United States Army Aviation Warfighting Center
Fort Rucker, Alabama
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UH-60A
STUDENT HANDOUT

UH-60 ELECTRICAL SYSTEM
4741-3

PROPONENT FOR THIS STUDENT HANDOUT IS:

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TERMINAL LEARNING OBJECTIVE:

Action: Identify system components, operational characteristics, and emergency procedures of the UH-60 electrical power systems.

Condition: Given an end of stage multiple choice evaluation without reference, a blank answer sheet in a classroom environment.

Standard: Correctly identify the components and operational characteristics of the Alternating and Direct Current electrical systems of the UH-60 helicopter IAW TM 1-1520-237-10 and the student handout.

Safety Requirements: Classroom: Use care when operating training aids and/or devices.

Risk Assessment Level: Low.

Environmental Considerations: It is the responsibility of all soldiers and DA civilians to protect the environment from damage.

Evaluation: This block of instruction is comprised of one scorable unit consisting of 6 questions from system evaluations 4749 (A/B), or 4776 (A/B), of which you must correctly answer four.

Learning Step/Activity 1. Identify the operational characteristics of the AC power electrical system.

a. Description-

(1) Alternating current (AC) is the primary source of power. The aircraft AC electrical system consists of three independent systems, each capable of supplying the total helicopter power requirements. The prime source of each system is a 115/200 volts alternating current (Vac) main generator.

(2) Each system contains an AC generator, a current transformer, a generator control unit, and current limiter, all of which are interchangeable

(3) A portion of each AC primary bus load is converted to 28 volts direct current (Vdc) by two 200 ampere converters.

(4) An auxiliary AC power system is a backup AC power source that provides electrical power for ground checkouts and emergency power for flight.

(5) An electric power priority feature allows either the No. 1 or No. 2 main generator to automatically supersede the APU generator, which, in turn, automatically supersedes external power

b. Components:

(1) No.1or No.2 Generators (main). (First priority)

(a) Location. The main generators are located on and driven by the transmission accessory modules, left (1) and right hand (2) side respectively.

(b) Description. Each main generator is rated at 30/45 kilo volts ampere (Kva), is brushless, oil cooled by the transmission lubrication system, and provides three independent phases (A, B, C) of 115/200 Vac, 400 Hz power.

(c) Capabilities. Each main generator has the capability of providing all AC power for the aircraft if the other generator should fail e*xcept* the blade de-ice system. If blade de-ice is installed and in use, two generators must be operational due to the current load (power demand) requirement of blade de-ice.

(d) Associated Cautions: There are two cautions associated with the main generators.

1 **#1 GEN** and/or **#2 GEN**. Generator(s) is/are not supplying power to the AC primary busses (GEN is off or has failed).

2 **#1 GEN BRG** and/or **#2 GEN BRG**. The main generator's primary bearing is worn or has failed. If the caution stays on longer than one minute, make an entry on the DA Form 2408-13-1. The auxiliary bearing will allow 10 additional hours of operation after the light goes on.

(e) Generator switches.

1. Location. The main generator control switches are located on the overhead panel.

2. Positions. There are three positions for the main generator control switch.

a. TEST. This position allows you to test the generator AC output with out connecting it to the generator's load. If the #1 GEN or #2 GEN cautions goes out when you go to the TEST position the generator is working within its parameter.

b. OFF/RESET. Takes the generator off line and resets the logic module inside the GCU.

c. ON. Allows 3 phase, 115 volts, 400 Hz of power to energize the electrical busses.

(2) APU Generator (Second priority).

(a) Location. The APU generator is located on the front of the APU.

(b). Description. The APU generator is a 3 phase, 115 Vac, 400 Hz, air cooled, brushless generator rated at 20/30 kva.

(c) Purpose. The APU generator provides AC power for ground operation and back-up emergency AC power for flight.

(d) Capabilities. The APU generator can provide power to all equipment on board the aircraft with two exceptions:

1. If the backup pump and the windshield anti-ice are on line at the same time, you will lose the windshield anti-ice because the APU generator can not power both systems at the same time, due to the current load (power demand) requirements of each system. The backup pump has priority.

2. If blade de-ice is installed and in use, two generators must be on and operational due to the current load (power demand) requirement of the blade de-ice system.

(e) APU Generator control switch.

