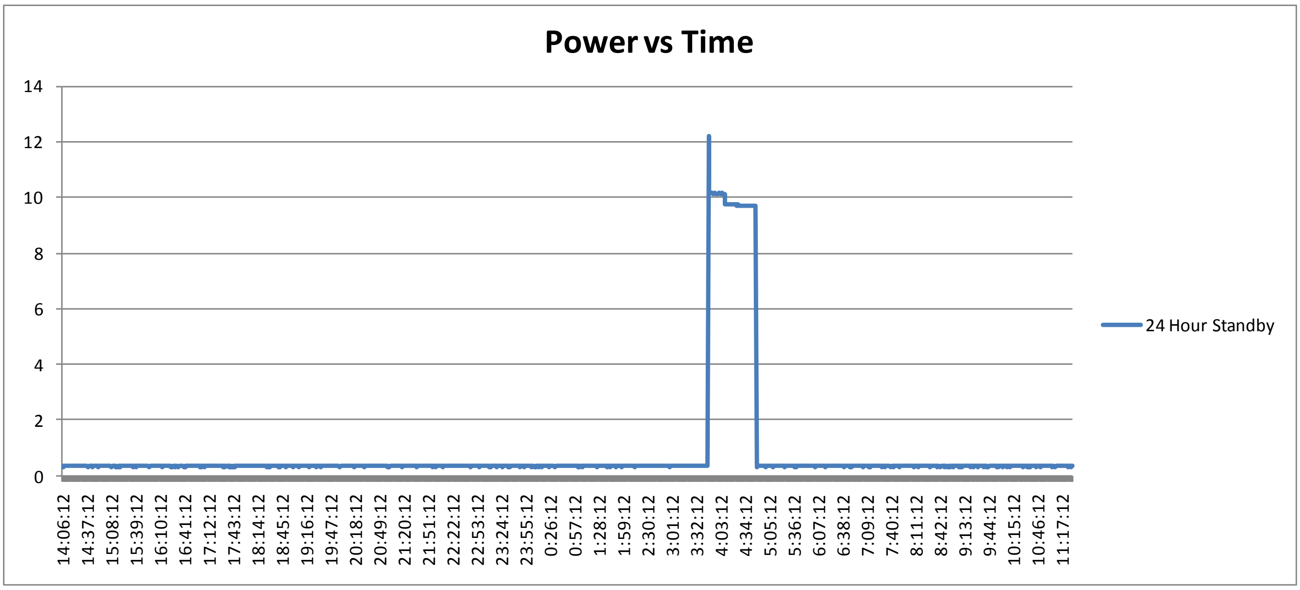
Table 2: Test results for Telstra T-Box

Telstra T-Box		
Mode	Function	Power (w)
Free-to-Air TV	High Definition play	12.1
	Standard Definition play	11.5
	High Definition record	12.3
	Standard Definition record	12.0
Internet	Movie download	11.6
	Movie play and download	11.8
	BigPond News Channel	11.3
Playback	Movie play	11.8
Standby Passive		0.34
24 Hour Standby Average		0.79

The results show that the power consumption of the Telstra T-Box in its various functional modes is considerably lower than the Austar MyStar STB and the Foxtel IQ2 STB. The results also indicate that the HDD is being operated all the time as there is little difference between any of the operating modes. The small difference between free-to-air High Definition functional modes and the other results (≈0.5W) is probably due to extra power needed to decode MPEG 2 HD content.

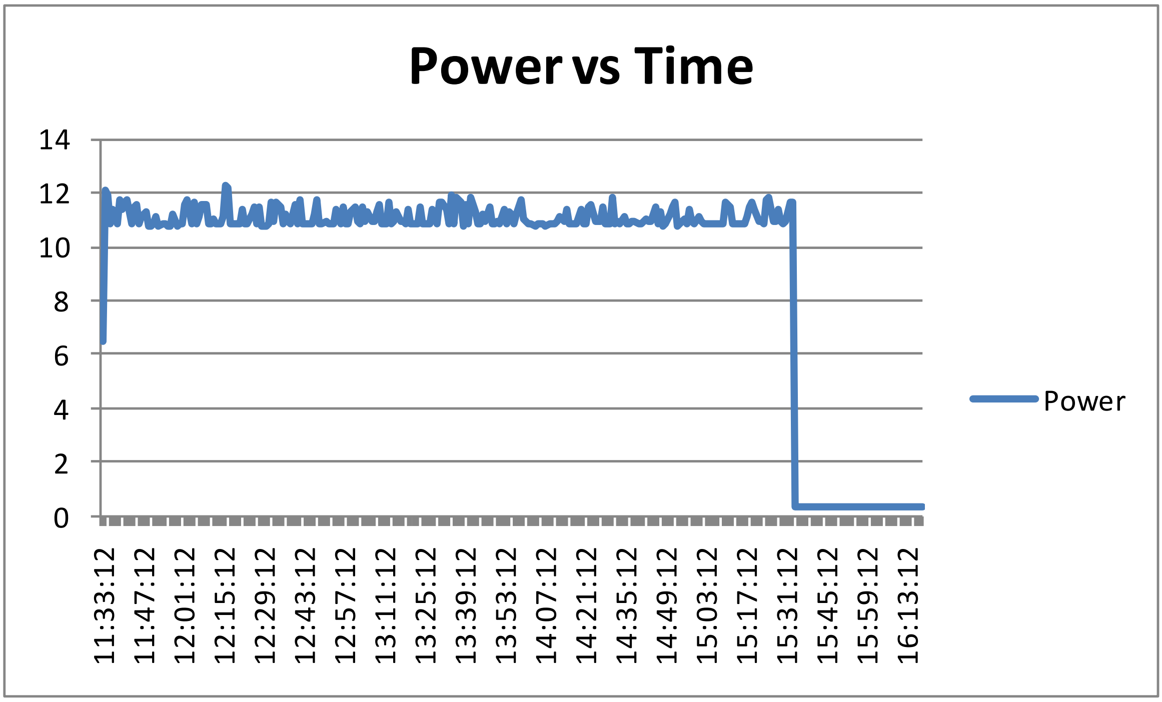
The Telstra T-Box was logged in its standby mode for 21 hours. The test was terminated after 24 hours as it was clear that the Telstra T-Box had woken up for a period of time between 3:00 am and 4:30 am as shown in Figure 3.

Figure 3: Telstra T-Box standby log over 21 hours



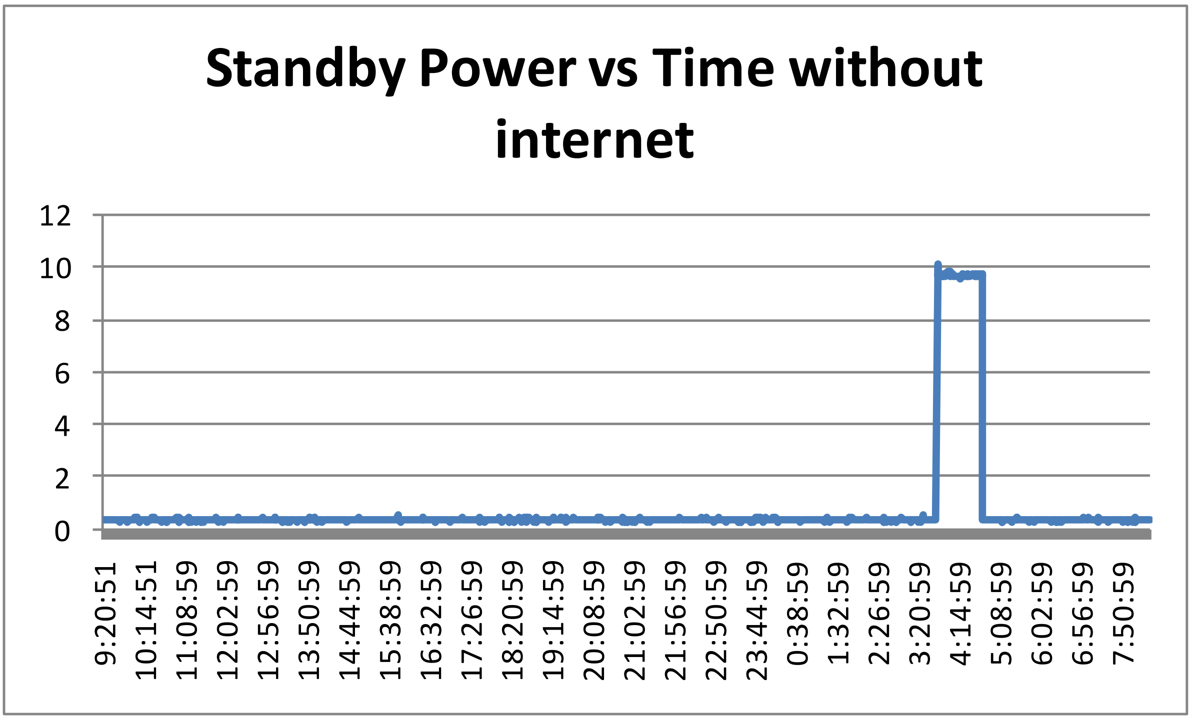
It was noted that the T-Box claimed to have an "Auto Power Down" function so a log was taken to test this function. Figure 4 shows the result of that log and confirms that after 4 hours of being on with no remote control actions the T-box did switch to its standby power mode.

