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Origin of 400 Hz in aircraft?

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jjmartin View profile More options Oct 7 1999, 3:00 am

I was wondering if anyone knows the **origin** of 400 **Hz** power being chosen for use with **aircraft** avionics. Why was 400 **Hz** settled on instead of, say, 200, 300, or 500, or perhaps something even higher? I'm guessing the choice was made sometime in the 1930s, but I'd also appreciate hearing if anyone knows a more accurate date.
R/ John Martin

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William Sommerwerck View profile More options Oct 7 1999, 3:00 am

I don't know the date of adoption, but the reason is simple. The higher the frequency, the less iron needed in the transformer for efficient performance.
That cuts weight. Ditto for the filter caps.

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nesesu View profile More options Oct 7 1999, 3:00 am

In article <37FC52E0.F6559...@phnx.uswest.net>,
jjmar...@phnx.uswest.net wrote:
> I was wondering if anyone knows the **origin** of 400 **Hz** power
> being chosen for use with **aircraft** avionics. Why was 400 **Hz**
> settled on instead of, say, 200, 300, or 500, or perhaps
> something even higher? I'm guessing the choice was made
> sometime in the 1930s, but I'd also appreciate hearing if
> anyone knows a more accurate date.
> R/ John Martin

There is nothing particularly magical about 400Hz, but by going to such a frequency, the size and weight of the generators and transformers can be cut to a fraction of that for, say, 60Hz. As the frequency goes up, the thickness of iron must go down, and for a given power and voltage, the copper must have a given cross section, so at some point (with the technology of the time) the advantages of increasing frequency are overtaken by iron losses and inadequate cooling potential. This fell in the area of 400Hz back about when you suggest, and once adopted, naturally was hard to change. The larger generators were commonly 3 phase for even better space/weight utilization. This was also used for mil ground mobile equipment.
Some post war Radars used 1000Hz, and they used this to time the 1ms pulse repitition rate, as well as make the motors and transformers even smaller. Man did they whistle.

Neil S.

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Bill Turner THE MAN KNOWS THE REASON, THE (Oct 7 1999, 3:00 am

nesesu In article <14653-37FCA7FE...@storefull-122 Oct 7 1999, 3:00 am

Randy Guttery View profile More options Oct 7 1999, 3:00 am

400hz. Well -- here are some "hints"...

1) think about (most) all of the airborne radios used during WWII and Korea. They used 400Hz? nope - DC (converted by dynamotors and in a few
cases - vibrators).

How about into the mid fifties - about the time R-390/1/As were hitting the street - were they 400Hz capable? - nope - the R-390 "airborne / mobile" used
a dynamotor...

Just when DO we see 400hz radio start popping up??? Early 400hz set - LORAN receiver - used in a submarine - around 1952... (there are some other equipment examples used in subs at the time - but since I don't know if they've been declassified - we'll just note that there were "some" and let it go at that).

Neither subs nor air craft were the "driving" force in miniaturization - missiles were. In the early 50's - Russia started beating us badly in the arms race. The Air Force had become it's own branch - and had taken over missile development - like the Red stone, etc. In these early missiles - guidance was the key - and this is where a lot of weight (and space) savings could be had. Some of the earliest solid state digital computers were developed using 400 **hz**. It was used in the power supplies - transformers to convert 115V 400hz to a couple of DC supplies. It also turned the magnetic memory "platter" which served not only as the memory for the system - by as a real time integrator. Since the 400 **hz** being generated was extremely accurate - it was used to convert acceleration against time = speed - and speed against time = distance. 400 **hz** is a handy number in time conversions for several reasons - but basically it's also a good compromise between high efficiency to use (vs. a lower frequency) while still not too difficult (then) to generate accurately (vs. even higher frequencies). So inertial navigation of missiles was one of the prime motivators towards 400hz.

As Russia extended their lead (announced a new ICBM that could "potentially" reach US soil) - the people in the US just sorta yawned. But then a couple of weeks later - Russia launched sputnik - and now the Russian's were over the American's head - making it clear they could let loose nuclear rain on us if they were so inclined.

Panic is a bit of an overstatement - but not by much. President Eisenhower took to TV to calm the nation's nerves... but then he quickly turned to the services and required that this new threat be met - and fast.

So the nation's fastest, most complex endeavor in it's history was undertaken. At the time - the technologies were being invented and perfected faster than during any other similar period in the history of this country. Technologies ranging from miniaturization of systems - to entire new fields that didn't exist before. One of the "benefits" was the perfection of high frequency power and control systems - to accuracy's that had been previously thought impossible. 400hz is used on FBMs for everything from power supplies of various equipment's, secondary navigation reference (the primary is 10,000cycles), to cooling fan motors - now 1/4 the size to their (equal in horsepower) 60 cycle

siblings.

After only 6 years in development - the Polaris deterrent system that sailed as the SSBN 598 George Washington contained incredible devices and equipment's that only a few years before would have filled a huge warehouse covering perhaps 2 city blocks - now functioning with a crew of 90+ in a tube about 33 feet in diameter and 380 feet long.

While the weight savings of 400 cycles was taken advantage of to some extent in air craft - they have no where near the amount of equipment (thus the opportunity of savings) that subs have.

The greatest "leap" in sub technology came in two stages - the perfection of Naval nuclear propulsion; and the creation of the greatest weapon system on the planet - the FBM submarine. That "era" started in 1950 - and was in full operation when the 598 launched the first Polaris in 1960.

