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Senior Design II: EML4552C

WIRELESS INFRARED MONITORING SYSTEM

OPERATION MANUAL

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SIEMENS

ABSTRACT

This project has delegated to our Senior Design Team of Florida State University's Mechanical Engineering Program by Siemens Energy in order to investigate a more effective, simplified preventative maintenance technique incorporating the use of Infrared Technology. Siemens has expressed their interest in a conceptual design of a Wireless Infrared Monitoring System that will monitor fossil fuel power plant equipment for potential problematic operation. They wish for this designed system to ultimately reduce costs through replacement of existing thermocouples used for temperature monitoring as preventative maintenance. A conceptualized system has been designed and consists of three major subsystems: the Monitoring System, the Power System, and the Mounting System. The Monitoring System is comprised of the infrared camera, pan tilt module, microcomputer and wireless adapter. The infrared camera will survey preselected targets thoroughly, precisely, and without interfering with the equipment. The pan tilt module will control the camera's position allowing it to target a wide range of equipment thus reducing the need for numerous systems. The microcomputer will control the camera and pan-tilt module as well as filter and package the infrared data to be sent wirelessly via an adapter to the control room. The Power System will consist of an accurately sized solar panel, charge controller, battery, and inverter to properly power the system throughout the systems lifetime making it self-sustaining. Finally, the Mounting Structure will consist of a pole, weather enclosure, supports, and fasteners necessary to house, secure, and protect all the monitoring and power components from the elements. Each of these three major subsystems and subsequent components must be integrated correctly for each of their respective functions to contribute to the final success of the system. This report will detail the product specification, assembly, and operation of the system [1].

ACKNOWLEDGEMENT

We would like to acknowledge our sponsor, Siemens Energy Inc., for their donation and support of this project and the Senior Design program at the College of Engineering. James Sharp, specifically, has always been available for technical advising and deliverable review and has served as a great liaison. We would also like to thank Seminole Electric for taking the time to give us a tour of their power plant, R.J. Midulla, and educating us on the equipment that our system will be monitoring. We would like to thank our faculty advisors; Dr. Patrick Hollis and Dr. Rajendra Arora and the instructors of Senior Design; Dr. Nikhil Gupta and Dr. Chiang Shih, all of who have provided valuable feedback and advising. Lastly we would like to thank Dr. William Oates for loaning his infrared camera for our prototype development.

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I. INTRODUCTION

Currently, most power plants use a large network of thermocouples and local vibration monitoring devices to capture temperature and vibrational data of operating equipment. The thermocouples only measure a small local area. Therefore, a vast number of thermocouples must be individually tapped at very particular locations that need to be monitored. Thus, there must be thermo-wells drilled through any protective casing or piece of equipment that necessitates temperature readings. The thermocouples are then wired to a local junction box, and then through underground conduit all the way back to the control room. The temperature and vibrational data is used to determine pre-explosive or pre-failure conditions indicative of maintenance. This is called preventative maintenance and is critical in power plants lifetimes after about 10 years. All of these individual systems are invasive, costly, and complicated to implement and beckons for consolidation, simplification, and improvement.

Siemens, as an energy service provider, is interested in investigating a more simplified and effective preventative maintenance technique. Specifically, they are interested in exploring the use of infrared technology. Infrared cameras can be utilized to monitor the temperature of operating equipment, enabling it to diagnose potential problems long before other traditional systems. The cameras are also noninvasive and do not require equipment interference.

Siemens Energy has initiated this project to explore incorporating this technology in a conceptual design of a Wireless Monitoring System to improve their preventative maintenance service. This project has been delegated to our team to find a plausible system solution to the following goal statement and four objectives. [2]

"*Design a proposed complete system that can monitor a wide range of equipment for problematic operation.*"

1. Decrease equipment interference on operating systems.
2. Create cost savings through the elimination of need for numerous existing systems.
3. Decrease manual work needed for preventative maintenance.
4. Design a stand-alone system that does not consume any plant power.

The following tables, Table 1 and 2, captures the design constraints of this project set forth by Siemens. [2]

Table 1. System Constraints.

Subject	Descriptor	Constraint
Location	Exclusively	Fossil Fuel Power Plants
Lifetime	At least	30 years
Monitoring	Type	Thermal Imaging, up to 300°C
Power	Source	Solar Harvesting
Battery Storage	At least	3 days
Communication	Wireless	300m
Communication	Protocol	HART
Compliance	Code	NERC, IBC2006
Weatherproofing	Rating	IP55
Movement	Range	360° in horizontal, 90° in vertical

System Cost	Maximum	$20,000
Prototyping Budget	Maximum	$3,000

Table 2. IBC2006 Code.

Seismic Loading	Occupancy Category III
	Site Class D
	$S_s = 0.41g$, $S_1 = 0.19g$
Wind Loading	$V_{3s} = 100$ mph
	Exposure C
Rainfall	5"/hr for 1 hr in a day
Ambient	0-110°F

The testing site that this product will be implemented on is a 2x1 combined cycle power plant called Richard J. Midulla. It is owned by Seminole Electric and provides about 810 MW to Hardee County, Florida. [3] The plant is almost 15 years old and at the height of its maintenance period. Below in Figure 1 is a top view layout of the site. The red boxed targets are the equipment and regions of interest for our designed monitoring system.

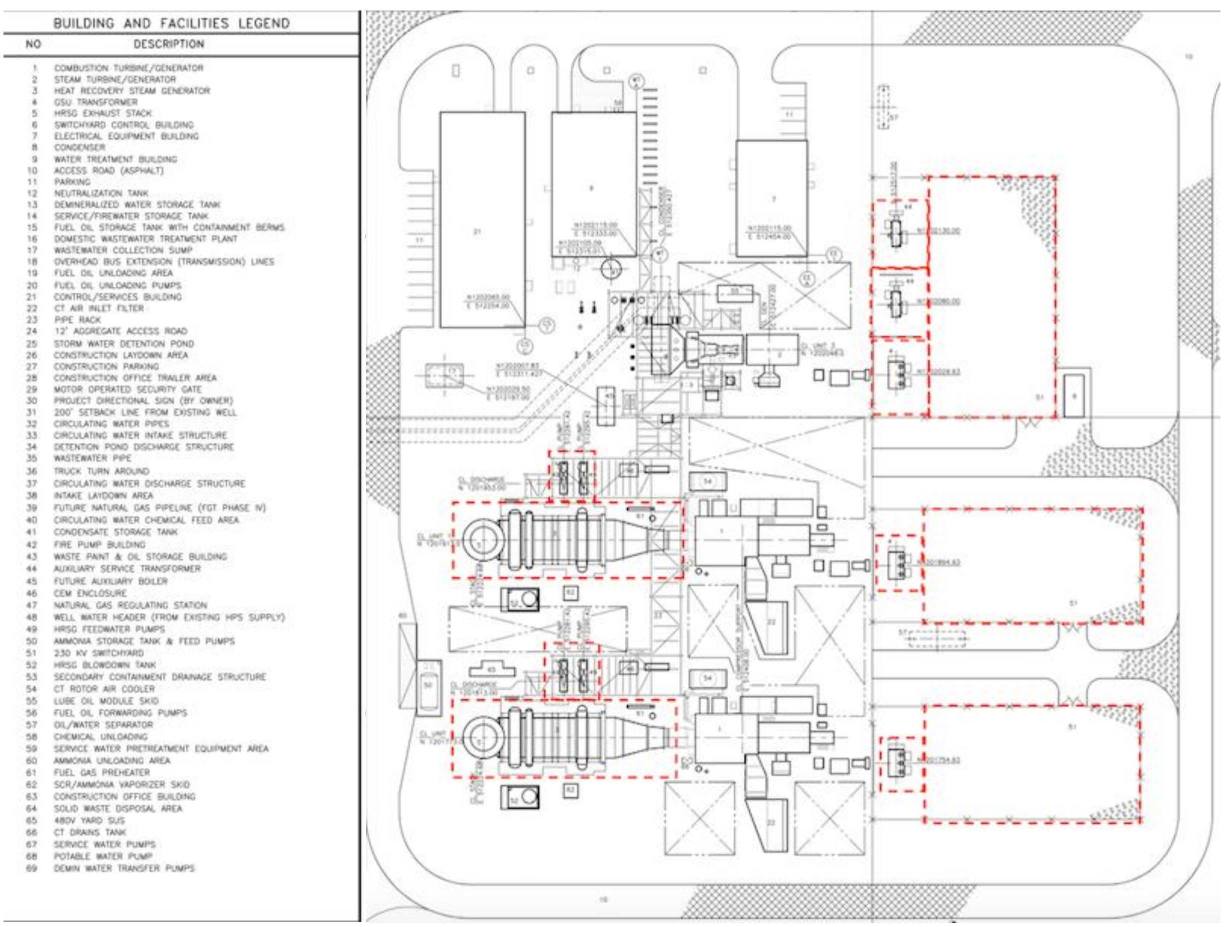

Figure 1. Implementation Site and Targets.

II. Functional Analysis

In order to accomplish our goal statement, it was conceptualized that our system's function could be classified into three main subsystems: the Monitoring System, the Power System, and the Mounting System. Under these three subsystems; components were selected in order to accomplish the subsystem overall function along with the specific objectives given. A block diagram of our sub-systems and their respective components can be seen in Figure 2 below. The following is a breakdown of each subsystem, its components, and their functions.

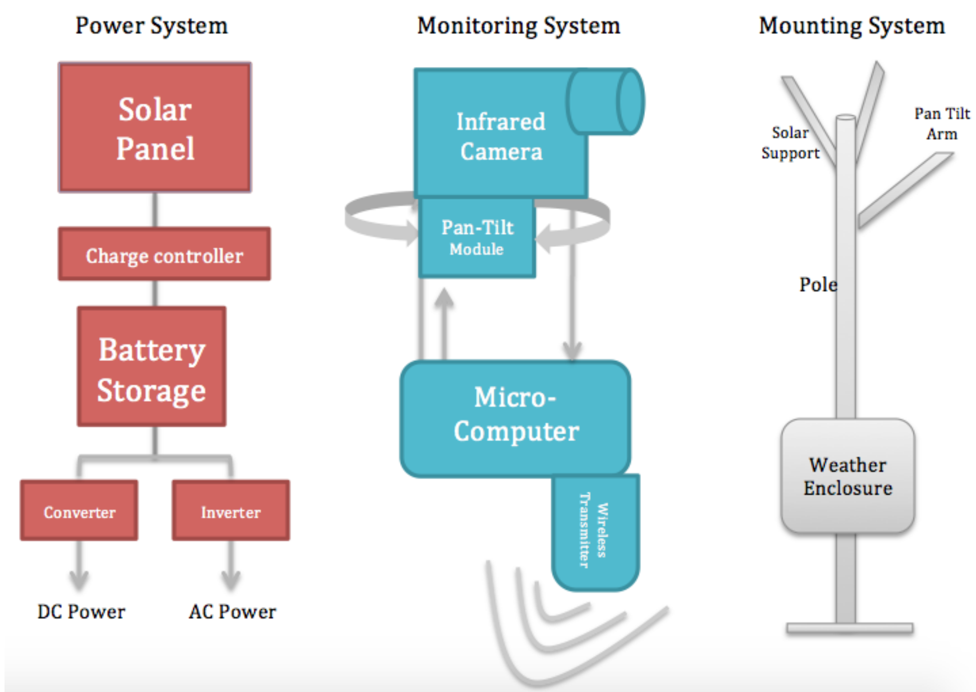

Figure 2. Sub-system Functional Diagram.

A. Monitoring System

The monitoring system will consist of the infrared camera, the pan tilt module, the microcomputer, and the wireless transmitter. An infrared camera was chosen for its ability to monitor the temperature of targets without interfering with their operation and reliability. The pan tilt module will rotationally position the camera, enabling it to monitor multiple pieces of equipment. This will decreases the number of systems needed to monitor the entire plant. The microcomputer and wireless communication module will package, analyze, and transmit the infrared data to the control room decreasing the amount of manual labor a wired network necessitates. All of these features will create overall cost savings, if successful. In order for this to happen successfully, these sub system components must be chosen and interfaced properly.

The infrared camera chosen for this project must be durable, low weight, efficient, and have good image and data resolution. The infrared camera should also have a minimum power consumption in order to reduce total system power consumption. In order to properly monitor the targets previously discussed in the Introduction; the camera must detect temperatures up to 572°F (300°C) with an accuracy of ±5%.

The pan/tilt module should operate in an auto scan mode that will cycle through fixed positions chosen by the operator while not consuming too much power. It should have the ability to have a continuous pan of 360° and have 90° of tilt motion. The pan tilt module should employ binary communications for dynamic applications to provide high bandwidth control. The motors of this module will need to be powered and controlled through the integration of a microcomputer through a RS 232, 422, or 485 serial or Ethernet connection [7].

The wireless system will be used to communicate between the microcomputer and the control room via a Wireless Local Access Network using Wi-Fi technology. To facilitate wireless communication for the monitoring system a few components will be needed: a router to create the wireless local access network (WLAN), an access point to access the WLAN from the microcomputer, and a directional antenna/bridge to boost the range of the wireless network in order for the field systems (clients) to be communicate with the control room (host). The router and antenna will be located in the control room for simplification and will not be considered as part of the system cost as they already exist in most control rooms. The wireless adapter will allow for a Telnet connection to be used to gain direct access to the infrared camera to control its functions to capture and save images of the targets.

The microcomputer acts as the onboard computer, executing programs and functions, and processing data. It is the "brains" of the operation. The microcomputer will have to seamlessly interface with the camera, pan-tilt, and wireless module or else the sub-system, as a whole, will not function. The microcomputer must also have a fast enough processor and storage space to support the necessary programs to compile the code i.e., Windows 7, CodeBlocks, API's, protocols, SDK's etc. [8].

These four components will be timed and executed in the following sequence. First the pan-tilt will move to the initial position specified by the operator, and then wait 5 seconds. During these five seconds, the camera will be prompted to focus, take a picture, and save the radiometric image. Two File Transfer Protocols will then be used to first save the image from the camera to the microcomputer and then to send it to the 'control room' for display and analysis.