Figure 4: Log of the Telstra T-Box to test auto power down



As shown in Figure 5, it was likely that the Telstra T-Box switches to a standby active mode in the early hours of the morning. This has been invoked by an internal timer rather than the internet connection. Unlike the Foxtel IQ STB and the Austar MyStar STB, this assumption could be tested by repeating the test with the internet disconnected and only the free-to-air TV antenna cable connected. This test proves that the T-Box switches from standby passive to standby active by way of an internal timer rather than through some form of messaging over the internet.

Figure 5: Telstra T-Box standby power vs. time without internet connected



Thermal imaging and tear down analysis of complex STBs

Overview of testing

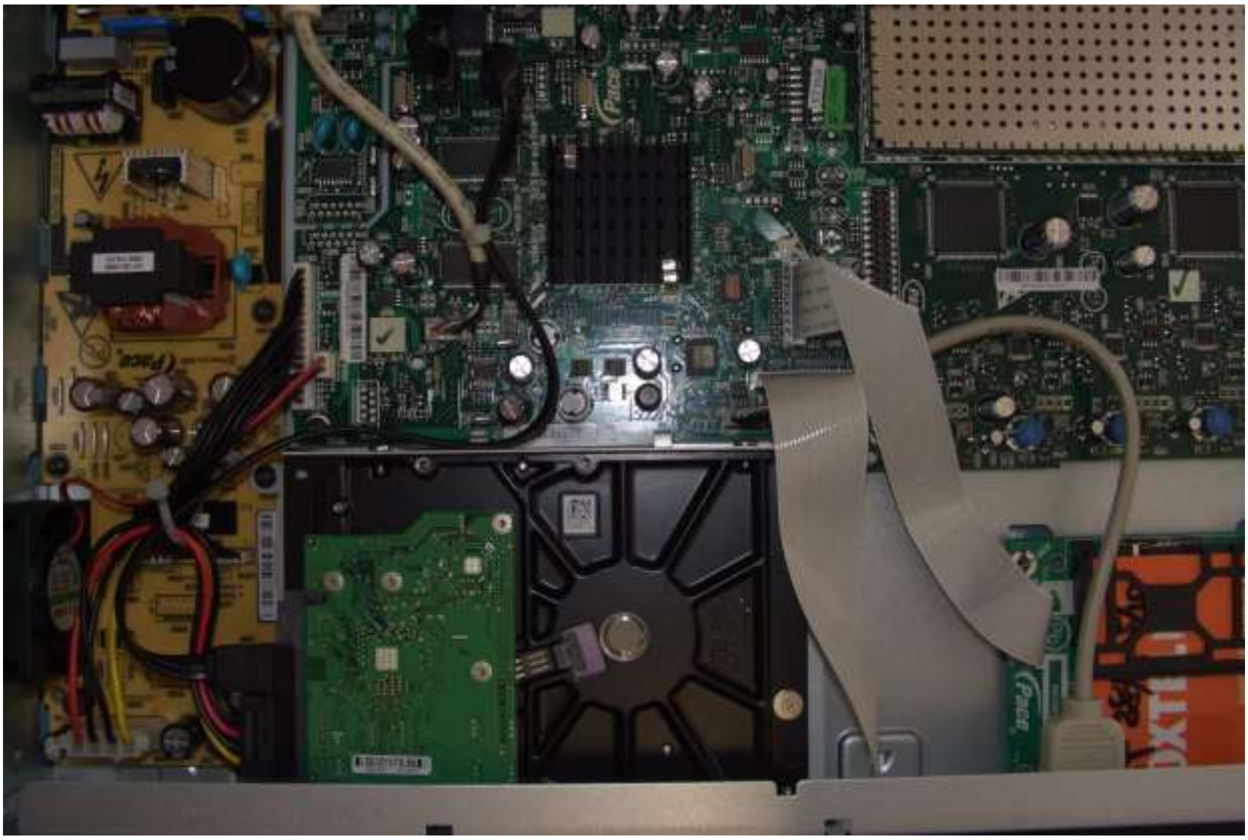
Thermal imaging testing allows for the identification of components that are operating at a high temperature level. It should be noted that this type of testing does not necessarily identify particular components that may be dissipating more heat than other components. The temperature of a component is related to the thermal resistance between the surface of the component and the surrounding air.

The two significant factors of thermal resistance are the type of material that the component is made of and the surface area of that material. If the thermal resistance is high then the component can reach high temperatures without dissipating a lot of heat. If the thermal resistance is low then the component may actually be dissipating quite a lot of heat but not at excessive temperatures. The main purpose of thermal imaging is to identify components that may have excessive heat dissipation.

Foxtel IQ2 STB

Figure 6 below shows the construction of the IQ2 STB. From the photo it is clear that there is a power supply board and a main processing board. The section on thermal imaging discusses the major heat emitting components.

Figure 6: Photo showing the construction of the IQ2 STB.



The only device that could be disconnected on the Foxtel IQ2 STB was the HDD. The resulting power reduction is shown in Table 1. As noted in this table the power consumption of the hard drive is 3.8W. One of the important functions of the STB is to provide real time review capability. Consequently the HDD needs to operate all the time. So there is little opportunity to save energy by controlling the spinning function of the HDD.

The main power consumption chips in the Foxtel IQ2 are:

- Conexant CX24117 Demodulator
- Broadcom BCM 7401FKPBIG MPEG Decoder
- Flash Memory

In addition to these components, the tuners are also responsible for power consumption. The Foxtel IQ2 STB has four satellite tuners. It was not possible to disable any tuner for this testing. However the impact of each tuner can be assessed by reference to the specification from the ASTRA CSTB Code of Conduct. This code of conduct provides an allowance of 5W-6W for each additional tuner. This allowance is based on a worst case scenario but it is likely that each tuner would be consuming approximately 3W to 4W and therefore contributing between 12W and 16W of the overall power consumption.

In Figure 7 below, the main decoding chip is identified as operating at 47.7 degrees Celsius. This is not surprising as it is the main processing chip on the board and is a major contributor to the power consumption. Decoder chips are invariably specified at 4W or higher. The power consumption of these chips is a characteristic of their basic substrate design and improvements will only occur as the basic semiconductor substrate design improves.

