ESA

ELECTRICAL SYSTEM ANALYZER

INSTALLATION AND OPERATIONS

MANUAL

MODEL: **M - 2001**
MODEL: **ESA - 2001**

Patent Pending

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ESA-2001

OPERATIONS AND INSTALLATION

Revision 1.1
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SECTION 1.0 DESCRIPTION

1.1 Introduction:

Congratulations! You have just acquired the ESA-2001 (ESA). An advanced, FIRST OF IT'S KIND, electrical system analyzer designed specifically for general aviation for pilots by pilots. The ESA-2001 was developed to minimize the pilots workload by continuously monitoring the electrical systems performance and provide the pilot with information not available from existing panel equipment. An EXCLUSIVE development from R. Philips Technology, **VOLTAGE (BVP) PROFILE,** an early warning detection circuit that can determine impending electrical system defects and alert the pilot of a problem with a digitally controlled alarm through the aircraft's audio system. The ESA-2001 also incorporates two, user-friendly, front panel push button switches that allows the pilot to interact with the analyzer.

This manual contains all information needed for the proper installation and operation of the ESA-2001. A flight manual supplement is provided at the end of this manual describing the proper use and operation of the ESA-2001.

1.2 Design Features:

The ESA was developed to enhance the pilots ability to fly safer and allow the pilot to concentrate on more demanding tasks. Important design features of the instrument: 1) Requires minimal pilot input, 2) Independent circuit functions for system redundancy and 3) Flexibility in panel mounting locations. Although it is desirable to mount the instrument in the pilots primary view, the ESA may be mounted out of the pilot immediate scan, field of view, because of it's audible alarm feature.

The ESA circuit incorporates a logic controlled alarm to inhibit, reset and prevent false alarms under a wide variety of electrical system conditions. The digital voltmeter resolves voltages to 0.1 volts which is significantly more accurate than any aircraft analog meter and was incorporated to provide additional information to the pilot. A front panel photo sensor automatically controls the digital voltmeter readout intensity for variations in cockpit lighting. However, both yellow LOW and red HIGH LED annunciators operate at full intensity to attract the pilots attention.

The ESA was miniaturized to provide for a wide variety of panel installation where panel space is at a premium. Units are available in two mounting styles, a standard round 2 1/4 inch instrument clock hole or a rectangular front mounting face plate, both with a maximum depth of 2 inches.

Unlike many aircraft avionics system, the ESA was designed with internal protection against such conditions as voltage spikes, over voltage, and reverse voltage. The ESA-2001 is temperature compensated to assure the ESA's long term stability and reliability. Because of it's **BUSS VOLTAGE PROFILING (BVP)** circuitry, the ESA is significantly more sensitive to detecting small electrical system voltage variations than any other existing instrument yet will not react to normal electrical system variations. <u>NOTE:</u> Two different voltage ranges of ESA's are available and are <u>not interchangeable</u>, one for 14 volt and another for 28 volt systems. Each unit is fully temperature cycled during a one hour life cycle test and then backed by a full one year warrant to insure complete satisfaction.

1.3 Operation:

The ESA continuously analyze and monitor the aircraft's electrical system performance and determine whether the system is functioning properly. The ESA is capable of detecting an electrical system failure the instant a problem occurs and immediately sounds an alarm through the aircraft cabin speaker and/or headsets. In addition to detecting abrupt

Mounting:	Fits standard 2 1/4" (5.71cm) clock hole or rectangular mounting 1.60" x 2.90" (4.06 x 7.36cm) face plate and requiring a 2.30" x 1.54" (5.84 x 3.9cm) panel cut-out.
Mounting Depth:	2" (5.08cm) maximum.
Weight:	8 Oz (226.8 grams).

SECTION 2.0 INSTALLATION

2.1 GENERAL:

Installation information in this section should be read completely and understood prior to attempting the installation of the ESA. **NOTE:** The ESA is installed and used in addition to existing aircraft instruments and was not intended to replace primary instruments. The ESA installation must conform to current AC 43.13 and applicable FAA procedures and regulations.

When the installation has been completed, fill out the necessary paper work, FAA form 337 and make the appropriate log book entries.

