From: Paul Harden
Date: 29 March 2002

EVLA Memo #37

The New "UX-to-X Band Converter" (T303) And the Ku, K, Ka and Q Band Block Conversion Scheme

This packet reflects the changes to the "Ku-to-X Band Converter" as a result of the new Ku, K, Ka and Q band block conversion scheme. It contains the preliminary converter design, tuning schemes, and proposed changes to the original block conversion concept. ***See attached drawings.***

Changes required to the Ku-to-X Band Converter

1. The module is renamed to the "**UX-to-X Band Converter**" (UX2X) as it now processes *both* Ku and X band inputs simultaneously. It is designated as **T303**.
2. The original FE PDR scheme called for 3 switches to select Ku-to-X band conversion products, the X-band direct, and routing of these signals to IF-A and/or IF-B, per polarization. This scheme results in some redundant combinations. A 2-switch scheme is proposed, which saves the costs of some components per converter, while maintaining full band coverage (up to 8GHz total bandwidth per receiver) with some further manipulation of the 1st LO-2 converter frequencies. This should also make the software-commanding of the switch settings in the converter, establishing the proper converter modes, easier to execute and understand by the user.

Cost concerns

1. The block conversion scheme about doubles the complexity and required components in the converter, adding about $5K per converter. The budget for the UX-to-X Converter needs to be adjusted accordingly.
2. It was suggested at the LO-IF PDR to include total power monitors for each of the four IF's to detect RFI, receiver compression, and as a troubleshooting aid. I agree with this. However, at the approximate -60 to -65dBm input power levels (after the 10dB directional couplers), this requires about 40dB of power gain to properly drive a tunnel diode detector, followed by nearly 40dB of voltage gain to provide 0.5V of monitor voltage to the M.I.B. This would cost about $1800 per IF channel (directional coupler, two 8-18GHz 20dB amplifiers and the total power detector), or an *additional* $7K per converter. *It needs to be decided if this monitoring feature justifies the cost.*

Performance Concerns

The majority of the performance concerns relate to controlling signal loss, image rejection, isolation of LO signals, and preserving passband flatness to achieve the system specifications of <2dB/2GHz.

Cable runs between the receivers and UX2X Converter (8-18GHz) can contribute significant signal loss and roll-off. I propose to mount the converter on the vertex room overhead in very close proximity to the Ku, K, Ka and Q band receivers to keep these cable runs at a minimum (2-4 feet).

Connectors. With the converter being a "box" very near the receivers, instead of a "transition module," SMA/2.9mm connectors, as appropriate, can be used throughout, avoiding the need for OSP or other types of modular mating connectors, and the losses and RFI concerns these connectors bring.

Band select switches connect the converter inputs to the proper receiver. These switches need to be selected carefully. Most coaxial switches are specified for operation to 18GHz, which is the 3dB attenuation point. *This alone would consume the entire 2dB/2GHz system spec for flatness!* Coaxial RF switches specified to at least 20GHz (or 26.5GHz) should be sought. Using 18GHz coaxial switches for the converter output select switches -- before the down converters -- is sufficient, as this is all 8-12GHz X-band IF's.

Overall system passband flatness (2dB/2GHz) may be difficult to achieve. With the block convert scheme, the receiver bandwidth is split into two 4GHz components, one being the source for IF-A ("X-direct" mode), and the second as IF-B following Ku-band conversion. This means that IF-A will receive one level of down-conversion for inverse IF tuning (inside the receiver), while IF-B will receive two levels of down conversion (one in the receiver, one in the converters), which returns IF-B to normal IF tuning ... that is, the IF low-end represents the RF low-end of the tuning spectrum. It should be pointed out that the resultant passband slopes of IF-B, after being converted and inverted twice, the *response slope* will be inverted twice as well -- for a *flatter passband* response than those converter modes where only one level of conversion takes place. Thus, the system specifications should probably be updated to include the three modes of the converter, as different passband responses will occur, and the users be made aware that using only IF-B and IF-D mode will yield the flattest passband response when the best flatness is needed. The exact passband response for the three converter modes will be measured following the prototyping and bench integration phase, as "X-band direct" may have the best response.

Power supplies required for the converter are nearly identical as for the receivers: +5V and +/-15V. It is proposed to likewise mount the power supplies in close proximity to the receivers and converters to avoid significant IR line losses and RFI . Power supplies for the Ku, K, Ka and Q band receivers and the converter should be separate from those used for the lower band receivers/converters.

+48V or 120VAC. The *total loading* on the power supplies for the Ku, K, Ka and Q receivers and the UX2X converter are fairly minimal: about +5V@6A, -15V@1.5A, +15V@7A, and +28V@2A. It is therefore proposed to use 120VAC input linear power supplies for this service to reduce as much as possible any RFI from the 48V switching power supplies and the dc-dc converters. If 48VDC power is to be used, it is recommended the switching power supplies be located outside the vertex room (in the pedestal room?) for maximum shielding from the receivers/converter.

Isolation has been maximized in the UX2X Converter by the inclusion of isolators on all converter input and output ports, LO distribution, and on all mixer ports, for at least 70dB of isolation. This may be compromised slightly by the 60dB isolation typical of the RF switches. Isolation is particularly critical for K- and Ka-bands, where the 2nd harmonics of the 1st LO-1 and LO-2 signals will occur, and the intentional doubling of 1st LO-1 and LO-2 (to 24-30GHz) within the UX2X converter. The 1st LO is distributed to the system at about +3dBm, and the 2x 1st LO (24-30GHz) exists up to +18dBm within the converter, requiring the high isolation of the LO's.