Figure 7: Thermal image of Foxtel IQ2 chip set

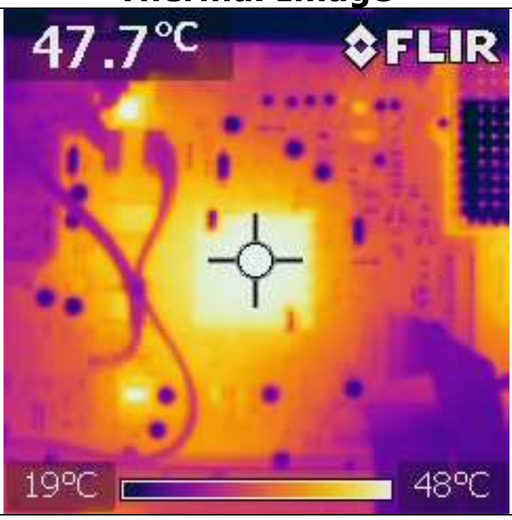
Thermal Image	Photo
	

Figure 8 below shows an example of a component that is quite small and operating at 51.3 degrees Celsius. This particular component is identified as the demodulator chip and could also be a significant contributor to the STBs energy consumption. Despite extensive searching, no data sheet could be found that specified the actual power consumption of this particular component.

Figure 8 is a section of the image that shows the tuner part of the circuit. The tuners are located under the shield at the top right hand side of the image. The shield itself has a low thermal resistance being made of steel and as such exhibits a relatively low temperature. Through the holes in the shield we can assess the operating temperature of the tuner component. It is clear that this part of the board has a relatively high temperature. This supports the findings of the tear down analysis where tuners were identified as significant contributors to power consumption.

Figure 8: Thermal image of hot components in Foxtel IQ2

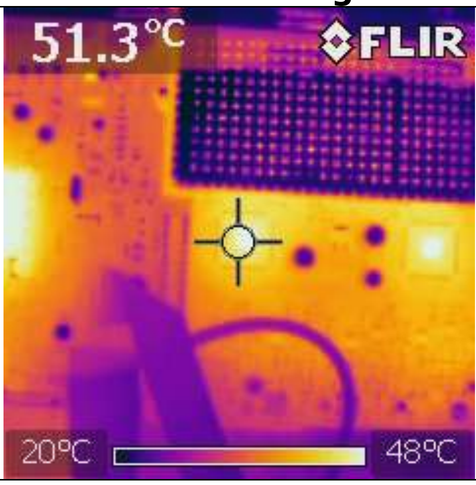
<table>
<tr><th>Thermal Image</th><th>Photo</th></tr>
<tr><td>
</td><td></td></tr>
</table>

Figure 9 below shows a component that is operating at 42.6 degrees Celsius. This component is a switching integrated circuit and is a relatively small component. While it would probably have a high thermal resistance as it is at a higher temperature, this component is actually only consuming less than 0.3W of power.

Figure 9: Thermal image of Foxtel IQ2 component

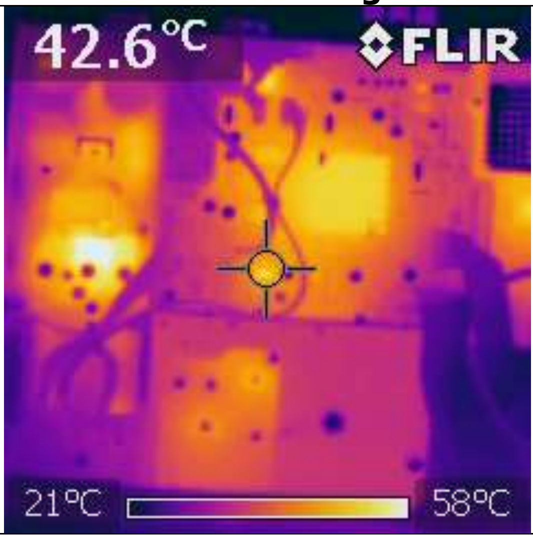
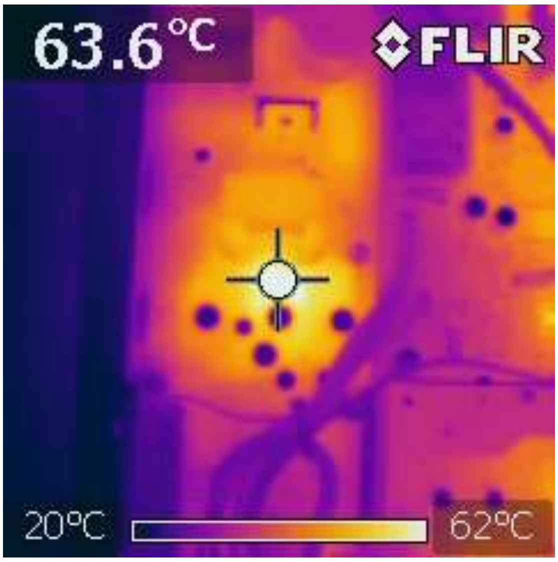
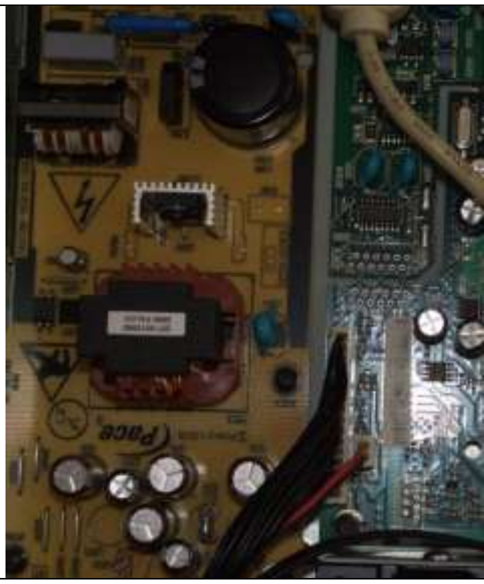
Thermal Image	Photo
	

Figure 10 below is an image of the main switching transformer in the power supply. It is operating at 63.6 degrees Celsius. As it has a relatively larger mass than many other components, to heat this component to this level indicates potentially high power dissipation. This reflects the energy efficiency of the power supply. Unfortunately the power supply is a multi-voltage type with protection circuits on the main board. Consequently it was not possible within the scope of this study to measure the energy efficiency to test this postulation.

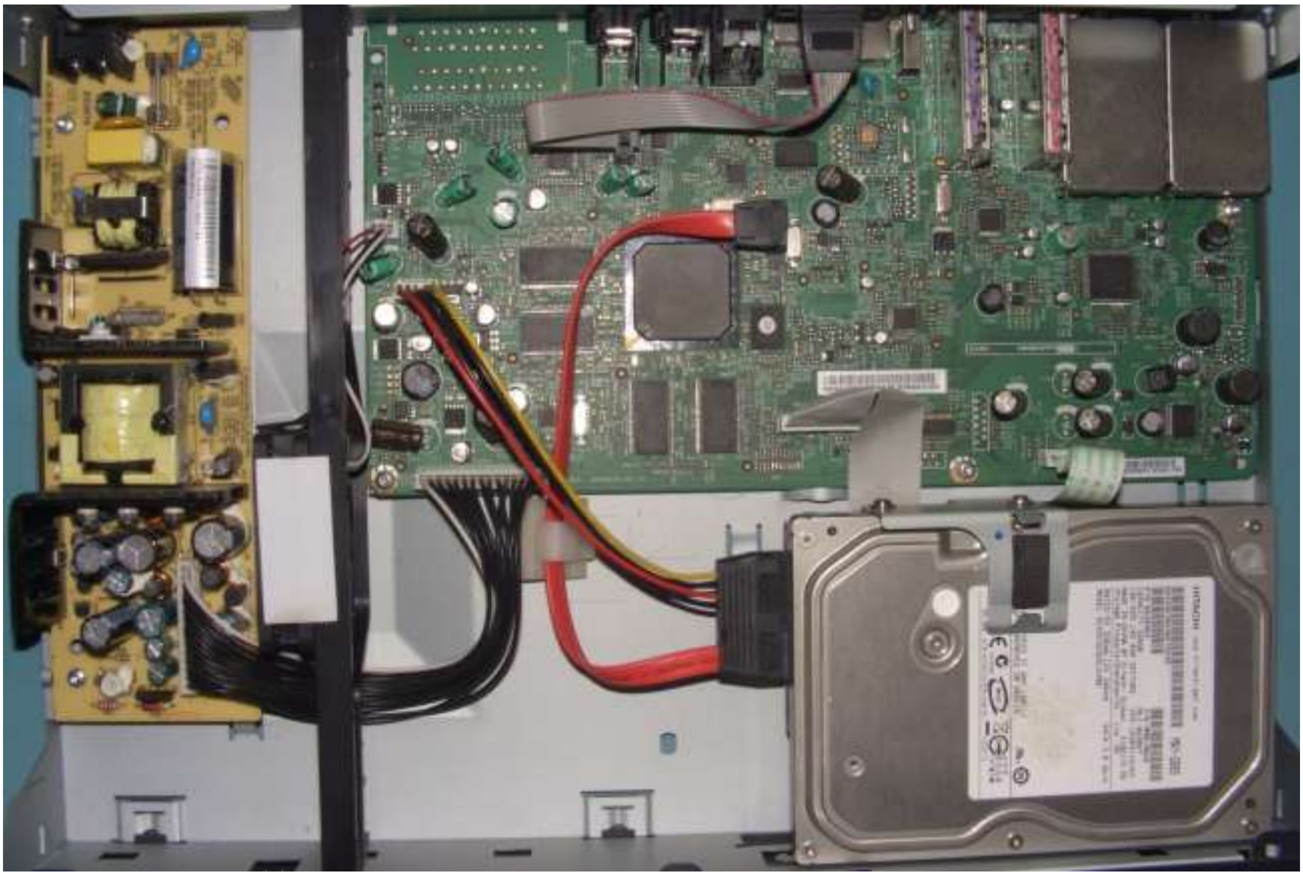
Figure 10: Thermal image of Foxtel IQ2 power supply