2.2 Installation Procedures:

2.2.1 Warnings:

Never disregard a circuit breaker or an in-line fuse when indicated and never change the rating of the breaker or fuse. When a wire gauge is specified, never use a smaller gauge. After crimping terminal pins, grasp the wire firmly and tug on the pin to assure a secure crimp and connection. When an airframe ground is shown or indicated, always select a good airframe ground and NEVER piggyback on any other ground. Always clean the metal properly prior to securing the ground terminal. Do not assume any spot on the airframe is an acceptable ground!! Ground by definition is considered a circuit reference point. If the selected ground is poor, an installed instrument may not perform as designed!

2.2.2 CABLING AND WIRING:

All wire should be 22 AWG minimum with Tefzel Mil-27500 insulation material or equivalent. Power for this system must be supplied by the main unswitched power buss and protected through a separate 1 AMP circuit breaker or in-line fuse. The 28 V version is supplied with a 100 ohm, 10 W resistor which should be covered with heat shrink and pinned into the connector. **DO NOT** connect the ESA syste'sm A+ power lead onto another breaker as the ESA-2001 **may not function properly.** The system ground should not be tapped into other grounds, but rather should be tied to the airframe by itself. **(SEE SECTION 2.2.1 "WARNINGS")** The audio wire from the ESA-2001 should be tied to the audio panel unswitched input so that the pulsed audio alert tone can not be accidentally turned off! If an unswitched input is not available, a switched audio input may be used with the switch appropriately labeled and the switch toggle fixed so that it can not be turned off.

Aircraft with headphones only (no cabin speaker) can tie the audio wire directly to the aircraft headphone jack. The alarm audio output level can drive headphones directly and be adjusted through a hole on the right side of the ESA case, with a jewelers screw driver, for any type of installation configuration. Depressing and holding the TEST button will sound the alarm and can be used to facilitate setting the alarm tone audio level. Harness layout is very important and the wires should be routed along an existing harness using service loops and secured properly.

2.2.3 MOUNTING:

The ESA will mount from the rear in a standard 2 1/4" clock hole without any metal re-work. The ESA is also available with a rectangular face plate for front mounting when panel space is limited. Drilling and cutting will be necessary when using the rectangular face plate, in most cases.

2.2.4 POST INSTALLATION CHECKOUT:

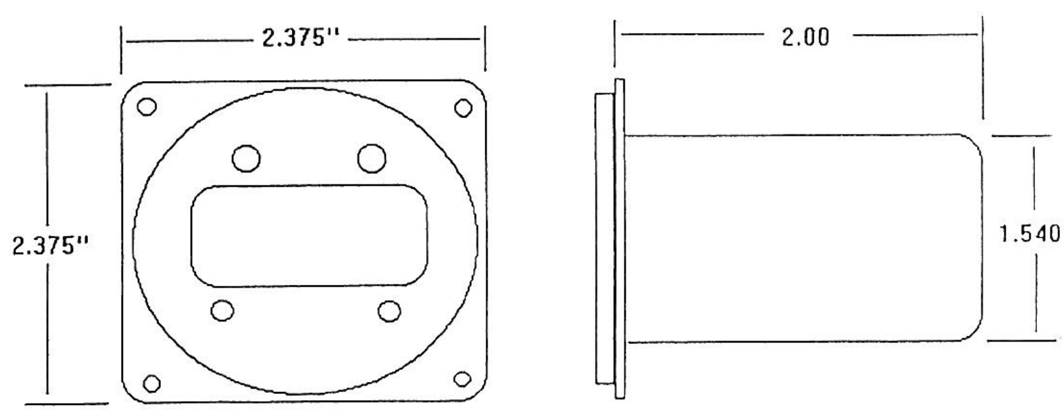
Prior to securing the harness connector to the ESA, check that the appropriate voltage is on the correct pin and continuity to ground is less that 0.5 ohms for the ground pin. When the above conditions have been met, attach the ESA to the A/C harness and perform the follow test:

ESA-2001 POWER "ON" SYSTEMS CHECK:

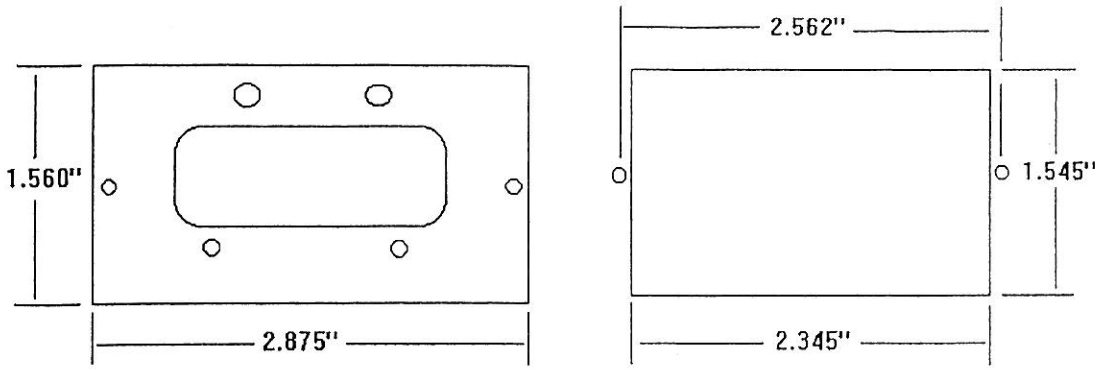
1. Turn "ON" the aircraft master and avionics master switch.
2. ESA should become active with no alarm output. If the A/C battery voltage is less than 12.6 V for 14 volt unit or 25.2V for the 28 volt unit as indicated on the digital voltmeter, the LOW LED will be illuminated and no alarm will sound.
3. Press TEST button - both LOW/HIGH LED will illuminate and the alarm will sound. **NOTE:** If the Digital Voltmeter reads less than 12.6 V for the 14 volt unit or 25.2 V for the 28 volt unit, the LOW LED will be illuminated and the Alarm will continue to sound when the TEST button is released.
4. Press the MUTE button to silence the Alarm.
5. Turn on all avionics including the auto-pilot and check to assure that all systems are functioning normally with no interference to existing avionics. If all functions are operating satisfactory, the aircraft may be returned to service when all appropriate log book entries, Flight Manual Supplement added to the A/C Operations Manual and completed FAA form 337.

2.3 INSTALLATION DRAWING:

Mechanical Outline an Drilling Layout:

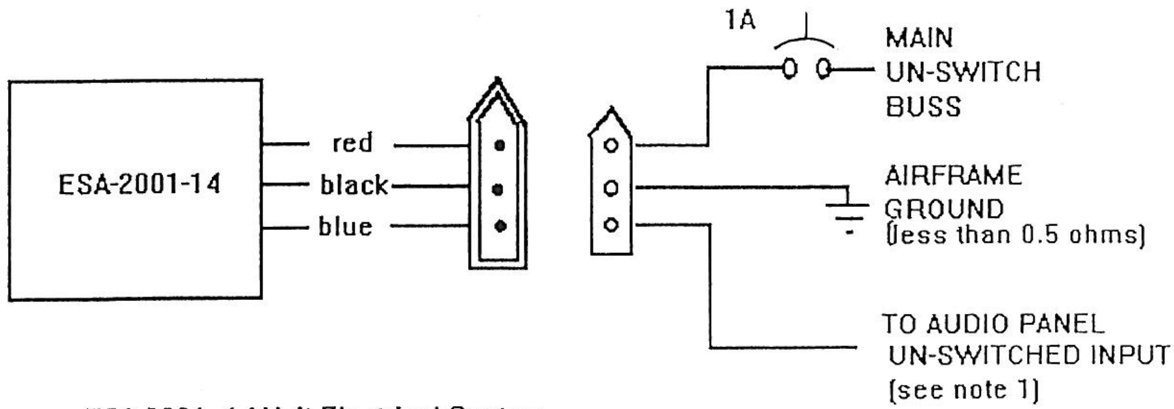


STANDARD 2/14 Inch Instrument mounting hole



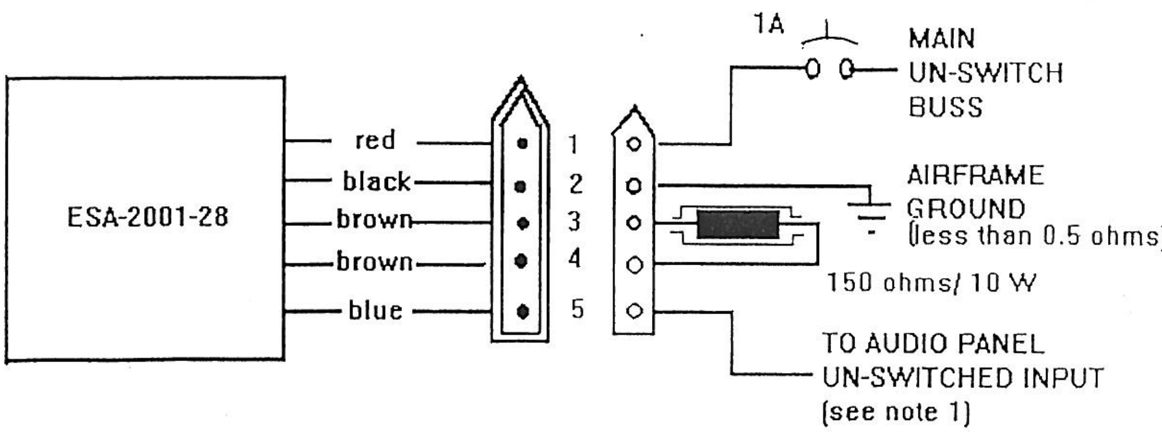
Rectangular Face Plate Mounting

2.4 INSTALLATION WIRING LAYOUT:



ESA-2001 14 Volt Electrical System

NOTE: 1. Connect to Phone Jack if A/C has no Speaker.
2. All wires are 22 AWG.



ESA-2001 28 Volt Electrical System

NOTE: 1. Connect to Phone Jack if A/C has no Speaker..
2. All wires are 22 AWG.

ELECTRICAL SYSTEM ANALYZER

FLIGHT MANUAL SUPPLEMENT

MODEL: **M - 2001**
MODEL: **ESA-2001**

S/N: ______________

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CHARGING VOLTAGE RANGES FOR 14 AND 28 VOLT ELECTRICAL SYSTEMS AND CONDITIONS

WITH ENGINE RUNNING AND ALTERNATOR ON LINE

ELECTRICAL SYSTEM VOLTAGE 28 V	ELECTRICAL SYSTEM VOLTAGE 14 V	RESULTING CONDITION	
GREATER THAN 31.2 V	GREATER THAN 15.0 V	**DANGEROUS OVERVOLTAGE CONDITION**	CAN RESULT IN: 1. Damaged Avionics. 2. Damage to all electrical components. 3. Battery Destruction. 4. Run away electrical system can result in an INFLIGHT FIRE.
		NOTE:	This condition must never be allowed to presist for any length of time. Shut off Alternator or Generator.
31.2 V	15.0 V	**EXCESSIVE CHARGING VOLTAGE** NOTE:	Will cause damage to electrical component, avionics and irreperable damage to battery.
29.0 V	14.2 V	**ACCEPTABLE CHARGING RATE**	COLD WINTER MONTHS
27.6 V	13.8 V	**IDEAL CONDITION**	This charging voltage range will provide optimal electrical system performance resulting in the lowest operational cost
27.5 V	13.7 V	**BELOW OPTIMAL CHARGING RATES**	CAN RESULT IN: 1. Partially charged battery. 2. Shortened Battery life. 3. Will reduce performance of all electrical system component as well as the Avionics.
25.2 V	12.6 V	**"WARNING"**	**COMPLETE ELECTRICAL CHARGING SYTEM FAILURE!**

ENGINE NOT RUNNING
MASTER/BATTERY SWITCH IN THE "ON" POSITION
Typical Open Circuit Voltage and Specific Gravity Values
FOR A 12 VOLT LEAD ACID BATTERY AT 80 F (26.7 C)

Charge Level	**Specific Gravity**	**Open Circuit Voltage**
100 %	1.265	12.6 V or greater
75 -- 100 %	1.225	12.4 - 12.6 V
50 -- 70 %	1.190	12.2 - 12.4 V
25 -- 50 %	1.155	11.7 - 12.2 V
0 %	1.120	11.7 V or less