1. Location. The APU generator control switch is located on the overhead panel.

2. Positions. There are three positions for the APU generator control switch.

a. TEST. This position allows you to test the generator AC output with out connecting it to the generator's load. If the APU GEN ON advisory light illuminates when you go to the TEST position the generator is working within its parameter.

b. OFF/RESET. Takes the generator off line and resets the logic module inside the GCU.

c. ON. Allows 3 phase, 115 volts, 400 Hz of power to energize the AC electrical busses.

(f) Associated Advisory: **APU GEN ON**. Advises you that the APU generator output is acceptable and being supplied to the AC busses. When the "**APU GEN ON**" advisory is illuminated, **both** main generators are not operational and the APU generator is the sole source of AC power.

(3) Generator Control Unit (GCU)

(a). Purpose: There are three GCUs mounted in the forward cabin ceiling which monitor voltage from the No. 1, No. 2, and APU generators thru current transformers and disconnect the generator(s) from the AC system (off-line) when malfunctions occur.

(b) Functions: The GCU receivers signal from the current transformers to provide:

1. Over voltage protection- The GCU will discontinue generator output when any of the three phases of power is between 124-126 Vac or greater.

2. Under voltage protection- The GCU will discontinue generator output when any of the three phases of power is less than 95-105 Vac for more than 1 second.

3. Under frequency protection- The GCU will discontinue generator output when on the ground (WOW switch) and %RPMR is at 93%-95% or less and generator frequency is 370-380 HZ or less for more than1-3 seconds.

4. Feeder Fault- The GCU will discontinue generator output when an excessive current differential (short) is detected between A, B, and C phases of power.

(4) Generator contact relays are used to connect generators in and out of the AC system.

(5) Buses (AC only).

(a) #1 AC Primary Bus is normally powered by the #1 generator.

(b) #2 AC Primary Bus is normally powered by the #2 generator.

(c) AC Essential Bus is normally powered by "B" phase, 115 volts, 400 Hz from the #1 AC Primary Bus. The AC Essential Bus can get power from the #2 AC Primary Bus should you lose "B" phase from the #1 AC Primary Bus.

(6) Current limiters.

(a) Location. There are six current limiters in the AC supply system which are rated at 60 AMPS and are located in the junction boxes in the overhead cabin area.

CURRENT LIMITERS

(b) Purpose. Provide protection to circuits in the event of excessive amperage or draw.

(c) Operation. Works like a fuse, excessive amperage melts the metal and opens the circuit that goes across the current limiter.

(7) External power (Third priority).

(a) Location. The external power receptacle is located on the right side of the fuselage under the crew chief's window.

(b) Description. The receptacle has six prongs. Three of the large prongs are for the three phase positive power, the remaining large prong is negative (Ground). The two small prongs are for the advisory on the Master Caution Panel. (**EXT PWR CONNECTED**).

(c) Advisory light. “EXT PWR CONNECTED” Advises you have external power connected (cable inserted).

(8) External power switch (Three position).

a. RESET. Resets the logic module inside the External Power Monitor Panel.

b. OFF. Stops any power from coming into the aircraft via the External Power Monitor Panel.

c. ON. Allows three phase, 115 volts (AC), 400 Hz of power into the aircraft via the External Power Monitor Panel.

(9) External Power Monitor Panel.

a. Location. The external power monitor panel is located over the right gunner station. (crew chief’s station)

b. Purpose. This panel monitors for correct phase rotation (A, B, C in order), over and under voltage protection, over and under frequency (HZ) protection. Once the cable from the external power source is plugged into the external power receptacle and the external power switch is moved to the “ON” position, 3 phase, 115 volts, 400 Hz of power will be introduced into the system if acceptable external power is connected

Note: If the aircraft does not receive AC power once the external power switch is in the ON position, move the switch to RESET then ON, (resetting the external power monitor panel).

Learning Step/Activity 2. Identify the components and operational characteristics of the DC electrical system.

a. Direct Current (DC) Power Supply system. The primary DC power is from two converters (transformer-rectifiers), with the secondary DC power source is from the battery. There is no external DC power connector.

b. Components:

(1) Battery— Supplies 24 Vdc to the battery utility bus, battery bus, and the DC essential bus when there is no DC power from the #1 or #2 DC primary busses and the batt switch is in the "on" position. The battery can be either a Nickel Cadmium (NICAD) or Sealed Lead Acid Battery (SLAB).