B. POWER SYSTEM

The power system will consist of the solar panel, charger controller, battery, and appropriate inverter/converter. These components will work together to harvest, store, and transmit power to the monitoring system making it self-sustaining, the last of our four objectives. The solar panel must be sized appropriately to produce the necessary power to the batteries to meet system load. The solar panel will be mounted at a tilt equal to the local latitude facing South and be protected by particle resistant tempered glass to reduce maintenance and panel degradation. Ideally, the solar panel should have a high power output warranty guaranteed by the vendor. This will ensure that the panel's efficiency will not degrade too much over the lifetime, although it is understood that some degradation is inevitable.

The batteries must be able to store and deliver enough to power the system during times of low solar insolation. Most batteries have very short lifetimes of about 3-5 years. This lifetime can be augmented however by a proper power management system consisting of a charge controller and an inverter. Also lifetime can be improved by never over-discharging the batteries. Deep Cycle AGM Lead Acid batteries are designed for a low depth of discharge and are ideal for our system application [10]. The size of the battery, while being constrained by the system load, must not be too excessive because it will be the heaviest component on our system. This will restrict their placement on the mount and to properly charge and discharge the battery according to the available solar power and load demand. Maximum Power Point Tracking Charge Controllers are the most efficient because they optimize the match between the solar panel output and battery bank by converting the solar panel voltage to maximize the charging current to the battery.

The power system sizing, selection, and design couldn’t be completed until the selection of all the monitoring system was finalized and the total electric load was known. However, it is known that the solar panel, charge controller, and battery bank voltage must match. The charge controller’s maximum current and voltage also must be higher than both the solar panel and batteries maximum. This will prevent the charge controller from being burnt out [11]. Finally, an inverter will be necessary if any electronic devices necessitate AC power as batteries and solar panels output DC. The inverter must also be oversized in order to compensate for the conversion losses and startup power demands [12].

C. Mounting System

The purpose of the mounting system is to support, centralize, and protect the other key components while allowing them to perform as best as possible. Thus, the mounting structure is broken into 4 components; the enclosure mounting, solar panel mounting, pan tilt mounting, and a centralized pole or mounting structure. These four components allow for rigidity as well as modularity. That is, each subsystem can be reliably secured to the pole and can also be removed and placed in different “stacking orders” and orientations. The standard mounting order from top to bottom should be solar, pan tilt, and then the enclosure. Making the mounting system modular allows for optimization of individual system performance. Modularity also allows the components of this system to be removed and mounted elsewhere in the facility. To further ensure universality of the mounting structures, a single set of hardware components will be used on almost all of the mounting systems.

III. Product Specification

The following are the final selected components for each subsystem. Their design specifications can be found in the respective datasheets in Appendix 1.

A. Monitoring System Component Selection

FLIR A310f was selected as the Infrared Camera. It was rated the highest in the decision matrix at 6.8 due to its all-around performance specifications in power consumption, weather-proofing, and temperature readings. It is the most expensive option selected but gives an accurate temperature reading of (± 2%) with a measurement temperature range of (32°F to 662°F) which exceeds our temperature constraint.

Figure 3. FLIR A310f Infrared Camera.

The FLIR camera was also selected due the available open source protocols, vast amounts of product support and thermography analytics software. FLIR cameras also come with a wide array of exchangeable lenses based upon the desired field of view (FOV). This was another large advantage of selecting a FLIR camera because multiple lenses could be ordered and utilized on different systems depending on the targets being monitored. For standardization, a 25° lens is recommended.

The Pan Tilt Module selected for this design is the YP-3040 by Axis Communications. It is designed as an optional accessory for Axis fixed network cameras with pan-tilt support. Even though it is preconfigured for several Axis fixed network cameras it uses the common Pelco-D protocol which can interface with the FLIR A310f [6]. The YP3040 is said to be ideal for an inexpensive solution when fine adjustments to a cameras field of view are needed. [4] It can pan 355° and tilt 90°. The Axis YP3040 also recommend several accessories, two of which we will be utilizing; the PS24 Mains Adapter and Mount. The Adapter will be used to step 120VAC down the 24VAC to power the camera. This adapter was chosen in order to protect and power the pan-tilt appropriately. The support arm will support and attach the pan tilt module to the pole securely.

Figure 4. Axis YP3040 Pan Tilt Module, PS24 Mains Adapter, and Arm Support.

The Tiger VersaLogic (Figure 5a) best matched the caliber of the rest of the monitoring system components and was the ultimate selection for the microcomputer. The Tiger takes advantage of Intel's Atom Z5xx (Menlow XL) processor, which was designed specifically for embedded applications. Based upon Intel's 45 nm hi-k Metal Gate Silicon technology, the Z5xx series Atom chip offers high performance, industrial temperature operation and radically reduced power requirements. The camera will be able to connect to the standard on-board gigabit Ethernet port with network boot capability. The Tiger is compatible with a variety of popular 64 bit operating systems, including Windows, Windows Embedded, and Linux. Video features include advanced 3D graphics, high-definition video, integrated LVDS, and optional analog VGA support. A N600 Netgear Wireless adapter was selected as to give the microcomputer wireless access to transmit the infrared data. This adapter is pictured below in Figure 5c with the Microcomputer and Breakout board. [8]

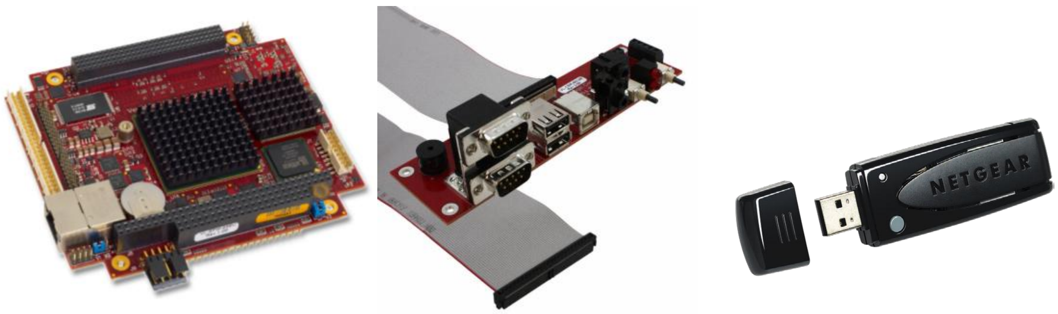

Figure 5. (a) Tiger Versalogic, (b) I/O Paddleboard, (c) and N600 Wireless Adapter.

B. POWER SYSTEM COMPONENT SELECTION

Based upon the power consumption of the previously listed electronics, a Renogy 150W Monocrystalline Panel was selected as our solar panel. [9] A single AJC 12V 100 Ah battery was chosen for the battery storage in lieu of 2 55A for circuit simplification. [10] The charge controller selected for this design is a 20A EcoWorthy MPPT Solar Charge Controller. It uses the common 3-stage Pulse Width Modulation charge algorithm and Maximum Power Point Tracking to efficiently charge the battery without cutting the solar panel's power production. It also has an LCD Display that shows the charging power and output status. This is a very functional feature when needing to know the status of the battery. [11] The selected solar panel, battery, and charge controller can be seen in Figure 6.

Figure 6. (a) Renogy Panel, (b) 100Ah AJC Battery, and (c) EcoWorthy MPPT Controller.

An inverter is needed to convert the DC power supplied by the panel to AC power required by the pan tilt module and microcomputer power supply. A Samlex 150 W inverter was chosen and can be seen in Figure 7. An inverter of this size will also accept the full output power of the panel if necessary as well as be able to deliver enough power for startup and power modes. The inverter will invert 12VDC to 120VAC for the Axis Mains Adapter and POE Splitter to power the pan-tilt and camera respectively. [12]

Figure 7. Samlex 150 W Inverter.

C. MOUNTING SYSTEM COMPONENT SELECTION

The mounting system was selected based upon our sponsors suggestions and industry standards. The full analyses of these selections performance can be seen in the Final Design section. A 6ft, 0.188" thick, 2" O.D carbon steel pole was selected to use as the centralized mounting structure. The weather enclosure selected for this project is the L-COM vented weatherproof NEMA 3R Enclosure, part number NB181608-00V. This enclosure has the internal dimensions of 17.7x15.7x10" which allows the inverter, battery, charge controller, and microcomputer to fit comfortably. The enclosure also has a ½" conduit connector to allow for the necessary connections to be made with the other external components without compromising the provided protection. A mounting plate is also provided to allow for easy mounting of components that require routine check-ups and easier access. The fasteners were selected so that a single set could be used on the majority of the mounting system components. For general fastening and assembly of mounting components, a 5/16-18, 1", stainless steel cap screw was selected. There was also matching zinc-aluminum coated steel hex nuts and zinc plated washers. Stainless steel U-bolts were selected to attach necessary component assemblies to a centralized mounting pole discussed in the next section of this report. Lastly, zinc plated strut clamps were selected for components that use strut channels. To build each of the components used in the mounting system, two types of stock were selected. The first of which is the 90 degree track which has perforated holes to allow for modification of the solar mounting system. The strut channel is used for mounting the enclosure to the mounting pole and functions similarly to the 90 track with the exception of added strength and a channel design to slide mounting components on and off. [15]

D. FINAL DESIGN

Below is a diagram of our final system setup incorporating the selected components above. The components in red comprise the power system, which consists of the Renogy 150W Monocrystalline Solar Panel hooked up to the EcoWorthy 20A MPPT Charge Controller. The 100AH 12V AJC Lead Acid AGM Battery is connected in parallel to the charge controller. The wires leaving the charge controller run to the electric loads (POE Splitter and Inverter at 12VDC). The POE Splitter splits the POE of the A310f Infrared Camera into 12VDC power from the charge controller and an Ethernet connection to the microcomputer. The 150W Samlex Inverter is also hooked up to the load line converting 12VDC to 120VAC. The inverter powers both the Mains Adapter and the microcomputer power supply. The Axis Mains Adapter steps the voltage down form 120VAC to 24AC to appropriately power the Axis Communications YP3040 Pan Tilt upon which the camera is secured. The Microcomputer Power supply steps down the 120VAC to 5VAC to power the Versalogic Tiger Microcomputer and wireless dongle. The dotted grey line represents the weather enclosure and everything that will be housed inside. All specifications and dimensions for the recommended design components can be found in Appendix 1. A complete Bill of Materials can be found in Appendix 3.

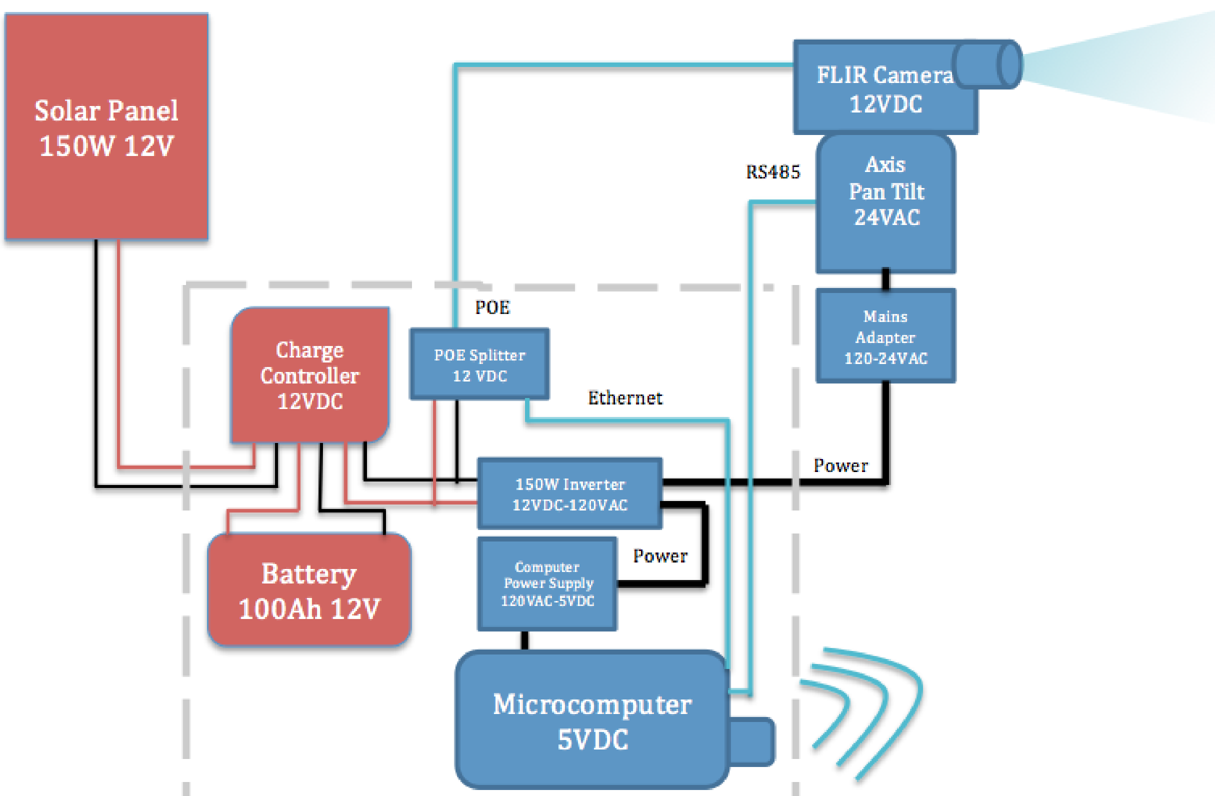

Figure 8. Final System Diagram.

The final model of our system design and recommended setup can be seen in Figures 8 and 9. This entails the solar panel being at the top of the pole with the pan tilt arm being located in the upper half and the weather enclosure being located towards the bottom for accessibility. Please refer to Appendix 4 for exploded views, subassemblies, and dimensioned part drawings.

Figure 9. Final Design Model and Exploded View.

IV. ASSEMBLY

Please refer to Installation Manuals for individual component setup. [14-19] Please then refer to Appendix 4 for assembly drawings. Please also refer to design for Manufacturing Report [20] for detailed assembly instructions. An exploded view of our system model can be seen below in Figure 10, below is the main components and subassemblies.