Image rejection in the original block convert scheme is assisted by an 8-18GHz bandpass filter on the converter inputs. It is proposed to band-limit the "X-band direct" signals with an 8-12GHz bandpass filter, and 12-18GHz bandpass filters (Ku band) ahead of each mixer, since the mixers are never used for X-band inputs. This will help reject Ku band power from the "X-band direct" paths, and X-band input power out of the Ku-band converters for further image rejection, and of course for out-of-band images.

Temperature stability of the converter is important. If mounted on the overhead as proposed, it would be operating at room temperate, unable to dissipate its heat. It is proposed to cool the converter with the vertex room cooling air, supplying it to the converter via a run of 3-4 inch dia. "elephant trunk," with the warm-air exhausting into the vertex room. The same can be done for the power supplies.

System decisions to be made

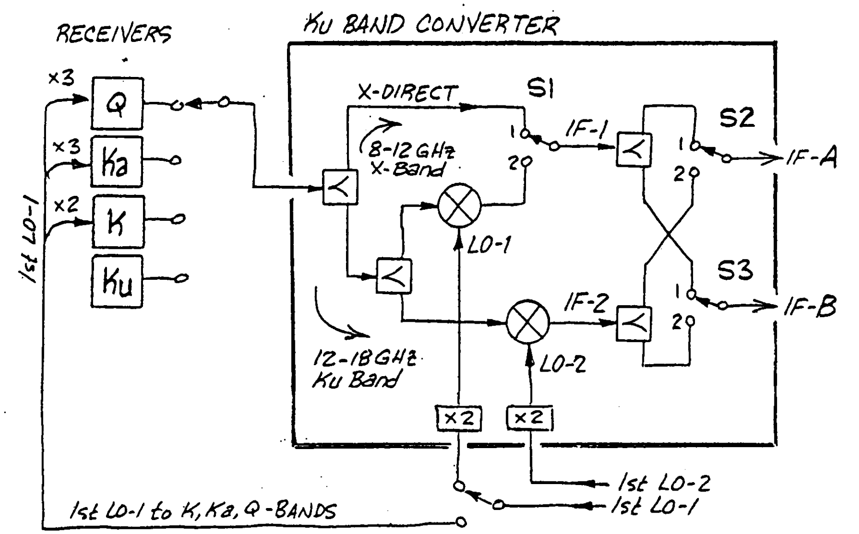
1. Does the attached proposed preliminary design satisfy system and scientific requirements?
2. Will the UX2X converter be a B-rack module or mounted on the vertex room overhead?
3. Are total power detectors for the four IF's to be included (cost issue)?
4. Will the converter have internal DC power supplies, or a common power supply system?
5. Will the power supplies be 120VAC linear supplies, or dc-dc converters from the 48V system?
6. Will the B-rack be a full-sized or half-sized rack? Where will it be located?

These issues need clarification before further development and prototyping of the UX2X Converters can proceed.

Ku, K, Ka and Q-BAND BLOCK CONVERSION SCHEME

REV	DATE	DESCR

ORIGINAL "PDR" SCHEME

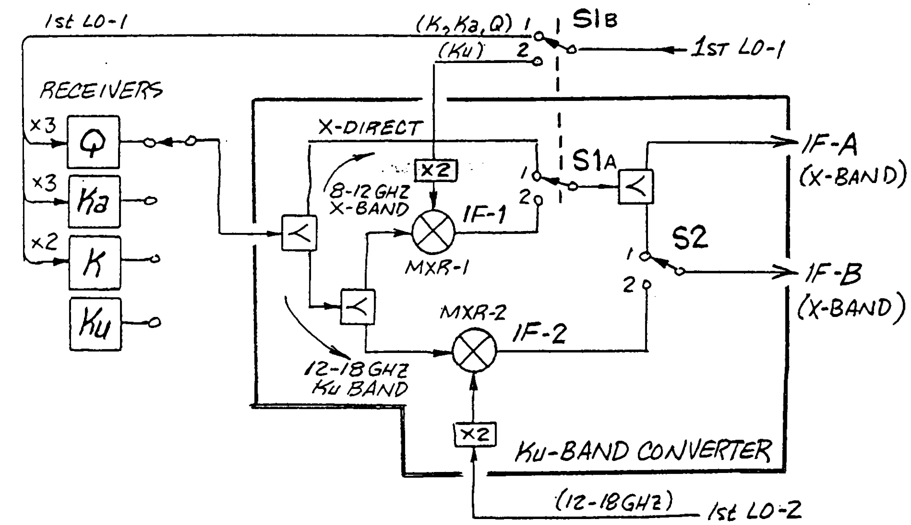


SWITCH S1-S3 TRUTH TABLE

	S1	S2	S3	IF-A	IF-B	
K, Ka & Q	1	1	1	X-DIRECT	X-DIRECT	
	1	1	2	X-DIRECT	IF-2	
	1	2	1	IF-2	X-DIRECT	✱
	1	2	2	IF-2	IF-2	✱
Ku-BAND	2	1	1	IF-1	IF-1	
	2	1	2	IF-1	IF-2	
	2	2	1	IF-2	IF-1	✱
	2	2	2	IF-2	IF-2	✱

✱ = REDUNDANT I.F. COMBINATIONS

NEW PROPOSED SCHEME



SWITCH S1-S2 TRUTH TABLE

S1	S2	IF-A	IF-B		
1	1	X-DIRECT	X-DIRECT	A=B	K, Ka, Q Bands
	2	X-DIRECT	IF-2	A≠B	
2	1	IF-1	IF-1	A=B	Ku-Band ONLY
	2	IF-1	IF-2	A≠B	

NEW SCHEME

1. CHANGE FROM 3-COAXIAL RELAYS TO TWO TO ELIMINATE REDUNDANT IF PAIRS.
2. EXTEND CONVERTER LO TUNING FROM 24-26GHz TO 24-30GHz FOR IDENTICAL BAND COVERAGES.
3. THIS SLAVES RELAY FOR 1st LO-1 DESTINATION TO Ku/K-Ka-Q SELECT RELAY (S1A + S1B)