(a) Description. NICAD - 24 Vdc, 5.5 amp hours with 20 cells, (19 battery cells and 1 sensing cell). SLAB - 24 Vdc, 9.5 amp hours.

(b) Purpose. To provide a secondary or emergency source of DC power during run-up or for flight emergencies..

(c) Operation times when the battery is the only source of DC power.

1. Day. NICAD - 22 minutes, SLAB - 38 minutes (at 80% capacity).

2. Night. NICAD - 14 minutes, SLAB - 24 minutes (at 80% capacity).

(2) If the battery is the sole source of DC power, the three DC busses that are energized are:

(a) Battery Utility Bus. Hot when the battery is connected.

(b) Battery Bus. Hot when the battery is connected and the battery switch is in the ON position.

(c) DC Essential Bus. Hot when the battery is connected, the switch is in the ON position and the battery bus is energized.

(3) Associated Cautions.

(a) #**1 CONV** and **#2 CONV**. This caution illuminates when either one or both converter(s) is/are not working.

(b) **DC ESS BUS OFF**. Caution indicates that no power is being supplied to the DC essential bus and is illuminated when the NICAD battery is at or below approximately 35% state of charge.

(c) **BATT LOW CHARGE**.

1. For a SLAB battery it indicates that the voltage on the battery utility bus is at or below 23 Vdc

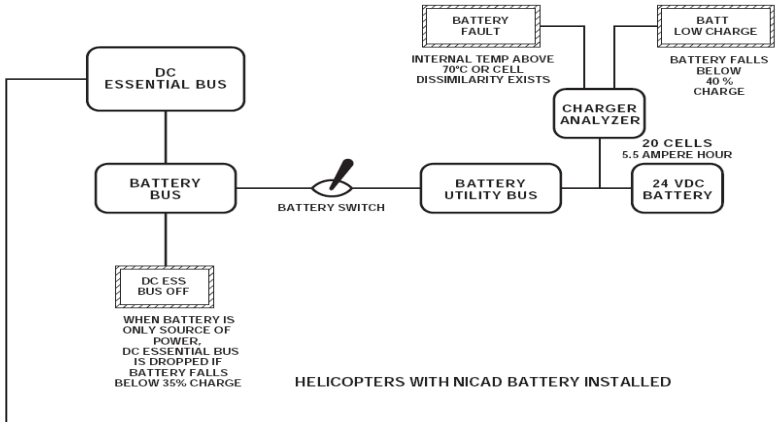
2. For a NICAD battery it indicates that the battery charge state is at or below about 40% of full charge state.

(d) **BATTERY FAULT** (NICAD battery only). This caution indicates that the battery has exceeded the safe operating temperature of 70° C (over temperature), or a battery cell dissimilarity exists.

(4) Charger/analyzer (**NICAD battery only**).

(a) Provides a constant charge to the battery when the #2 AC primary and #2 DC primary busses are energized.

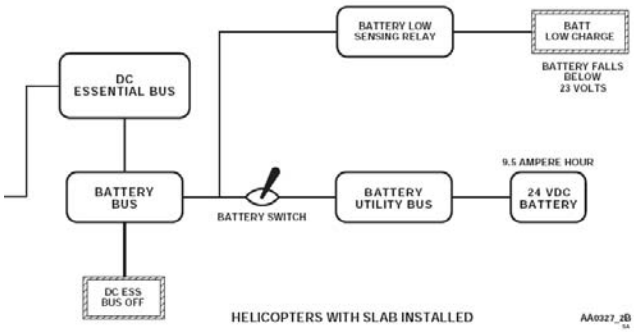
(b) Analyzes the battery, controls the **BATT LOW CHARGE** and the **BATTERY FAULT** cautions, and disengages the DC essential bus when the battery capacity drops below 35%.



(5) Battery Low Sensing Relay (SLAB only).

(a) On helicopters equipped with the sealed lead acid battery (SLAB) the system charges the battery through the battery charging relay with one or both converters on.

(b) Illuminates the **BATT LOW CHARGE** caution when the voltage on the battery utility bus drops below 23 Vdc.



(6). Converter system (primary DC power source).

(a) Two 200-ampere converters, each powered by the No. 1 and No. 2 AC primary buses respectively, turn AC power into DC power and reduce it to 28 volts. The converter output is applied to the No. 1 and No. 2 DC primary buses whenever AC power is applied to the AC primary buses.

(b) Associated Cautions s. **#1 CONV** and /or **#2 CONV**. If one or more cautions are illuminated, either one or both converter(s) is/are not working.