1. Solar Panel
2. Solar Mount
3. Infrared Camera
4. Pan-Tilt Module
5. Pan Tilt Arm
6. Mains Adapter
7. Pole
8. Electronics Enclosure

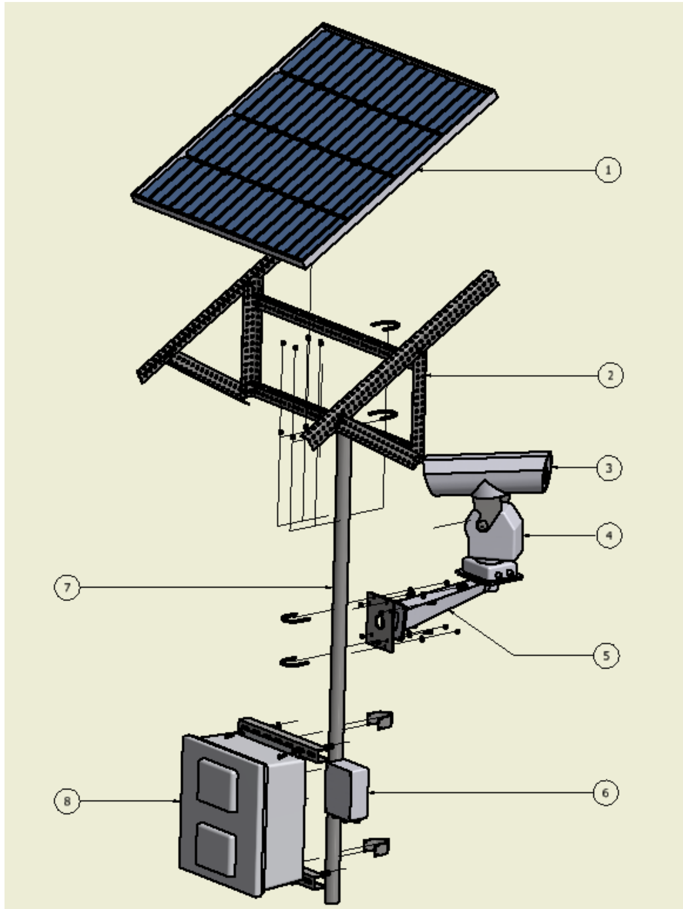

Figure 10. System Exploded View.

V. OPERATIONS MANUAL

The following operation steps are to be performed after the complete system has been assembled. [20] They govern the initializing of the monitoring system's autonomous operation. Batch file X will be used to establish Telnet connection with camera, and execute camera image capturing and saving to memory automatically. Batch File Y will set up FTP Connection #1 (camera to microcomputer) using WinSCP program in order to then transfer image file to microcomputer through a script. Batch File Z will establish FTP Connection #2 between Microcomputer (host) and Control Room (client) to transfer images to saved folder on Control Room computer. Batch File J will then grab files from Control Room Master Folder, time stamps them, saves them in an archive folder, and then opens them in ThermoCam Research PR0 2 for analysis. All these batch files will be executed in sync by Batch File A. The only step needed for operation after initializing is to execute Batch File A. All the software programming can be found in Appendix 5. Please refer to Installation Manuals for troubleshooting of individual components. The following steps are the initializing steps that need to be performed in order to set the monitoring system on its autonomous operation. Figure 11 shows what will be displayed in the Control Room GUI for analysis.

1. Initialize FTP Server with camera using ITS Manager.
2. Ensure correct IP Addresses of Camera are bound to the server.

3. Initialize FTP Server between Microcomputer (server) and Control Room computer (client).
4. Execute Batch File A.
5. Ensure images are being opened in ThermoCam application on 'Control Room' computer. See Figure 11.

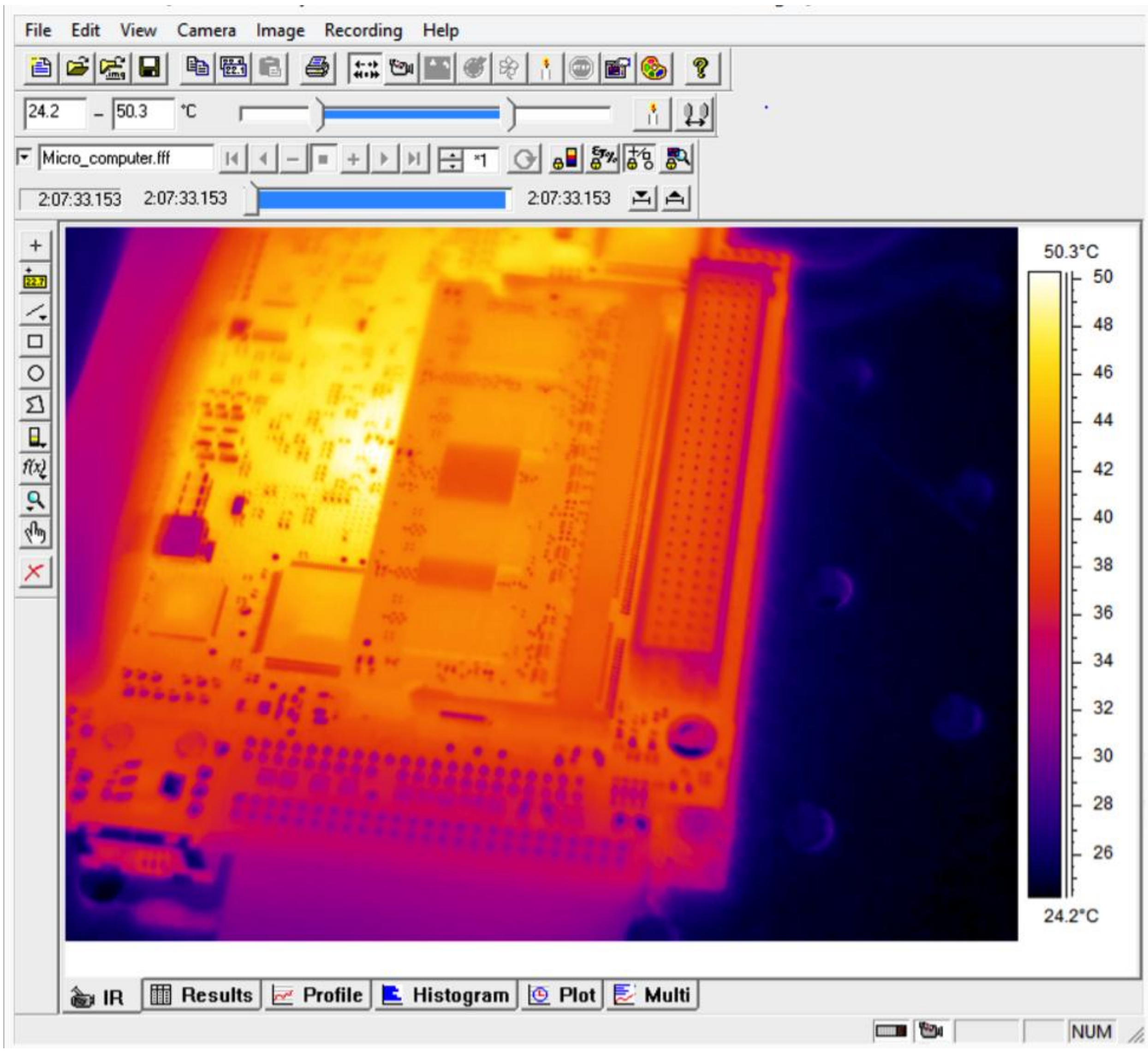

Figure 11. Infrared Image displayed in Control Room GUI.

A. REGULAR MAINTENANCE

The lead acid battery needs to be replaced approximately every 6 years according to our simulation. When this is to occur, the system needs to be completely powered down. The solar panel should be wiped with a clean cloth every month to prevent particulate build up and optimal results. This does not require system shut down. The mounting system should be checked for loose bolts, as well as damage or water induction after major storms. Please refer to Installation Manuals for individual component maintenance.

VI. Conclusion

In conclusion, the monitoring system, power system, and mounting system components were selected to complete the objectives set forth by Siemens. The completed system will be able to monitor a wide range of equipment for problematic operation. Furthermore, the operation of this system should be simple and virtually automated with the exception of necessary routine maintenance. See Design for Manufacturing, Reliability, and Economics Report for more design details.

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[18] Charge Controller Installation Manual. http://eco-worthy.com/catalog/download/20AMPPT.pdf

[19] Inverter Installation Manual. http://www.batterystuff.com/files/manual-11001-pst-1500-2000-12-24-0513.pdf

[20] S.W.I.M.S Design for Manufacturing, Reliability, and Economics Report.

APPENDIX 1: COMPONENT SPECIFICATION DATASHEETS

A. INFRARED CAMERA

FLIR

Technical Data

FLIR A310f 25°

Part number:

61201-1103

Copyright

March 08, 2012, 07:56 AM

Corporate Headquarters

FLIR Systems, Inc.
27700 SW Parkway Ave.
Wilsonville, OR 97070
USA
Telephone: +1-503-498-3547

Website

http://www.flir.com

Customer support

http://support.flir.com

Legal disclaimer

Specifications subject to change without further notice. Camera models and accessories subject to regional market considerations. License procedures may apply.

Information and equipment described herein may require US Government authorization for export purposes. Diversion contrary to US law is prohibited.

Imaging and optical data

IR resolution	320 × 240 pixels
Thermal sensitivity/NETD	< 0.05°C @ +30°C (+86°F) / 50 mK
Field of view (FOV) / Minimum focus distance	25° × 18.8° / 0.4 m (1.31 ft.)
Focal length	18 mm (0.7 in.)
Spatial resolution (IFOV)	1.36 mrad
Lens identification	Automatic
F-number	1.3
Image frequency	30 Hz
Focus	Automatic or manual (built in motor)
Zoom	1–8× continuous, digital, interpolating zooming on images

Detector data

Focal Plane Array (FPA) / Spectral range	Uncooled microbolometer / 7.5–13 µm
Detector pitch	25 µm
Detector time constant	Typical 12 ms

Measurement

Object temperature range	–20 to +120°C (–4 to +248°F) 0 to +350°C (+32 to +662°F)
Accuracy	±4°C (±7.2°F) or ±4% of reading

Measurement analysis

Spotmeter	10
Area	10 boxes with max./min./average/position
Isotherm	1 with above/below/interval
Measurement option	Measurement Mask Filter Schedule response: File sending (ftp), email (SMTP)
Difference temperature	Delta temperature between measurement functions or reference temperature
Reference temperature	Manually set or captured from any measurement function
Atmospheric transmission correction	Automatic, based on inputs for distance, atmospheric temperature and relative humidity
Optics transmission correction	Automatic, based on signals from internal sensors
Emissivity correction	Variable from 0.01 to 1.0
Reflected apparent temperature correction	Automatic, based on input of reflected temperature
External optics/windows correction	Automatic, based on input of optics/window transmission and temperature
Measurement corrections	Global and individual object parameters

Alarm

Alarm functions	6 automatic alarms on any selected measurement function, Digital In, Camera temperature, timer

FLIR A310f 25°

P/N: 61201-1103

Alarm	
Alarm output	Digital Out, log, store image, file sending (ftp), email (SMTP), notification
Set-up	
Color palettes	Color palettes (BW, BW inv, Iron, Rain)
Set-up commands	Date/time, Temperature°C/°F
Storage of images	
Storage media	Built-in memory for image storage
File formats	Standard JPEG, 16-bit measurement data included
Ethernet	
Ethernet	Control, result and image
Ethernet, type	100 Mbps
Ethernet, standard	IEEE 802.3
Ethernet, connector type	RJ-45
Ethernet, communication	TCP/IP socket-based FLIR proprietary
Ethernet, video streaming	MPEG-4, ISO/IEC 14496-1 MPEG-4 ASP@L5
Ethernet, image streaming	16-bit 320 × 240 pixels @ 7-8 Hz - Radiometric
Ethernet, power	Power over Ethernet, PoE IEEE 802.3af class 0
Ethernet, protocols	Ethernet/IP, Modbus TCP, TCP, UDP, SNTP, RTSP, RTP, HTTP, ICMP, IGMP, ftp, SMTP, SMB (CIFS), DHCP, MDNS (Bonjour), uPnP
Digital input/output	
Digital input, purpose	Image tag (start/stop/general), Input ext. device (programmatically read)
Digital input	2 opto-isolated, 10–30 VDC
Digital output, purpose	As function of ALARM, Output to ext. device (programmatically set)
Digital output	2 opto-isolated, 10–30 VDC, max 100 mA
Digital I/O, isolation voltage	500 VRMS
Digital I/O, supply voltage	12/24 VDC, max 200 mA
Digital I/O, connector type	6-pole jackable screw terminal
Composite video	
Video out	Composite video output, PAL and NTSC compatible
Video, standard	CVBS (ITU-R-BT.470 PAL/SMPTE 170M NTSC)
Power system	
External power operation	12/24 VDC, 24 W absolute max
External power, connector type	2-pole jackable screw terminal
Voltage	Allowed range 10–30 VDC
Environmental data	
Operating temperature range	–25°C to +50°C (–13°F to +122°F)
Storage temperature range	–40°C to +70°C (–40°F to +158°F)
Humidity (operating and storage)	IEC 60068-2-30/24 h 95% relative humidity +25°C to +40°C (+77°F to +104°F)
EMC	• EN 61000-6-2 (Immunity) • EN 61000-6-3 (Emission) • FCC 47 CFR Part 15 Class B (Emission)
Encapsulation	IP 66 (IEC 60529)
Bump	5 g, 11 ms (IEC 60068-2-27)
Vibration	2 g (IEC 60068-2-6)

FLIR A310f 25°

P/N: 61201-1103

Physical data

Weight	5 kg (11.0 lb.)
Size (L × W × H)	460 × 140 × 159 mm (18.1 × 5.5 × 6.3 in.)
Base mounting	TBA
Housing material	Aluminum

System features

External power operation (heater)	24 VDC 25 W max w/heater @ 24 VDC
External power, connector type (heater)	2-pole jackable screw terminal
Voltage (heater)	Allowed range 21-30 VDC
Automatic heaters	Clears window from ice

Scope of delivery

- Cardboard box
- Infrared camera with lens and environmental housing
- Calibration certificate
- Downloads brochure
- FLIR Sensors Manager CD-ROM
- Lens cap
- Printed Getting Started Guide
- Printed Important Information Guide
- Service & training brochure
- Small accessories kit
- User documentation CD-ROM
- FLIR Tools & Utilities CD-ROM
- Registration card