Thermal Image	Photo
	

Austar MyStar STB

Figure 11 shows the circuit boards for the Austar MyStar STB. Like the Foxtel IQ2 STB, the HDD is the only part of the STB that can be disconnected and still enable the STB to operate. Referencing Table 1 above, the HDD of the Austar MyStar STB uses 2.8W. As one of the important functions of the STB is to provide real time review capability, the HDD will need to operate all the time so there is little opportunity to power down the HDD down to save energy.

Figure 11: Photo of the construction of the MyStar STB.



The discussion of what components are dissipating higher levels of heat is in the section on thermal imaging.

The main power consuming components in the Austar MyStar STB are:

- STi7109 – Decoder Chip Set
- STV 0900 - Satellite Demodulator
- STV 0362 - Terrestrial Demodulator
- Flash Memory
- Terrestrial Tuners
- Satellite Tuners

The tuners are major power consumers. In addition to the two satellite TV tuners, the Austar MyStar STB also has two terrestrial TV tuners. It is not possible to disable any of these tuners as part of this testing. However to assess the impact of each tuner, the specification from the ASTRA CSTB Code of Conduct can be referenced. This code of conduct allows 5W to 6 W for each additional tuner. As this allowance is based on a worst case scenario, it is likely that each tuner would be consuming around 3W to 4W of power. Therefore the tuners would be contributing between 12W and 16W of the overall power consumption.

Figure 12 shows the image for the main chip and like the Foxtel IQ2 STB it is operating at a higher temperature (49.6 degrees Celsius). The same comments for the Foxtel IQ2 STB describing the results in Figure 7 apply to Figure 12 below for the Austar MyStar STB.

Figure 12: Thermal Image of the MyStar chip set.

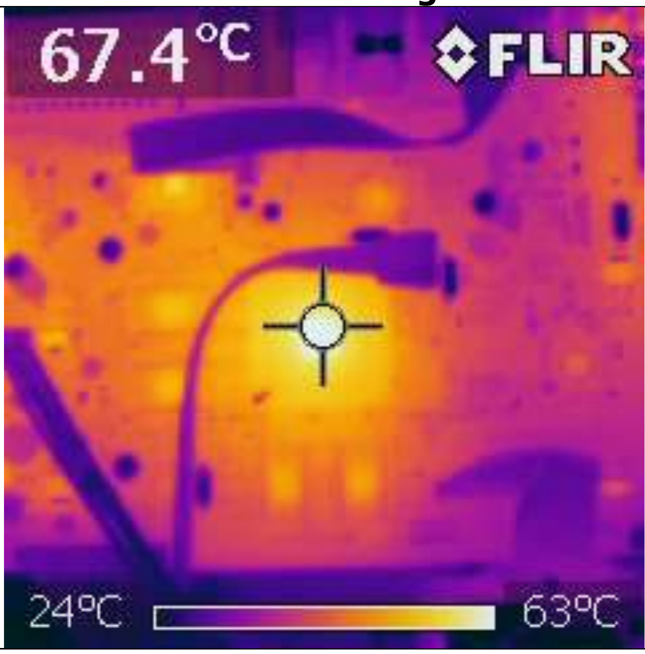
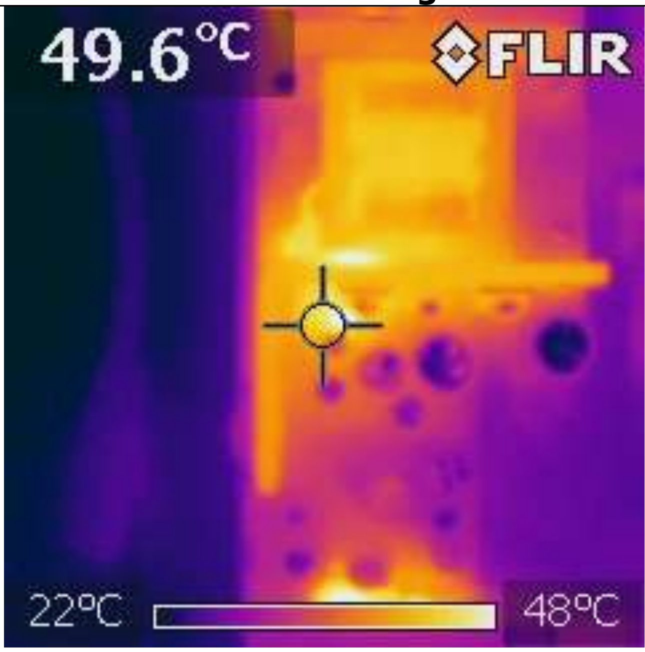
Thermal Image	Photo
	

Figure 13 below shows the image of the Austar MyStar STB power supply. For this particular power supply the switching transformer is warmer than, but not as hot as, some surrounding components. Due to its mass it is actually dissipating more heat. The surrounding components are smaller and have higher thermal resistance. While these components have a relatively higher temperature, they are dissipating significantly less heat.