TABLE I: 14 VOLT BATTERY CONDITION

ENGINE NOT RUNNING
MASTER/BATTERY SWITCH IN THE "ON" POSITION
Typical Open Circuit Voltage and Specific Gravity Values
FOR A 24 VOLT LEAD ACID BATTERY AT 80 F (26.7 C)

Charge Level	**Specific Gravity**	**Open Circuit Voltage**
100 %	1.265	25.2 V or greater
75 -- 100 %	1.225	24.8 - 25.2 V
50 -- 70 %	1.190	24.4 - 24.8 V
25 -- 50 %	1.155	23.4 - 24.4 V
0 %	1.120	23.4 V or less

TABLE II: 24 VOLT BATTERY CONDITION

BUSS VOLTAGE PROFILE (BVP) CIRCUIT -- The Buss Voltage Profile circuit is the heart of the ESA-2001 analyzer. This circuit analyzes the Buss Voltage for anomalies and determines whether the system is in or out of performance tolerance. Any out of tolerance conditions will sound a warning Alarm, thus '**EARLY WARNING DETECTION**'. If the Alarm should sound intermittently , DON'T IGNORE THE WARNING, have the electrical system check out as soon as possible for safety and reduced maintenance cost.

LOW/HIGH LED -- These high intensity colored LED's give the pilot a quick visual cue, at a glance, as to the nature of one type of electrical system problem. These LED's are controlled by a voltage limit sensing circuit and will respond faster to voltage spikes and extreme system fluctuations than the digital voltmeter. A HIGH Voltage indication will immediately WARN the pilot of an extremely dangerous condition and immediate action is required by the pilot - like **shutting down** the Alternator to prevent damage to the electrical system and other
electrical components and the avionics. Allow the charging system to remain off for at least 10 seconds, turn all avionics off, reduce the electrical load to a minimum and recycle by turning the alternator back "ON". If a HIGH voltage condition still persist, turn the Alternator back "OFF", reduce the electrical load to essentials and

land the aircraft as soon as possible. A LOW voltage indication informs the pilot of a COMPLETE charging system failure and follow the same procedure as the HIGH indication. SEE TABLE I and **II** for voltage ranges and conditions. Of course, certain flying conditons or situations may dictate different action, but the main point to be made is that an electrical system problem exist requiring immediate action.

ALARM -- The ESA produces a pulsing ALARM tone that will not startle the pilot yet can not be easily ignored. A MUTE button gives the pilot a means of silencing the ALARM and thus acknowledging that a problem may exist. The ESA-2001 Buss Voltage Profile circuit and digital logic will automatically RESET and MUTE the alarm under specific conditions so as to respond only to impending or actual failure conditions. A voltage limit sensing circuit controls the LOW and HIGH LED will also trigger the Warning Alarm.

VOLTMETER -- The ESA Digital Voltmeter was designed for faster response to voltage changes than similar meters available for aircraft use. As a result, trends can be detected such as systems fluctuations not possible with other types of voltmeters. A normal charging system voltage should be 13.8 V for a 14 volt system and 27.5 V for the 28 volt electrical system. This voltage level can normally be set by adjusting the voltage regulator and should only be accomplished by a qualified mechanic, if necessary. Any charging system voltage greater than the voltage specified above will shorten battery life and greatly effect avionics performance. Battery condition can be easily determined using TABLE I and II and with the LEAD ACID BATTERY discussion while having the aircraft Master Switch "ON" and no electrical load.

NOTE: The ESA was designed to be fully operational once the A/C Master Switch is turned "ON". This is possible because the ESA-2001 is internally protected against voltage polarity reversals, positive and negative voltage spikes and extreme temperature conditions. It, therefore, does not have to be turned off during engine startup as other avionics.

Lead Acid Batteries Discussion:

An aircraft charging system can have a profound effect upon the life of a battery. A high voltage regulator setting can cause excessive gassing, water loss, thermal runaway, and eventually destroy a battery. On the other
hand, if the voltage regulator setting is set too low and the changing system is not capable of handling the electrical load, the battery will be in a constant state of discharge. When this condition persist for a long period of time, the battery will sulfate and the sulfate deposits can become crystalline. In this sulfated state, the crystalline sulfate may actually created a short circuit between the plates.

