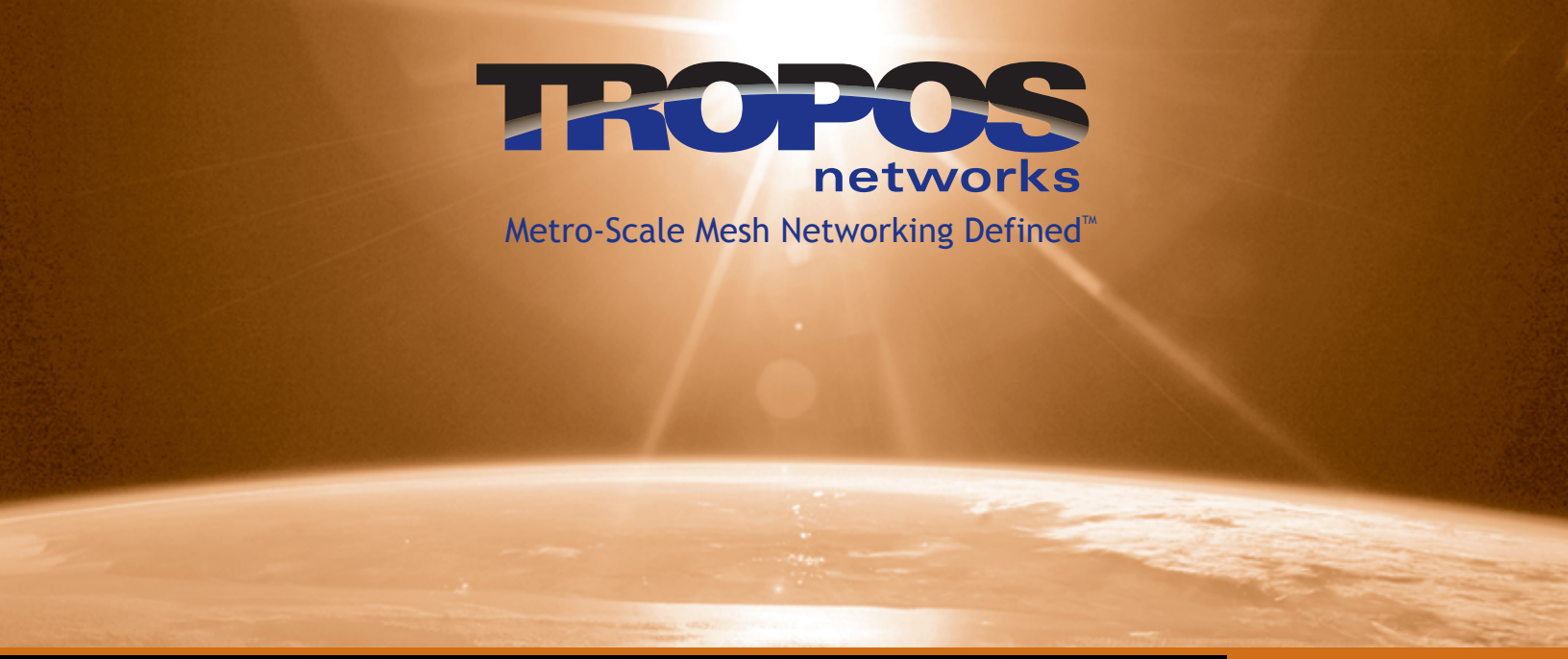


MetroMesh™ Resilient Power Operation

A Technology Brief
July, 2007

The Tropos Networks MetroMesh system provides a robust communications infrastructure that is fast and simple to deploy, cost-effective, and ubiquitous. This application note discusses how to ensure that the Tropos MetroMesh network performs regardless of the presence or reliability of an electrical service and backhaul. Increasing the reliability of the power source feeding individual routers is a key component to improving overall system reliability and is important for public safety, natural disasters, and hostile environments.