Figure 13: MyStar power supply

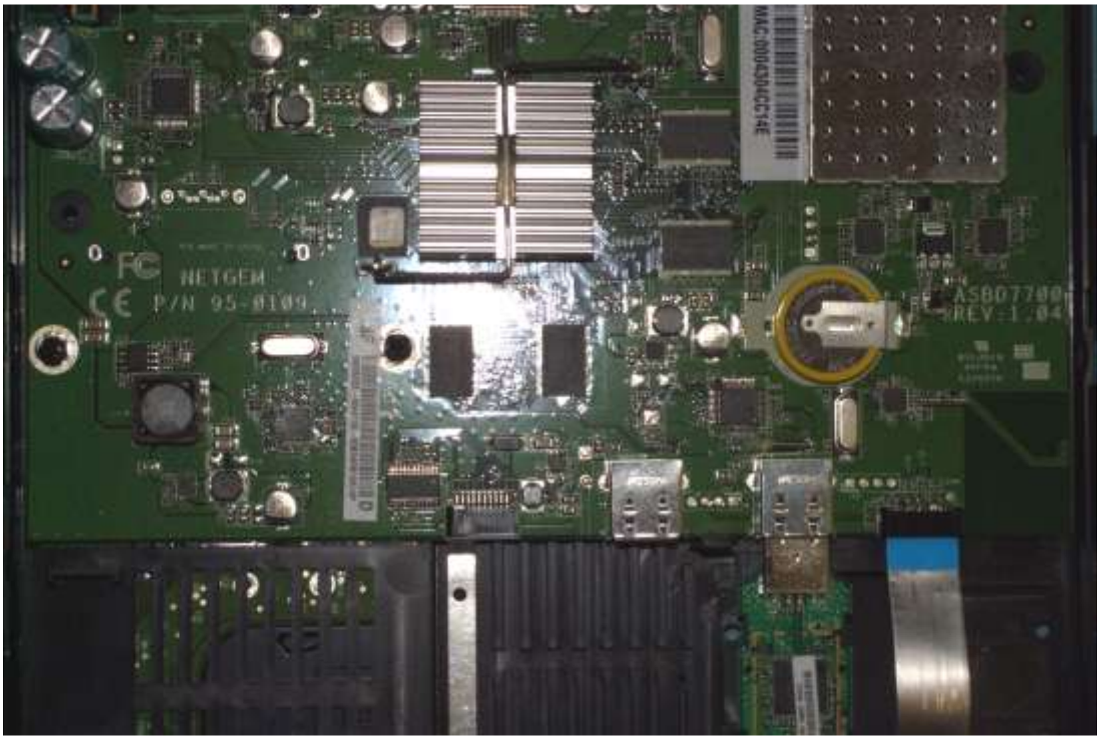
Thermal Image	Photo
	

Telstra T-Box

Figure 14 below shows the circuit board of the Telstra T-Box. The Telstra T-Box is powered by an external power supply (EPS). This means that the Telstra T-Box only requires a main processing board.

As the main processing integrated circuit board is specially designed for Telstra, there is no data sheet publicly available.

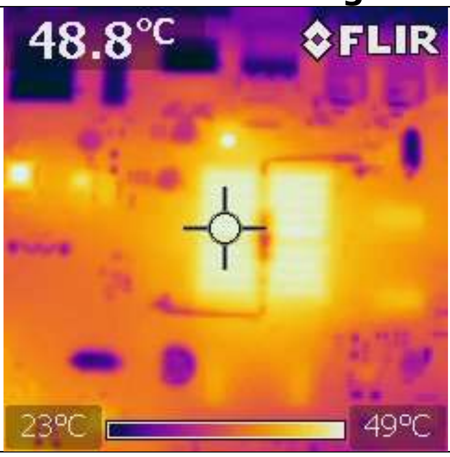
Figure 14: Circuit board for the Telstra T-Box



It is noted that the Telstra T-Box tested has only two terrestrial TV tuners which could be consuming between 6W and 8W of power. If the Telstra T-Box had four tuners then it would be consuming between 12W and 16W of power. As a consequence the power consumption of the Telstra T-Box would increase to a level similar to the Austar MyStar STB or the Foxtel IQ2 STB.

Figure 15 below illustrates the contribution that the main chip has on the power consumption. As the Telstra T-Box is powered by an EPS, there is no image of the power supply.

Figure 15: **Thermal image of Telstra T-Box**

Thermal Image	Photo
	

Power scaling and control opportunities for STBs

None of the STBs tested have power scaling functionality. There is opportunity for power scaling by power managing multiple tuners where they exist. The units tested did not power manage the tuners fitted when they were not in use. Consequently, if the tuners were consuming 3W some 12W is being used even if only one tuner is active. This difference in power is most evident when comparing the power consumption of the Telstra T-Box, which had two tuners, compared to the Austar MyStar STB or the Foxtel IQ2 STB, each of which had four tuners.

Where fitted, the HDD used to record programmes could also be power scaled by managing the spinning functionality of the HDD. In these particular STBs the HDD is spinning all the time because they have a review function that is constantly on. However, without the review function, the HDD could be spun down when not recording thus saving the power consumed by the HDD stepper motors.

Potential for power consumption savings and benchmarking for STBs

Another candidate for significant power savings is to improve the way in which conditional access management is conducted. The Foxtel IQ2 STB and Austar MyStar STB maintain a relatively high active standby power to update conditional access keys and to maintain electronic program guides.

Changing the management of these processes to allow each of these particular STBs to be placed into a passive standby mode, as occurs with the Telstra T-Box, and switching the STBs to a higher active standby to update conditional access keys would save considerable energy.

IP phones

Overview of power consumption testing

Three models in each of the following IP phone types were tested.

1. Handset type
    - Cisco WIP310-G4 model
    - Siemens Gigaset A58IP model
    - NetComm V905 model
2. Modem/router type
    - Dynalink RTA1046VW model
    - Billion 7404VNPX model
    - NetComm NB9WMAXXN model
3. Router type
    - Cisco SPA3102-AU model
    - Linksys WRP400-G4 model
    - NetComm V210P model

Power measurement of IP phones

Tables 3, 4 and 5 set out the power measurements for each of the models under each IP phone type.

Table 3 below sets out the power measurements for the handset type IP phones. The results for each model can be summarised as follows:

- The Cisco model has the lowest power usage suggesting that savings can be made between waiting in standby and the ringing, calling and talking modes.

- The Siemens Gigaset model actually showed higher power consumption in its 'waiting standby mode' than when ringing, calling and talking modes.

- The Netcomm model shows little difference between any power mode (≈0.5W)

Overall the power consumption of handset IP phones is relatively low compared to the router type IP phone.

Table 3: Power measurement results for handset type IP phone

		Handset					
Brand and Model Number		Cisco: WIP310-G4		Siemens Gigaset: A58IP		NetComm: V90S	
		Watts	pf	Watts	pf	Watts	pf
Standby	Waiting	1.15	0.42	3.74	0.53	3.63	0.51
	Ringing	2.6	0.53	3.08	0.51	3.99	0.53
On Mode	Calling	2.5	0.52	3.26	0.51	4.12	0.53
	Talking	2.51	0.52	3.81	0.53	4.17	0.53

In Table 4 below the results of the energy performance tests of the router/modem type of IP phone are set out for the different energy saving modes.

These results show that there is some potential for power consumption savings when the device is in a 'standby waiting mode'. There is a slight difference in energy consumption when the device is directly connected to the ADSL phone line to operating through another computer network via the router.

It should be noted that these units also perform the normal functions of a modem/router. Consequently the underlying power consumption for these functions is included.

In Table 5 below, the results of the energy performance tests of the router type of IP phones are set out for the different energy saving modes.

The results show that there is some potential for power consumption savings when the router is in a 'standby waiting mode' or a 'ringing mode'. As with the router/modem type of IP phone, the results show a slight difference in power consumption when the router is directly connected to an ADSL modem or may be operating through another computer network via the router.

Again it should be noted that these devices also perform the normal functions of a router the underlying power consumption for these functions are included.

Table 4: Power measurement results for router/modem type of IP phone

		Modem Router[1]											
		Stand Alone		Connected to Network		Stand Alone		Connected to Network		Stand Alone		Connected to Network	
Brand and Model Number		Dynalink: RTA1046VW				Billion: 7404VNPX				NetComm: NB9WMAXXN[2]			
		Watts	pf	Watts	pf	Watts	pf	Watts	pf	Watts	pf	Watts	pf
Standby	Waiting	11.83	0.65	12.65	0.67	9.58	0.52	10.34	0.53	8.9	0.55	9.65	0.56
	Ringing	13.95	0.71	14.8	0.71	11.03	0.53	11.73	0.54	9.9	0.54	10.66	0.53
On Mode	Calling	13.95	0.71	14.9	0.71	11.05	0.53	11.73	0.54	9.8	0.54	10.66	0.53
	Talking	13.97	0.71	14.9	0.71	11.02	0.54	11.75	0.54	9.9	0.54	10.66	0.54

[1] Also known as a modem/gateway
[2] This unit also has an analog telephone adapter but this was not connected for the test. It also has wireless connection but only the wired connection was tested.