A 100% fully charged, lead acid battery with a stabilized open circuit voltage should have a terminal voltage of 12.6 V for 14 V system and 25.2 V for a 28 V system. A single 100% charge cell represents an open circuit voltage of 2.1 volts per cell. A 12 V battery is made up of 6 cells for a 12.6 volt terminal voltage and a 24 volt battery is made up of 12 cells of a 25.2 volt terminal voltage with a specific gravity of 1.265 at 80 F (26.7 C). Table I and II can be very useful in determining the state of a lead acid battery. The values shown in these TABLES are for a battery that has been idle for sometime and do not exhibit any surface charge
. *NOTE: Before reading the open circuit battery voltage with TABLE I and II, observe the "surface charge" considerations and note that the specific gravity is a function of temperature. To obtain an accurate open circuit voltage reading for a lead acid battery that was just charge, apply a light load to the battery for at least 30 seconds and then let stand idle for another three minutes before reading the voltage. This will stabilize the voltage to remove the "surface charge" from the plates which would give a false higher voltage reading.* The primary function of an aircraft battery and it's relationship with the charging system is to: 1) Supply power to the engine starter motor for engine starting, 2) Act as a filter which voltage stabilizes the charging system output, 3) If the battery is properly charged, a short term emergency back-up if your primary power supply (the alternator) fails. This last item is what makes the ESA's early warning capabilities so valuable.

Operating an electrical system with a weak battery, or one with higher than normal internal resistance, will not properly stabilize the charging system output. A weak battery will result in large voltage fluctuations and spikes on the electrical system output with varying electrical loads which is detrimental to avionics or any other electrical device. *CAUTION: Never operate any electrical charging system with the battery disconnected when any electronic device is being operated on the power buss because severe voltage fluctuations and voltage spikes will be present.* To provide proper battery charging and longer term alternator reliability, the aircraft's continuous maximum electrical load, maximum alternator rated output, should not exceed 80% of the alternators maximum capacity.

TROUBLESHOOTING

The ESA-2001 can be used to analyzed problems with your aircaft electrical system.

Symptom	POSSIBLE PROBLEM
1. Pulsing voltage - increase in voltmeter reading and rate changes with increasing or decreasing electrical load. This will show up as a constant rapidly pulsing pamel ampmeter needle which is not relating to the tail beacon flash rate.	A. Resistance between the alternator field breaker and voltage regulator input. B. Loose wire or terminal. C. Bad field switch resulting from too much contact resistance or loose connection. D. Check for defective circuit breaker. E . Defective over voltage relay. **NOTE:** This is a condition that must be taken seriously and iimmediately corrected!!!
2. Battery electrolyte level always low when checked.	A. Possible battery over charging. B. Alternator output over 14.4 V will reduce battery life. C. Adjust voltage regulator for 13.8 for a 14 V system and 27.5 V for a 28 V system on the ESA readout. D. See Section --- for Lead Acid Battery discussion.
3. Battery voltage reads 12.4V or less after at least 1/2 hour of engine operation with only the master switch "ON" and no electrical load.	A. Weak battery. B. Remove battery from A/C, clean and recharge. C. Replace battery if necessary.
4. Voltmeter indicates voltage variations of 0.5 V or greater with changing loads.	A. Weak battery B. Check battery as in symptom 3. **NOTE:** A weak battery has an increase internal resistance which can cause wide voltage fluctuations. C. Slipping alternator belt. D. Defective voltage regulator. E. Check complete electrical system for loose connection.
5. Intermittent LOW LED illuminates and Alarm sounds.	A. Defective regulator, alternator, field switch and loose or burned connections.
6. Intermittent HIGH LED illuminates and Alarm sounds.	A. Defective regulator. B. Possible arcing alternator slip rings
7 Voltage drops below 12.6V for a 14 V or 25.2 V for a 28 V Electrical System when engine is brought to idle.	A. Defective Alternator.
8. Engine cranks hard with a voltmeter reading of 12.2V or less .	A. Defective starter relay, start motor, loose corroded connections or mis-aligned start motor.

NEVER IGNORE ANY ESA-2001 ALARM ! IF THE ALARM SOUNDS, A PROBLEM HAS BEEN DETECTED. REMEMBER THAT THE ESA-2001 PROVIDES EARLY WARNING FAULT DETECTION.