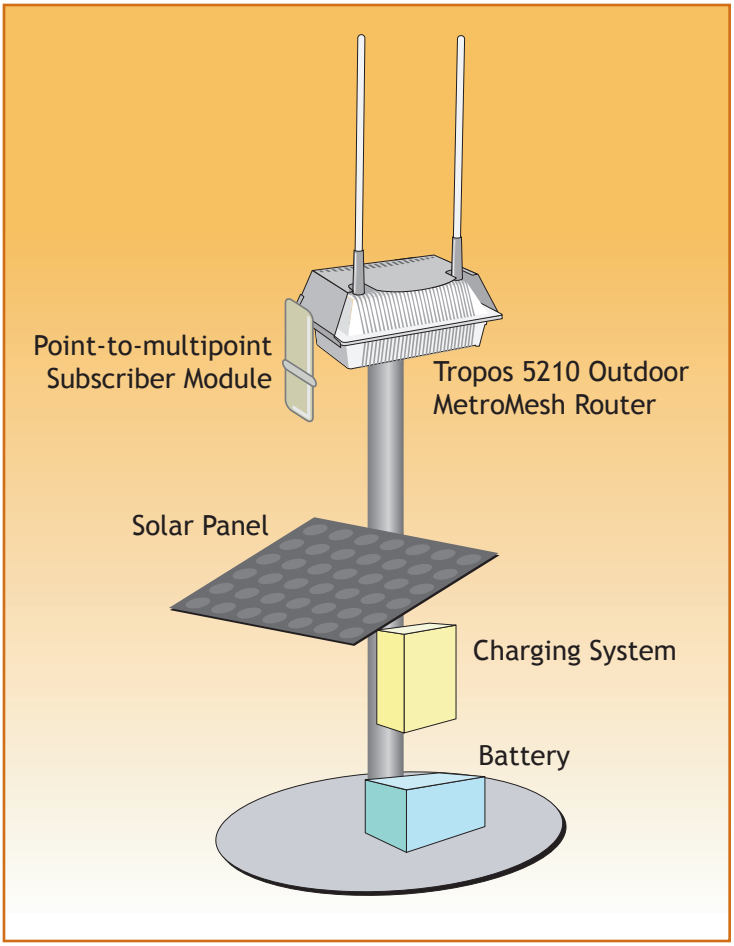
Service Reliability

Reliable communication networks are a necessity in today's society but how is reliability measured and under what conditions? Standard measures discuss total system uptime, with the benchmark being 99.999% up-time, during normal operating conditions. This assumes power is generally available through the electrical grid, or outages are contained, and that the wired infrastructure is intact or without downed lines.

What happens when there isn't a reliable power source or a wired infrastructure readily available? This is more common than one would think with the obvious examples being the result of natural disasters such as earthquakes, floods, tornados and hurricanes. Other occurrences such as black outs, ice storms, and even terrorist events can take what was once a reliable network and create a communications void during a time when reliable communications is most needed. More mundane uses for a self-sustaining communications network that is free from wired constraints include deployments in areas with bank-switched lighting, in rural areas, or for events like concerts, county fairs, car shows and flea markets.

System Components

Those developing resilient power systems to support the Tropos MetroMesh will consider many different design components. As shown in the diagram below, the components considered include a wireless mesh router, backhaul source, point to point radio, batteries, a charging system, and a mounting location. The components included in the final resilient power system design will vary by application. This section outlines the components considered and provides some insight into determining the right components for any particular application.



Mesh Network

The goal is to provide a robust communications network so the discussion starts with which Tropos MetroMesh Router to use as the basis of the network.

The Tropos MetroMesh Router is the foundation for a network as it provides the prevailing coverage in the mesh infrastructure using a 4W EIRP radio with -100dBm receive sensitivity. The Tropos routers are fully featured, environmentally hardened units that provide not only the client and mesh connectivity but also backhaul

points to the Internet. Tropos routers are available in several power options;
Power Options:

- AC powered
- DC powered
- Power-Over-Cable (POC) Hybrid Fiber Coax (HFC) quasi-square wave powered (only available on limited models).