Table 5: Power measurement results for router type of IP phone

		Router[3]											
		Stand Alone		Connected to Network		Stand Alone		Connected to Network		Stand Alone		Connected to Network	
Brand and Model Number		Cisco: SPA3102-AU				Linksys: WRP400-G4				NetComm: V210P			
		Watts	pf	Watts		Watts	pf	Watts	pf	Watts	pf	Watts	pf
Standby	Waiting	4.16	0.44	4.52	0.45	6.35	0.5	6.47	0.51	4.18	0.45	4.37	0.46
	Ringing	4.18	0.44	4.6	0.45	7.7	0.5	8.1	0.52	4.2	0.46	4.41	0.46
On Mode	Calling	4.62	0.46	5.1	0.46	7.81	0.52	8.23	0.52	4.89	0.49	5.13	0.5
	Talking	4.6	0.46	4.98	0.46	7.82	0.52	8.19	0.52	4.91	0.49	5.2	0.51

[3] Also known as a 'gateway'

Thermal imaging and tear down analysis of IP phones

The comments about the relationship between temperature, thermal resistance and heat dissipation are particularly relevant for IP phone handsets, IP phone routers and IP phone modem/routers.

Most of the components in these devices will not have heat sinks and are plastic cased semiconductors which have a high thermal resistance. Plastic cased integrated circuits would typically have a thermal resistance of between 20-70 degrees per Watt. This means at an ambient temperature of 22 degrees Celsius such devices without heat sinks would operate between 32 degrees Celsius and 57 degrees Celsius when only dissipating 0.5W. In the images below there are many devices that exhibit this characteristic without necessarily being high power consuming devices.

For this reason care should be taken when drawing conclusions from these thermal images.

Handset type IP phones

The handset type IP phones could not be thermally imaged due to their construction.

IP router/modem type of IP phones

Figure 16 and Figure 17 below provide the thermal images of the Dynalink router/modem type of IP phone.

The operating temperatures for the Dynalink RTA 1046VW model of router/modem are somewhat higher than for the other models tested. This is also reflected in the power consumption for this modem/router which was around 3W-4W higher than the other two units.

The use of a voltage regulator is again noted.

Figure 16: Thermal image of the RTA1046VW router/modem for BCM348KBG

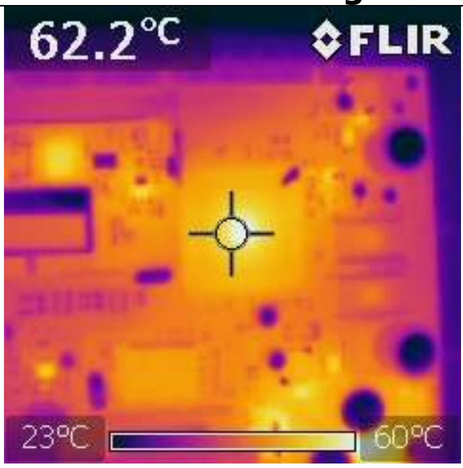
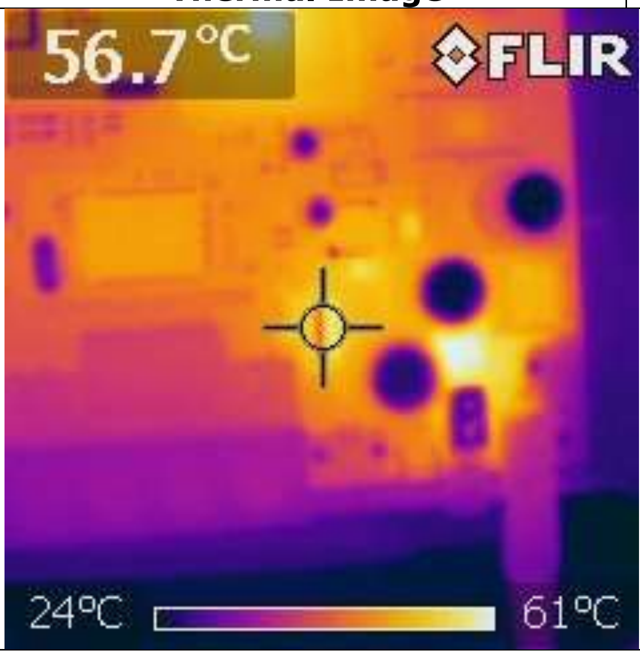
Thermal Image	Photo
	

Figure 17: Thermal image of the RTA1046VW router/modem for LM7805

Thermal Image	Photo
	

The power consumption of the main components of the Dynalink RTA1046W router/modem is set out in Table 6.

Table 6: Main components for the Dynalink RTA1046W router/modem

Device	Function	Power Consumption
BCM6348	SINGLE-CHIP ADSL2+ CPE CHIP	No Data
LM7805	VOLTAGE REGULATOR	Up to 2W
BCM6341	VOIP PROCESSOR	No Data
EPS	Mark IV	4.26W

Figure 18 and Figure 19 show that heat sinks have been used on most of the main devices which are working to keep temperatures relatively low. A rectifier is being used to produce extra voltage supplies.

Figure 18: Thermal image of Billion 7404VNPX router/modem

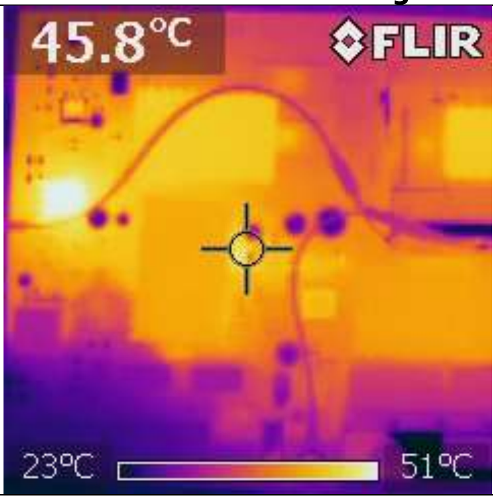
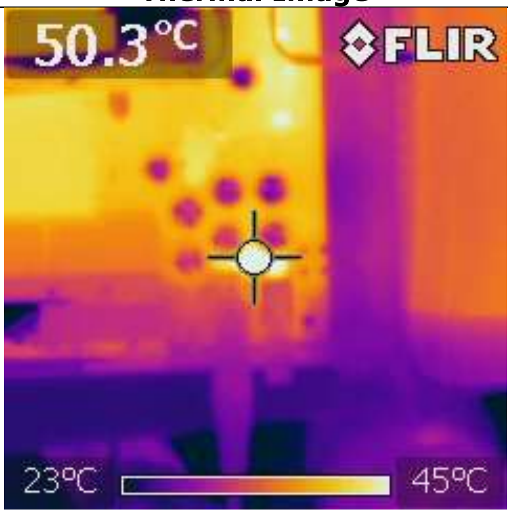
Thermal image	Photo
	

Figure 19: Thermal image of Billion 7040VNPX router/modem showing rectifier B240

Thermal Image	Photo
	

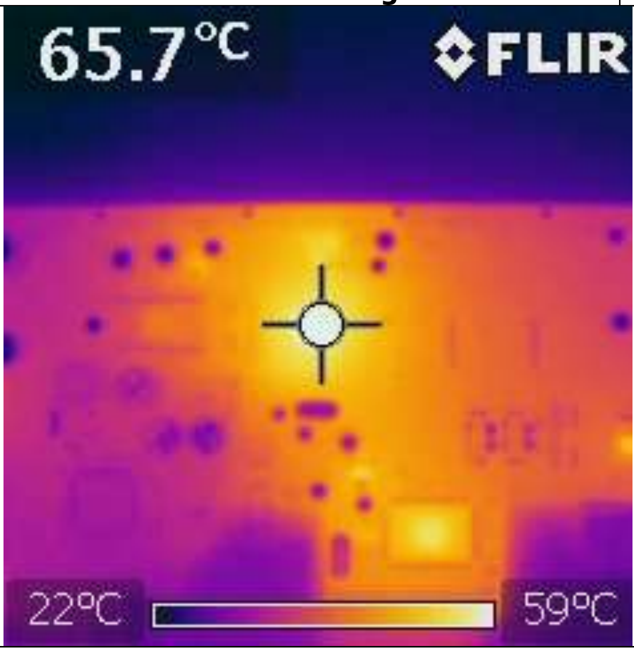
The power consumption of the main components of the Billion 7404VNPX router/modem is set out in Table 7.