HARDWARE SAVINGS
(PER Ku BAND CONVERTER)

2 COAX. RELAYS 2 × \$180 = \$ 360
2 PWR. SPLITTERS 2 × \$550 = 1100
\$1460 PER CONV.

×30 ≈ \$44K FOR PROJECT

EVLA	PROJ T303 Ku-BAND CONVERTER		SHT of ___
	TITLE BLOCK CONVERSION SCHEME		
	BY PAUL HARDEN	DATE 3-2002	REV

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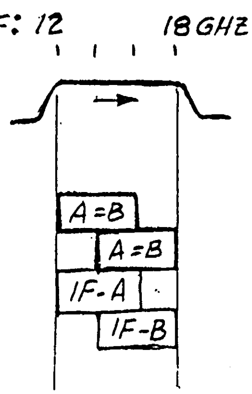
NEW TUNING SCHEME & BAND COVERAGE

REV	DATE	DESCRIPTION

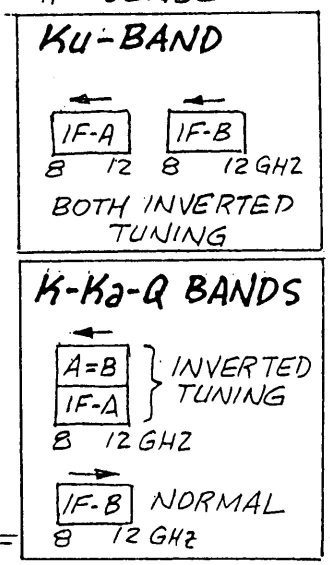
Ku-BAND

SWITCH S1	SWITCH S2	LO1 GHZ	LO2 GHZ
2	1	24	—
2	1	26	—
2	2	24	26



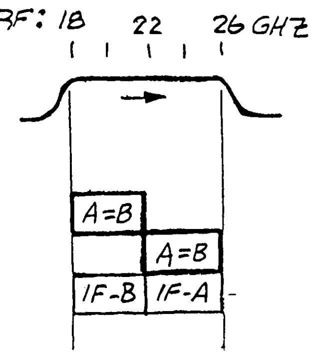
A=B = IF-A & IF-B

IF "SENSE"