The AC powered version of the Tropos router supports an optional, factory installed, battery backup option which utilizes a Lithium Ion battery that supports between four (4) and twelve (12) hours of system up-time in a typical installation. The Tropos MetroMesh AC powered router also supports Power-Over-Ethernet (PoE) Power Sourcing Equipment (PSE) output capability in order to support remote powering of ancillary equipment, discussed later. The Tropos MetroMesh DC powered and POC/HFC powered versions do not support the battery backup option and they do not support PoE PSE output capability.

The Tropos Mobile MetroMesh Routers are vehicle mounted and are used to extend coverage beyond, or fill coverage holes within, the fixed mesh infrastructure. Mobile coverage is important in times of emergency because it provides an extended coverage area to public safety or utility workers when others are not available. The Tropos Mobile MetroMesh Router is DC powered, supports an extended temperature range and provides a 4W EIRP radio with -100dBm receive sensitivity.

Please note that while the Tropos Mobile MetroMesh Router was intended to be deployed within a vehicle it can easily be used outdoors by protecting the unit from the elements with a NEMA enclosure.

Mounting

Traditional mounting assets for a fixed metro-area network include street lights, traffic signals, utility poles and even aerial strand mounting. These are opportunistically chosen because they offer a good mounting location for RF propagation down city streets and typically provide a reliable power source. Many street lights have power that is always on and with the light being switched “on” through the use of a photo-sensor. Other street lights are powered from a bank switched grid which is manually switched “on” in the evening and “off” during the day. Applications utilizing bank-switched power use battery packs for power for over 12 hours, during the day, and then are powered and re-charged via the power grid during the evening.

More novel approaches to mounting assets include vehicles, roof tops, siren poles and temporary telescoping poles. These may also be chosen opportunistically based upon mounting and power availability as well as network service and coverage needs. For example, in rural areas where street lights are less than abundant, siren poles or public

buildings may be used to host the MetroMesh Routers. These mounting assets coupled with high powered, vehicle mounted Mobile MetroMesh Routers may be more than sufficient to provide public safety coverage. Fully kitted temporary networks utilizing telescoping pole mounts can be quickly deployed on the ground or rooftops for dual use at events and during times of emergency. The dual-use concept allows organizations not only to prepare for emergencies but also to opportunistically take advantage of revenue opportunities at special events and festivals.

Peripherals

Tropos AC powered MetroMesh Routers provide the ability to supply up to 30 watts of power, via Power over Ethernet (PoE), to other equipment. The Tropos PoE PSE output capabilities allows for peripheral equipment to be deployed without the need for additional power sources, saving on installation time and additional power equipment.

The Tropos AC powered MetroMesh Router's PoE power sourcing voltage is programmable to either +/-12Vdc, +/-24Vdc or +/-48Vdc capability enabling support for many proprietary PoE interfaces. The Tropos AC powered MetroMesh Router PoE power sourcing feature is not 802.3af compliant, however, most 802.3af compliant PoE Power Devices (PD) interoperate with the Tropos AC powered MetroMesh Router PoE power sourcing feature without any issue.

The 30 watts of power supplied by PoE is sufficient to support most point-to-point / multipoint radios. These radios are an excellent backhaul alternative when wired assets are not readily available. Other appliances, such as video surveillance cameras, hazardous material detectors and automatic meter reading (AMR) equipment, can also be powered from the Tropos PoE source. Video surveillance equipment can be used in public safety applications, emergency services and is also a useful tool in temporary installations for event or festival security.

Backhaul

The MetroMesh system requires a backhaul point for Internet connectivity. This may be provided via available telephony, fiber and/or HFC infrastructure through the use of modems or media converters.

In the event that existing infrastructure is not available, point to point/multi-point radio systems and even satellite data services are a viable alternative.