B. PAN-TILT MODULE

www.axis.com

Technical Specifications - YP3040 Pan-Tilt Motor

57018/EN/M3.2/092014

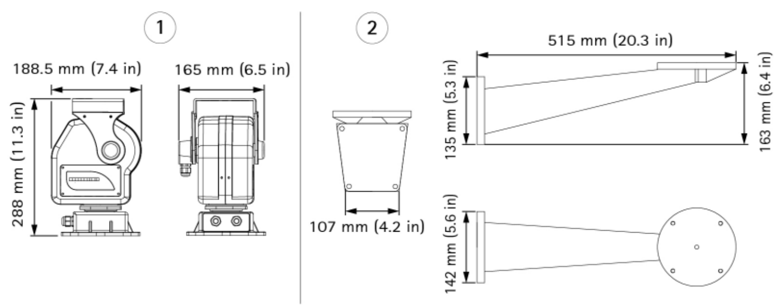
Models	YP3040 Pan-Tilt Motor
General	
Supported cameras	AXIS P13-E, AXIS Q16-E, AXIS Q1755-E and AXIS Q1765-LE PT Mount Network Cameras, AXIS Q1910-E, AXIS Q1922-E, AXIS Q1931-E PT Mount and AXIS Q1932-E PT Mount Thermal Network Cameras, AXIS T92A and AXIS T92E Housings
Pan/Tilt/Zoom	Pan range 0° to 355° Tilt range 10° to -80° Pan speed 7.5°/s Tilt speed 6°/s Designed for operator control
Casing	Aluminum alloy Color: White NCS S 1002-B
Supported protocols	Pelco-D
Connectors	1x RS485 port
Mounting	Wall mounting Torque: 1.5 N m (1.1 lb ft) Maximum load: 8 kg (17.6 lb)
Power	Consumption: 30 W Input: 24 V AC 50/60 Hz AXIS PS-24 Mains Adaptor recommended (not included)
Operating conditions	-20 °C to 65 °C (-4 °F to 149 °F)
Approvals	IEC/EN 60529 IP66
Dimensions	288 x 165 x 188.5 mm (11 x 6 x 7 in)
Weight	4.2 kg (9 lb)
Included accessories	Mounting kit, Drill template, Installation guide
Optional accessories	AXIS T8310 Video Surveillance Control Board, YP3040 Wall Bracket, AXIS T92A20 Housing, AXIS T92E05 Housing, AXIS T92E20 Housing, AXIS PS-24 Mains Adaptor
Warranty	Axis 1-year warranty, www.axis.com/warranty

More information is available at www.axis.com

Dimensions

1. YP3040 Pan-Tilt Motor

2. YP3040 Wall Bracket



Optional accessories

1. YP3040 Wall Bracket

2. Axis housings

3. AXIS T8310 Video Surveillance Control Board

4. AXIS PS-24 Mains Adaptor

AXIS COMMUNICATIONS

C. MICROCOMPUTER

VERSALOGIC CORPORATION

TIGER
PC/104-*Plus* Single Board Computer

is critical in many OEM applications.

The Tiger features an embedded BIOS with OEM enhancements from Phoenix Technologies. The field-reprogrammable BIOS supports custom defaults and the addition of firmbase applications for security processes, remote booting, and other pre-OS software functions. The Tiger is compatible with a variety of popular operating systems including Windows, Windows Embedded, Linux, VxWorks, and QNX.

Ordering Information

Model	Processor	Speed	Operating Temp.	Cooling
VL-EPM-24SU	Intel Atom Z530P	1.6 GHz	0° to +60°C	Fanless
VL-EPM-24EU	Intel Atom Z520PT	1.33 GHz	-40° to +85°C	Fanless

Accessories

Part Number	Description
VL-CKR-TIGER	Development cable kit. *Includes bold items below.*
VL-CBR-1008	**ATX power adapter cable**
VL-CBR-2012	**20" 24-bit LVDS flat panel cable (Hirose)**
VL-CBR-2014	**LVDS to VGA adapter board**
VL-CBR-4405	**IDE adapter board**
VL-CBR-4406	**IDE cable**
VL-CBR-5012	**I/O cable set and paddleboard**
VL-HDW-105	**0.6" standoff package (metric thread)**
VL-CBR-1401	Cable assembly for (2) SPX modules
VL-CBR-1402	Cable assembly for (4) SPX modules
VL-CBR-1603	Quad USB transition cable
VL-CBR-2010	20" 18-bit LVDS flat panel cable (Hirose)
VL-CBR-2011	20" 18-bit LVDS flat panel cable (JAE)
VL-CDD-xxxx	CD-RW/DVD-ROM drive
VL-ENCL-5D	Development enclosure
VL-F20-xxxx	Disk on Module (IDE)
VL-HDD25-xxx	2.5" hard drive (IDE)
VL-HDW-106	0.6" standoff package (English thread)
VL-HDW-108	DOM hardware kit (metric thread)
VL-HDW-203	PC/104 extractor tool, metal
VL-MM8-xxxx	DDR2 RAM module
VL-PS200-ATX	200W ATX-style development power supply
VL-SPX-x	SPX expansion modules

** Power specifications represent operation at +25°C with +5V supply running Windows XP with 2 GB RAM, Ethernet, keyboard, and mouse. Typical power computed as the mean value of Idle and Maximum power specifications. Maximum power is measured with 95% CPU utilization.*

† Signal lines on this port are TVS protected (enhanced ESD protection)

‡ Power pins on this port are overload protected

02/20/13

SPECIFICATIONS

General	Board Size	PC/104 compliant: 114 mm x 96 mm (4.49" x 3.78")
	Processor + Chipset	Model / Processor / Speed / Chipset: VL-EPM-24SU / Atom Z530P / 1.6 GHz / US15WP; VL-EPM-24EU / Atom Z520PT / 1.33 GHz / US15WPT. 533 MHz FSB. Dynamic 512 KB L2 cache. Supports Enhanced Intel SpeedStep Technology and Hyper-Threading Technology (HTT).
	Power Requirements*	Model / Sleep (S3) / Typical: VL-EPM-24SU / 0.21A (1.05W) / 1.20A (6.0W); VL-EPM-24EU / 0.23A (1.15W) / 1.18A (5.9W)
	Hardware Monitors	Watchdog Timer: 1 second to 255 minutes. Warm reset, cold reset, or power down. Power Quality Monitor: System reset on undervoltage conditions
	Stackable Bus	PC/104-*Plus* (PCI, ISA)
	Other I/O Expansion	VersaLogic SPX interface
	RoHS	Compliant
Environmental	Operating Temperature	Model / Operating Temperature: VL-EPM-24SU / 0° to +60°C; VL-EPM-24EU / -40° to +85°C
	Storage Temperature	-40° to +85°C
	Airflow Requirements	Model / Airflow Requirements: VL-EPM-24SU / Free air from 0° to +60°C; VL-EPM-24EU / 100 LFPM from +60° to +85°C
	Thermal Shock	5°C/min. over operating temperature
	Humidity	Less than 95%, noncondensing
	Vibration, Sinusoidal Sweep	MIL-STD-202G, Method 204, Modified Condition A: 2g constant acceleration from 5 to 500 Hz, 20 minutes per axis
	Vibration, Random	MIL-STD-202G, Method 214A, Condition A: 5.35g rms, 5 minutes per axis
	Mechanical Shock	MIL-STD-202G, Method 213B, Condition G: 20g half-sine, 11 ms duration per axis
Memory	System RAM	SO-DIMM socket. Up to 2 GB DDR2 SDRAM.
Video	General	Integrated high-performance video. Intel GMA 500 graphics core supports advanced 3D graphics and high-definition video decode.
	VRAM	Up to 256 MB shared DRAM
	OEM Flat Panel Interface	18/24-bit LVDS interface. CMOS-selectable TFT panel types. Up to 1280 x 1024 (24 bits) @ 85 Hz.
	Desktop Display Interface	Analog output (VGA) via optional adapter cable †
Mass Storage	Hard Drive	IDE controller (ATA-6, UDMA/100) supports two IDE devices
	Flash	Right angle IDE Disk on Module (DOM) site with retention screw
Network Interface	Ethernet †	Autodetect 10BaseT/100BaseTX/1000BaseT port
	Network Boot Option	Intel boot agent (downloadable) supports PXE protocol. Argon Managed Boot Agent (optional with royalty fee) supports PXE, RPL, NetWare, TCP/IP (DHCP, BOOTP) remote boot protocols.
Device I/O	USB †‡	Seven USB 2.0/1.1 ports (one client, six host)
	COM 1/2/3/4 †	RS-232/422/485 selectable. 16C550 compatible. 460 Kbps.
	Audio	Intel High Definition Audio (HDA) compatible. Stereo line in/out.
Software	BIOS	Phoenix Technologies Embedded BIOS with OEM enhancements. Field reprogrammable. Support for USB boot. User-configurable CMOS defaults.
	Sleep Mode	ACPI 2.0 compatible
	Operating Systems	Compatible with most x86 operating systems including Windows, Windows Embedded, Linux, VxWorks, and QNX

VersaLogic Corporation • 12100 SW Tualatin Rd., Tualatin, OR 97062 • (503) 747-2261 • Info@VersaLogic.com • www.VersaLogic.com

D. Wireless Communication

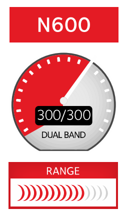
NETGEAR®

N600 WiFi Dual Band USB Adapter

Data Sheet

WNDA3100

Performance & Use



- Dual band avoids interference for reliable connections
- Faster WiFi speeds 300/300 – Up to 600 Mbps†
- Works with any WiFi router or modem router

The NETGEAR Dif erence - WNDA3100

- Faster downloads
- Push 'N' Connect—push button security
- Reliable and compatible
- Easy setup with NETGEAR® genie®

Overview

The NETGEAR N600 Wireless Dual Band USB Adapter wirelessly connects your notebook or desktop computer to a Wireless- N network for applications, such as HD video streaming, online gaming, a secure and reliable connection to the Internet. NETGEAR genie® is included for easy installation. WiFi dual band technology avoids interference for reliable connections. With the NETGEAR Push 'N' Connect feature, enjoy a secured wireless Internet connection, at the push of a button.

PUSH 'N' CONNECT—WPS

A secured connection at the push of a button[1]

STEP 1	STEP 2	STEP 3
Install CD and push the button on the adapter 	Push the Push 'N' Connect button on the router 	Secure wireless connection  

[1] Works with devices supporting Wi-Fi Protected Setup® (WPS).

PAGE 1 OF 3

E. MPPT CHARGE CONTROLLER

ECO-WORTHY
Solar panels and renewable energy products shop

www.eco-worthy.com
Email: info@eco-worthy.com

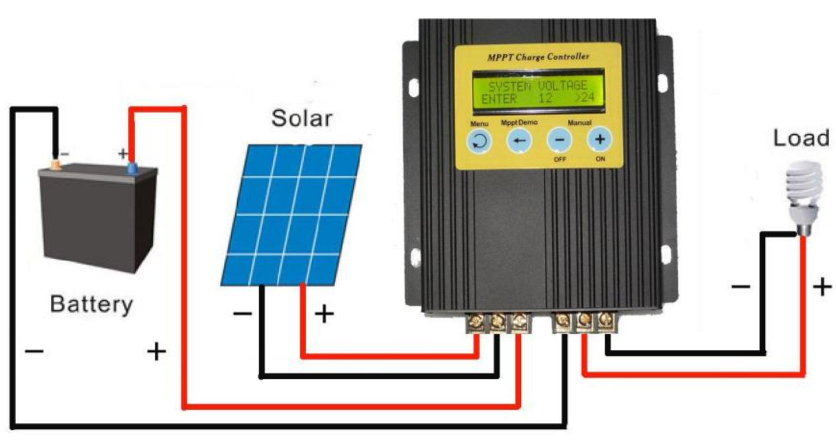
- **Low stand-by power consumption**

Specifications

Item No.	ECO-MPPT-20A
Rated system voltage	12V/24V DC
Max open circuit voltage of solar panel	15— 50V DC
Max solar panel power	300W 12V/ 600W 24V
Max output current	20A
Max discharge current	20A
Over discharge voltage	10.2—12.5V (±0.2) 12V/ 20.4—25.0V (±0.2) 24V
Restart voltage	10.3—13.5V (±0.2) 12V /20.5—27.0V (±0.2) 24V
Constant voltage（Over charge）voltage	13.0—15.5V (±0.2) 12V / 26.0—31.0V (±0.2) 24V
Float voltage	12.5—14.5V (±0.2) 12V / 25.0—29.0V (±0.2) 24V
Converter type	Buck
Converter efficiency	> 96%
Max increase efficiency	> 43%
Tracking efficiency	> 98%
Precision of clock	±50S/Month
Charging algorithm	PWM 3 stage
Stand by power consumption	<15mA 12V / <25mA 24V
Operating temperature	-20 to +50℃
Protect class	IP22
Size	140(L) × 147(W) × 42(H) (mm）
Weight	550g

★(1) Max input current：Solar panel maximum output current
★(1) Max output current：Controllers maximum output current

Wiring diagram



F. INVERTER

samlexamerica 150W

DC-AC Inverter
Pure Sine Wave

Model
SA-150-112
12 VDC-110 VAC
SA-150-124
24 VDC-110 VAC

Design Features

- Pure sine wave output (THD < 6%)
- Switch selectable output frequency: 50 / 60 Hz
- Remote ON/OFF control using external mechanical / transistor switch
- Input and output are fully isolated
- Advanced micro-controller
- Load controlled cooling fans save power consumption
- Tri-color LED for display of operational status and fault indications
- **Protections:** overload, short-circuit, leakage, low and high DC input voltages, high temperature and reverse polarity
- **Safety:** Listed to UL Standard UL-458
- **EMC:** Complies with FCC Part 15(B), Class B