Note: If you have both **#1 CONV** and **#2 CONV** cautions illuminated, you lose converted DC power to the #1 and #2 DC Primary Busses.

(c) Busses powered by the converters. (AC power available)

1. #1 DC primary bus is normally powered by the #1 converter.

2. #2 DC primary bus is normally powered by the #2 converter.

3. DC Essential bus is normally powered by the #1 DC primary bus. If a short should

occur in the #1 DC primary bus, the DC essential bus will get power from the #2 DC primary bus.

4. Battery bus is normally powered by the DC Essential bus.

(7) Current limiter- One 100 amp current limiter is located between the #1 and #2 DC primary busses, provides circuit protection in the event of excessive amperage draw. This excessive amperage melts the metal and opens the electrical path between the two DC primary buses.

Learning Step/Activity 3. Identify which cautions are illuminated and which DC buses are energized when starting the APU during run-up.

a. Battery power for starting APU.

(1) Battery switch on. Note the following cautions on.

(a) **#1 CONV** and **#2 CONV**. At this point you have no AC power being converted to DC power. Also both of your DC primary buses are off line, because the DC primary buses receive power to operate from the converter(s).

(b) **AC ESS BUS OFF**. Since "B" phase of both AC primary buses are cold, the AC essential bus can not be energized.

(c) **BOOST SERVO OFF**. No hydraulic pressure to the collective and yaw boost servos.

(d) **STABILATOR** (and audio). The Stabilator is in the manual mode due to loss of electrical power to the stabilator amplifiers.

(e) **SAS OFF**. No hydraulic pressure to the pitch, roll, yaw SAS actuators, and the pitch boost servo.

(2) DC electrical buses energized.

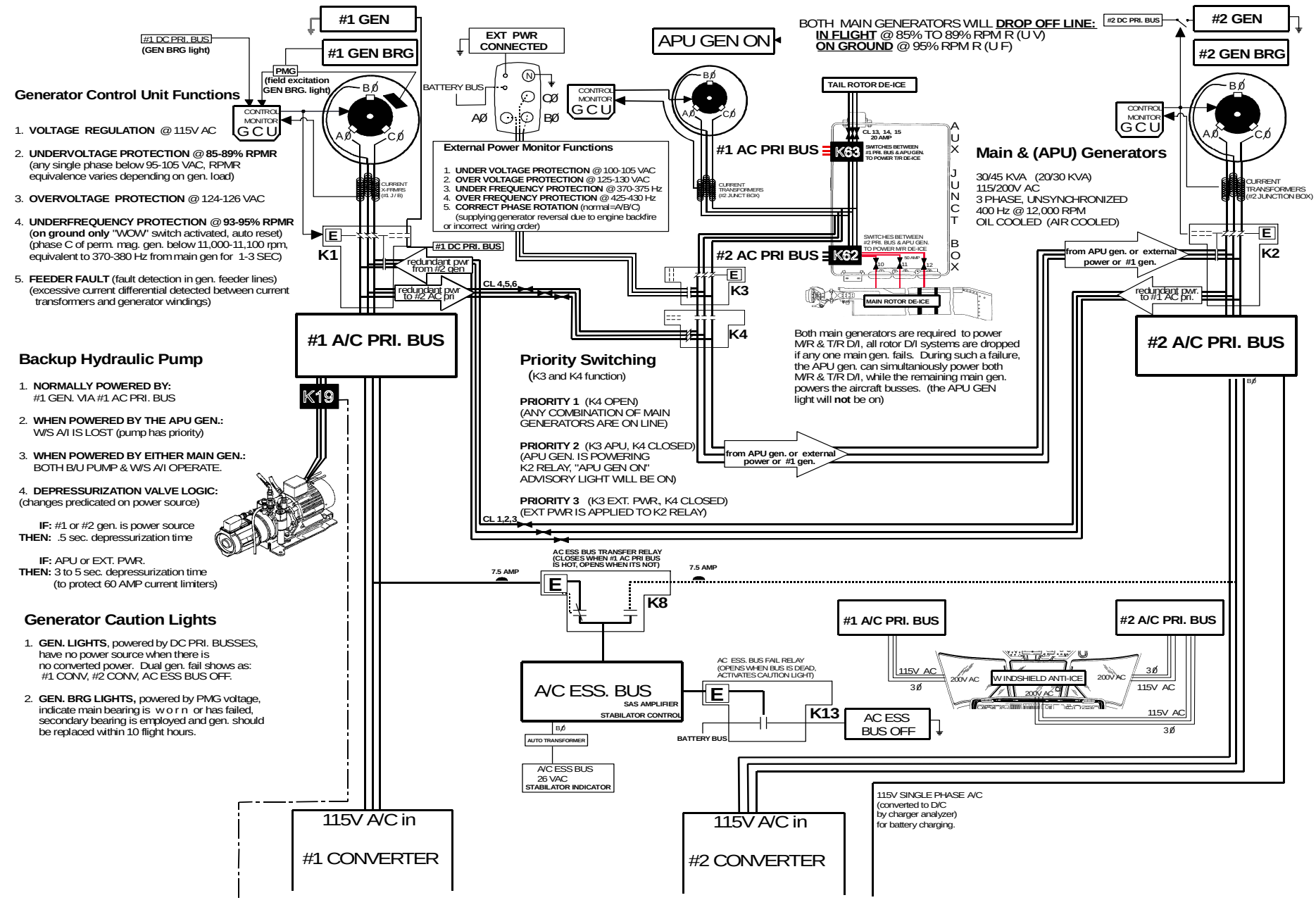
(a) BATTERY UTILITY BUS (BUB). The BUB is energized as soon as the battery's electrical connector is connected.