Environmental Protection

Enclosures

While the Tropos MetroMesh Router is environmentally hardened other parts of the system, such as batteries and charging electronics, may require enclosures to protect them from wind, rain and lightning. Waterproof enclosures that meet the National Electrical Manufacturers Association (NEMA) standards are readily available and required for all electrical and electronic components including the battery. Depending on battery technology, the battery enclosure may need to be vented and separated from the electrical system to prevent fire and/or explosion.

	Lead Acid Batteries	Lithium Ion Batteries
General	• Mainstay of the traditional battery backup industry • Telecom, solar systems • Very stable technology	• Highest energy density battery technology • Used in laptops, cell phones, and other portable electronics
Price	Inexpensive	Expensive
Power Density	• Low power density • 816W-Hr system including charger is ~74lbs and 12x11x7 inches in volume • Concorde SunXtender PVX-1040T has about 68A-Hr capacity with a 4 hour charge rate	• High power density • 760W-Hr system including charger is ~13lbs and 10x8x8 inches in volume • OceanServer PS-320, MP-08, and 8x CA-95-FL are examples
Size & Weight	Large and heavy	Small and light
Charge Cycles & Lifetime	~3,000 charging cycles and up to 10-years of service free life	~1,000 charging cycles and up to 3-years of service free life
Operating Temperature Range	-20C to +55C • Need to be equipped with battery heaters and/or oversized for cold weather operations	-30C to +55C • Need to be equipped with battery heaters and/or oversized for cold weather operations
Environmental	• Emits hydrogen gas during charging cycles • Must be separated from electronics in a vented enclosure • Disposal considerations due to use of sulfuric acid & lead	• Chemical reaction does not produce free gases • Not exothermic
Chargers	• Chargers are common • Universal input chargers available • Newmar PT-25 is an example • A step-down 4:1 transformer for high voltage installations (in cases where the system is connected to 440V electrical service) may be needed	• Chargers are common • Universal input chargers available • OceanServer PS-320 & MP-08 are examples • A step-down 4:1 transformer for high voltage installations (in cases where the system is connected to 440V electrical service) may be needed

Batteries

A number of factors should be taken into consideration when choosing a battery. First the batteries must be sized to the power the system, including peripheral equipment, for the required amount of time. Power consumption assumptions and run-time analysis dominate

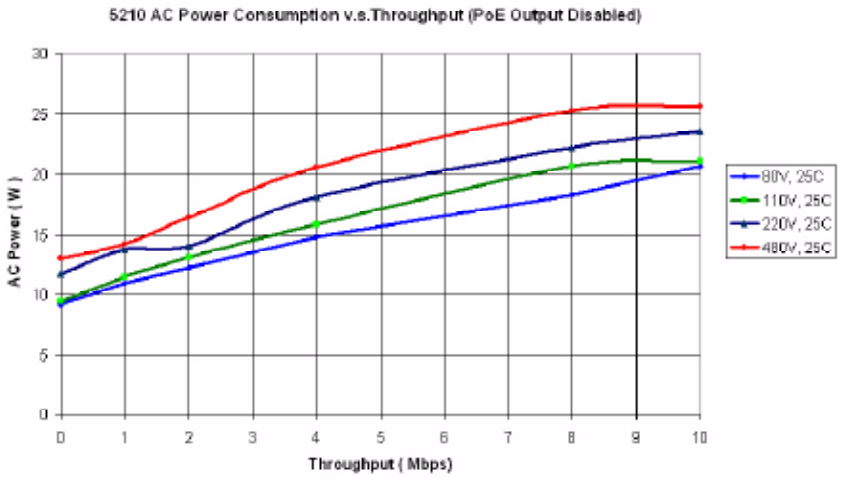
battery sizing. The second consideration is the battery technology. There are two major battery technologies common to the industry, Lead-Acid and Li-Ion. Other considerations include the charging method, temperature range and the ability to support fast charging.
A short comparison of the two prevalent battery technologies is included below.