2 YEAR WARRANTY

	MODEL NO.	SA-150-112	SA-150-124
OUTPUT	OUTPUT VOLTAGE	110 VAC, ± 5%	110 VAC, ± 5%
	OUTPUT FREQUENCY	50 / 60 Hz ± 0.3% (Selected by Switch)	50 / 60 Hz ± 0.3% (Selected by Switch)
	TYPE OF OUTPUT WAVEFORM	Pure Sine Wave	Pure Sine Wave
	TOTAL HARMONIC DISTORTION OF OUTPUT WAVEFORM	< 6%	< 6%
	CONTINUOUS OUTPUT POWER (At Power Factor = 1)	150W	150W
	SURGE OUTPUT POWER (At Power Factor = 1)	200W	200W
	PEAK EFFICIENCY (At full load)	87%	88%
	AC OUTPUT CONNECTIONS	Dual NEMA-15R receptacles with GFCI protection	
INPUT	NOMINAL DC INPUT VOLTAGE	12 VDC	24 VDC
	DC INPUT VOLTAGE RANGE	10.5 to 15 VDC	21.0 to 30 VDC
	DC INPUT CURRENT AT NO LOAD	0.3A	0.35A
	DC INPUT CONNECTIONS	Detachable pair of wires with Anderson Power Pole Connectors on inverter side	
DISPLAY	STATUS OPERATIONS & PROTECTIONS	By steady / flashing patterns of 3 - color LED	
REMOTE OPERATION	WIRED ON/OFF CONTROL	By external contact closure through mechanical / transistor switch	
PROTECTIONS	LOW DC INPUT VOLTAGE SHUTDOWN	10.5 VDC	21.0 VDC
	HIGH DC INPUT VOLTAGE SHUTDOWN	15.3 VDC	30.6 VDC
	SHORT CIRCUIT SHUTDOWN	Yes	Yes
	OVERLOAD SHUTDOWN	Yes	Yes
	GROUND FAULT SHUTDOWN	GFCI protected dual NEMA5-20R receptacles	
	OVER TEMPERATURE SHUTDOWN	Yes	Yes
	REVERSE POLARITY ON DC INPUT SIDE	Yes. Internal fuses will blow.	Yes. Internal fuses will blow.
COOLING	FORCED AIR COOLING	Thermostatically controlled fan	Thermostatically controlled fan
COMPLIANCE	SAFETY	UL Listed to UL-458	UL Listed to UL-458
	EMI / EMC	Meets FCC Part 15(B), Class A	Meets FCC Part 15(B), Class A
ENVIRONMENT	OPERATING TEMPERATURE RANGE	0°C to +40°C / 32°F to 104°F	0°C to +40°C / 32°F to 104°F
	STORAGE TEMPERATURE RANGE	-30°C to 70°C / -22°F to 158°F	-30°C to 70°C / -22°F to 158°F
DIMENSIONS	(L X W X H), MM	200 x 132 x 72	200 x 132 x 72
	(L X W X H), INCHES	7.9 x 5.2 x 2.8	7.9 x 5.2 x 2.8
WEIGHT	KG	2.7	2.7
	LBS	5.6	5.6

NOTE: Specifications are subject to change without notice

12003-SA-150-112-124-1112

To view a full selection of Samlex products visit our website at www.samlexamerica.com or contact us: 1(800) 561-5885 or sales@samlexamerica.com

G. POE SPLITTER

PoE Splitter, Fast Ethernet, 1 Port

There are no reviews yet. | Write a review

PRIMUS CABLE

NT1-3195-R

Availability: **In Stock**

Ships Within 1-3 Business Days

$23.19

Quantity: 1 Add to Cart

Estimate Shipping

Description Features Specifications Reviews (0)

Specs:

Standards and Protocols		IEEE 802.3, 802.3u, 802.3af CSMA/CD, TCP/IP
Basic Function		Compatible with IEEE 802.3af compliant PSEs Delivers power up to 100 meters Optional 12VDC or 5VDC power supply Plug-and-Play
Ports	LAN Port	1 10/100M Auto-Negotiation RJ45 port (Auto MDI/MDIX)
	PoE Port	1 10/100M Auto-Negotiation RJ45 port (Auto MDI/MDIX)
Network Media		10BASE-T: UTP category 3, 4, 5 cable (maximum 100m) EIA/TIA-568 100Ω STP (maximum 100m) 100BASE-TX: UTP category 5, 5e cable (maximum 100m) EIA/TIA-568 100Ω STP (maximum 100m)
LED Indicator		PWR
Safety & Emission		FCC, CE
Dimensions (W*D*H)		3.2*2.0*0.9 in.(81*52*24 mm)
Environment		Operating Temperature: 0°C-40°C (32°F-104°F) Storage Temperature: -40°C-70°C (-40°F-158°F) Operating Humidity: 10%-90% non-condensing Storage Humidity: 5%-90% non-condensing
Power Output		12W (12VDC) or 11.5W (5VDC)

H. SOLAR PANEL

RNG-150D

Key Features

- Top Ranked PTC Rating
- High Module Conversion Efficiency
- Fast and Inexpensive Mounting
- Maximizes System Output by Reducing the mismatch Loss
- 100% EL Testing on Every Renogy Modules, Guaranteed No Hot Spot
- Guaranteed Positive Output Tolerance (0+3%)
- Withstands High Wind (2400 Pa) and Snow Loads (5400 Pa)
- Excellent Performance in Low Light Environments

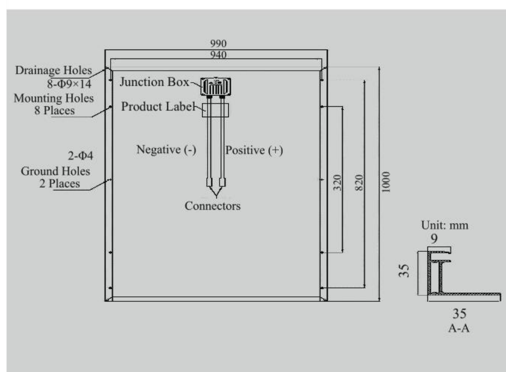
Application

- Off-Grid Rooftop/Ground Mounted
- Residential/Rural
- 12 V Battery Charging

Electrical Characteristics

Maximum Power at STC (Pmax)	150W
Optimum Operating Voltage (Vmp)	17.9 V
Optimum Operating Current (Imp)	8.38 A
Open-Circuit Voltage (Voc)	22.5 V
Short-Circuit Current (Isc)	9.05 A
Cells Efficiency	19.0%
Maximum System Voltage	

Module Diagram



Mechanical Characteristics

Solar Cell	Monocrystalline 156 x 16mm
No. of Cells	36 (6 x 6)
Dimensions	1000 x 990 x 35 mm (39.5 x 39 x 1.4 inches)
Weight	11.5 kgs (25.5 lbs)
Front Glass	3.2 mm (0.13 inches) tempered glass
Frame	Anodized aluminum alloy
Junction Box	IP65 rated
Output Cables	4.0 mm^2(0.006 $inches^2$), 1000mm (39.3 inches)
Connectors	MC4 connectors
Fire Rating	Classs C

Maximum Ratings

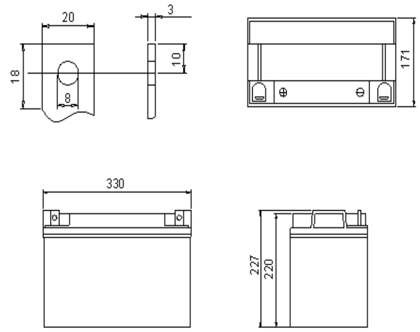
Operating Module Temperature	-40°C to +80°C
Maximum Series Fuse Rating	15 A

Temperature Characteristics

Nominal Operating Cell Temperature (NOCT)	47±2°C
Temperature Coefficient of Pmax	-0.44%/°C
Temperature Coefficient of Voc	-0.30%/°C
Temperature Coefficient of Isc	0.04%/°C

I. Battery

Sealed Lead-Acid Batteries

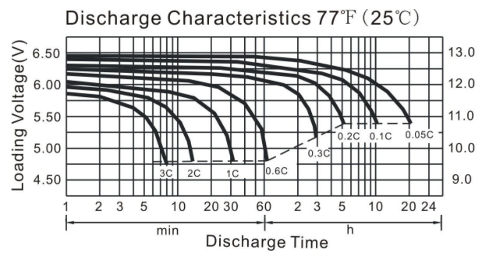


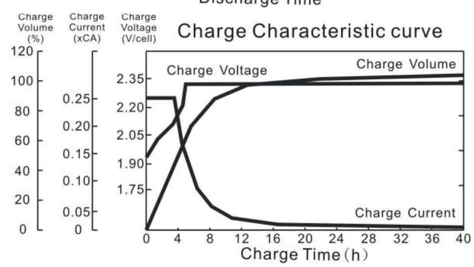
- **Specifications**

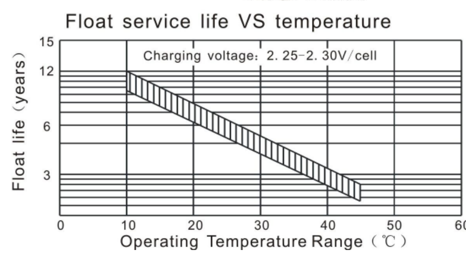
Nominal Voltage		12V
Rated Capacity 77⁰F(25⁰C) (10HR)		100.0Ah
Dimensions (mm/inch)	Length	330 (12.99)
	Width	171 (6.73)
	Height	220 (8.66)
	Total Height	227 (8.94)
Approx. Weight (kg/Ibs)		30.6 (67.46)
Terminal		T6/T12

- **Characteristic**

Capacity 77^0F(25^0C)	20HR (5.30A)	106.0Ah
	10HR (10.0A)	100.0Ah
	5HR (17.0A)	85.0Ah
	1HR (55.0A)	55.0Ah
	15 min rate (175.0A)	43.8Ah
Internal Resistance	Full Charged Battery 77^0F(25^0C)	Approx. 5mΩ
Temperature dependence of capacity (10HR)	104^0F(40^0C)	102%
	77^0F(25^0C)	100%
	32^0F(0^0C)	85%
	5^0F(-15^0C)	65%
Self-Discharge 68^0F(20^0C) (Capacity after)	3 months	90%
	6 months	80%
	12 months	60%
Max. Discharge Current, 77^0F(25^0C)		800A(5s)
Floating design life, 77^0F(25^0C)		10 years
Constant Voltage Charge, 77^0F(25^0C)	Cycle	14.4~14.7V(-24mV/^{0}C) max. current: 25 A
	Float	13.6~13.8V(-18mV/^{0}C)







Constant Current Discharge Characteristics (A), 77^0F(25^0C)

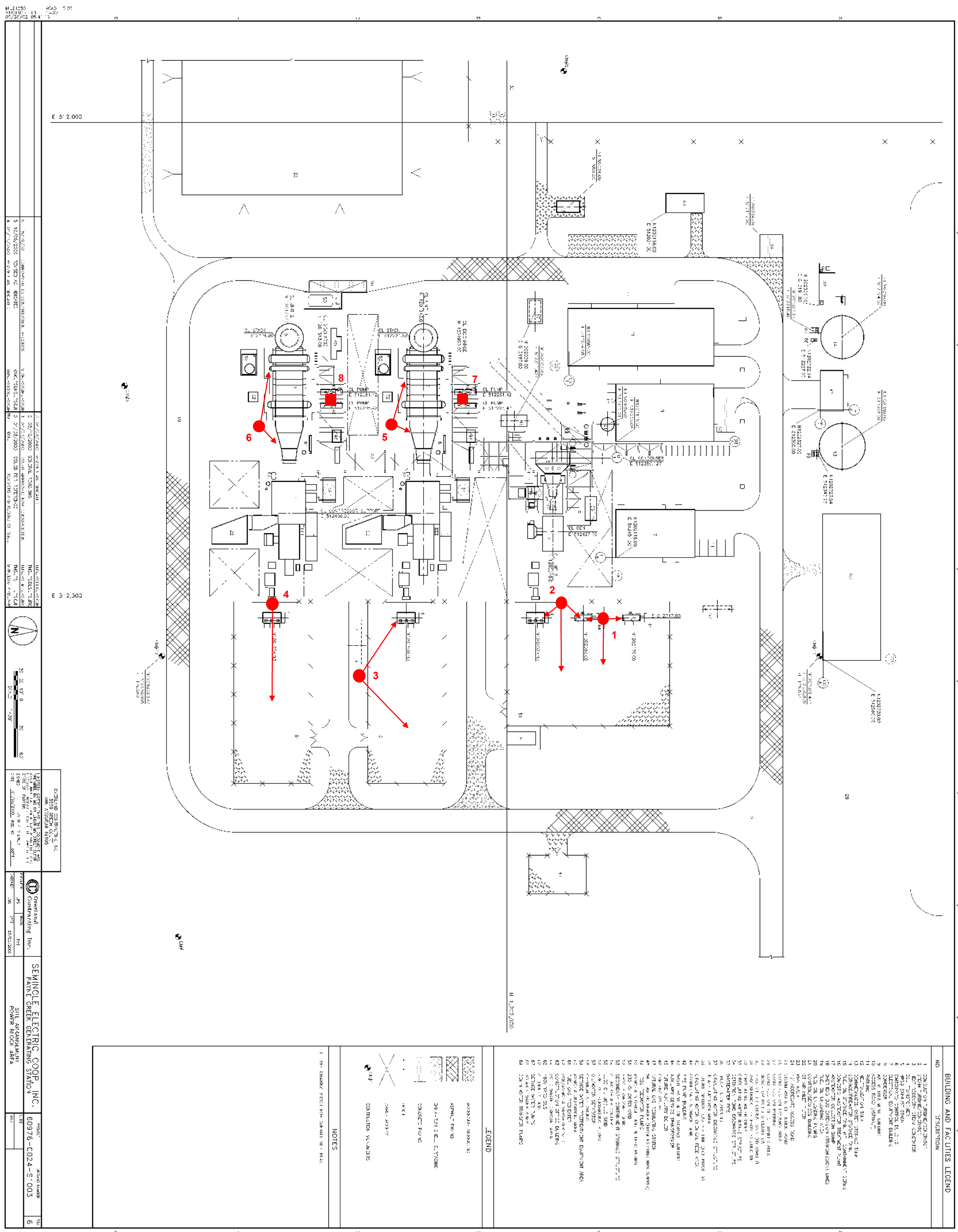
F.V/TIME	5min	10min	15min	30min	60min	2H	3H	5H	8H	10H	20H
1.60V/cell	340.0	220.0	175.0	100.0	58.1	36.03	26.56	17.95	12.00	10.43	5.45
1.70V/cell	323.0	209.0	167.1	95.6	56.0	34.65	25.95	17.62	11.88	10.33	5.40
1.75V/cell	308.0	196.0	164.1	93.6	55.0	34.00	25.44	17.30	11.63	10.15	5.35
1.80V/cell	289.0	181.0	161.2	91.8	54.1	33.41	25.00	17.00	11.50	10.00	5.30