Table 7: Main components for the Billion 7404VNPX router/modem

Device	Function	Power Consumption
3055L	Mode Field Effect Transistor	3W
AX3001	2A PWM DC to DC Converter	Less than 2W
B240	Rectifier	Less than 5W
EPS	Mark IV	2.19W

The NetComm router/modem uses chipsets that do not have heat sinks. As can be seen in Figure 20: Thermal image of NetComm NB9WMAXXN router/modem, the integrated circuit board is relatively cool and from the power measurements it has the lowest power consumption of the router/modems.

Figure 20: Thermal image of NetComm NB9WMAXXN router/modem

Thermal Image	Photo
	

The power consumption of the main components of the Netcomm N89 router/modem is set out in Table 8.

Table 8: Main components for the NetComm N89

Device	Function	Power Consumption
BCM5325	SIX-PORT MANAGED 10 100 ROBO SWITCH	Less than 1W
BCM6358	ADSL2+ INTEGRATED ACCESS DEVICE.	No Data
EPS	Mark IV	2.77W

Router type of IP phones

The thermal images of the Linksys WRP400 show that the components are operating within what would be considered a normal temperature range.

In Figure 21 and Figure 22 there are examples of router type models with plastic cased integrated circuits that are operating at moderate temperatures of around 44 degrees Celsius to 47 degrees Celsius. However this Linksys router type model will not necessarily be consuming higher power as the operating temperature is being caused by the large thermal resistance.

By contrast there is an integrated circuit that has a large heat sink attached which is probably responsible for much of the power consumption of the router but as the thermal resistance is low the device is almost operating at ambient temperature.

Figure 21: Thermal image of Linksys WRP400-G4 router (image 1)

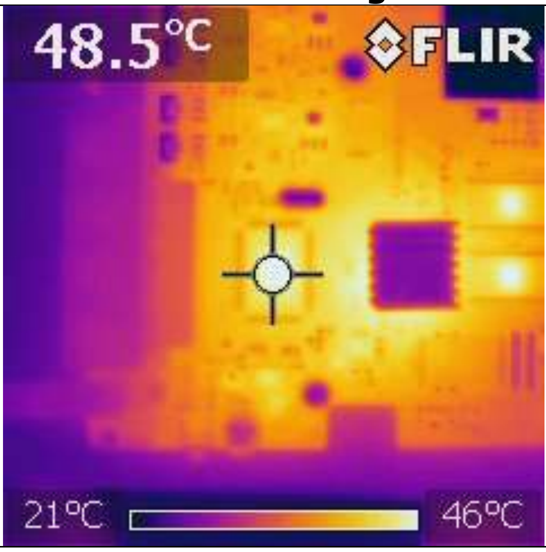
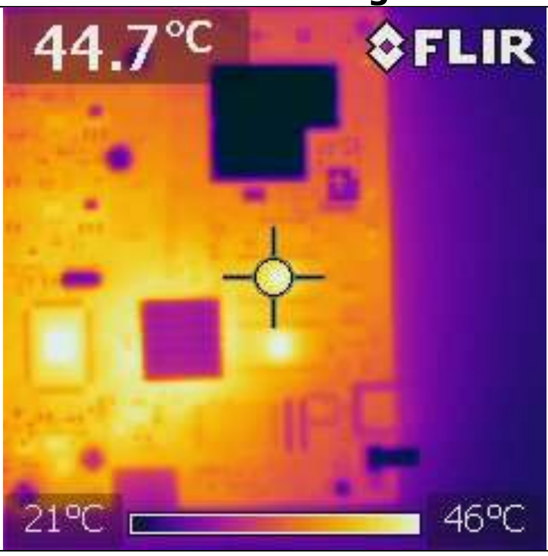
Thermal Image	Photo
	

Figure 22: Thermal Image of WRP400-G4 Router (image 2)

Thermal Image	Photo
	

The power consumption of the main components of the Linksys WRP 400 router/modem is set out in Table 9.

Table 9: Main components of the Linksys WRP 400

Component	Description	Power Consumption
Obscured by Heatsink	Likely to be a CPU	More than 1W
88E6061	7-Port Fast Ethernet Switch	Less than 1W
W9812G6IH	2M X 4 BANKS X 16 BITS SDRAM	1W
EPS	Mark IV	2.63W

The thermal images of the Cisco SPA 3012-AU router type of IP phone are shown in Figure 23 and Figure 24. There are two moderately warm integrated circuits and neither has a heat sink. Consequently the thermal resistance will be quite high. However it is likely that these integrated circuits are consuming under 1W of power.

Figure 23: Thermal image of Cisco SPA3102- device NF4256N

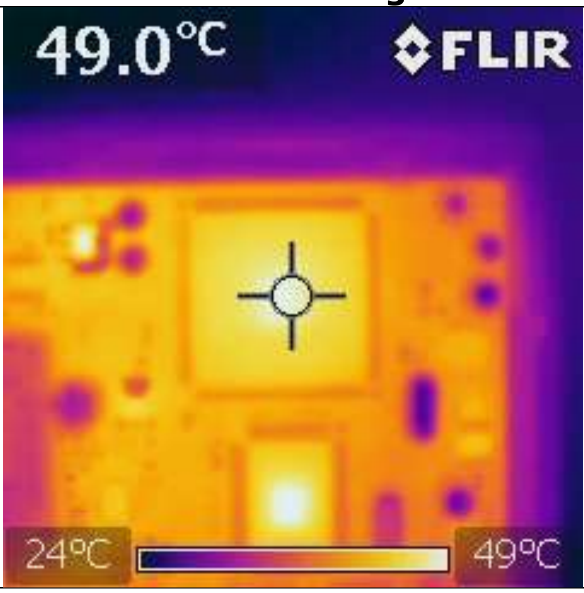
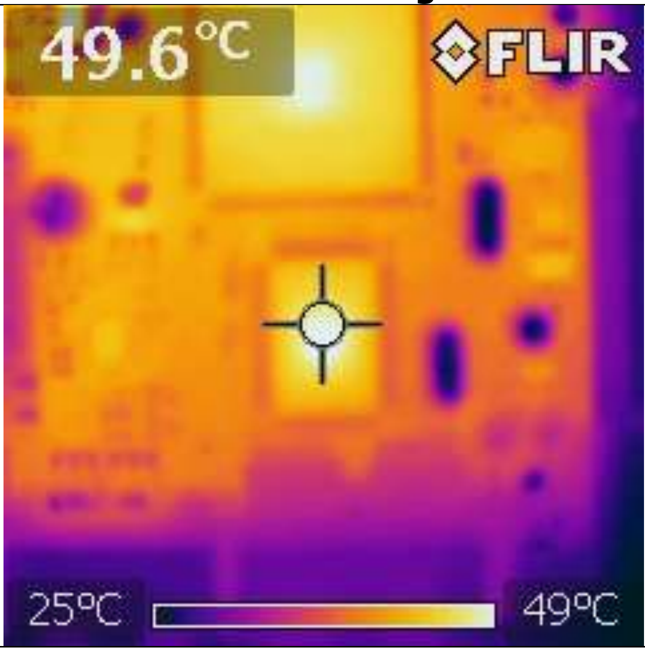
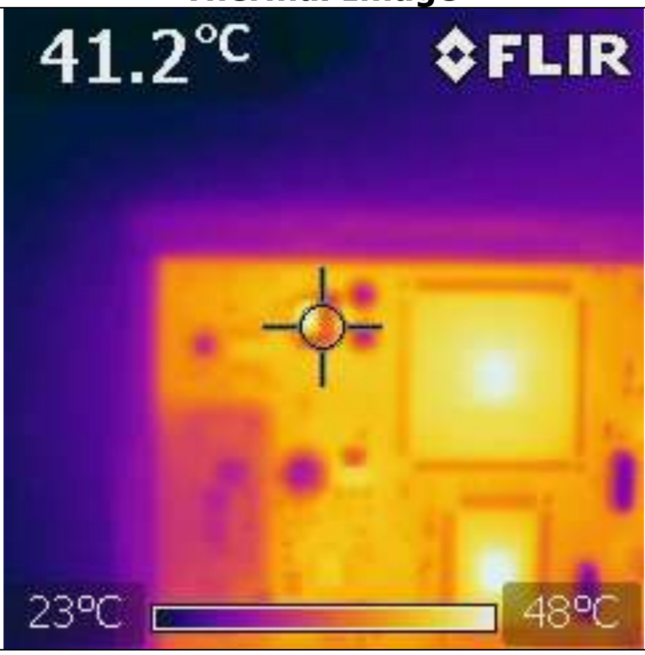
Thermal Image	Photo
	