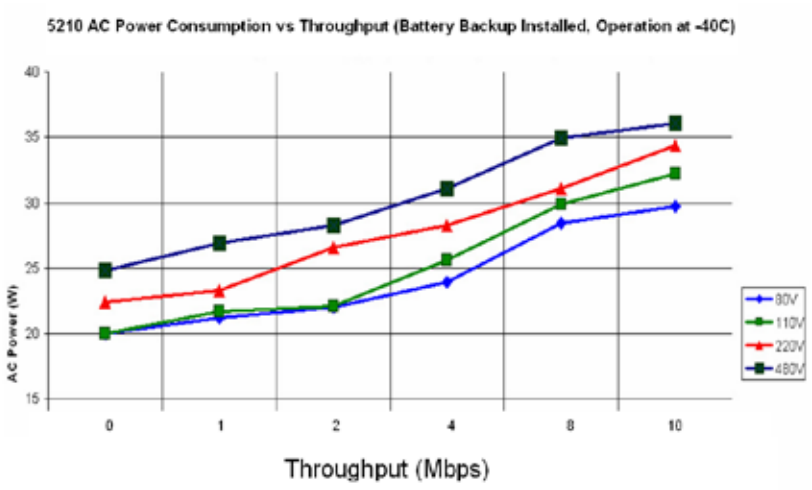
Tropos AC Powered MetroMesh Router Power Consumption

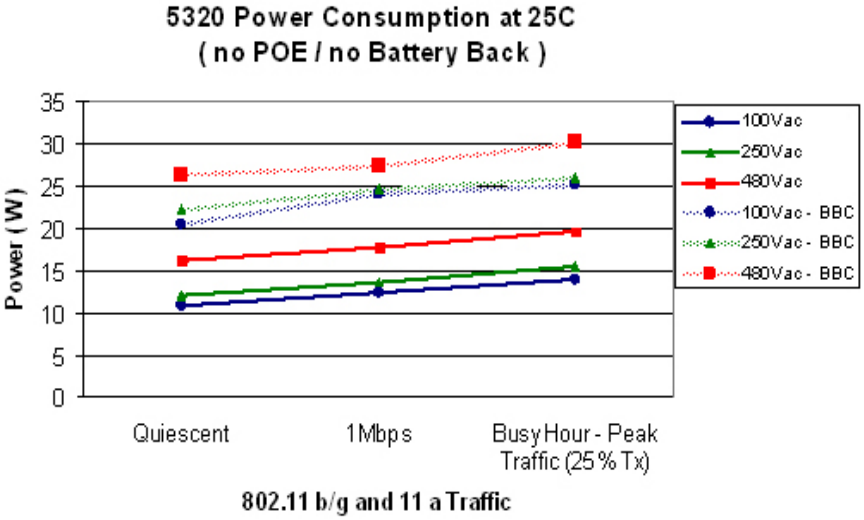
Several factors influence the power consumption at any given time, including the level of network traffic and whether a powered peripheral device is connected to the LAN or Management port of the Tropos MetroMesh Routers. Temperature may also influence the power consumption for units configured with battery backup, due to the freeze protection capability associated with the internal battery module. The figure below shows the basic relationship between throughput and AC power consumption at normal temperatures.

When a Tropos MetroMesh Router with battery backup is exposed to cold temperatures (below -12 degrees C), the internal heater associated with the battery is activated. This causes the router to draw additional AC power, as shown in the next figure.

The AC power consumption for the Tropos 5320 and 9532 MetroMesh routers is slightly higher than the for the Tropos 5210 MetroMesh router. BBC refers to the power consumption of the unit when charging the battery. The Tropos MetroMesh router battery charge time is about 10 hours.