(b) BATTERY BUS (BATT BUS). The BATT BUS is energized once the battery is connected and the battery switch is placed in the ON position.

(c) DC ESSENTIAL BUS (DC ESS BUS). The DC ESS BUS is energized as soon as the BATT BUS gets it power, as long as the battery is above 35% state of charge (NICAD only).

Note: The BATT LOW CHARGE caution illuminates when the battery charge is at or below approximately 40+5% capacity (NICAD), and 23 Volts (SLAB).

UH-60 AC & DC ELECTRICAL SYSTEM OVERVIEW



Generator Control Unit Functions

1. **VOLTAGE REGULATION** @ 115V AC
2. **UNDERVOLTAGE PROTECTION @ 85-89% RPMR** (any single phase below 95-105 VAC, RPMR equivalence varies depending on gen. load)
3. **OVERVOLTAGE PROTECTION** @ 124-126 VAC
4. **UNDERFREQUENCY PROTECTION @ 93-95% RPMR (on ground only** "WOW" switch activated, auto reset) (phase C of perm. mag. gen. below 11,000-11,100 rpm, equivalent to 370-380 Hz from main gen for 1-3 SEC)
5. **FEEDER FAULT** (fault detection in gen. feeder lines) (excessive current differential detected between current transformers and generator windings)

External Power Monitor Functions

1. **UNDER VOLTAGE PROTECTION** @ 100-105 VAC
2. **OVER VOLTAGE PROTECTION** @ 125-130 VAC
3. **UNDER FREQUENCY PROTECTION** @ 370-375 Hz
4. **OVER FREQUENCY PROTECTION** @ 425-430 Hz
5. **CORRECT PHASE ROTATION** (normal=A/B/C) (supplying generator reversal due to engine backfire or incorrect wiring order)

Main & (APU) Generators

30/45 KVA (20/30 KVA)
115/200V AC
3 PHASE, UNSYNCHRONIZED
400 Hz @ 12,000 RPM
OIL COOLED (AIR COOLED)

Both main generators are required to power M/R & T/R D/I, all rotor D/I systems are dropped if any one main gen. fails. During such a failure, the APU gen. can simultaniously power both M/R & T/R D/I, while the remaining main gen. powers the aircraft busses. (the APU GEN light will **not** be on)

Priority Switching

(K3 and K4 function)

PRIORITY 1 (K4 OPEN)
(ANY COMBINATION OF MAIN GENERATORS ARE ON LINE)

PRIORITY 2 (K3 APU, K4 CLOSED)
(APU GEN. IS POWERING K2 RELAY, "APU GEN ON" ADVISORY LIGHT WILL BE ON)

PRIORITY 3 (K3 EXT. PWR., K4 CLOSED)
(EXT PWR IS APPLIED TO K2 RELAY)