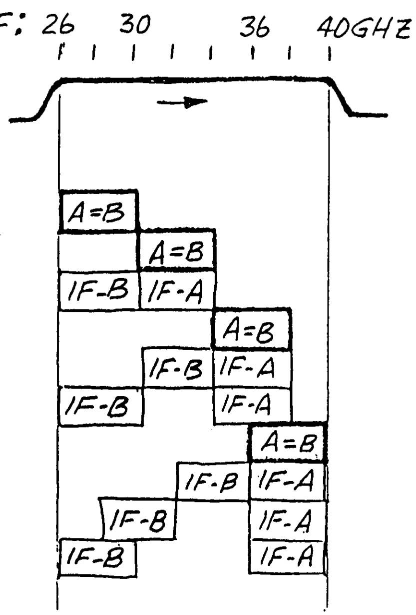
K-BAND

SWITCH S1	SWITCH S2	K LO	Ku LO
1	1	30	—
1	1	34	—
1	2		24



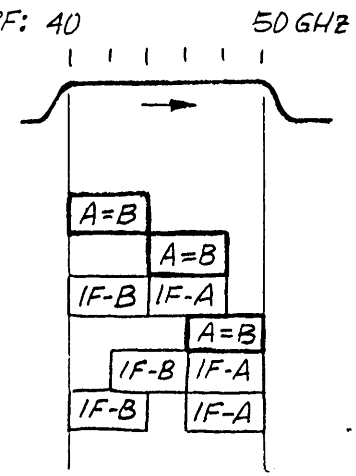
Ka-BAND

SWITCH S1	SWITCH S2	Ka LO	Ku LO
1	1	38	—
1	1	42	—
1	2		24
1	1	46	—
1	2		24
1	2		28
1	1	48 GHZ	—
1	2		24
1	2		28
1	2		30



Q-BAND

SWITCH S1	SWITCH S2	Q LO	Ku LO
1	1	52	—
1	1	56	—
1	2		24
1	1	58 GHZ	—
1	2		24
1	2		26



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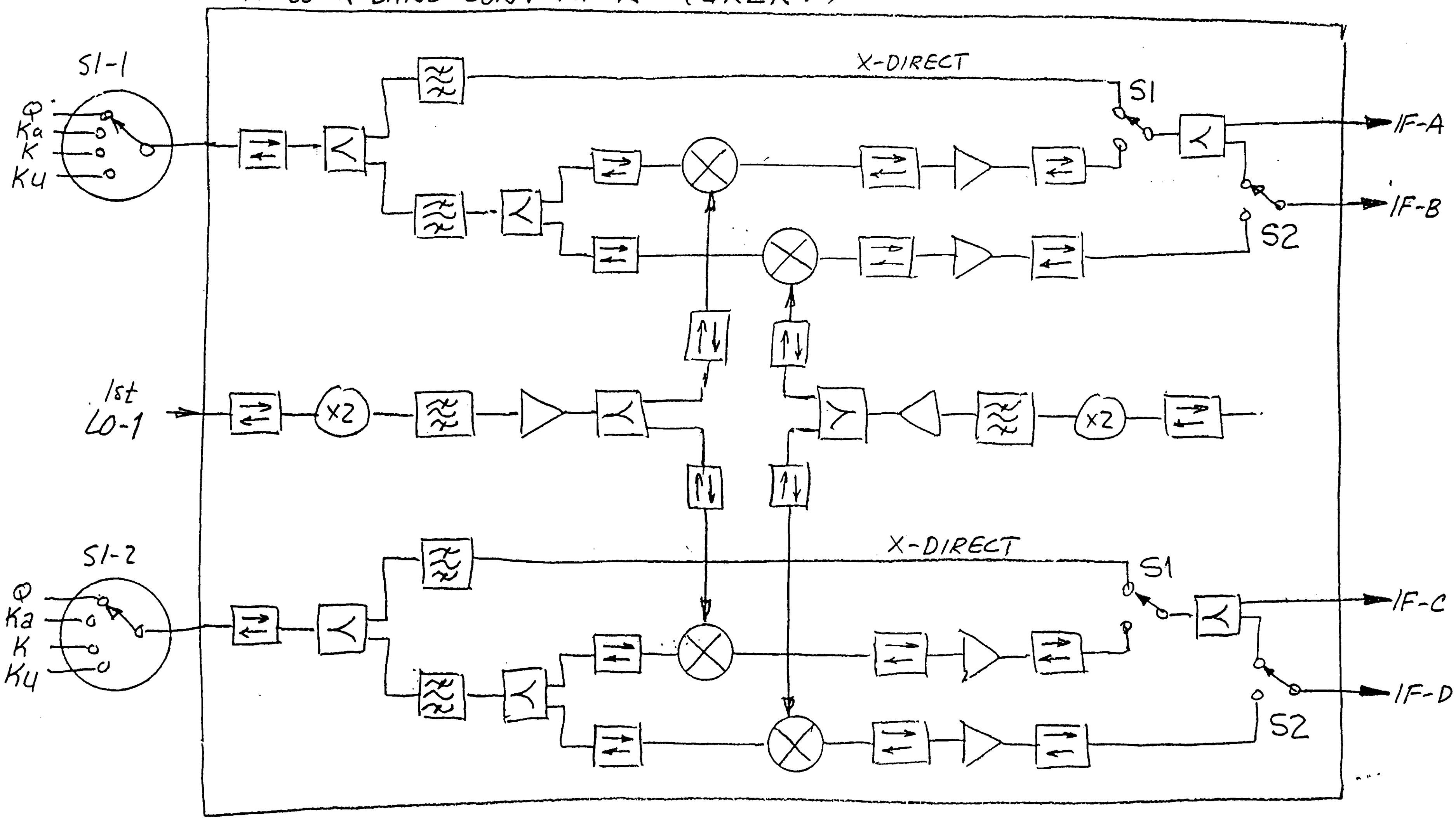
PROJECT T303 Ku-BAND CONVERTER

TITLE NEW TUNING SCHEME

BY PAUL HARDEN | DATE 3-2002 | REV

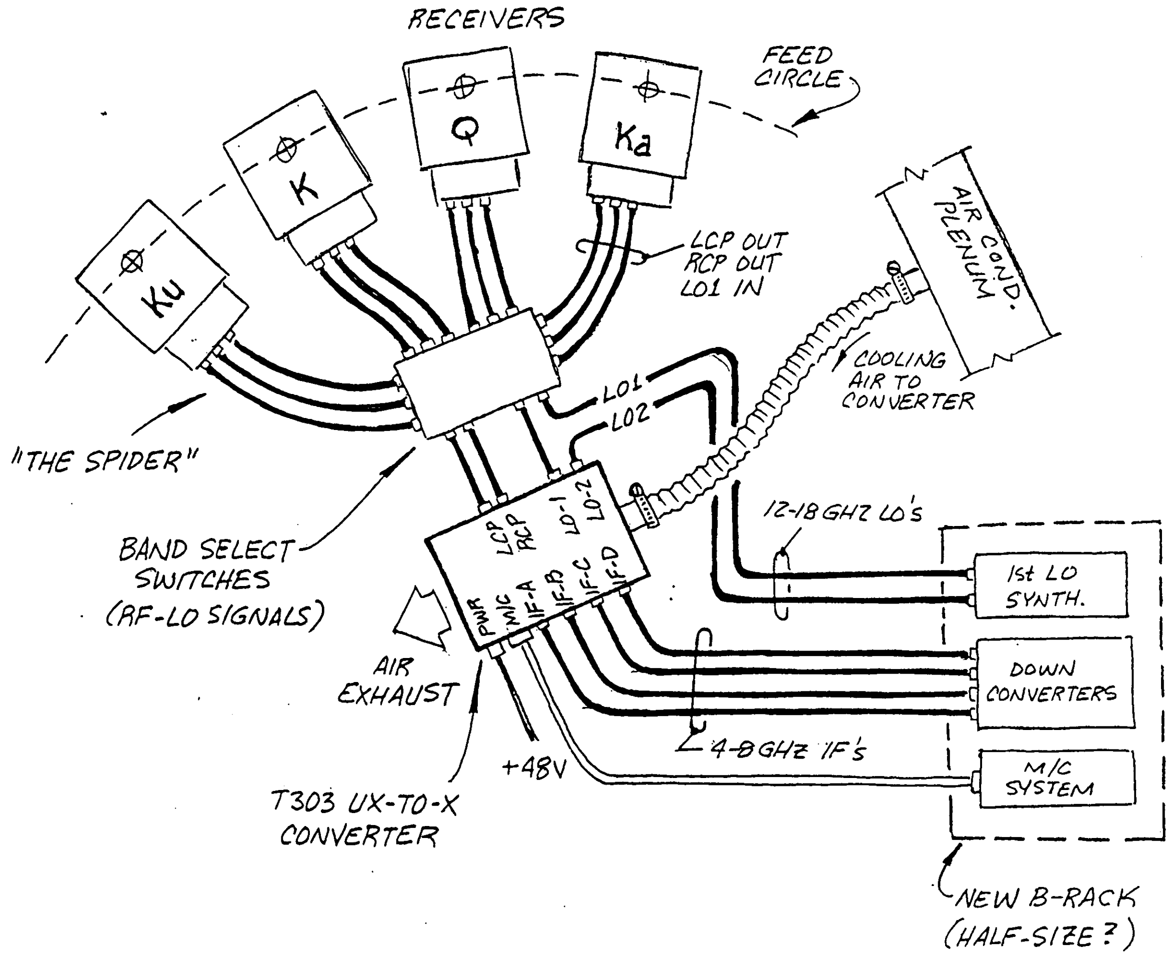
REV	DATE	DESCRIPTION
B	3-2002	FROM 3-SWITCH TO 2-SWITCH SCHEME