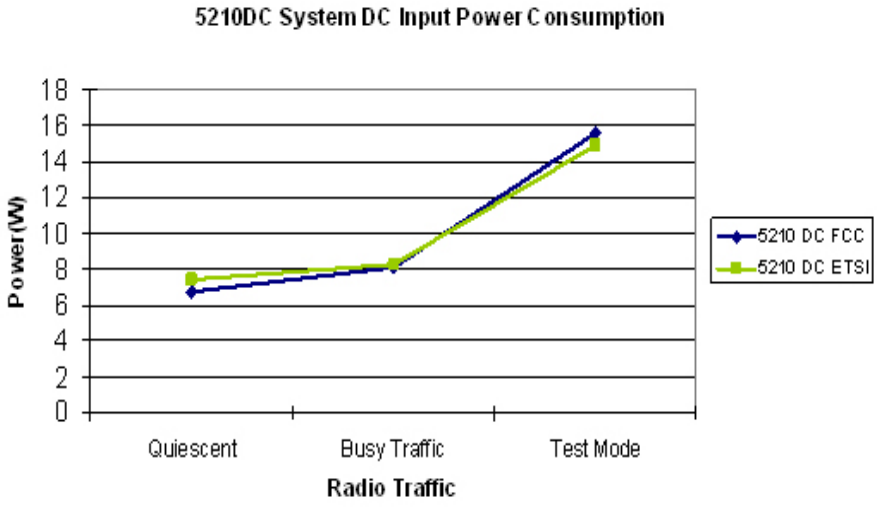




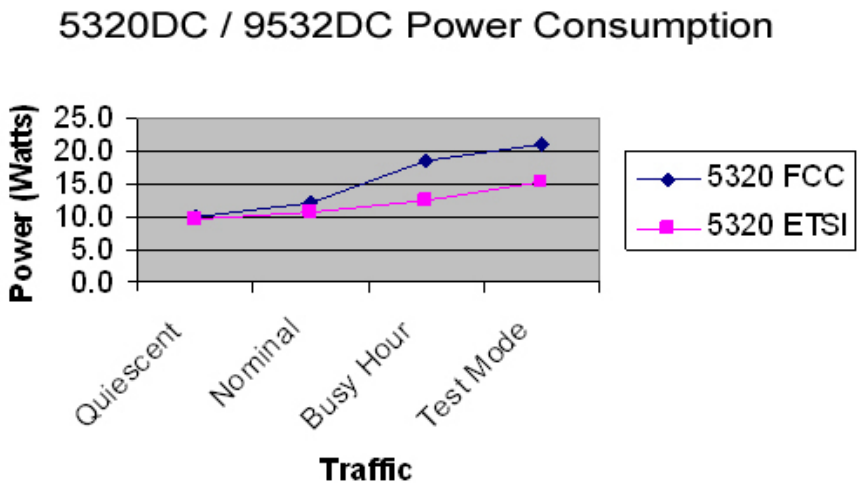
Tropos DC Powered MetroMesh Router Power Consumption

The Tropos DC powered MetroMesh Routers are often the most appropriate product for achieving resilient power systems because the DC power version is the most power efficient of the Tropos product offerings. Tropos DC powered routers eliminate the need for DC to AC power converters and reduces the battery capacity requirements of the resilient power system.

Note: The Tropos 5210/5320/9532 DC powered routers do not support PoE Power Sourcing output capability. The DC powered routers do not support an optional factory installed Battery Back-Up option. Ancillary peripheral equipment must derive power from the resilient power system directly.



The Tropos DC power router consumption depends upon the amount of traffic being forward across the wireless mesh network. Generally speaking, most applications maintain a fairly low level of back ground traffic the vast majority of the time but peak once or twice a day with heavy usage. The heavy usage periods are commonly referred to as "Busy Hour" times. It is not uncommon for a network to experience two "Busy Hours" in a 24 hour period, each lasting 1 to 2 hours each.



The power consumption of the Tropos 5320DC and 9532DC routers is slightly greater than that of the 5210 DC powered router.