Backup Hydraulic Pump

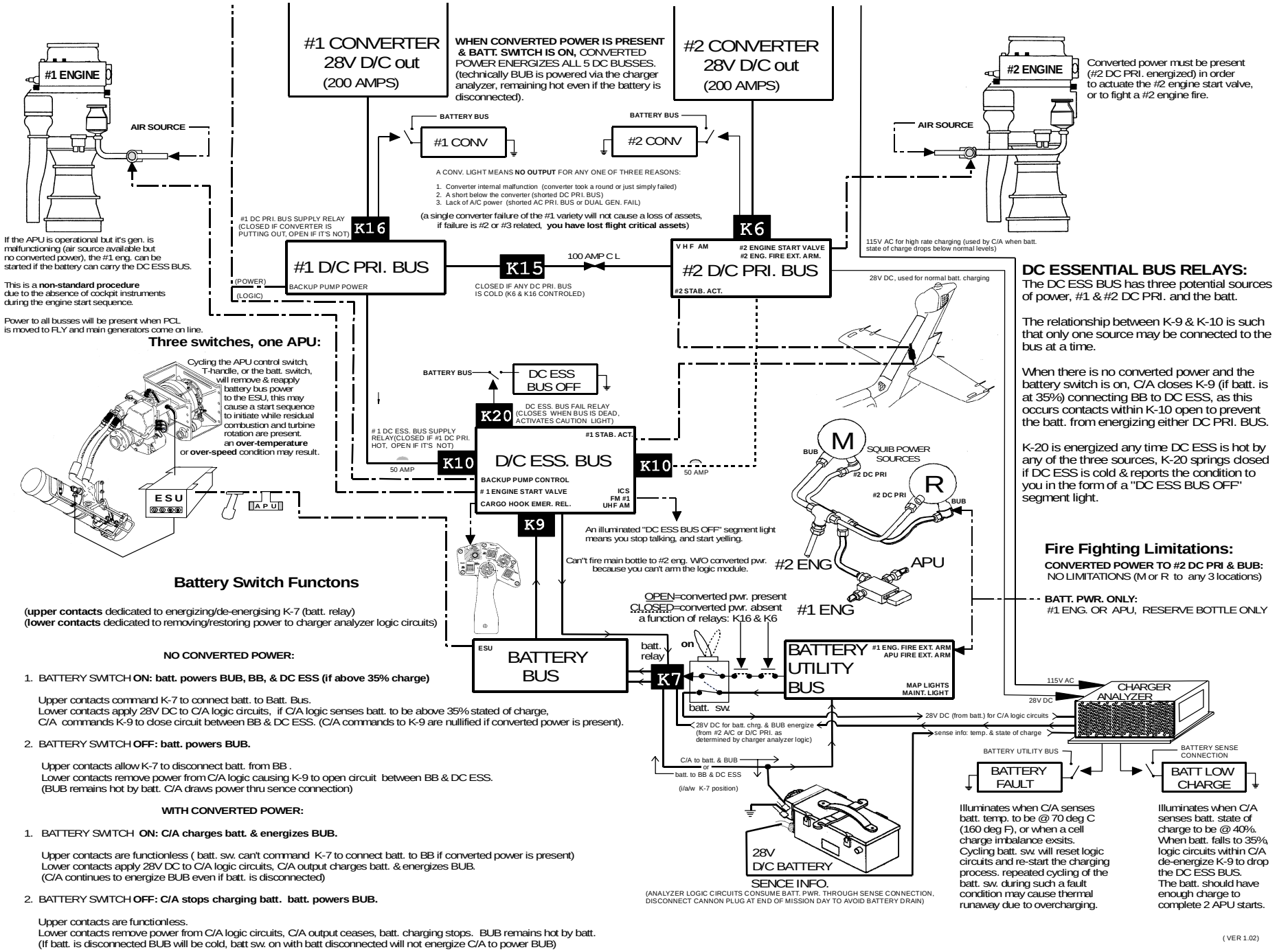
1. **NORMALLY POWERED BY:** #1 GEN. VIA #1 AC PRI. BUS
2. **WHEN POWERED BY THE APU GEN.:** W/S A/I IS LOST (pump has priority)
3. **WHEN POWERED BY EITHER MAIN GEN.:** BOTH B/U PUMP & W/S A/I OPERATE.
4. **DEPRESSURIZATION VALVE LOGIC:** (changes predicated on power source)

IF: #1 or #2 gen. is power source
THEN: .5 sec. depressurization time

IF: APU or EXT. PWR.
THEN: 3 to 5 sec. depressurization time (to protect 60 AMP current limiters)

Generator Caution Lights

1. **GEN. LIGHTS**, powered by DC PRI. BUSSES, have no power source when there is no converted power. Dual gen. fail shows as: #1 CONV, #2 CONV, AC ESS BUS OFF.
2. **GEN. BRG LIGHTS,** powered by PMG voltage, indicate main bearing is w o r n or has failed, secondary bearing is employed and gen. should be replaced within 10 flight hours.