Other refinements - important improvements were made since to be sure - but never in the the history of "technology" has so much been accomplished in such a short space of time.

Big statement???? Consider this:

It was this same "technology" path that allowed Armstrong to stroll on the Moon less than 9 years after the 598 launched her first missile----

best regards...
==========
randy guttery

A Tender Tale - a page dedicated to those Ships and Crews so vital to the Silent Service:
http://www.mississippi.net/~comcents/tendertale/ttp0.html

Reply to author Forward

Doug. Houston View profile More options Oct 8 1999, 3:00 am

At the end of WWII, there were quite a few pieces of surplus equipment that operated on 400 Cycles. This was about the time I was becoming acquainted with superlative (military) electronic equipment. Indeed, a lot of it was 24VDC, and an appreciable amount was 400CPS.
I worked on the Redstone and Jupiter missiles in the 1954-60 era, and designed some components of the measuring system on those birds. There
were a very few things that operated on the 24VDC batteries that supplied power. There were three inverters that supplied the 400 Cycle power to everything; one dedicated to guidance. One of the features of 400 CPS that nobody mentioned is the available synchronous speed from 400 Cycles. For a 2 pole motor at 400 CPS, the synchronous speed is 24000 RPM. While the gyro motors may not have used this full speed, the available high RPMs were ideal for gyros and selsyns. The 400 CPS afforded fine resolution for selsyns. As far as power supply ripple is concerned, we used the three phase power from the inverter for the power transformer in the signal adapters. Each phase was full-wave rectified and shunt fed the system. The ripple frequency was 800 X 3 or 2400CPS. You didn't need many microfarads to filter that supply!

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Randy Guttery "Doug. Houston" wrote: > I worked or Oct 8 1999, 3:00 am
Bill Turner Now THATS the answer the man asked fo Oct 8 1999, 3:00 am
Gene Warner View profile More options Oct 8 1999, 3:00 am

Output alternator frequency is the product of stator pole pairs and rotor RPM. F=(PP}(RPM)/60. One can only stuff so many pole pairs into an alternator or inverter before size and weight become significant a factor for airborne equipment. Speed is also a prime design consideration
given engine driven or DC motor both of which are limited as to their rated or safe maximum speeds. Weight and size savings due to smaller and lighter power supply components were simply a desired-by product of the choice to make 400Hz the standard.At one time both 800 and 1000 **Hz** power supply frequencies were tried but 400 was likely chosen as the best compromise of size/weight vs power output.
Good question John; I'm sure every response to your question will have a different explanation. I flew in Navy B-24s back in the 50s. The entire electrical system was 28Volts DC, with higher voltages via dynamoters. We once flew the plane to Bendix in NJ for the installation of a electrically operated gyro stabilized compass and directional gyro both powered by a small 26 Volt, 3 phase, 400 **Hz** invertr. We needed these
for deployment to northern Greenland. Possible first use of 400Hz power.
Regards, Gene

In article <37FC52E0.F6559...@phnx.uswest.net>,
jjmar...@phnx.uswest.net
says...

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Gene Warner A dynamotor outputs Direct Current Vo Oct 8 1999, 3:00 am
Gene Warner In article <7tlgd0$4i...@delphi.ridgenet Oct 8 1999, 3:00 am
Bill Turner SUBSTITUE THE WORD "INVERTER" F Oct 8 1999, 3:00 am
jjmartin View profile More options Oct 8 1999, 3:00 am

Many thanks to all who replied. It's an interesting topic to be sure.
I thought some pieces of 1930s avionics used 400 **Hz**, but perhaps
I am mistaken. In any case, I appreciate everyone's inputs as to
why 400 was chosen over any other 'nearby' frequency.
R/ John Martin

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Randy Guttery View profile More options Oct 8 1999, 3:00 am

jjmartin wrote:

> Many thanks to all who replied. It's an interesting topic to be sure.
> I thought some pieces of 1930s avionics used 400 **Hz**, but perhaps
> I am mistaken.

There probably were some "unique" and special equipments then... there are few "absolutes"... As Doug Houston noted - there were a few pieces of 400hz stuff "surplussed" out of WWII... they were the exceptions -

rather than the "mainstream".

Something not mentioned in discussions about higher frequencies - the higher you get - the more opportunities to "radiate"... which is NOT desirable in most instances. But there were all sorts of experiments with "power distribution" in those early days...

best regards...
randy guttery

A Tender Tale - a page dedicated to those Ships and Crews so vital to the Silent Service:
http://www.mississippi.net/~comcents/tendertale/ttp0.html

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Bill Turner View profile More options Oct 9 1999, 3:00 am

I HAVE BEEN TRYING TO REMEMBER IF THE ADF'S IN DC-3'S USED 400 **HZ**, I
BELIEVE THEY DID BUT I CAN'T REMEMBER FOR SURE. I HAVE NOT WORKED ON
THEM IN 35+ YEARS.

disregard caps, visual problem
Bill Turner WA0ABI
1117 Pike Street
Saint Charles, MO 63301
636-949-2210

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Discussion subject changed to "AWESOME ANTIQUE & COLLECTABLE

Linda Rulau SHOP OR SELL ON OUR ON-LINE M Oct 11 1999, 3:00 am

Discussion subject changed to "Origin of 400 Hz in aircraft?" by Hagstar

Hagstar Randy Guttery wrote: As Russia extended Oct 12 1999, 3:00 am

Randy Guttery Hagstar wrote: > I could have writte Oct 12 1999, 3:00 am

End of messages

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