Uninterruptible Power Supplies for Wireless Devices

Power supply platforms which incorporate batteries, charger, surge protection, and PoE power-data injectors are available from vendors like Alpha Technologies and others. The Alpha Technologies FlexNet MPS48-12M product is specifically designed to support wireless devices and mesh router installations at sites with centrally controlled bank-switched streetlights. These products are commonly available in an environmentally hardened versions and often support extended temperature ranges with battery heater accessory options.

Solar Power Considerations

The section describes the technical requirements for designing a solar powered platform to support Tropos MetroMesh Routers.

If the installation is installed in the northern hemisphere and meet the following conditions, then the installation may be a candidate for solar power:

- exposed to the southern horizon
- clear of overhead obstructions such as trees and buildings
- free of aesthetic restrictions

There are several solar power systems providers who can provide turn-key solutions for your Tropos MetroMesh Router installation. SunWize Technologies at www.sunwize.com, Alpha Technologies at www.alpha.com, LuminIP (www.luminip.com) and Eco Energies at www.ecoenergies.com are some of the solar solutions providers available. A typical solar power system will cost between $1500 and $2500, depending upon mounting location, accessories, component quality, and other factors.

Solar power system design is a two step process. Step one involves calculating the battery capacity. Defining the battery capacity involves understanding the power consumption of the equipment, allowing for bad weather and accounting for cold weather, since battery performance is dependent upon operating temperature.

The second step involves sizing the photovoltaic panel which will supply the solar power. Sizing the solar panel (or photovoltaic panel) requires knowing the daylight hours available for charging the battery, the efficiency of the battery charging system, and the worst case battery charging requirements for the solar powered system. The solar power solutions provider is best suited to design and select components for this part of the system.

Example Solar Powered MetroMesh Router Installation

System Voltage for the Tropos DC Powered MetroMesh Router

Solar powered systems are generally available with 12V or 24Vdc output power. The Tropos DC powered MetroMesh routers operate from 12Vdc to 60Vdc.

Tropos 5210 DC Input Voltage and Current:

- Tropos 5210 DC Input Voltage: 12 or 60Vdc
- Tropos 5210 DC Input Current (maximum): 3.5 amp

Tropos 5320/9532 DC Input Voltage and Current:

- Tropos 5320 DC Input Voltage: 12 or 60Vdc
- Tropos 5320 DC Input Current (maximum): 3.5 amp

Tropos 4210/9422 DC Input Voltage and Current:

- Tropos 4210 DC Input Voltage: 10 or 32Vdc
- Tropos 4210 DC Input Current (maximum): 3.5 amp

Calculating Tropos DC Electrical Load - Example

The Tropos DC powered MetroMesh router electrical load depends upon the quantity of throughput traffic. The Daily Load assumes a separate traffic profile during daytime versus nighttime. Use the Tropos MetroMesh Router power curves, in this case the Tropos 5210 DC power curves, to determine the power utilization at any given average throughput rate.

- Daily Load = (Daytime Load) + (Nighttime Load)
- Daytime Load (assume busy hour avg throughput) = (10W/24V)*12 = 5.0AH
- Nighttime Load (assume low traffic avg throughput) = (8W/24V)*12 = 4.0AH
- Daily Load = 5.0 + 4.0 = 9.0AH

For Maximum Storm Strength, 8 days should be adequate for many environments. If the calculations are for high reliability network applications, the preferred Maximum Storm Strength number is 10 or 11 days.

- Storm Load: Daily Load * Days
- Storm Load: 9AH * 8 = 72AH

A 20% reserve is factored in so that the batteries are not fully drained at the end of the Storm period;

- Storm Load with 20% Reserve: = 72AH*(1.20) = 86AH

Since battery performance is dependent upon the ambient operating temperature, an environmental factor is used to compensate for operating the equipment in a cold environment. Capacity multipliers are available from the battery manufacturers. Almost all lead-acid batteries have similar performance over temperature. For this calculation, we

assume an average winter temperature of 30 degrees F. For this scenario, the minimum operating temperature of the solar powered platform is 0 degrees F.