Figure 24: Thermal image of Cisco SPA3102-AU Router Showing CPU SPNZ80103

Thermal Image	Photo
	

The regulator shown in Figure 25 was also found in some of the other routers and modem/routers. It would appear that manufacturers have used off the shelf external power supplies that provide only one voltage to keep the build cost down. Where the designs require other voltage supplies, these are created on the integrated circuit board with linear voltage regulators. However these are for the most part inefficient as they will consume power due to the voltage drop across them and the current they are providing.

Figure 25: Thermal image of Cisco SPA3102 showing voltage regulator RT9164A

Thermal Image	Photo
	

The alternative is highly efficient switching power supplies specifically designed with multiple voltage outputs.

The power consumption of the main components of the Cisco SPA 3102 router is set out in Table 10.

Table 10: Main Components of the Cisco SPA 3102

Device	Function	Power Consumption
SPNZ801030	Micro CPU Chip	No Data Sheet
SIP316ff	VOIP Processor	No Data Sheet
RT9164A	Voltage Regulator	Up to 1.5 W
EPS	Mark IV	1.45W

The same comments from above equally apply to the thermal images of the NetComm V210P IP phone router shown in Figure 26 and Figure 27.

Figure 26: Thermal image of V210P router chip

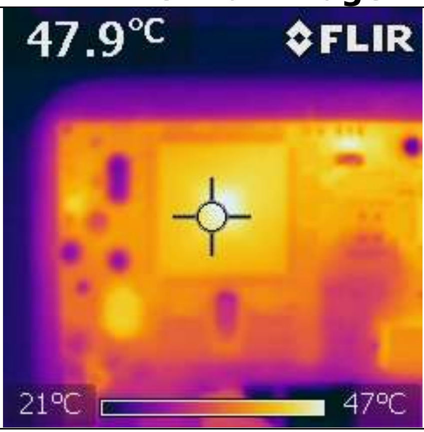
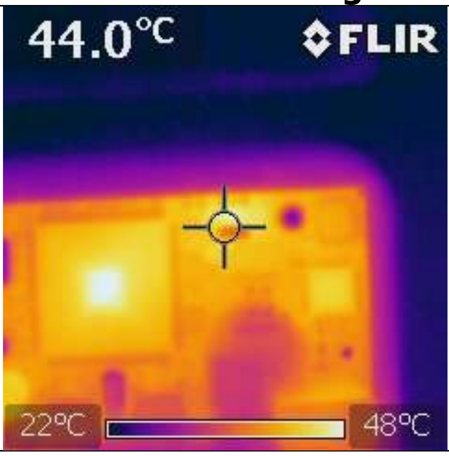
Thermal Image	Photo
	

Figure 27 below again shows the use of a regulator to provide additional voltages for the design.

Figure 27: Thermal image of V210P regulator MT1117

Thermal Image	Photo
	

The power consumption of the main components of the NetComm V21OP router is set out in Table 11.

Table 11: Main Components for the NetComm V210P

Device	Function	Power Consumption
CM5000LF	Universal Synchronous Asynchronous Receiver	No Data but probably around 1W
MT1117	Regulator	Up to 1W
EPS	Mark IV	1.34W

Power scaling and control opportunities for IP Phones

There is some evidence of power scaling particularly between the operating modes ‘waiting for a call’ and ‘ringing, calling and talking’. The measurements indicate however that this scaling is quite moderate being between 1W and 2W where it exists.

Potential for power consumption savings and benchmarking for IP Phones

From the above analysis custom-made multi-voltage switching power supplies could be used to avoid the unnecessary power loss due to the use of linear regulators and rectifiers. However this is probably a more expensive option for manufacturers.

Of the three router/modem type of IP phones tested, the Netcomm NB9WMAXXN uses between 1W and 3W less than the other two. It seems therefore that there is scope for improvements by design that focuses on energy consumption as well as performance.

For the router type of IP phones, there was some 3W difference between the best and worst performing models. Again this suggests that improvements could be made with better designs.

Game Consoles

Overview of power consumption testing

The three game consoles tested were the Microsoft Xbox 360, the Sony PlayStation PS3 and the Nintendo Wii. Several games were procured for each unit representing the differing genres used for game playing.

It should be noted that at the time of the testing the Sony web site had been shut down so only one game was available for testing. This is not perceived as a significant problem as the likelihood of significant difference in power consumption between differing genres is likely to be quite low. This was demonstrated by the testing w of different game genres for the Nintendo Wii and Microsoft Xbox. The closure of the Sony PlayStation website did not allow for the measurement of download power consumptions for the PS3.

The results shown in Table 12 below demonstrate the higher power consumption for game consoles which have considerably higher graphics capability - notably the Microsoft Xbox 360 and the Sony PlayStation3 - compared to the lower graphics capability of the Nintendo Wii.

Power measurement of game consoles

Table 12: Power consumption for the selected game consoles

		Microsoft Xbox 360			Sony PS3			Nintendo Wii		
			Power	pf		Power	pf		Power	pf
Standby	Off		0.67	0.05		0.05	0		5.93	0.41
Standby	Passive(No Game Running)		76.86	0.61		67.56	0.87		13	0.49
Standby	Active(Paused)		75.01	0.61		75.15	0.88		15.19	0.51
On Mode		Genre			Genre			Genre		
On Mode		Sports	82.97	0.61	Action	76.62	0.88	Platform	15.12	0.51
On Mode		Arcade	80.99	0.61				Platform	15.12	0.54
On Mode		Sports	79.65	0.61				Action	13.96	0.53
On Mode		Action	81.79	0.61				Action	13.42	0.52
On Mode		Sports	80.63	0.61				Sport	14.25	0.53
On Mode		Platform	81.56	0.61				Sport	14.95	0.53
On Mode		Platform	80.24	0.61				Sport	14.12	0.52
On Mode		Sports	82.61	0.61						
Download	Wired		73.89	0.61					13.7	0.5
Download	Wireless		77.62	0.63					13.95	0.53

The download power consumption for the Nintendo Wii did not vary significantly whether it was wired or wireless but for the Microsoft Xbox 360 there was a 3.73W difference.

It was also noted that the Sony PlayStation 3 had an 'auto off' function after one hour of inactivity while the Microsoft Xbox did not go to 'auto off' mode until after 6 hours of inactivity.

Thermal imaging and tear down analysis of game consoles

Thermal imaging for game consoles was not possible as the three models of game consoles tested were not able to be powered after being deconstructed. The tear down analysis for game consoles would not produce useful results as the construction method has masked most useful component detail.

Power scaling and control opportunities for game consoles

The game consoles tested did not have any power scaling.

Potential for power consumption savings and benchmarking for game consoles

The main opportunity for power saving for game consoles is to develop a more sophisticated method to switch to lower power levels when not in use.