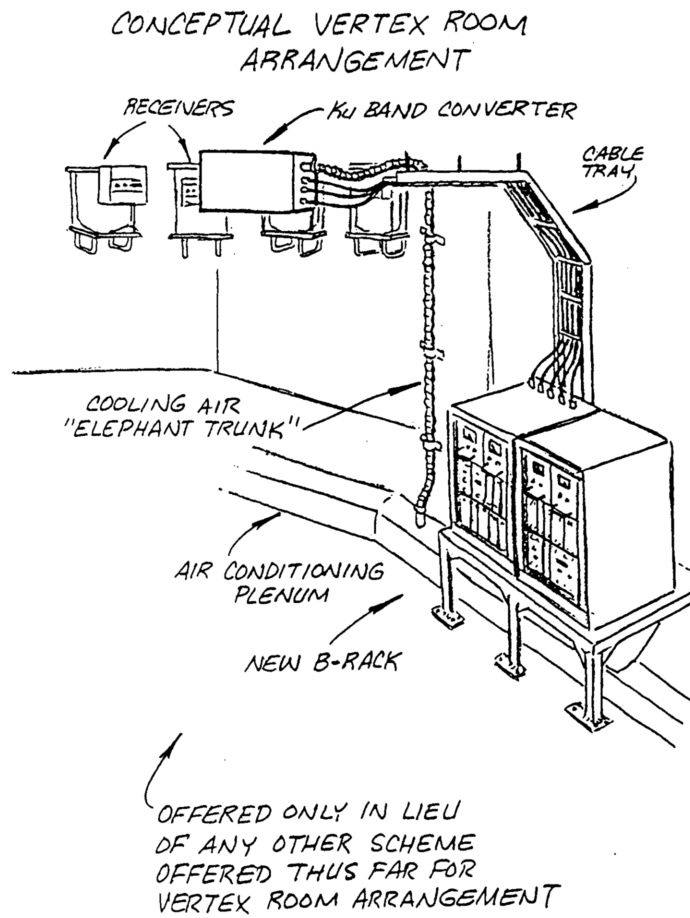
UX-to-X BAND CONVERTER (UX2X ?)



JIM JACKSON —
NEW BLOCK DIAGRAM OF Ku/X to X CONVERTER
FOR SYSTEM BLOCK DIAGRAM

EVLA	
	PROJECT T303 CONVERTER
	TITLE BLOCK DIAGRAM (SYSTEM LEVEL)
	BY PAUL HARDEN · DATE 3-2002 · REV B





PROPOSED SCHEME FOR Ku-BAND BLOCK CONVERT

MOUNT BAND SELECT SWITCHES AND Ku-BAND CONVERTER ON VERTEX ROOM OVERHEAD IN VERY CLOSE PROXIMITY TO Ku, K, Ka and Q-BAND RECEIVERS AS SHOWN TO MINIMIZE CABLE LENGTHS OF THE Ku AND X-BAND IF'S FROM EACH RECEIVER. FOR CONTROL OF LOSS AND PASS BAND FLATNESS.

RF UNITS & CABLING

REV	DATE	DESCR

EVLA	PROJ T303 Ku-BAND CONVERTER	SHT 1 of 2
	TITLE PROPOSED PHYSICAL SCHEME & INSTALLATION	
	BY PAUL HARDEN	DATE 3-2002 REV