Constant Wattage Discharge Characteristics (Watt), 77^0F(25^0C)

F.V/TIME	5min	10min	15min	30min	60min	2H	3H	5H	8H	10H	20H
1.60V/cell	603.5	399.7	320.8	184.2	107.5	67.26	50.02	34.11	23.00	20.34	10.63
1.70V/cell	578.7	383.2	309.1	177.7	104.5	65.26	49.31	33.77	22.97	20.32	10.62
1.75V/cell	557.0	362.6	306.3	175.6	103.6	64.60	48.76	33.44	22.68	20.13	10.61
1.80V/cell	527.4	337.9	303.6	173.7	102.8	64.04	48.33	33.15	22.62	20.00	10.60

sales@batteryclerk.com (888) 808-3520 www.batteryclerk.com

APPENDIX 2: PROPOSED LOCATIONS



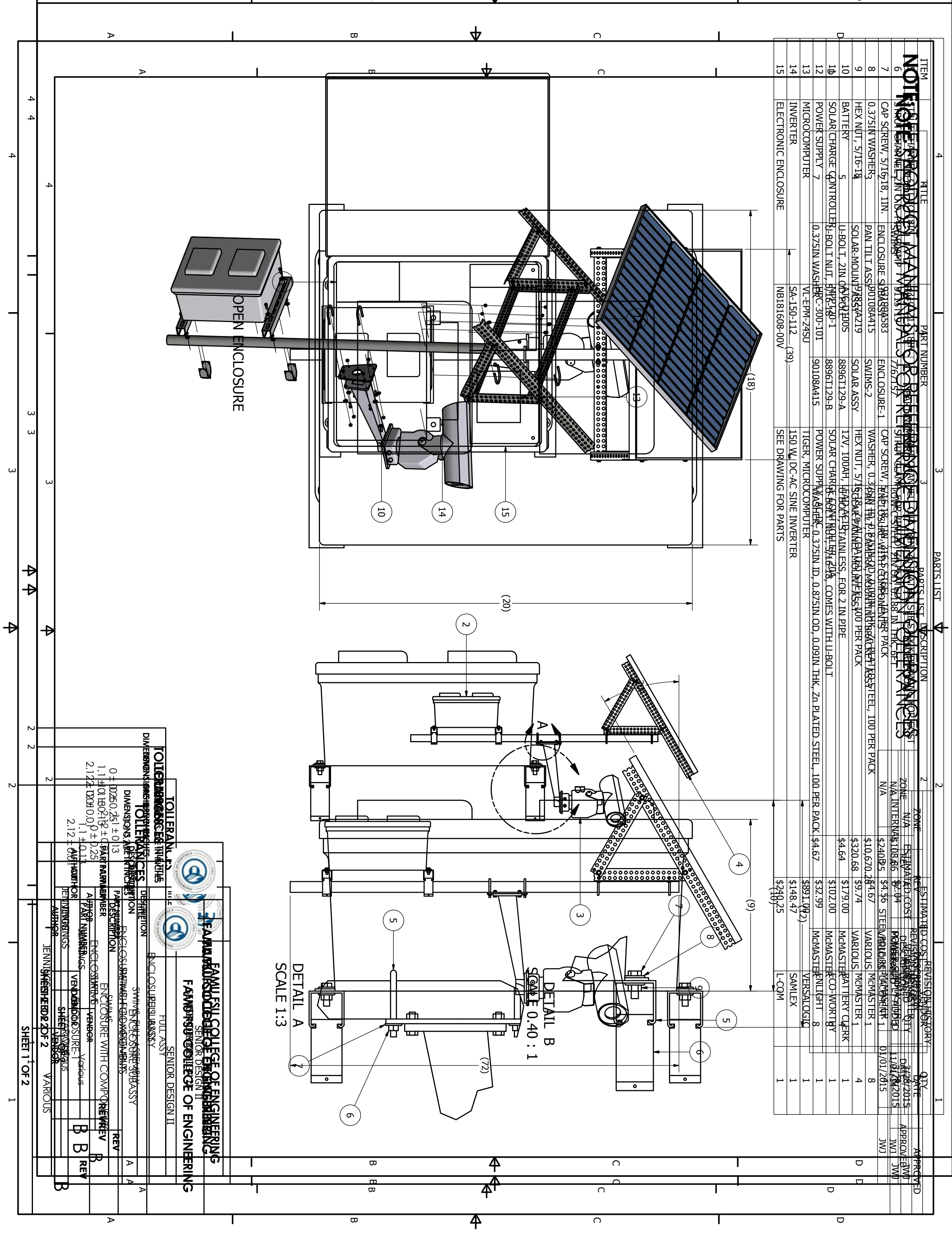
APPENDIX 3: BILL OF MATERIALS

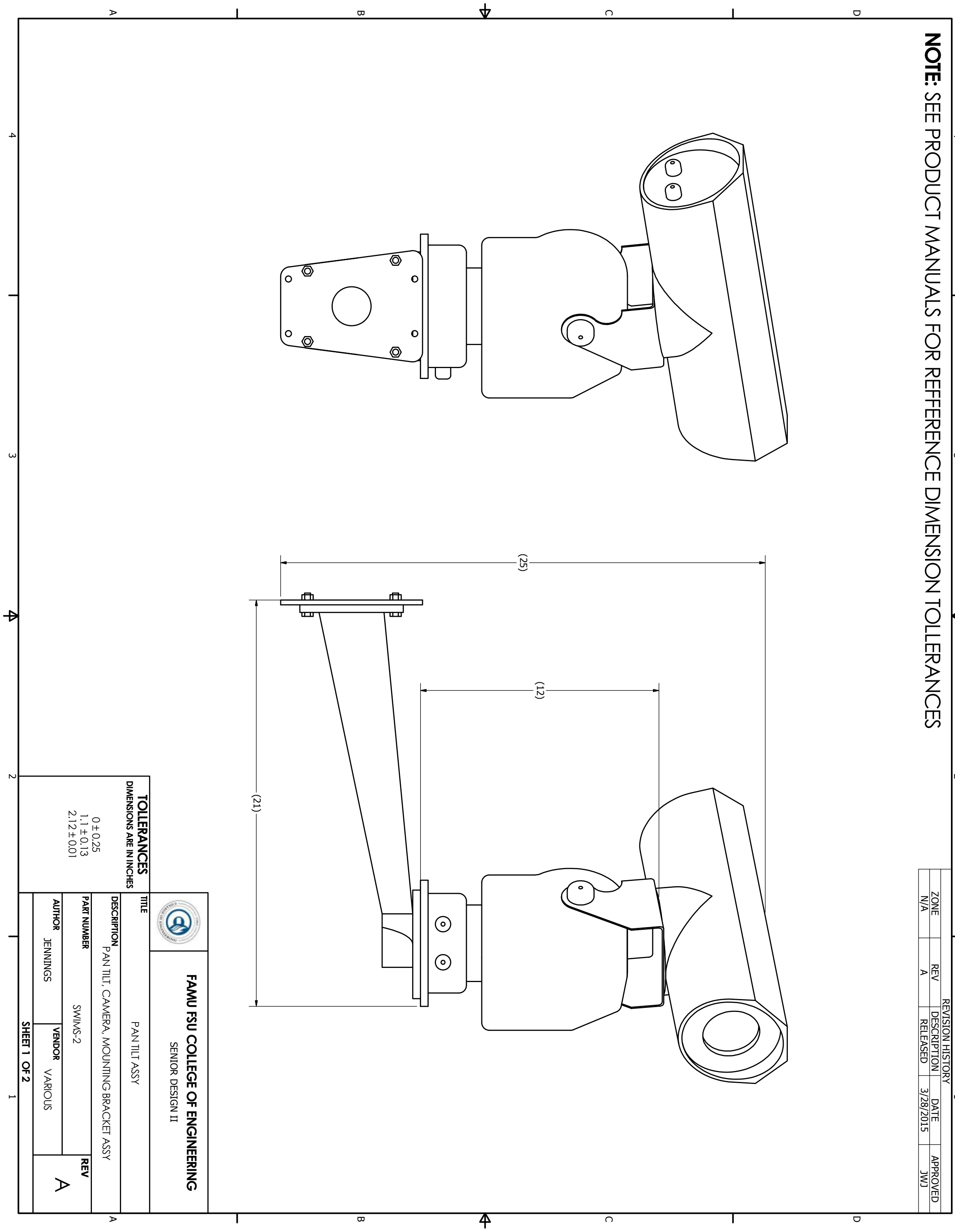
Design Cost				
Component	**Selection**	**Vendor (Part)**	**Quantity**	**Cost**
Infrared Camera	FLIR A310F 25deg	Spectrom Group (61201-1103)	1	$10,115.61
Pan Tilt	Axis Communications YP-3040	Surveillence Video (Axis 5502-461)	1	$446.43
AC Adapter	Axis PS24 Adapter	Surveillence Video (Axis 5000-001)	1	$135.43
Pan Tilt Arm	Axis Communications	Surveillence Video (Axis 5502-471)	1	$43.92
Microcomputer	Versalogic VL-EPM-24SU	DigiKey (1241-1006-ND)	1	$891.00
Breakout Paddleboard	Versalogic VL-CBR-5012	DigiKey (1241-1081-ND)	1	$66.00
ATX Power Adapter	Versalogic VL-CBR-1008	DigiKey (1241-1041-ND)	1	$33.00
LVDS to VGA Adapter	Versalogic VL-CBR-2014	Digikey (1241-1000-ND)	1	$100.00
2.5" IDE DRIVE CABLE	Versalogic VL-CBR-4406	DigiKey (1241-1083-ND)	1	$28.00
IDE Adapter Board	Versalogic VL-CBR-4405	DigiKey (1241-1084-ND)	1	$34.00
20" 24-BIT LVDS CABLE	Versalogic VL-CBR-2012	DigiKey (1241-1001-ND)	1	$41.00
Solar Panel	Renogy 150W 12V Mono	Renogy-150D	1	$219.99
Solar Panel Cables	Renogy 16 ft 12 AWG Cables	Renogy (TRAYCB016FT-12	1	$22.99
Solar Cable Adaptor Kit	Renogy 10 ft Cable Adaptor	Renogy (AK-10FT-12)	1	$20.99
Charge Controller	20 A MPPT	EcoWorthy (MPPT20-1)	1	$102.00
Battery	AJC 100Ah 12V AGM Battery	Battery Clerk (AJC-D100S-J-0-140935)	1	$179.00
Inverter	Samlex America 150W	Inverter Supply (SA-150-112)	1	$148.47
Wireless Adapter	A6100 Netgear Wi-Fi adapter	Walmart (551928248)	1	$36.40
POE Splitter	POE Splitter, 1 Port	Primus Cable(NT1-3195-R)	1	$23.19
Memory Module	2GB, Standard Temp	not purchased	1	$35.00
ATX Power Supply	200W	Enlight (HPC-300-101)	1	$32.99
IDE Hardrive	CD RW / DVD ROM	not purchased	1	$60.00
Serial Communication Cable	RS 232 9 pin	not purchased	1	$45.90
Mains Power Cable	120VAC 16 AWG Cable	not purchased	1	$7.99
Pole	Low Carbon Steel, 6 Ft, 2in OD	McMaster (7767T57)	1	$108.86
Weather Enclosure	Electronics Enclosure	LCOM (NB181608-00V)	1	$240.25
Strut Channel	120 in, Zn PLATED	McMaster (3310T212)	1	$34.68
Strut Channel Pipe Clamp	2 in OD, Zinc Plated	McMaster (3115T19)	2	$2.04
Ubolt	2 in OD Pole U Bolt	McMaster (8896T129-A)	4	$4.64
Pan Tilt Mounting Bracket	Machined	Custom	1	$50.00
Solar Panel Mount	Solar Panel Mounting	McMaster (Solar-1)	1	$100.69
90 Deg Track	72 in, Zn Plated	McMaster(8968K27-17.5in)	3	$20.43
Cap Screw	5/16-18 in, 316 S.Steel, 10 pk	McMaster (93190A583)	3	$4.56
Hex Nut	5/16-18 Zn-Al Coated Steel, 100 pk	McMaster (93827A219)	1	$9.74
Washers	.375in ID, .875in OD, Steel, 100pk	McMaster (90108A415)	1	$4.67
Total				**$13,392.22**