#1 CONVERTER
28V D/C out
(200 AMPS)
WHEN CONVERTED POWER IS PRESENT & BATT. SWITCH IS ON, CONVERTED POWER ENERGIZES ALL 5 DC BUSSES. (technically BUB is powered via the charger analyzer, remaining hot even if the battery is disconnected).
#2 CONVERTER
28V D/C out
(200 AMPS)
#1 ENGINE
AIR SOURCE
BATTERY BUS
#1 CONV
BATTERY BUS
#2 CONV
A CONV. LIGHT MEANS NO OUTPUT FOR ANY ONE OF THREE REASONS:
1. Converter internal malfunction (converter took a round or just simply failed)
2. A short below the converter (shorted DC PRI. BUS)
3. Lack of A/C power (shorted AC PRI. BUS or DUAL GEN. FAIL)
(a single converter failure of the #1 variety will not cause a loss of assets, if failure is #2 or #3 related, you have lost flight critical assets)
#2 ENGINE
AIR SOURCE
Converted power must be present (#2 DC PRI. energized) in order to actuate the #2 engine start valve, or to fight a #2 engine fire.
#1 DC PRI. BUS SUPPLY RELAY (CLOSED IF CONVERTER IS PUTTING OUT, OPEN IF IT'S NOT)
K16
K6
If the APU is operational but it's gen. is malfunctioning (air source available but no converted power), the #1 eng. can be started if the battery can carry the DC ESS BUS.
This is a non-standard procedure due to the absence of cockpit instruments during the engine start sequence.
Power to all busses will be present when PCL is moved to FLY and main generators come on line.
#1 D/C PRI. BUS
BACKUP PUMP POWER
(POWER)
(LOGIC)
K15
100 AMP C L
CLOSED IF ANY DC PRI. BUS IS COLD (K6 & K16 CONTROLED)
V H F AM
#2 ENGINE START VALVE
#2 ENG. FIRE EXT. ARM.
#2 D/C PRI. BUS
#2 STAB. ACT.
115V AC for high rate charging (used by C/A when batt. state of charge drops below normal levels)
28V DC, used for normal batt. charging
DC ESSENTIAL BUS RELAYS:
The DC ESS BUS has three potential sources of power, #1 & #2 DC PRI. and the batt.
The relationship between K-9 & K-10 is such that only one source may be connected to the bus at a time.
When there is no converted power and the battery switch is on, C/A closes K-9 (if batt. is at 35%) connecting BB to DC ESS, as this occurs contacts within K-10 open to prevent the batt. from energizing either DC PRI. BUS.
K-20 is energized any time DC ESS is hot by any of the three sources, K-20 springs closed if DC ESS is cold & reports the condition to you in the form of a "DC ESS BUS OFF" segment light.
Three switches, one APU:
Cycling the APU control switch, T-handle, or the batt. switch, will remove & reapply battery bus power to the ESU, this may cause a start sequence to initiate while residual combustion and turbine rotation are present. an over-temperature or over-speed condition may result.
ESU
APU
BATTERY BUS
DC ESS BUS OFF
K20
DC ESS. BUS FAIL RELAY (CLOSES WHEN BUS IS DEAD, ACTIVATES CAUTION LIGHT)
1 DC ESS. BUS SUPPLY RELAY(CLOSED IF #1 DC PRI. HOT, OPEN IF IT'S NOT)
K10
50 AMP
#1 STAB. ACT.
D/C ESS. BUS
BACKUP PUMP CONTROL
1 ENGINE START VALVE
CARGO HOOK EMER. REL.
ICS
FM #1
UHF AM
K10
50 AMP
K9
M
SQUIB POWER SOURCES
BUB
#2 DC PRI
#2 DC PRI
R
BUB
#2 ENG
APU
#1 ENG
An illuminated "DC ESS BUS OFF" segment light means you stop talking, and start yelling.
Can"t fire main bottle to #2 eng. W/O converted pwr. because you can't arm the logic module.
OPEN=converted pwr. present
CLOSED=converted pwr. absent
a function of relays: K16 & K6
Fire Fighting Limitations:
CONVERTED POWER TO #2 DC PRI & BUB:
NO LIMITATIONS (M or R to any 3 locations)