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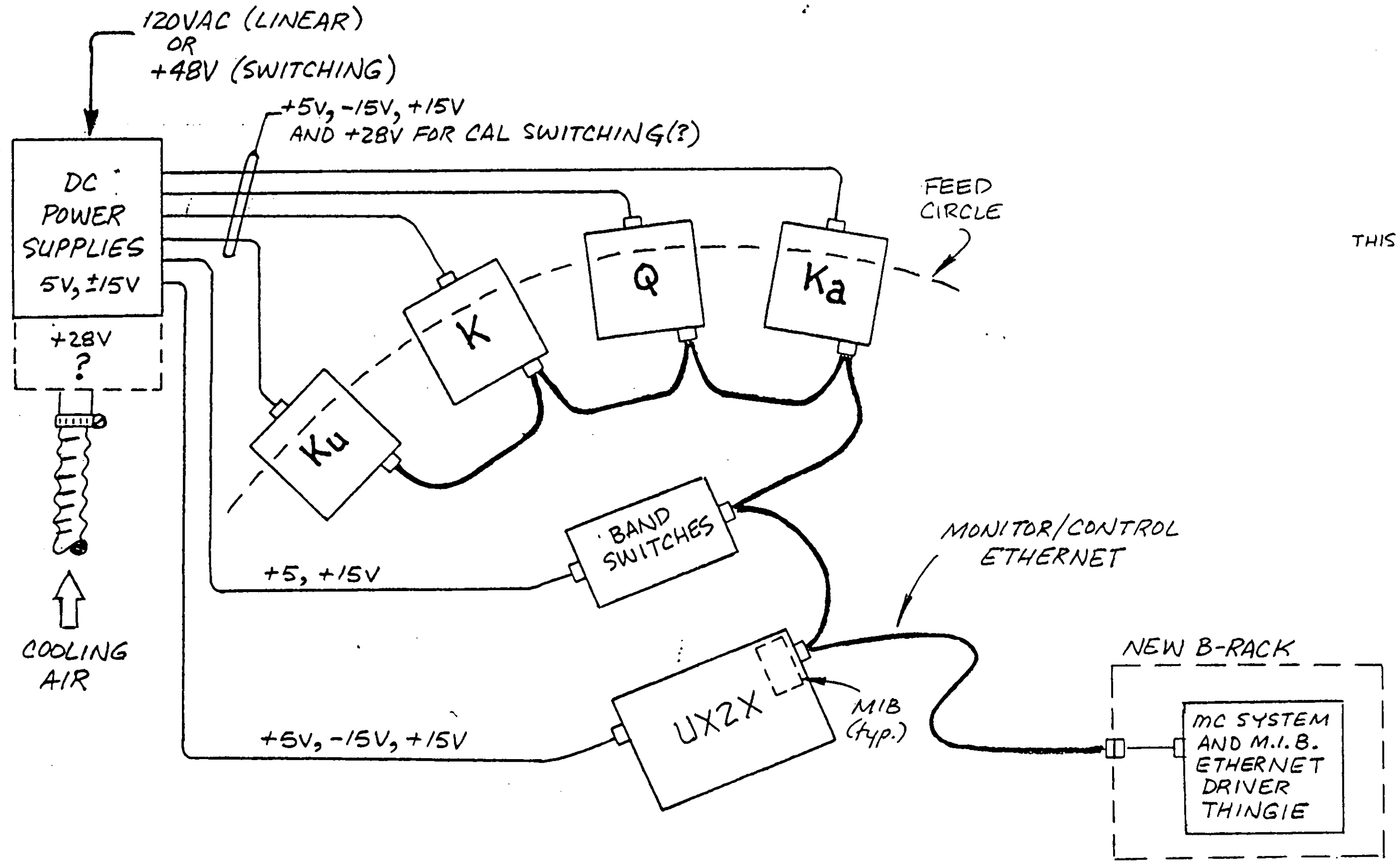
REV	DATE	DESCR



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APPROXIMATE POWER SUPPLY LOADING

LOAD	+5V	−15V	+15V	+28V
Ku RCVR	1A	0.3A	1.2A	.5A
K RCVR	1A	0.3A	1.2A	.5A
Ka RCVR	1A	0.3A	1.2A	.5A
Q RCVR	1A	0.3A	1.5A	.5A
SWITCHES	0.5A	—	0.3A*	—
UX2X CONV.	1A	0.3A	1.0A	—
TOTAL	6A	1.5A	7A	2A

*ONLY WHEN SWITCHES ARE CHANGING

RECOMMEND SIMILAR (AND SEPARATE) POWER SUPPLIES FOR 4, P, L, S, C AND X-BAND RECEIVERS

POWER SUPPLY & CONTROL UNITS

SHT 2 of 2

EVLA	PROJ T303 UX-TO-X CONVERTER		
	TITLE PROPOSED PHYSICAL SCHEME & INSTALLATION		
	BY PAUL HARDEN	DATE 3-2002	REV

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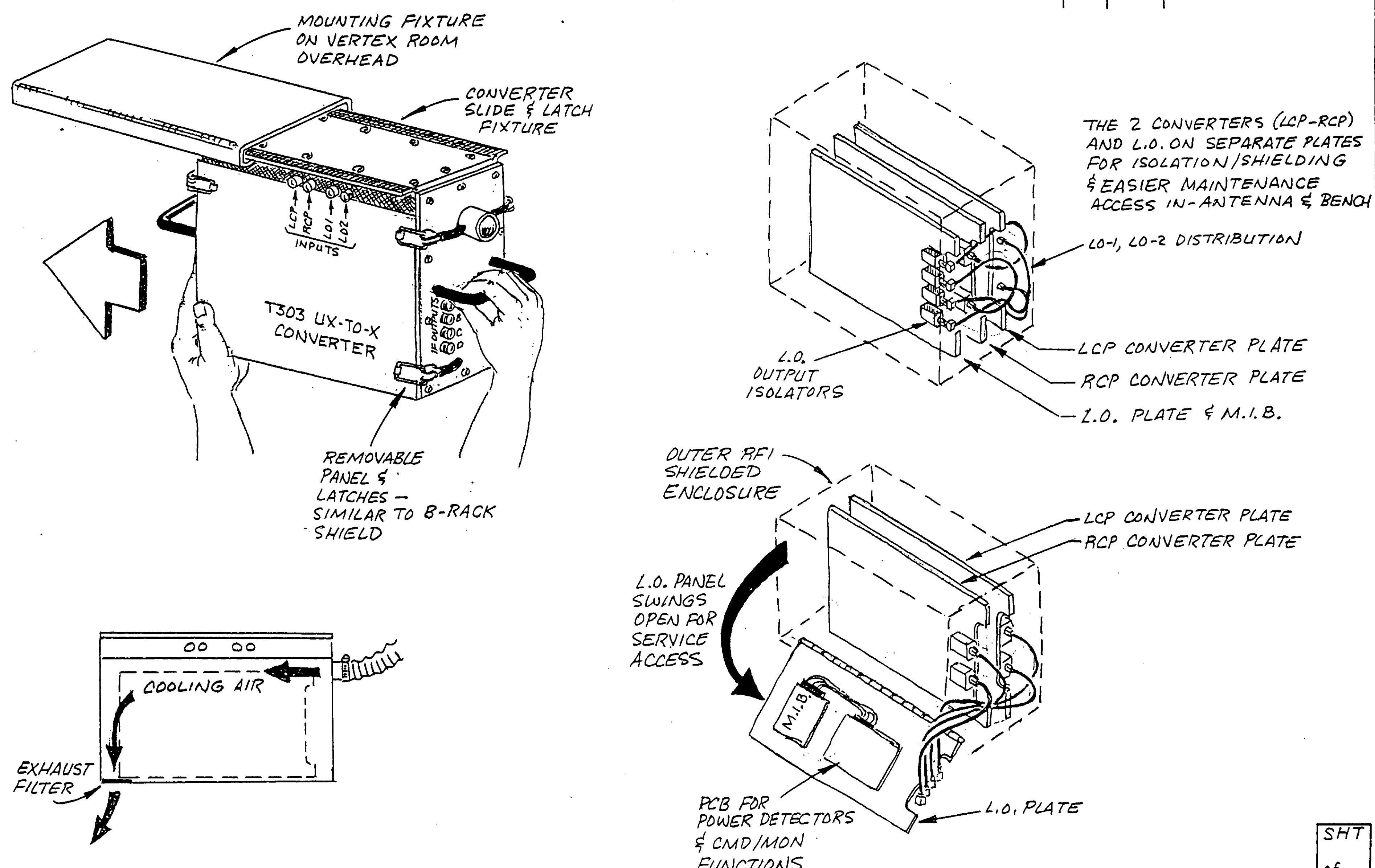