- Average Temperature: 30F use 1.59 capacity multiplier
- Battery Requirements: 86AH * 1.59 = 137AH

Therefore the solar powered platform requires a minimum battery capacity of 137AH.

The powering needs of peripheral equipment, such as point to multipoint backhaul and surveillance equipment, is determined in the same manner and simply added to the Tropos MetroMesh Router powering needs to arrive at the total system power and capacity requirements.

Calculating Solar Power Requirements

Solar power solution providers may offer optional lightning protection. Tropos Networks highly recommends installing lightning protection on any solar powered equipment. Another area not to be overlooked is power and data port protection and conditioning that may be needed for safety compliance and to protect the users and equipment against lightning induced surges.

Installation in the northern hemisphere should have solar panels with an optimal tilt angle and be installed in a generally southern facing direction. This horizon should be free of obstructions such as trees and buildings.

Power Protection

Solar power solution providers may offer optional lightning protection. Tropos Networks highly recommends installing lightning protection on any solar powered equipment. Another area not to be overlooked is power and data port protection and conditioning that may be needed for safety compliance and to protect the users and equipment against lightning induced surges.

Equipment Vendors

Equipment Category	Equipment Type	Vendor Name	Product Name	Model Number	Web Site	Contact Name
Backhaul	Pt to Multipoint Radio	Motorola	Canopy	5700AP, 5700SM	motorola.canopywireless.com/prod_specs.php?specs_cat=0	Tom Flannigan, e65001@Motorola.com, +1 (847) 538-2046
	Pt to Multipoint Radio	Alvarion	BreezeACCESS VL		www.alvarion.com	Jasper Bruinzeel, 760.685.2015, jasper.bruinzeel@alvarion.com
	Satellite Data	Echostar	Dish			
	Satellite Data	DirecTV				
Power and Battery	Power and Battery	Alpha Power	Call for selection	Varies	www.alpha.com	Dealers on website
	Solar Power	SunWize	Call for selection	Varies	www.sunwize.com	800-817-6527
Surveillance	Surveillance Cameras & DVR	Sony	Varies	Varies	b2b.sony.com	
	Surveillance Cameras	Panasonic	Varies	Varies	www.panasonic.com/business/security/network_cameras.asp	
	Surveillance Cameras & DVR	Axis	Varies	Varies	www.axis.com/products/video/camera/product_list.htm#Fixed%20indoor	
	VDVR system	ONSSI	Varies	Varies	www.onssi.com	
Mouting	Mounting Structures	Antenna Mast			www.antennamast.com/home.htm	See website
		Will-Burt, Inc			www.willburt.com	
		Floatograph			www.floatograph.com/powertrailer	
		Alumatower			www.alumatower.com/new/telescoping.html	
		Antenna Products			www.antennaproducts.com/TELMINDEX.htm	

Summary Conclusions

The Tropos family of MetroMesh Routers provides a robust communications infrastructure that is fast and simple to deploy, cost-effective, and ubiquitous. Deploying Tropos MetroMesh Routers with resilient power improves the overall system reliability and enables network deployment regardless of the presence or reliability of an electrical service and backhaul which is important for public safety, natural disasters, and temporary events.

System components for resilient power can range from a simple battery and charging system for bank-switched lighting to fully self-contained and self-sustaining systems that include mounting hardware, solar power systems, backhaul and video surveillance equipment. The key to assembling a good resilient power system for your Tropos MetroMesh Router is determining the power availability and power capacity needed. Throughput and peripheral products are the main determinants of these numbers while battery technologies can be chosen based upon size, power and budgetary constraints.

Please call your Tropos Networks representative for more assistance.

555 Del Rey Avenue • Sunnyvale, Ca 94085
phone 408.331.6800 • fax 408.331.6801
www.tropos.com • sales@tropos.com