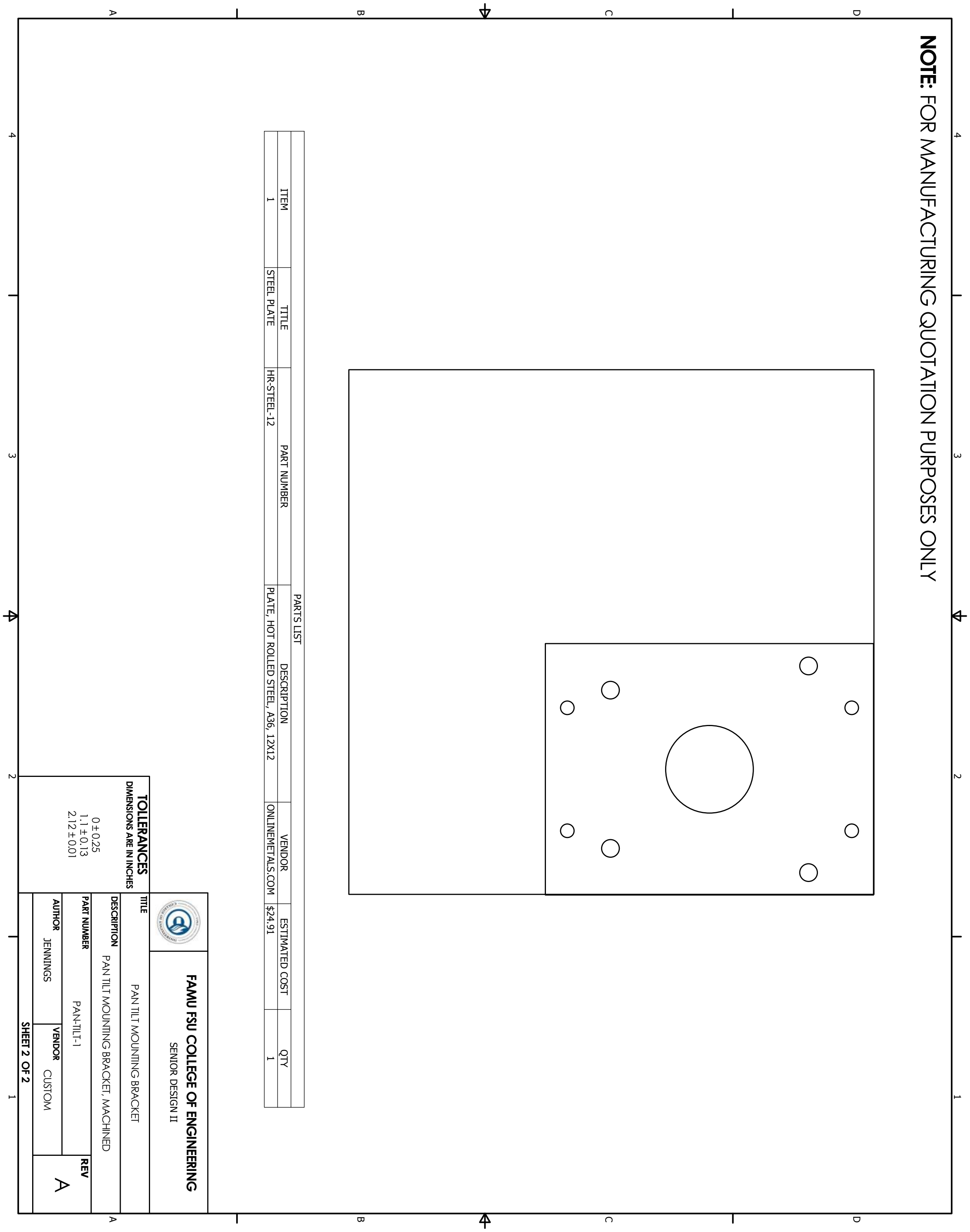
Remaining Budget	**$6,607.78**

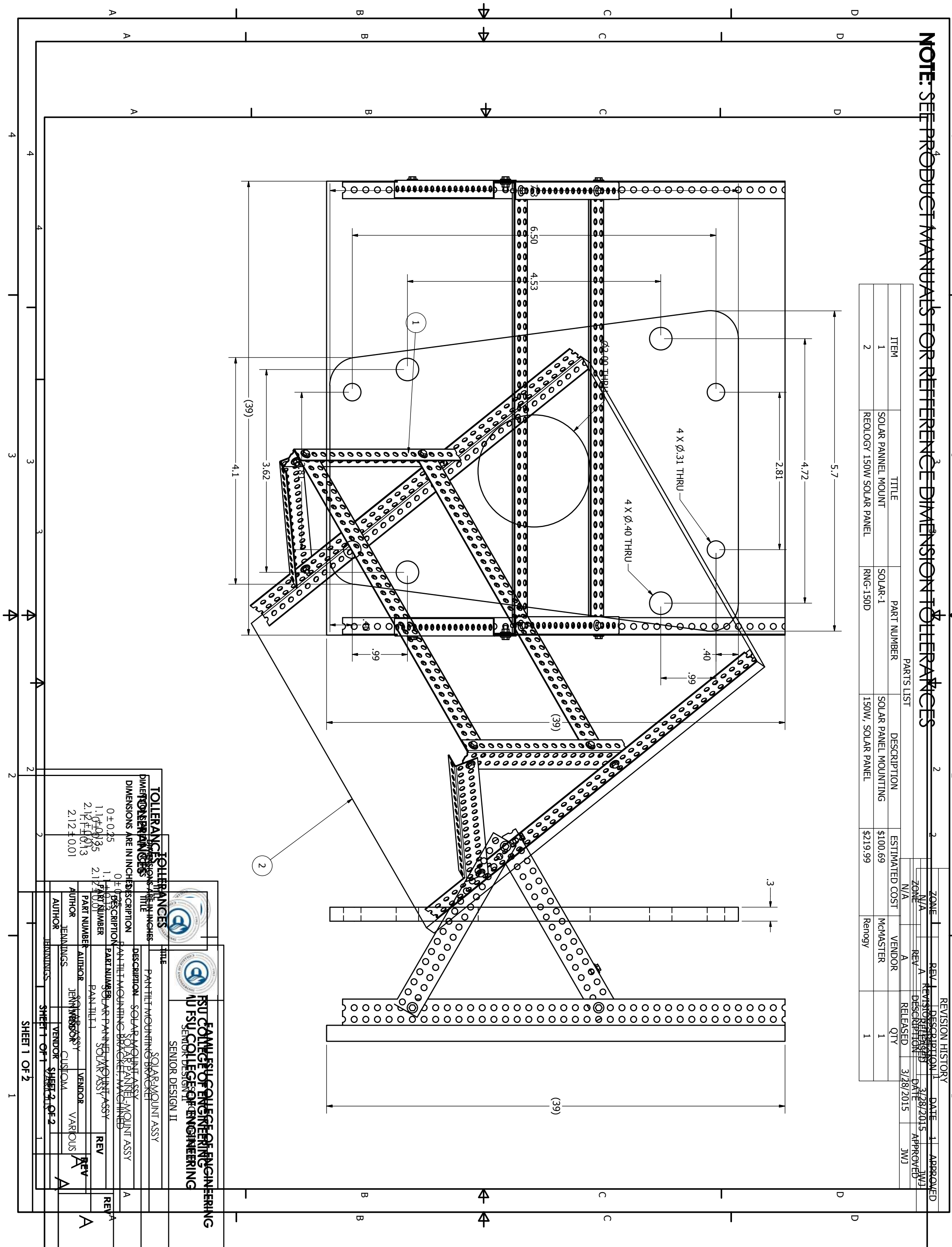
Prototype Cost			
Component	**Selection**	**Vendor (Part)**	**Cost**
Infrared Camera	FLIR A655sc	Dr. Oates	$-
Pan Tilt	Axis Communications YP-3040	Surveillence Video (Axis 5502-461)	$446.43
AC Adapter	Axis PS24 Adapter	Surveillence Video (Axis 5000-001)	$135.43
Pan Tilt Arm	Axis Communications	Surveillence Video (Axis 5502-471)	$43.92
Microcomputer	Versalogic VL-EPM-24SU	DigiKey (1241-1006-ND)	$891.00
Breakout Paddleboard	Versalogic VL-CBR-5012	DigiKey (1241-1081-ND)	$66.00
ATX-EPM Power Adapter	Versalogic VL-CBR-1008	DigiKey (1241-1041-ND)	$33.00
LVDS to VGA Adapter	Versalogic VL-CBR-2014	Digikey (1241-1000-ND)	$100.00
2.5" IDE Drive Cable	Versalogic VL-CBR-4406	DigiKey (1241-1083-ND)	$28.00
IDE Adapter Board	Versalogic VL-CBR-4405	DigiKey (1241-1084-ND)	$34.00
24-BIT LVDS Cable	Versalogic VL-CBR-2012	DigiKey (1241-1001-ND)	$41.00
Solar Panel	Renogy 150W 12V Monocrystalline	Renogy-150D	$219.99
Solar Panel Cables	Renogy 16 ft 12 AWG Solar Cables	Renogy (TRAYCB016FT-12	$22.99
Solar Cable Adaptor	Renogy 10 ft Cable Adaptor	Renogy (AK-10FT-12)	$20.99
Energy Analyzer	Renogy 150A High Precision Analyzer	Renogy (TrcrMtr-MT-150)	$38.99
Wireless Adapter	A6100 Netgear Wi-Fi adapter	Walmart (551928248)	$36.40
Charge Controller	20 A MPPT	EcoWorthy (MPPT20-1)	$102.00
Battery	AJC 100Ah 12V AGM Battery	Battery Clerk	$179.00
Inverter	Samlex America 150W	Inverter Supply (SA-150-112)	$148.47
Mains Power Cable	120VAC 16 AWG Cable	Home Depot	$7.99
Shipping			**$34.85**
Prototype Total			**2,630.45**
Remaining Budget			**$369.55**

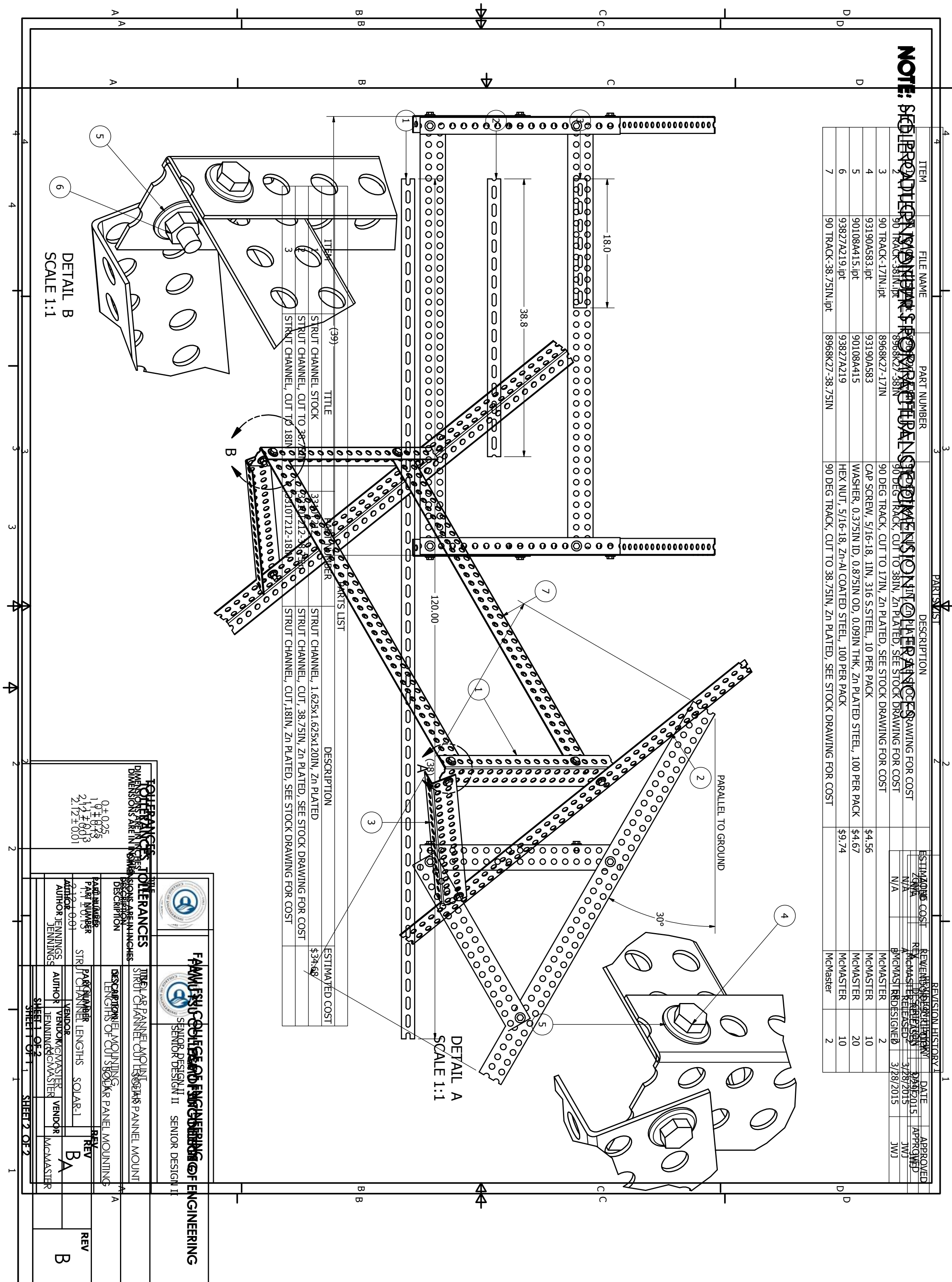
Appendix 4: Exploded Views and Drawings




NOTE: SEE PRODUCT MANUALS FOR REFFERENCE DIMENSION TOLLERANCES
(25)
(12)
(21)
REVISION HISTORY
ZONE
N/A
REV
A
DESCRIPTION
RELEASED
DATE
3/28/2015
APPROVED
JWJ
TOLLERANCES
DIMENSIONS ARE IN INCHES
0 ± 0.25
1.1 ± 0.13
2.12 ± 0.01
FAMU FSU COLLEGE OF ENGINEERING
SENIOR DESIGN II
TITLE
PAN TILT ASSY
DESCRIPTION
PAN TILT, CAMERA, MOUNTING BRACKET ASSY
PART NUMBER
SWIMS-2
REV
A
AUTHOR
JENNINGS
VENDOR
VARIOUS
SHEET 1 OF 2

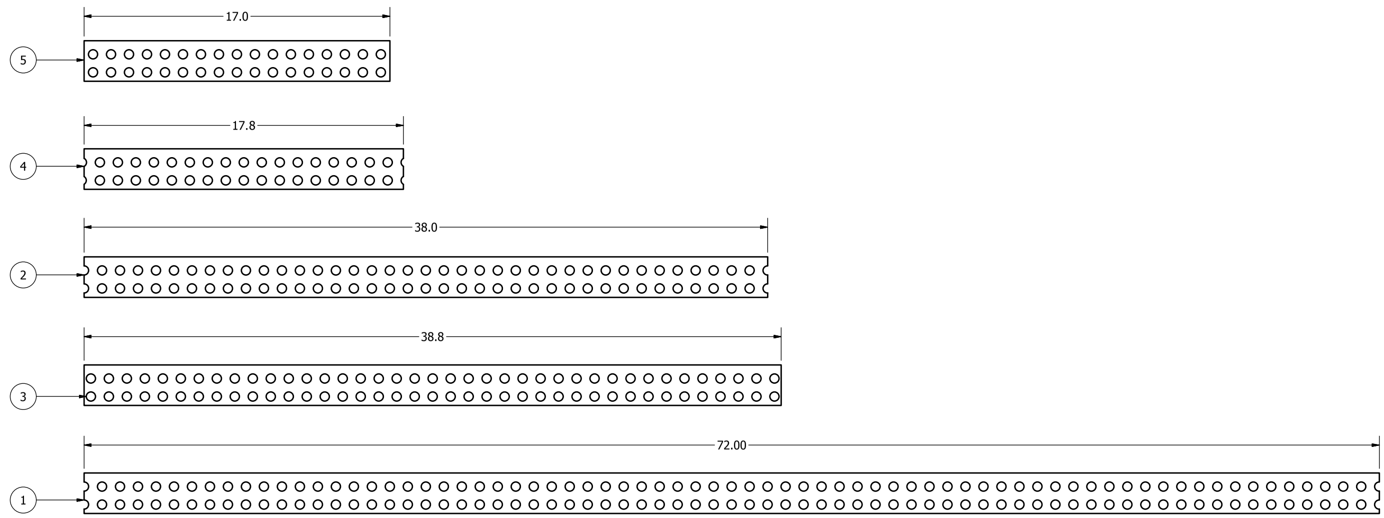

NOTE: FOR MANUFACTURING QUOTATION PURPOSES ONLY
PARTS LIST
ITEM | TITLE | PART NUMBER | DESCRIPTION | VENDOR | ESTIMATED COST | QTY
1 | STEEL PLATE | HR-STEEL-12 | PLATE, HOT ROLLED STEEL, A36, 12X12 | ONLINEMETALS.COM | $24.91 | 1
TOLERANCES
DIMENSIONS ARE IN INCHES
0 ± 0.25
1.1 ± 0.13
2.12 ± 0.01
FAMU FSU COLLEGE OF ENGINEERING
SENIOR DESIGN II
TITLE
PAN TILT MOUNTING BRACKET
DESCRIPTION
PAN TILT MOUNTING BRACKET, MACHINED
PART NUMBER
PAN-TILT-1
REV
A
AUTHOR
JENNINGS
VENDOR
CUSTOM
SHEET 2 OF 2