REV	DATE	DESCR

SHT of ___

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EVLA

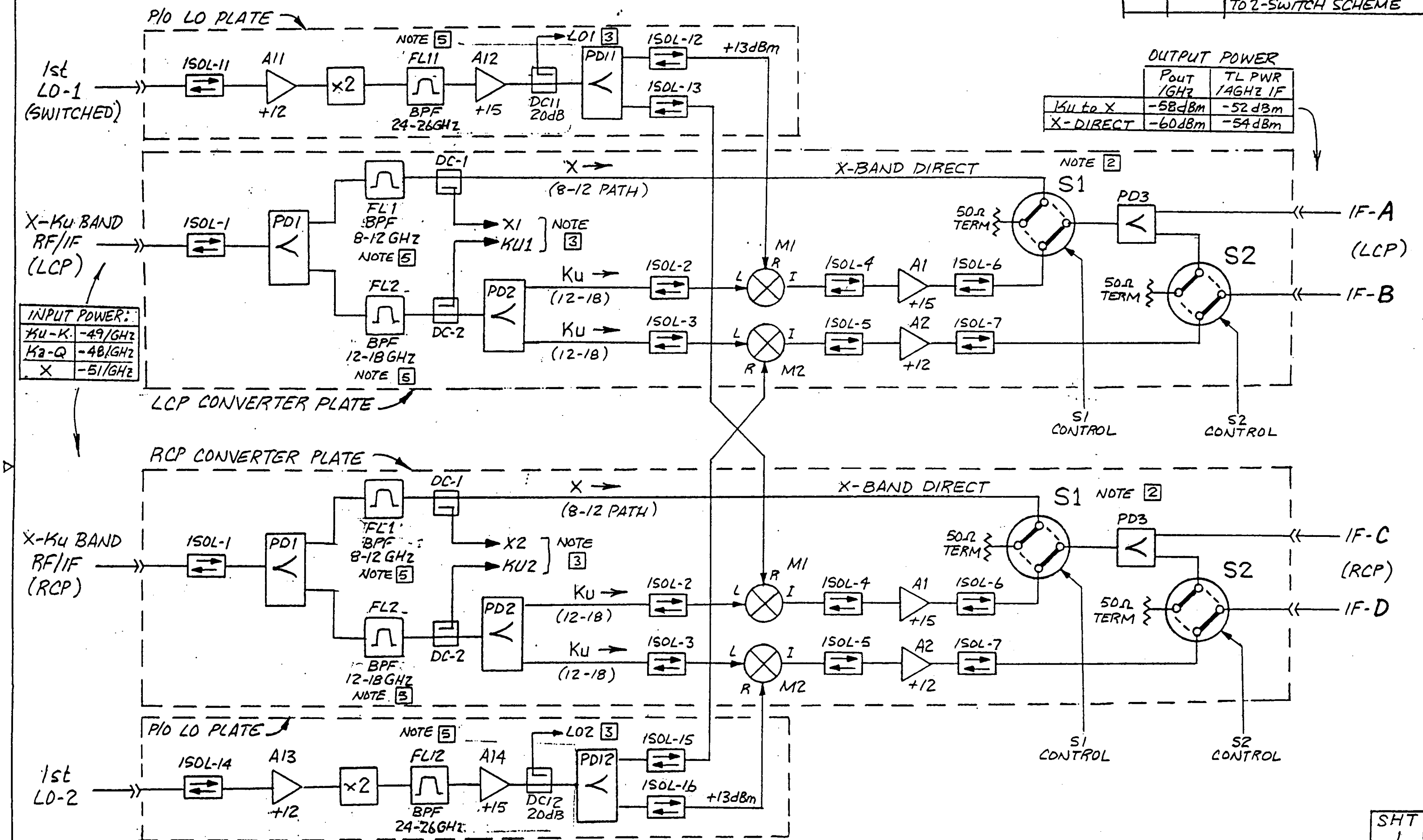
PROJ T303 UX2X CONVERTER

TITLE DOODLES & MUSINGS FOR CONVERTER PACKAGING IDEAS

BY PAUL HARDEN | DATE 3-2002 | REV

NA5N

REV	DATE	DESCR
B	3-2002	CHANGED FROM 3-SWITCH TO 2-SWITCH SCHEME



INPUT POWER:

Ku-K	-49/GHz
Ka-Q	-48/GHz
X	-51/GHz

OUTPUT POWER

	P_{OUT} /GHz	TL PWR /4GHz IF
Ku to X	-58dBm	-52dBm
X-DIRECT	-60dBm	-54dBm

1. ALL COMPONENTS ARE COAXIAL WITH SMA OR 3mm CONNECTORS
2. RF TRANSFER SWITCHES S1-S2 SHOWN IN Ku-BAND CONVERTER POSITIONS
3. DIRECTIONAL COUPLERS GO TO POWER MONITOR CIRCUIT - SEE SHT. 2
4. LCP & RCP CONVERTER PLATES ARE IDENTICAL AND REPLACEABLE UNITS
5. FL1 3dB ≈ 9-13 GHz, FL2 3dB ≈ 10.5-20GHz, FL11-FL12 3dB ≈ 20-30 GHz (COTS)

SHT 1 of 2

EVLA

PROJ T303 UX-TO-X-BAND CONVERTER

TITLE SCHEMATIC RF COMPONENTS

BY PAUL HARDEN DATE 3-2002 REV B

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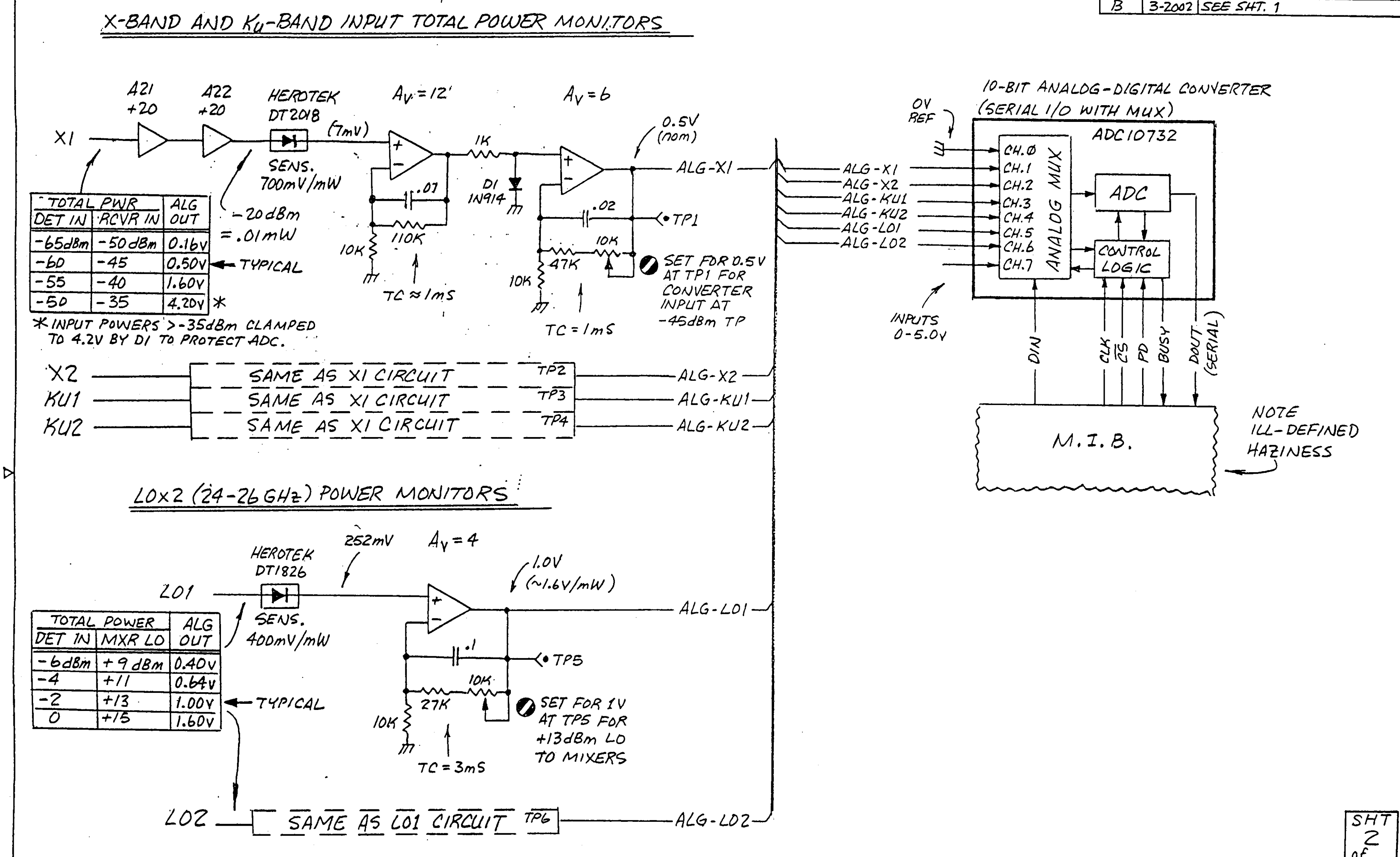

TOTAL PWR DET IN	RCVR IN	ALG OUT
-65dBm	-50dBm	0.16V
-60	-45	0.50V ← TYPICAL
-55	-40	1.60V
-50	-35	4.20V *

* INPUT POWERS > -35dBm CLAMPED TO 4.2V BY D1 TO PROTECT ADC.

TOTAL POWER DET IN	MXR LO	ALG OUT
-6dBm	+9 dBm	0.40V
-4	+11	0.64V
-2	+13	1.00V ← TYPICAL
0	+15	1.60V

REV	DATE	DESCR
B	3-2002	SEE SHT. 1

SHT 2 of

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PROJ T303 UX-TO-X CONVERTER

TITLE SCHEMATIC POWER MONITORING

BY PAUL HARDEN | DATE 3-2002 | REV B

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