BATT. PWR. ONLY:
#1 ENG. OR APU, RESERVE BOTTLE ONLY
Battery Switch Functons
(upper contacts dedicated to energizing/de-energising K-7 (batt. relay)
(lower contacts dedicated to removing/restoring power to charger analyzer logic circuits)
NO CONVERTED POWER:
1. BATTERY SWITCH ON: batt. powers BUB, BB, & DC ESS (if above 35% charge)
Upper contacts command K-7 to connect batt. to Batt. Bus.
Lower contacts apply 28V DC to C/A logic circuits, if C/A logic senses batt. to be above 35% stated of charge,
C/A commands K-9 to close circuit between BB & DC ESS. (C/A commands to K-9 are nullified if converted power is present).
2. BATTERY SWITCH OFF: batt. powers BUB.
Upper contacts allow K-7 to disconnect batt. from BB .
Lower contacts remove power from C/A logic causing K-9 to open circuit between BB & DC ESS.
(BUB remains hot by batt. C/A draws power thru sence connection)
WITH CONVERTED POWER:
1. BATTERY SWITCH ON: C/A charges batt. & energizes BUB.
Upper contacts are functionless (batt. sw. can't command K-7 to connect batt. to BB if converted power is present)
Lower contacts apply 28V DC to C/A logic circuits, C/A output charges batt. & energizes BUB.
(C/A continues to energize BUB even if batt. is disconnected)
2. BATTERY SWITCH OFF: C/A stops charging batt. batt. powers BUB.
Upper contacts are functionless.
Lower contacts remove power from C/A logic circuits, C/A output ceases, batt. charging stops. BUB remains hot by batt.
(If batt. is disconnected BUB will be cold, batt sw. on with batt disconnected will not energize C/A to power BUB)
ESU
BATTERY BUS
batt. relay
on
K7
BATTERY UTILITY BUS
#1 ENG. FIRE EXT. ARM
APU FIRE EXT. ARM
MAP LIGHTS
MAINT. LIGHT
batt. sw.
28V DC for batt. chrg. & BUB energize (from #2 A/C or D/C PRI. as determined by charger analyzer logic)
C/A to batt. & BUB
or
batt. to BB & DC ESS
(i/a/w K-7 position)
28V D/C BATTERY
SENCE INFO.
(ANALYZER LOGIC CIRCUITS CONSUME BATT. PWR. THROUGH SENSE CONNECTION, DISCONNECT CANNON PLUG AT END OF MISSION DAY TO AVOID BATTERY DRAIN)
115V AC
28V DC
CHARGER ANALYZER
28V DC (from batt.) for C/A logic circuits
sense info: temp. & state of charge
BATTERY UTILITY BUS
BATTERY SENSE CONNECTION
BATTERY FAULT
BATT LOW CHARGE
Illuminates when C/A senses batt. temp. to be @ 70 deg C (160 deg F), or when a cell charge imbalance exsits. Cycling batt. sw. will reset logic circuits and re-start the charging process. repeated cycling of the batt. sw. during such a fault condition may cause thermal runaway due to overcharging.
Illuminates when C/A senses batt. state of charge to be @ 40%. When batt. falls to 35%, logic circuits within C/A de-energize K-9 to drop the DC ESS BUS. The batt. should have enough charge to complete 2 APU starts.
(VER 1.02)

Learning Step/Activity 4. Analysis malfunctions in the UH-60 electrical system and discuss emergency procedures.

Note: For all malfunctions that apply to the electrical system refer to TM 1-1520-237-10 chapter 9:

a. Section 9.26 ELECTRICAL SYSTEMS

(1) #1 and #2 Generator Failures

(2) #1 or #2 GEN Caution Appears

(3) #1 and #2 CONV Cautions Appear

(4) BATTERY FAULT Caution Appears

(5) BATTERY FAULT Caution Appears

(6) BATT LOW CHARGE Caution Appears

b. Section 9.22 ROTORS, TRANSMISSIONS, AND DRIVE TRAIN

MAIN XMSN OIL PRESS Caution Appears/XMSN OIL PRESS LOW/XMSN OIL TEMP HIGH or XMSN OIL TEMP Caution Appears.