NOTE: SEE PRODUCT MANUALS FOR REFERENCE DIMENSION TOLLERANCES
PARTS LIST
ITEM | TITLE | PART NUMBER | DESCRIPTION | ESTIMATED COST | VENDOR | QTY
1 | SOLAR PANNEL MOUNT | SOLAR-1 | SOLAR PANEL MOUNTING | $100.69 | McMASTER | 1
2 | REOLOGY 150W SOLAR PANEL | RNG-150D | 150W, SOLAR PANEL | $219.99 | Renogy | 1
REVISION HISTORY
ZONE N/A REV A DESCRIPTION RELEASED DATE 3/28/2015 APPROVED JWJ
4 X Ø.31 THRU
4 X Ø.40 THRU
6.50
4.53
(39)
4.1
3.62
2.81
4.72
5.7
.99
.40
.3
TOLLERANCES
DIMENSIONS ARE IN INCHES
0 ± 0.25
1.1 ± 0.13
2.12 ± 0.01
TITLE SOLAR MOUNT ASSY
DESCRIPTION SOLAR PANNEL MOUNT ASSY
AUTHOR JENNINGS
VENDOR VARIOUS
REV A
FAMU-FSU COLLEGE OF ENGINEERING
SENIOR DESIGN II
SHEET 1 OF 1


DETAIL A
SCALE 1:1
DETAIL B
SCALE 1:1
PARALLEL TO GROUND
120.00
38.8
18.0
30°

NOTE: HOLE PATTERNS DO NOT MATCH ACTUAL STOCK

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED
N/A	A	RELEASED	3/29/2015	JWJ



PARTS LIST				
ITEM	TITLE	PART NUMBER	DESCRIPTION	ESTIMATED
1	90 DEG TRACK	90 TRACK	90 DEG TRACK, Zn PLATED	$20.43
2	90 DEG TRACK, CUT TO 38IN	8968K27-38IN	90 DEG TRACK, CUT TO 38IN, Zn PLATED, SEE STOCK DRAWING FOR COST	
3	90 DEG TRACK, CUT TO 38.75 IN	8968K27-38.75IN	90 DEG TRACK, CUT TO 38.75IN, Zn PLATED, SEE STOCK DRAWING FOR COST	
4	90 DEG TRACK, CUT TO 17.5IN	8968K27-17.5IN	90 DEG TRACK, CUT TO 17.5IN, Zn PLATED, SEE STOCK DRAWING FOR COST	
5	90 DEG TRACK, CUT TO 17IN	8968K27-17IN	90 DEG TRACK, CUT TO 17IN, Zn PLATED, SEE STOCK DRAWING FOR COST	

TOLLERANCES
DIMENSIONS ARE IN INCHES
0 ± 0.25
1.1 ± 0.13
2.12 ± 0.01

FAMU FSU COLLEGE OF ENGINEERING
SENIOR DESIGN II

TITLE 90 DEG TRACK CUT STOCK
DESCRIPTION DIFFERENT LENGTHS OF REQUIRED 90 TRACK
PART NUMBER 90 TRACK LENGTHS
REV A
AUTHOR JENNINGS
VENDOR McMASTER
SHEET 1 OF 1

APPENDIX 5: SOFTWARE PROGRAMMING

```
@echo off

rem This batch file is used to display the images of targets once it has been received from the
microcomputer

        :loop
rem Time stamp
        set timestamp=%DATE:/=-%_%TIME::=-%
        set timestamp=%timestamp: =%
rem Target files
set file_1=C:\Users\%USERNAME%\Desktop\Target_pic\Target_1\Target1
set location_1=C:\Users\%USERNAME%\Desktop\Target_pic\Target_1
set file_2=C:\Users\%USERNAME%\Desktop\Target_pic\Target_2\Target2
set location_2=C:\Users\%USERNAME%\Desktop\Target_pic\Target_2
set file_3=C:\Users\%USERNAME%\Desktop\Target_pic\Target_3\Target3
set location_3=C:\Users\%USERNAME%\Desktop\Target_pic\Target_3
set file_4=C:\Users\%USERNAME%\Desktop\Target_pic\Target_4\Target4
set location_4=C:\Users\%USERNAME%\Desktop\Target_pic\Target_4
rem ----------------------------------------------------------------------------------------------------------------
-----------------
rem Target 1
rem Does file exist?
        if exist %file_1%.FFF (
rem Copy time stamp and delete
        copy %file_1%.FFF %file_1%_%timestamp%.FFF
        del %file_1%.FFF
rem Does ID_1 exist?
if not [%ID_1%]==[] ( Taskkill /PID %ID_1% /F )
        start Research.exe %file_1%_%timestamp%.FFF
        for /f "tokens=2" %%x in ('tasklist ^| findstr Research.exe') do set ID_1=%%x
        cmdow "New session [%location_1%] - ThermaCAM Researcher Professional 2.10"
/mov 0 0 /ren "S.W.I.M.S. Target: 1" /siz 768 413
)
rem end of if file
rem ----------------------------------------------------------------------------------------------------------------
-----------------
rem Target 2
rem Does file exist?
        if exist %file_2%.FFF (
rem Copy time stamp and delete
        copy %file_2%.FFF %file_2%_%timestamp%.FFF
        del %file_2%.FFF
rem Does ID_2 exist?
if not [%ID_2%]==[] ( Taskkill /PID %ID_2% /F )
```

```
	start Research.exe %file_2%_%timestamp%.FFF
	for /f "tokens=2" %%x in ('tasklist ^| findstr Research.exe') do set ID_2=%%x
	cmdow "New session [%location_2%] - ThermaCAM Researcher Professional 2.10" 
/mov 768 0 /ren "S.W.I.M.S. Target: 2" /siz 768 413
)
rem end of if file exists
rem ------------------------------------------------------------------------------------------------------------
-----------------
rem Target 3
rem Does file exist?
	if exist %file_3%.FFF (
rem Copy time stamp and delete
	copy %file_3%.FFF %file_3%_%timestamp%.FFF
	del %file_3%.FFF
rem Does ID_3 exist?
if not [%ID_3%]==[] ( Taskkill /PID %ID_3% /F )
	start Research.exe %file_3%_%timestamp%.FFF
	for /f "tokens=2" %%x in ('tasklist ^| findstr Research.exe') do set ID_3=%%x
	cmdow "New session [%location_3%] - ThermaCAM Researcher Professional 2.10" 
/mov 0 413 /ren "S.W.I.M.S. Target: 3" /siz 768 413
)
rem end of if file exists
rem ------------------------------------------------------------------------------------------------------------
-----------------
rem Target 4
rem Does file exist?
	if exist %file_4%.FFF (
rem Copy time stamp and delete
	copy %file_4%.FFF %file_4%_%timestamp%.FFF
	del %file_4%.FFF
rem Does ID_4 exist?
if not [%ID_4%]==[] ( Taskkill /PID %ID_4% /F )
	start Research.exe %file_4%_%timestamp%.FFF
	for /f "tokens=2" %%x in ('tasklist ^| findstr Research.exe') do set ID_4=%%x
	cmdow "New session [%location_4%] - ThermaCAM Researcher Professional 2.10" 
/mov 768 413 /ren "S.W.I.M.S. Target: 4" /siz 768 413
)
rem end of if file exists
rem ------------------------------------------------------------------------------------------------------------
-----------------
goto loop
```

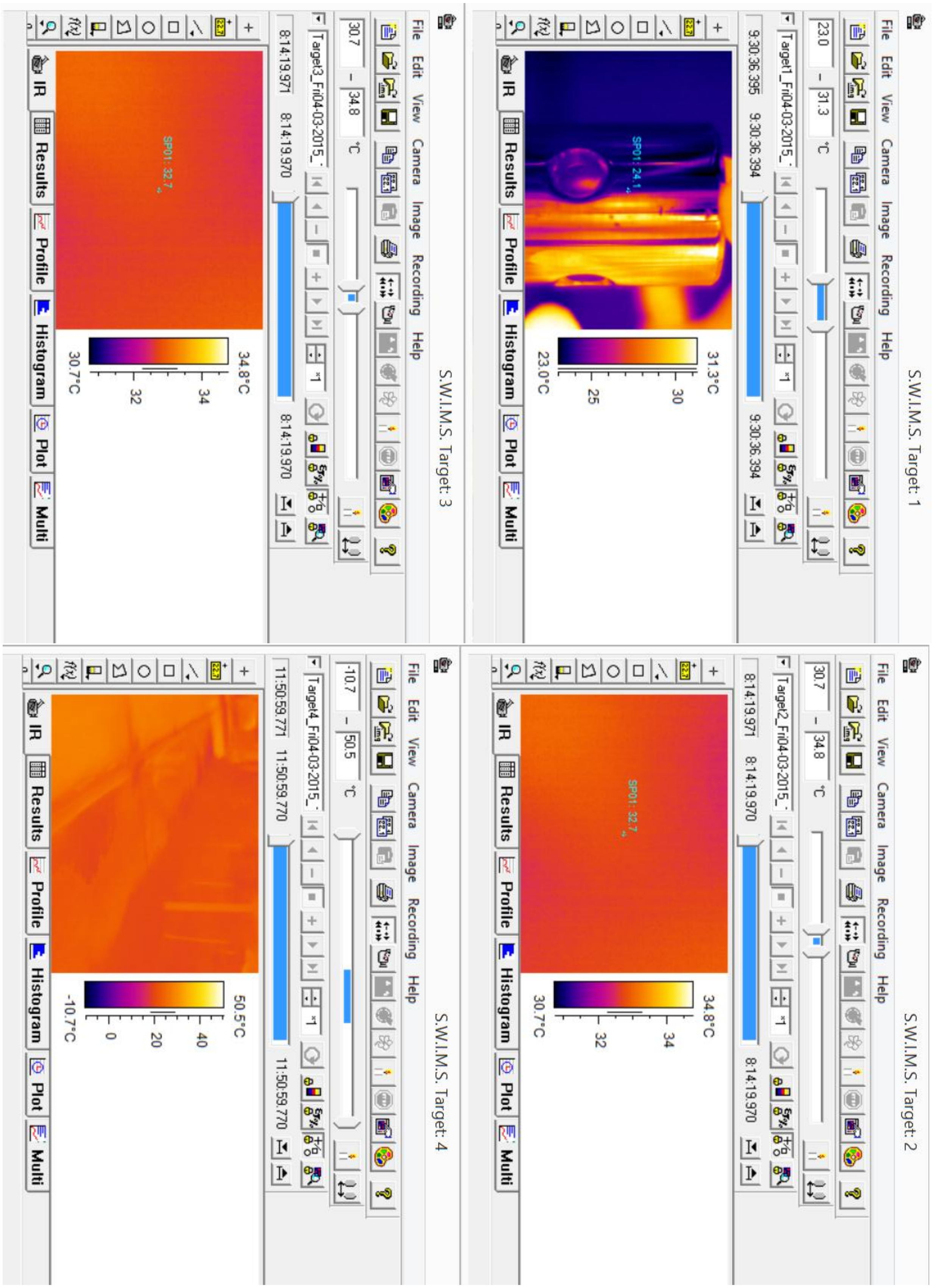


Figure 12. Control Room View of Targets.

Biography

Michelle Hopkins - Project Manager

Michelle is a senior in Mechanical Engineering completing her final year as a Co-op with Siemens Energy. She specialized in, and is currently working on, Thermal Systems. She is currently a founding brother of the FSU Chapter of Theta Tau. Michelle plans to accept a full offer from Siemens Energy at the conclusion of the spring semester.

Nixon Lormand - Mechanical Engineering Lead

Nixon is a senior in Mechanical Engineering completing his final year. He specializes in mechatronics and robotics. Nixon is a member of ASME, NSBE, and Theta Tau and runs a blog about a robotics project he is a part of. He also does robotics research for Dr. Moore at the National High Magnetic Field Laboratory.

Kenny Becerra - Electrical Engineering Lead

Kenny is a senior and is double majoring in Computer and Electrical Engineering. He is an active member of SHPE and IEEE. He specializes in programming and embedded system software. Currently, he has an offer from PG&E as an IT Developer. He is interested in going back for his Masters in Computer Engineering after spending some time in industry.

Joseph Besler - Procurement Chair

Joseph is a senior in Mechanical Engineering and specialized in Dynamics. He is the secretary for SAE and interned for US Patent and Trademark Office. Joseph hopes to begin his engineering career in spring by getting a full time offer.

Alexander Hull- Programming Chair

Alex is a senior in Computer Engineering. He has interned at National Institute of Standards and Technology as well as worked under Dr. Edward Jones on programming an automated grading program. Alex plans on attending graduate school for Artificial Intelligence after finishing his undergraduate degree.

Jonathan Jennings - Prototype Chair

Jonathan is a senior in Mechanical Engineering and specializes in mechanical design/simulation. He is a founding brother and current President of the FSU Chapter of Theta Tau. He has previously interned at the National High Magnetic Field Laboratory in their Research and Development Department. He would like to pursue a career in Automotive or Marine Design.